Government of Meghalaya
North Eastern Region Capital Cities Development Investment Programme

(ADB Loan No. 2834-IND)

SPECIFICATION DOCUMENT

Volume III

Issued on:

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List of Content

General Specification for Civil Works

LIST OF BUREAU OF INDIAN STANDARD CODES (BIS)

Following is the consolidated list of various Indian standards relevant to the civil engineering work:

Sr. No	IS No	Subject
1.	IS 4082-1977	1. Carriage of materials. Recommendation of stacking and storage of construction materials at sites(1st revision)(reaffirmed 1990)
2	IS 1200(part 1)1992	2. Earth work Method of measurement of building and civil engineering works(part 1)Earth work (4rth revision)
3	IS 4081-1967	Safety code for blasting and related drilling operations (reaffirmed -1991)
4	IS 6313(part ii)-1981	Code of practice for anti-termite measures in buildings (part i) constructional and measures (1st revision)(reaffirmed-1991)
5	IS 6313(part ii) 1981	Code of practice for anti-termite measures in buildings(partii) pre-constructional chemical cement measures (1st revision)(amendment 3)(reaffirmed 1991)
6	IS 6313(part iii)1981	Code for practice for anti-termite measures in buildings (part iii)Treatment for existing building (1st revision)(amendment 3)(reaffirmed-19941)

1.1 List of Other BIS Codes That May be Reaffirmed

Sr. No	Indian standard Nos.	Concerned Subject	Title of Indian standard	Year of reaffirmation
(1)	(2)	(3)	(4)	(5)
1	IS 1200(part-22)1988	Method of measuring materials	Method of measurement of building and civil Engineering works part 22 materials	1989
2	IS 11134-1984	Setting out of buildings	Code of practice for setting out of buildings	1990
3	IS 875(part 1)-1987	Unit weight of materials	Code of practice for design loads (other than Earthquake) for buildings and structures part 1 dead loads unit weights of building materials & stored materials	1992
4	IS 2309-1989	Safety measures in construction works	-code of practice-	-
5	IS 818-1968	Do	Code of practice for safety and health requirement In Electric and Gas welding and cutting operations	1991
6	IS 3696(part 1) 1987	Safety measures in construction work	Safety code for scaffolds and ladders -	1996
7	IS 3696(part 2) 1991	Do	DO part -2	1996
8	IS 5121-1969	Do	Safety code for pulling and other deep foundations	1990
9	IS 3764-1969	Do	Excavation work-code of safety	1969
10	IS 7205-1974	Do	Safety code for erection of structural steel work	1995

Sr. No	Indian standard Nos.	Concerned Subject	Title of Indian standard	Year of reaffirmation
(1)	(2)	(3)	(4)	(5)
11	IS 7293-1974	Do	Safety code for working with construction machinery	1990
12	IS 7969-1975	Do	Safety code for handling and storage of building materials	1996
13	IS 8989-1978	Do	Safety code for erection of concrete framed structure	1991
14	IS 4081-1986	Do	Safety code for blasting and related drilling operations	1991
15	IS 4130-1991	Do	Demolition of buildings-code of safety	1996
16	IS 4912-1978	Do	Safety requirements for floor and wall openings and toe boards	1996
17	IS 5916-1970	Do	Safety code for constructions involving the use of hot bituminous materials	1990
18	IS 4014(part 2) 1967	Do	Code of practice for steel tabular scaffolding part 2 safety regulations for scaffolding	1990
19	IS 3016-1982	Do	Code of practice for fire precautions in welding and cutting operations	1990
20	IS 14401-1996	Do	Handling and storage of building times-guidelines	-
21	IS 13416(parat1)1992	Falling material hazard	-part-1 falling material hazard prevention	1996
22	IS 13416p-2 1982	Fall prevention	fall prevention	1996
23	IS 13416 p-3-1994	Recommendation for disposal of debris	–part 3-disposal of debris (MULBA)	-
24	IS 13416-p-4 1994	Hazards for timber structures	-part-4-timber structure	-
25	IS 13416-p-5-1994	Fire protection	Preventive measures against hazards at work place recommendations-part-5-fire protection	-
26	IS 4082-1996	Stacking and storage of materials	Stacking and storage of constructions materials and components at site recommendations	1990
27	IS 1904-1986	Earth work	Code of practice for design and construction of foundations in soils-general requirements	1995
28	IS 9759-1981	Do	Guidelines of dewatering during construction	1987
29	IS 8237-1985	Do	Code for practice for protection of slop for reservoir embankments	1990
30	IS 6313-p-1-1981	Do	constructional measures	1991
31	IS 6313-p-2-1981	Do	-2-pre-constructional chemical treatment measures	1991
32	IS 6313-p-3-1981	Do	Code of practice for anti-termite measures in buildings part-3-treatment for existing buildings	1991
33	IS 4015-1998	Earth work and horticulture	Guide for handling cases of pesticide poisoning	-
34	IS 1200-p-1-1992	Earth work		-
35	IS 1200-p-27-1992	Do	Method of measurements of buildings and civil Engineering works part-27 Earth work done by	-

Sr. No	Indian standard Nos.	Concerned Subject	Title of Indian standard	Year of reaffirmation
(1)	(2)	(3)	(4)	(5)
			mechanical Appliances	
36	IS 6922-1973	Do	Criteria for safety design of structures subject to underground blasts	1995
37	IS 712-1984	Use of buildings	Building Limes	1995
38	IS 4098-1983	Do	Lime pozzolana mixture	1989
39	IS 10772-1983	Do	Quick setting lime pozzolana mixture	1989
40	IS 1635-1992	Do	Code of practice for field slaking of building lime and preparation of putty	-
41	IS 269-1989	Use of cement	33 grade ordinary Portland cement	-
42	IS 455-1989	Use of cement	Portland slag cement	-
43	IS 3812-1981	Do	Fly ash for use as pozzolana and admixture	1992

1.1.1 Reference mentioned herein shall be applicable to all sections to the extent the context permits and are intended to supplement the provisions in the particular section. In case of any discrepancy/ deviation, the provision in the particular section shall take precedence.

1.1.2 The rates for all items of work unless clearly Specified otherwise shall include cost of all labour materials and other inputs involved in the execution of the items.

1.2 Interpretations

1.2.1 The Director General (Works) CPWD shall be the sole deciding authority as to the meaning, interpretation and implications for various provisions of the Specification His decision in writing shall be final.

1.3 IS

The Standards specifications and code of practices issued by the Bureau of Indian Standards.

1.4 Best

The word 'Best' when used shall mean that in the opinion of the Engineer-in-charge there is no superior material/article and workmanship obtainable in the market and trade respectively. As far as possible the standard required shall be specified in preference to the word 'Best'.

1.5 Floor and Levels

1.6 Buildings:

1.6.1 Floor 1 is the lowest floor above the ground level in the building unless otherwise specified in a particular case. The floors above floor 1 shall be numbered in sequence as floor 2floor 3 and so on. The number shall increase upwards.

1.6.2 Floor Level: For floor 1, top level of finished floor shall be the floor level and for all other floors above floor 1top level of the structural slabs shall be the floor level.

1.7 Plinth Level: Floor 1 Level or 1.2 M above the Ground Level whichever is Lower shall be the Plinth Level.

1.8 Special Structures:

1.8.1 For structures like retaining walls chimneys over head reservoirs/tanks and other elevated structures, where elevations/height above a defined datum level have not been specified and identification of floors cannot be done as in case of buildings levels at 1.2 m above the ground level shall be the floor 1 level as well as plinth level. Level at a height of 3.5 m above floor 1 level will be reckoned as floor 2 level and level at a height of 3.5 m above the floor 2 level will be floor 3 level and so on. Where the total height above floor 1 level is not a whole number multiple of 3.5 metres top most floor level shall be the next in sequence to the floor level below even if the difference in height between the two upper most floor levels is less than 3.5 metre.

1.9 Explanatory Notes and Comments

1.9.1 Special Structures

[CPWD Specification Clause 0.5.2]

Identification of levels for Special Structures-Overhead Reservoirs

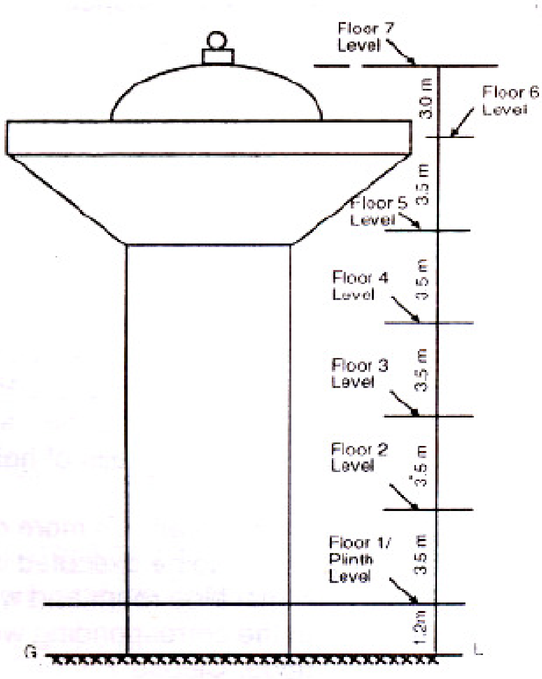


Exhibit 0.3(a): Fixing Levels as per CPWD Specification Clause 0.5.2.1

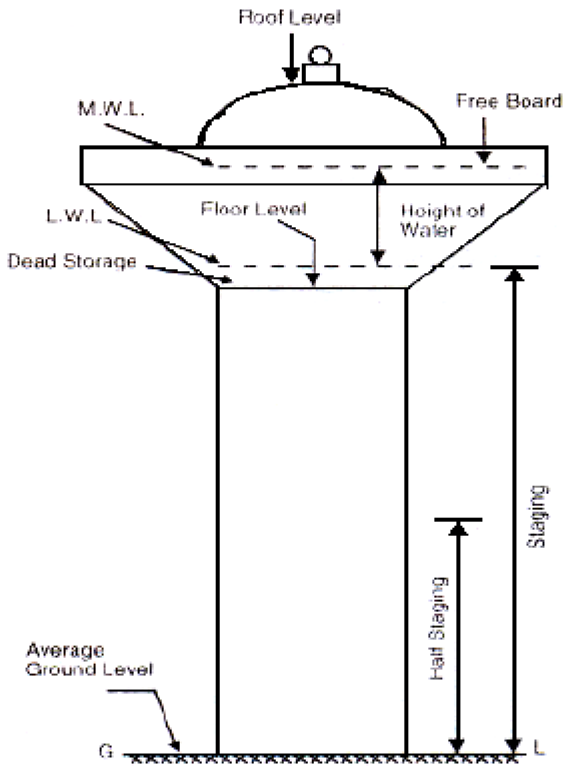


Exhibit 0.3(b): Fixing Levels as per I.S. 11682

(i) In CPWD Specification clause 0.5.2, the structures like Retaining walls, wing walls, chimneys, overhead reservoirs/tanks and other elevated structures have been clubbed under special structures. Generally the wing walls being part of bridge or culvert work are executed throughout the country on MOST (Ministry of Surface Transport) Specification and the various codes published by the Indian Road Congress (A society of Ministry under Ministry of surface Transport).

(ii) Incidentally the MOST Specification does not specify any plinth level and floor levels. They base their structures on working bench marks, and adopt only two stage I e work in foundation (below ground level) and the work in superstructure (above ground level).

(iii) However notable difference is seen in overhead reservoirs/tanks .The public health Engineering Department or water and sewerage boards are constructing a number if overhead Reservoirs/tanks all over the country in village as well Metros, through the year. They base their construction work mostly on Indian standard specifications.

(iv) The Bureau of Indian Standards have published a number of standards (cods)on water retaining structure and one such code is I.S. 11682,which mainly deals with certain definitions to be followed which covers the portion of different levels as well. The relevant extracts from the code are reproduced below.

(a) Capacity: Capacity of the tank shall be the volume of water it can store between the designed full supply level (F S L or M.W.L.) and lowest supply level(L.W.L.) (I e the level of the lip of outlet pipe).

(b) Height of staging is the difference between the lowest supply level of tank and the average ground level at the tank site.

(c) Water Depth: Water depth in tank shall be the difference of level between lowest supply level (L.W.L.) and full supply level (F S L or M.W.L.) of the tank.

(d) Ground Level: Average Ground Level.

(e) Tank Floor Level The top of bottom slab of the tank or top of circular girder if the bank bottom is with a Dome

(v) Thus it can be seen that the I.S. code is more descriptive and practical.

(vi) The provisions of CPWD specification and the Indian standard specification have been compared in Exhibit 0.3(a) and 0.3(b) which is self explanatory and one can decide for himself the method to be adopted especially for the types of structures in question.

1.10 Foundation and Plinth

The work in foundation and plinth shall include:

(a) For buildings : All works up to 1 2 metres above ground level or up to floor 1 level whichever is lower.

(b) For abutments pires and well setting All works up to 1.2m above the bed level,

(c) For retaining walls, wing walls compound walls chimneys over head reservoirs/tanks and other elevated structures all works up to 1.2 metres above the ground level,

(d) For reservoir/tanks (other than overhead reservoirs/tanks) All works up to 1.2 metres above the ground level,

(e) For basements : All works up to 1.2 m above ground level or up to floor 1 level whichever is lower

Note: Specific provision shall be made in the estimate for such situations where the foundation level is more than 3 m depth from the plinth for all types of structures mentioned above.

1.11 Explanatory Notes and Comments

Foundation and Plinth: [(CPWD Specification Clause 0.6]

a) **For Abutments piers and well staining:** (CPWD Specification Clause 0.6(b)

As per CPWD Specification clause 0.6(b) the work in plinth and foundation is to be considered up to 1.2m from bed level.

(i) As explained in para (2)(i)and (ii)earlier ,all items mainly pertaining to bridge work are generally executed as per "MOST Specification where there is no question of plinth level etc.

(ii) However exhibit 0.4 above shows the correct position of foundation and plinth as per CPWD Specifications.

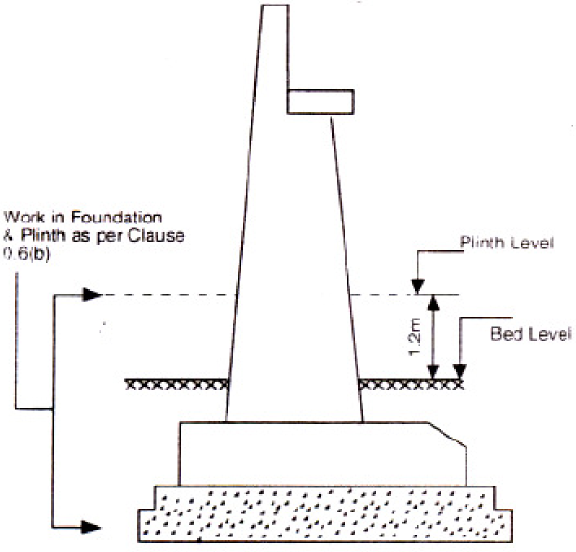
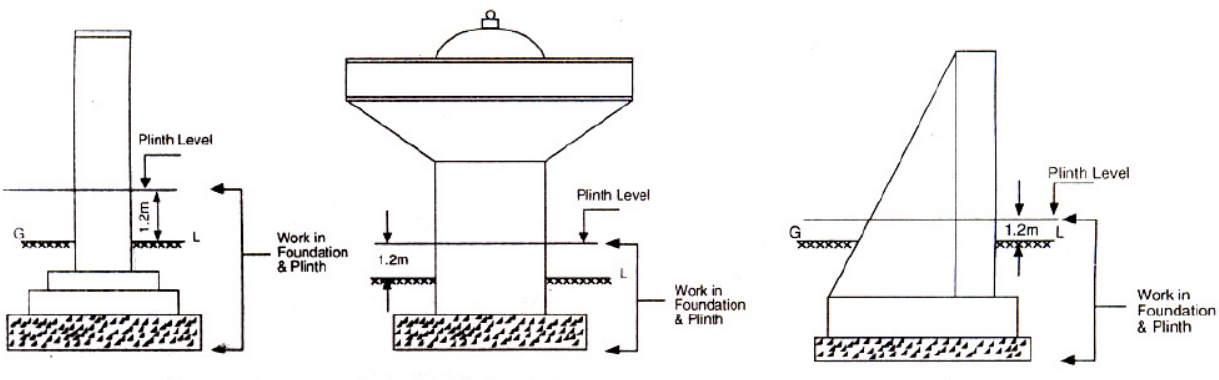
 Abutment	As per CPWD Specification Clause 0.6(b) the work in plinth &foundation is to be considered up to 1.2m from Bed Level.

Exhibit 0.4: Work in Foundation & Plinth for Abutments

(iii) For Retaining Walls Wing Walls compound walls overhead reservoirs/tanks and other elevated structures: (CPWD Specification clause 0.6 (c)

(iv) As discussed earlier ,wing walls are constructed mostly as per "MOST Specification where there is no mention about plinth level at all similarly overhead reservoirs/tanks are constructed as per Indian standard specification and here also there is no mention of plinth level for this type of construction.



Compound Wall. Overhead Reservoir/Tank. Retaining Wall

Exhibit 0.5: Work in foundation and plinth for Retaining Walls, Wing Walls, Compound Walls, Chimneys, Overhead Reservoirs/Tanks

(v) However keeping controversies aside Exhibit 0.5 above ,drawn as per CPWD specification clearly shows the plinth level and the portion of the work to be considered under foundation and plinth fir some of the structures named above as per CPWD Specification ,clause 0.6(c),the work in foundation and plinth is to be considered up to 1.2m from G.L.

b) For reservoirs/tanks (other than over head reservoirs/tanks: (CPWD Specification Clause 0.6(d))

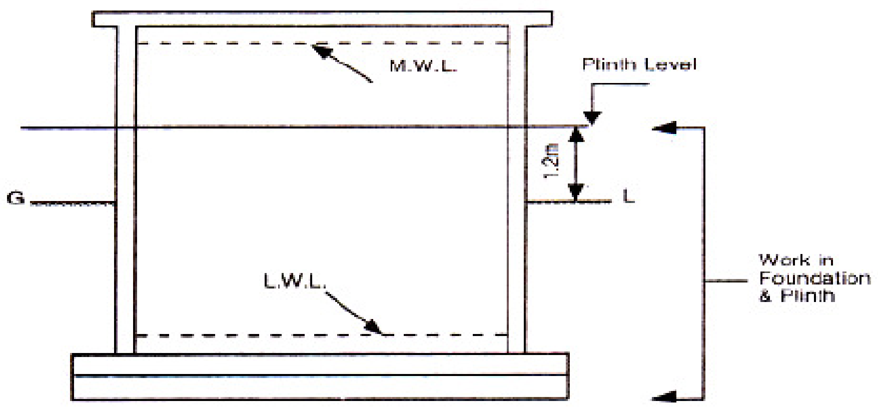
(i) Normally three types of reservoirs/tanks other than the overhead reservoirs/tanks are constructed in our Country These are (i) Underground reservoir/tank,(2)Ground level reservoir/tank and (3)Partially underground reservoir/tank.

(ii) In fact the structures of this type are executed throughout the year in very large numbers all over the country mostly with specifications and codes published by Bureau of Indian Standards where there is no mention of plinth level etc

(iii) However the procedure is being adopted only by CPWD Hence based on the above specification Exhibits 0.6,0.7 and 0.8show the position of plinth and the portion of work to be measured under foundation and plinth as per CPWD Specification clause 0.6(d).Problem mainly arises in underground reservoir/tanks where normally the depth of the tank would be considerable.

(iv) In CPWD specification note under clause 0.6 clearly states that a specific provision in the estimate should be made for the types of structures constructed where the depth of construction is more than 3.0m from the plinth level This special provision in the estimate is nothing but the addition of enhanced cost in the rate due to additional lift etc As added for ever floor/3.0m lift in superstructure.

(v) Any way for practical purposes the rate in superstructure for floor-1 can be considered as the rate for a depth of 3.0m below the 3.0m portion from the plinth level unless detailed Rate Analysis is done and additional rates derived and fixed.



Under Ground Reservoir (Partially Underground)

Exhibit 0 6: Work in foundation and plinth for Reservoirs/tanks (other than overhead reservoirs/tanks underground reservoir (partially underground)

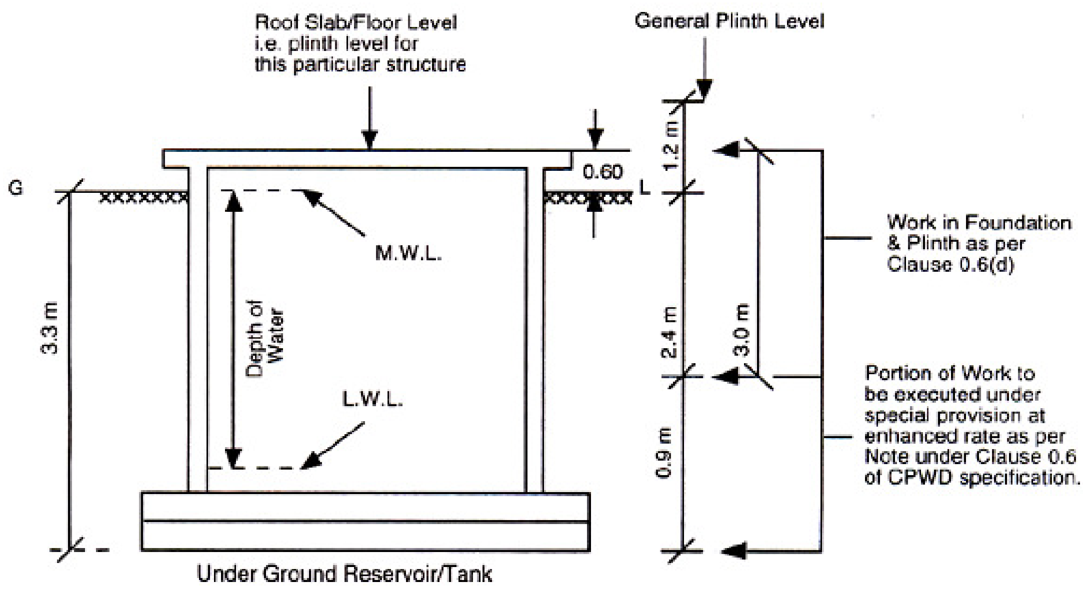


Exhibit 0.7: Work in foundation & plinth & also works, 3.0 m below plinth level for Reservoirs/Tanks (other than overhead Reservoirs)

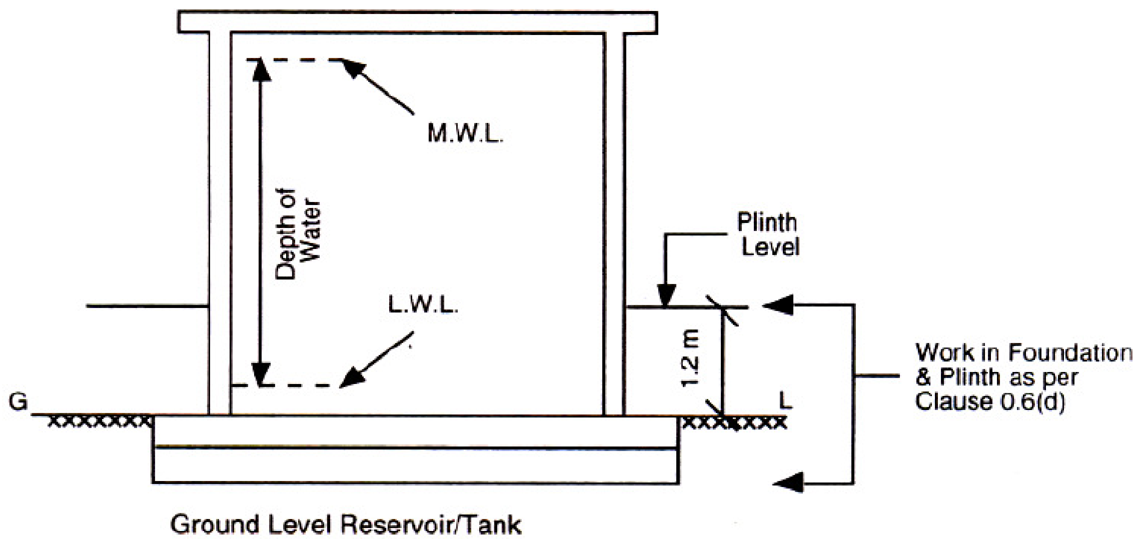


Exhibit 0.8: Work in foundation & plinth for Reservoirs/Tanks (other than overhead Reservoirs)- Ground Level Reservoir/Tanks

Note:

(1) As per clause 0.6(d)the work in foundation and plinth is to be considered up to 1.2m from G.L However in case of underground tank the roof level is less than prescribed 1.2m level but the same is considered as plinth level ,as per clause 0.5.1.3.

(2) As per note under clause 0.6 a special provision in estimate is proposed for all works below 3.0 m depth from plinth for all structures.

c) For Basements: (CPWD Specification clause 0.6(e))

(i) There is not much difference between the basement and the partially underground water reservoir/tank as far as the question of fixing the plinth/floor-1level is concerned.

(ii) According to clause 0.6 (e) of the CPWD specification the plinth level should be 1.2 m above the ground level or the floor level itself whichever is lower.

(iii) However in this case also the problem of making the specific provision in the estimate for the portion of construction which will fall beyond a depth of 3.0m from the plinth level/floor level persists.

(iv) In Exhibit 0.9 the portion falling under the height of 3.0m below plinth/floor level is clearly shown for a basement with a clear height of 3.0m from plinth level with height of plinth/floor level as 1.2m above the ground level.

(v) In case the height of plinth decreases and the clear height of basement is maintained at 3.0m only the quantam of work in the additional height will increase.

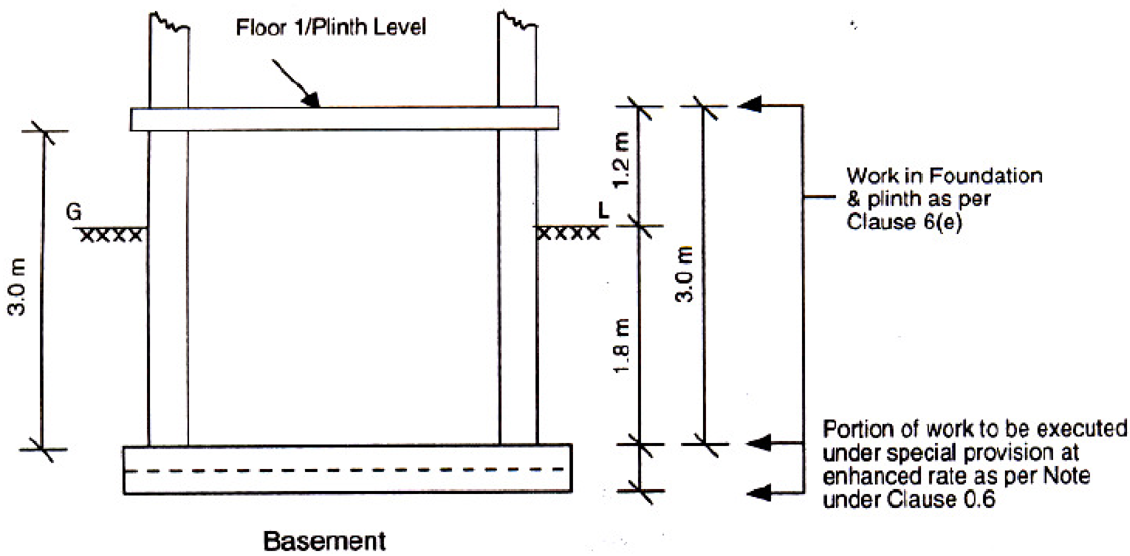


Exhibit 0.9 Work in foundation and plinth for Basements and also the works 3.0m below plinth level

d) Specific provision to be made in Estimate for all types of works below 3.0m from plinth/floor Level:(Note below CPWD specification clause 0.6)

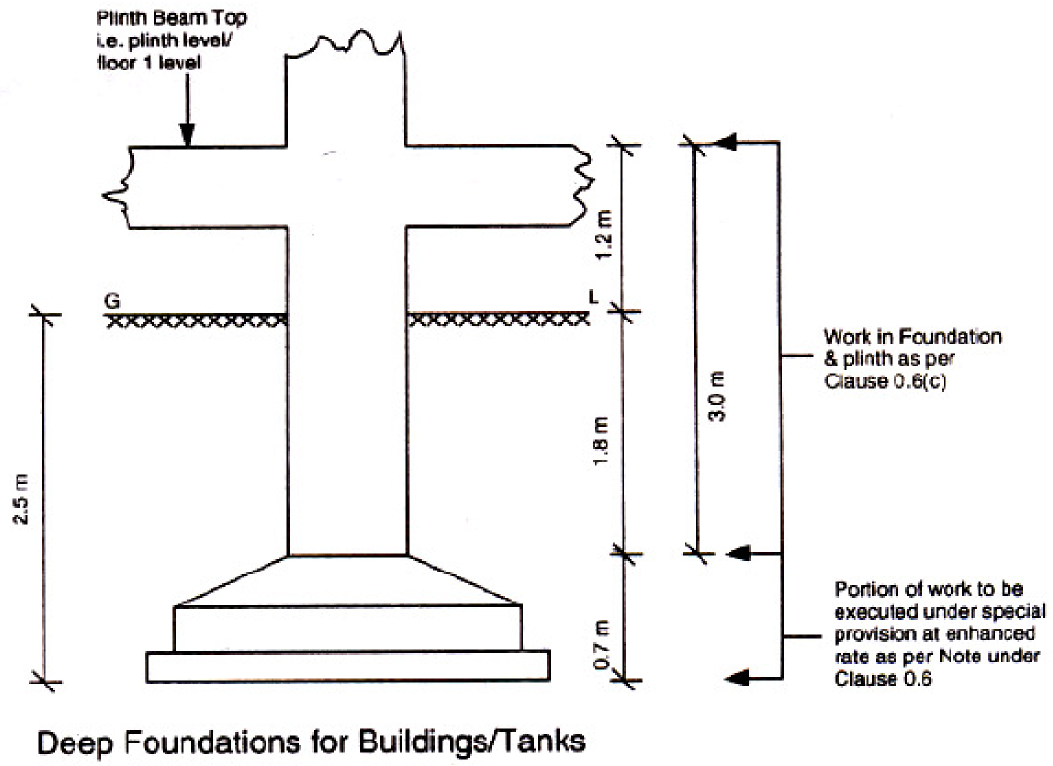


Exhibit 0.10 Work in foundation and plinth and also the works 3.0m below plinth level for deep foundations of structures

(i) This provision seems to have gone un-noticed so far or the same has been put on hold by the department the result is non usage of the provision in general.

(ii) The Delhi schedule of rates does not have any additional rates in the item of concrete brick-work stone work or plastering for the work of additional depth I e depth beyond 3.0m depth from plinth/floor level.

(iii) In the Delhi schedule of rates the expression used for the item like concreting is "all work up to plinth level similarly for brick-work and stone work the expression is little different i.e. work in plinth and foundation.

(iv) The case of finishing is still different The general rate for plaster inD.S.R.is for a height of 10.0m from the ground level and for every additional 3.0m height there is a provision of additional rates But no rate has been prescribed for the works below ground level Thus the work of plastering in basements or underground tank will not be in the purview of the rates in D.S.R.as these works are below ground level.

(v) Even if detailed drawings are to be supplied to the contractor before quoting his rates he is usually asked to pursue the drawing in the office The contractor should qute his rates with a condition that the rates are applicable only for the depth of work below plinth level as described in the note below clause 0.6 of CPWD specification I e up to a depth of 3.0m from plinth/floor level and for works of further depths he conquote separate rate The client/department cannot take protection of the expression work below plinth in view of the clear condition in the specification.

(vi) Similar is the case for brickwork and stone work when the rates to be quoted are for work in plinth and foundation and as plinth floor level Thus even if the drawings are supplied beforehand the work done below 3.0m level can always be considered for an enhanced rate.

(vii) Hence the contractor before quoting his rates should get the points cleared well in advance otherwise he will have to take recourse to arbitration.

(viii) Exhibits 0.7, 0.9 and 0.10 depict the work below 3.0m depth from the floor/plinth which will enable the read to understand the implication easily.

1.12 Measurements:

In booking dimension the order shall be consistent and in the sequence of length and height or depth or thickness.

1.13 Rounding Off:

Rounding off where required shall be done in accordance with IS 2The number of significant places rounded in the rounded off value should be as specified.

DIMENSIONS AND UNIT WEIGHTS OF VARIOUS BUILDING MATERIALS UNDER CLAUSE 0.8.10

The dimensions of various materials as prescribed by BIS and utilized in the construction industry given in Annexure iv also giving the relevant BIS codes.

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	(i)BRICKS AND CEMENT BLOCKS		
	Modular bricks Nominal dimension Soil cement Blocks Nominal dimension Heavy duty bricks Nominal dimension Hollow concrete Block Nominal dimension Perforated Bricks Nominal dimension	1077-1992 1725-1982 2180-1988 2185-part1 1979 2222-1991	200X100X100 200X100X50 200X100X100 200X100X50 300X200X100 200X100X100 200X200X100 400X300X200 400X200X200 400X100X200 200X100X100 200X200X100

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
			300X100X100
			300X150X100
	(ii)TIMBER PRODUCTS		
	Plywood	303-1989	Thickness mm
	No of ply		3 4 5 6
	(a)3ply		5 6 8 9
	(b)5ply		9 13 16
	(C)7ply		13 16 19
	(d)9ply		19 22 25
	(e)11ply		Sizes in mm
			2400X1200
			2400X900
			2100X1200
			2100X900
			1800X1200
			1800X900
			1500X1200
			1500X900
			1200X1200
			900X900
	Timber cut to size	1331-1971	50X25
	(a)battens		50X50
			38X25
			50X12
			75X50
	(b)planks		150X25
			200X25
			225X25
			75X38
			100X38
			125X38
			100X50
			125X50
			150X50
			175X50
			150X12
			150X19
			200X19

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
			125X25
			200X25
			300X25
			150X38
			200X38
			225X38
			75X75
	(c)Scantling:	-	100X75
			125X75
			100X100
			125X100
			150X100
			150X75
			175X75
			200X75
			125X125
	(d)Baulk		150X150
			200X150
			175X100
	Fiber hard boards		200X100
	Type of board		150X125
	(a)semi hard board		175X125
			200X200
			250X125
	(b)hard board	-	300X150
		1658-1977	Thickness in mm
			6 8 10 12
			Width 1200
			Length 1200 1800
			2400 3000 3600
			4800 5500
			Thickness in mm
			3 4 5 6
			Width 1200
			Length 1200 1800
			2400 3000 3600
			4800 5500

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	Block boards	1659-1990	Thickness in mm 12 16 20 25 30 32 35 40 45 50 Width 1200 900 Length 2400 2100 1800 1500 1200
	(iii)STEEL SELECTIONS		
	(1)Steel plates	1730-1989	Nominal thickness 5 6 8 10 12 14 16 18 20 22 25 28 32 36 40 45 50 56 And63mm Width 900 1000 1100 1200 1250 1400 1500 1600 1800 2000 2200 2500 mm Length 2200 2500 2800 3200 3600 4000 4500 5000 5600 6300 7100 8000 9000 10000 11000 and 12500 mm
	(2)Steel sheets	1730-1989	Nominal thickness 0.40 0.50 0.63 0.80 0.90 1.00 1.12 1.25 1.40 1.60 1.80 2.00 2.24 2.50 2.80 3.15 3.55and 4.00 mm Width 600 750 900 1000 1100 1200 1250 1400 1500 mm Length 1800 2000 2200 2500 2800 3200 3600 4000 mm
	Steel strips	1730-1989	Nominal thickness 1.60 1.80 2.00 2.24

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
			2.50 2.80 3.15 3.55
			4.00 4.50 5.00 6.00
			8.00 10.00 mm
			Width 100 125 160
			200 320 400 500
			650 800 950 1050
			1150 1250 1300
			1450 1550 mm
	Steel Flats	1730-1989	Thickness 3 4 5 6
	Square Bars	1732-1989	8 10 12 16 18 20
	(iv)REINFORCEMENTS	1785-	25 32 40 mm
	Plain hard drawn	Part1 2-1983	Width 10 15 20 25
	Sheet wire for pre-		30 35 40 45 50 55
	Stressed concrete	2090-1983	60 65 70 75 80 90
	High tensile steel		100 110 120 130
	Bars for prestressed		140 150 200 250
	Concrete		300 400 mm
	(v)FLOOR COVERINGS.	653-1992	Nominal side width
	Linoleum		5 6 8 10 12 16
			20 25 28 32 40
	Glazed Earthern-	777-1988	45 50 56 63 71
	Ware tiles		80 90 100 110 125
			140 160 180 200 mm
			Nominal Diameter
	Rubber Flooring	809-1992	2 2.5 4 5 7 8 mm
			Nominal Diameter
			10 12 16 20 22 25
			28 32 mm
		1237-1980	Nominal thickness in
	Cement Concrete		Mm 6.7 6 4.5 3.2
	Flooring tiles		2.0 1.6
		1478-1992	Nominal thickness in
	Clay Flooring tiles		Mm 6.5 8.00 9.5
			Size
			99X99mm
	(vi)ROOF COVERINGS	459-1992	148.5X148.X

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	Corrugated Asbestos		Nominal thickness in
	Cement sheets		Mm 3.2 4.8 6.4
			size
	Semi Corrugated	459-1992	200X200 mm
	Asbestos cement		300X300 mm
	Sheets		450X450 mm
			Nominal size
	Mangalore pattern	654-1992	250X250 300X300
	tiles		200X200 mm
			Nominal size
			150X150 200X200
	(PIPES AND TUBES.	404-	225X225 mm
	Lead pipes	Part 1-	
		1993	Nominal thickness
		458-1988	6 7 mm
	Concrete pipes		Width 1050 mm
			Length 1500 1750
			2000 2250 2500
			2750 3000 mm
			Pitch of corrugation
		651-1992	=146 mm
	Salt glazed		Depth of corrugation
	Stoneware pipes		=48 mm
			Thickness 6 7 mm
			Width 1100 mm
			Length 1500 1750
			2000 2250 2500
			2750 3000 mm
		784-1978	Pitch of Corrugation
	Pre-stressed concrete		=338 mm
	Pipes		Depth of corrugation
			=45 mm
			Effective length
		1161-1979	320 340 350 mm
	Steel tubes for		Effective width
	Structural purposes		210 215 220 mm
		1230-1979	
	Cast Iron rain water		Diameter 10 15 20
	Pipes	1239-	25 32 40 50 75

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	Mild steel Tubes	Part 1	100 150 mm
		1989	Diameter 80 100
			150 250 300 350
		1536-1989	400 450 500 600
	Centrifugally cast		700 800 900 1000
	(spun)iron pressure		1100 1200 1400
	Pipes		1600 1800 mm
	(a)socket and spigot		Diameter
	pipes-class LA		100 150 200 250
	A and B		300 350 400 450
			500 600
			Length 2000 mm
			Diameter 80 100
			125 150 250 300
	(b)flanged pipes		350 400 mm
	With screwed		Length 2500 mm
	Flanged-class		Diameter 450 500
	A and B		600 700 800 900
			1000 1100 1200
			1400 1600 1800 mm
		1537-1976	Diameter 15 20
	Vertically cast Iron		25 32 40 50 65 80
	Pressure pipes		90 100 125 150 mm
	(a)spigot and socket		Diameter 50 75
	Pipes-Class A and B		100 125 150 mm
			Diameter 6 8 10
			15 20 25 32 40 50
			65 80 90 100 125
			150 mm
		1537-1976	
	(b)Flanged pipes-		
	Class A and B		Diameter 80 100
			125 150 200 250
			300 350 400 450
			500 600 700 750 mm
			Working length
			3660 4000 4880
		1592-1989	5500 mm
	Asbestos cement		Diameter 80 100

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	Pressure pipes		125 150 200 250
			300 mm
			Working length
			2000 2800 3000
			4000 4880 5000
		1626-	5500 mm
	Asbestos cement	part1-	
	Building pipes	1994	Diameter 80 100
		1916-1989	125 150 200 250
	Steel Cylinder		300 350 400 450
	Reinforced concrete		500 600 700 800
	pipes		900 1000 1100
			1200 1500 mm
			Working lengths
	(VIII)DOORS AND WINDOWS.	2191-	3660 4000 4880
	(a)Flush door	Part 1 and 2	5500 mm
	Shutters (hollow	1983	Diameter 80 100
	Core)	2202-1962	125 150 200 250
	(b)Flush door	Part 1 and 2	300 350 400 450
	Shutters	1991	500 600 700 800
	(solid core)		900 1000 1100
	(IX)BUILDERS HARDWARE.	204-	1200 1500 mm
	Tower bolts.	part 1-1991	Working length
	(a)Barrel Tower	&	1000 mm to 4000 mm
	Bolts	204 part 2-	Diameter (Nominal
	(b)semi barrel	1992	Bore)=50 80 100
	Tower bolts		125 150 200 250
	(c)skeleton Tower		300 450 600 900
	Bolts	206-1992	1000 mm
	Strap hinges		Length 3000 mm to
			4000 mm
		362-1991	Nominal bore 50
	Parliament Hinges		60 80 90 100 125
			150 mm
		452-1973	Diameter 200 250
	Door springs		300 350 400 450
	Rat-tail type	453-1993	500 600 700 900
	Double Acting		1100 1200 1400
	Spring Hings	451-1972	1600 1800 mm

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	Wood screws		
			Thickness 30 35
			40 mm
			Thickness
		1363-parts	25 30 35 40 mm
	Bolts &screws	1 2&3-	
		1992	
		&	Nominal size 75
		1364-parts	100 150 200 250
		1 2 3 4-	&300 mm
		1992	Nominal size 100
			150 200 250 300 mm
			Nominal size 375
			450 600 750 &900 mm
			Nominal size 75
			100 125 150 225 &
		1568-1970	300 mm
			Nominal size 50
			65 75 100 125
			150 175 200 mm
			Nominal size
			300 375 mm
		1929-1982	Nominal size
			100 125 150 mm
		2155-1982	Length 4 6 8 10
			12 15 20 25 30 35
			40 45 50 60 65
			70 75 80 85 90 95
	(X)SERVICE EQUIPMENTS.	774-1984	100 110 125 150
	Flushing cistern		175 200 mm
		2326-1987	Length 6 8 10 12
	Automatic flashing		14 16 20 25 30 35
	Cistern urinals		40 45 50 55 60 65
	(XI)MISCELLANEOUS.	278-1978	70 75 80 90 100
	Galvanized steel		110 120 130 140
	Barbed wire for		150 160 170 180
	Fencing		190 200 220 240
	(a)line wire		260 280 320 340

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
	(i)type 1		360 380 400 mm
			Second choice 7 9
			11 18 22 28 32 38
	(ii)type 2		85 95 105 115 125 mm
			Gauge designation
			(size of square open-
	(iii)type 3		Ing in decamicrones)
			160G 140G 120G
			100G 85G 80G 70G
	(iv)type 4		60G 50G 40G
			Diameter 1.6 2 2.5
			3 4 5 6 8 10 12
	(b)point wire		14 16 18 20 22 24
	(i)Type 1		27 30 33 36 39 42
			48 mm
	(ii)Type 2		Discharge capacity
			In litres 5 10 15
			Nominal capacity in
	(iii)Type 3		Litres 5 10 15.
	(iv)Type 4		
		405-	
	Lead sheets	Part 2-	
		1992	Dia of wire=2.50mm
			Dist bet two barbs
			=75mm
		2835-1987	Dia of wire=2.50 mm
	Sheet glass		Dist bet two barbs
			=150 mm
		2140-1987	Dia of wire=2.24 mm
	Standard galvanised		Dist bet two barbs=75 mm
	Sheet wire for fencing		Dia of wire=2.24 mm
	(i)3 ply wire strand		Dist bet two barbs
	(ii)7 ply wire strand		=150 mm
			Dia of wire =2.24 mm
			Dist bet two barbs
			=75 mm

Sr. No	NAME OF MATERIALS	BIS NO	Dimensions in mm
			Dia of wire=2.24 mm Dist bet two barbs =150 mm Dia of wire=2.24 mm Dist bet two barbs =75 mm Dia of wire=2.24 mm Dist bet two barbs =150 mm Thickness 0.5 0.8 1.6 2.0 2.5 3.2 3.5 4.0 4.5 5.0 5.5 6 7 8 9 10 11 12 14 16 mm Thickness 2.0 2.5 4.0 5.0 5.5and 6.5 mm Diameter 1.60 2.24 2.50 2.80 3.15 3.55 Diameter 0.50 0.80 1.25 1.60 2.24 2.50 2.80 3.15 3.55

1.14 Safety In Construction

1.14.1 The contractor shall employ only which methods of construction tools and plant as are appropriate for the type of work or as approved by Engineer-in-charge in writing.

1.14.2 The contractor shall take all precautions and measures to ensure safety of works and workmen and shall be fully responsible for the same Safety pertaining to construction works such such as excavation centring and shuttering trenching blasting demolition electric connections scaffolds ladders working platforms gangway mixing of bituminous materials electric and gas welding use of hoisting and construction machinery shall be governed by CPWD safety code relevant safety codes and the directions of Engineer-in-charge.

EXPLANATORY NOTES AND COMMENTS
Safety in Construction(Clause 0.9)
The construction hazards as experienced on various sites and safety measures to be taken are given in Annexure 0.6.

ANNEXURE 0.6

CONSTRUCTIONAL HAZARDS AND SAFETY MEASURES

Sl. No.	Stage and Nature of Construction Hazard	Safety measures expected to be taken by the Contractors and Site Engineers
1	Excavation in soft loose & slushy soil above 2.00 m depth-sliding of earth or collapsing of sides.	The excavation beyond 1.5 m to be done in steps of minimum 500 mm offsets as shown in clause 2.18(b)and also planking and strutting should be done as in clause 2.19.1
2	Excavation in slippery area (water logged)-The labour may fall or machinery on site may slip.	Try to dewater the area and spread minimum 150 mm thick sand layer to avoid slipping.
3	Excavation in Rock where chiseling is involved-The fall of hammer may injure the hand small rock pieces may injure the eyes and legs.	For hammer work only experienced and skilled labour should be employed Chisel should not be held by hand while hammering but chisel holding clamp should be provided The labour should be provided with goggles and leg cover to protect eyes and legs from injuries due to small rock pieces.
4	Excavation in Rock where blasting is involved-careless handling may lead to injury to main worker or a passer by	The work of blasting should be entrusted to only experienced persons provides sufficient lengths of fuse to give ample margin of time from the time of lighting to the time of explosion .A danger zone at least 180 m diameter is to be flagged off 10 minutes before actual firing man who should be provided with a whistle.
5	Excavation for drain across road or manhole adjacent to a road-chances of a passer by falling into the excavation portion	The area should be well barricaded &a red lamp provided at night A watchman should be deputed to prevent any movement of persons or vehicles.
6	During excavation or sometimes even while concreting-snake bites or scorpion.	In place where the movement of snakes are more the contractor should provide the labour with gum boots gloves etc and also make snake antidotes available on site A particular care that has to be taken on such site is to always keep a vehicle available on site to rush the patient to a doctor. This applies to snake stinged patients as well.
7	Centring (from-work)and scaffolding-from-work collapse while concreting or just before concreting especially when wooden ballies are used.	Many times ballies joined together give way due to weak joint Hence the use of joined ballies should be restricted Only 2 joined ballies out of 8 ballies should be allowed In case of double staging for a slab at a height utmost care should be taken to see that the top belli rests on the bottom balli A particular care that should be taken during each concreting operating of slabs and beams is that one carpenter and two helpers with spare nallies nails etc should be deputed below the slab/beam that is being concreted to whatch any disturbance in the supports of the form work below during concreting and in case of any doubt the concreting should be stopped immediately and other form work strengthened .Never allow bricks below a balli to make up the required height this is most dangerous.
8	From work for beams and slabs .The bottom of beam collapses and many a times brings down the slab as well injuring the labour ad supervision staff.	This case is noticed when slender ballies are used without branching in fact no concreting should be allowed without branching at 300 mm above ground and at mid way in normal beams & slabs The branching should be for the support of beams as well as slabs.

Sl. No.	Stage and Nature of Construction Hazard	Safety measures expected to be taken by the Contractors and Site Engineers
9	From work for sides of a slab-The labour just rests his foot on the plank and looses balance and falls resulting a fatal accident	This is noticed when the carpenter fixed the side shuttering of reinforcements and by wooden pieces nailed and wall and plank This is so weak a portion that with little pressure the plank gives away. Hence side shuttering should be done with a direct balli support from ground or floor and the practice of tying planks with binding wire to the steel reinforcements should be totally avoided A temporary railing along the periphery of slab will guard the life of labour and supervision staff.
10	From work for beams and slabs-opening the form-work-Accident due to fall of materials during removing the forms.	In fact this is a most dangerous work On should be very careful while form-work is removed only trained carpenters should be deputed for the work a safe resting place outside the area of slab as a temporary measure should be constricted from where the slab can be removed safely removal of form work during night should not be permited under any circumstances.
11	Scaffolding-Fall of work-man Supervision staff standing on chalis not tied properly or tied only at one end (Chalis mainly made Bamboos).	This is very common negligence on the part of labour who do scaffolding work The challis on which they work either span over its complete length or is tied loosely and many a times at one end only Hence care must be taken that the chali do not span over the full length but some middle support should be provided and also the same is tied properly on both ends.
12	Ladeers-Balli or bamboo ladders-The horizontal member breaks and the person falls Some time the top face just rests on wall and whole ladder tilts causing an accident.	The ladders should be strong enough to bear the weight of a labour with materials on head as far as possible a hand rail should be provided ar one end The horizontal member should be preferably fixed with bolt & nuts or strong nails When the ladder is placed across a wall the top portion should be tied firmly to a strong support so that the ladder does not move laterally.
13	Column reinforcement column reinforcements mainly in independent footings collapse-Injury to persons working nearby.	The tendency of bar-benders is to is to tie the vertical steel with coir rope of 8 mm steel rods as ties on all four sides of the column reinforcements This method of supporting the column reinforcement results in a weak support hence the column reinforcements should be supported by strong ballis on all four sides of reinforcements and as far as possible a combined platform should be constructed out of ballies over which the reinforcements can be supported.
14	Concreting chajjas-When chajjas are connected without care and on opening the form-work the chajja would collapse causing injury to labour on top or bottom of chajja.	While concreted sajjas care must be taken that the labour do not stand on the reinforcement and disturb the position A separate scaffolding mist be tied over which the labour can stand and work without disturbing the reinforcements .The main reason is in chajja the steel is placed on top face but if the labour stands on the steel it will bend and come to bottom face and hence the chajja will fall when form-work is removed thus causing injury to labour working on top or bottom.
15	Dismantling_Dismantled materials may fall on passer by or the person engaged in dismantling work may fall due to slipping The dismantled materials may	When work of demolition is to be taken up the area should be closed for all outsiders No one should be allowed up to 50 m from the place of demolition The workers engaged in demolition

Sl. No.	Stage and Nature of Construction Hazard	Safety measures expected to be taken by the Contractors and Site Engineers
	fall on persons working below.	should be asked to wear safety belts helmets must be worn by all the workers engaged in dismantling work The place should be strictly guarded at night with red lights at prominent places and watchman should be posted.
16	Electric connections/cables etc High tension/L.T Electric wire passing near the slab structure-while bending lifting or tying reinforcements the bar benders may sustain the electric shock causing fatal injury.	The work in such places should not be allowed to the workers themselves but in such position the work must be executed under the strict supervision of a responsible foreman or a supervisor
17	Electeic connections/cables etc cables below ground may get punctured during excavation & thus electrocute the labour working similarly when concreting is in progress the punctured cable may prone to be fatal to the labour	Before taking up the work all available drawings should be studied local enquiry to be made to know to position of cables and work in such area should be got executed under strict supervision of an experienced foreman or a supervisor
18	Electric connections/cables etc Temporary electric lines near damp walls near joinery stretched on a considerable length-There is every chance that the wire may get cut due to usage and may develop short circuits/leakages etc and may electrocute the person touching the wire accidently.	The electric wire should be maintained by an electrician who should regularly check up the insulation of wires especially placed near steel items & damp areas. The temporary wiring should be supported properly. As far as possible a good quality wire should be used which may not get damaged easily.
19	Electric and gas welding work Drilling polishing work-done by temporary cables used on a number of works due to the fact that the wires are old and when they come in contact with water even in the process of curing the surrounding area may get affected due to leakage in the electric current thus causing damage to the workers & supervision staff.	All wiring works to be inspected by experienced electrician. All wires to be properly insulated and fixed at height on temporary poles. No welding work should be permitted near damp area. The welders to be provided with welder's goggles & gloves. As far as possible machine in good condition should be used.
20	Construction machinery & Lifts-Concrete mixer-safety precautions a mixer with hopper tried to be operated by an helper could not release brake in time thus causing injury to the person near hoper –sometimes fatal one .	The mixers with hopper should be operated by an experienced mixer operator and such mixers should not be allowed to be handled by a helper or a labour
21	Construction machinery &Lifts-Lifts-safety precaution	
	The lift pit if left unguarded the children of workers may fall in the pit resulting in fatal accident.	A brick protection wall of minimum 1.00 m height should be constructed around the lift pit thus preventing the children going near the pit A special care should be taken to see that the children are not allowed to come near the machinery
	The manually operated brakes of the lift failed or the communication between the labour at the top and the liftman failed and thus the lift was not controlled and resulted in fatal accident.	The condition of the lift must be maintained properly The lift operator should be smart and active enough to convey the message of stopping and releasing the lift to lift operator properly.
22	Water storage Tank for general use & curing chances of children of workers falling in the tank with fatal accident	The water tank constructed on site should be protected by at least 1.00 m high walls on four sides so that the children do not fall.
23	Misuse of the lift by labour and sometimes supervision staff the lift that	No person should be allowed to go to upper floors by lifts that are mainly meant for conveying the

Sl. No.	Stage and Nature of Construction Hazard	Safety measures expected to be taken by the Contractors and Site Engineers
	are meant for lifting materials used by labour to go to upper floors the labou thus traveling many a times get injured.	building materials Fatal accidents have taken place due to above action of workers
24	Site clearing-clearing top floors of buildings upper portion of any structure throwing waste materials broken concrete pieces bricks bats sand etc straightway from top to ground injuring person below or even a passerby.	The dangerous practice should not be allowed at all The materials should be brought to the ground with the help of lift or the use of rope over pulley with a bucket thus bringing down materials safely.
25	Bar bending work-helpers of bar benders to follow short cut method through surplus steel pieces from top floors to ground and cause fatal injuries.	This is very bed practice the helpers should bring the rods to ground with the help of lift or rope pulley

0 10 ABBREVIATIONS

The following abbreviations wherever they appear in the specifications shall have the meaning or implication hereby assigned to them:

Mm	Millimeter	T	Tone
Cm	Centimeter	Fps system	Foot pound system
M	Meter	.c	Degree Celsius temperature
Km	Kilometer	Fig	Figure
Mm2/sqmm	Square millimeter	Re/Rs	Rupee/Rupees
Cm2/sqcm	Square centimeter	No	Number
Dm2/sqdm	Square decimeter	Dia	Diameter
M2/sqm	Square meter	Ac	Asbestos cement
Cm3/cubic cm	Cubic centimeter	Ci	Cast iron
Dm3/cubic dm	Square decimeter	Gc	Galvanized corrugated
M3/cum	Cubic meter	Gp	Galvanized plain
Ml	Milliliter	Gi	Galvanized Iron
Kl	Kiloliter	PVC	Polyvinyl chloride
Gm	Gram	RCC	Reinforced cement concrete
Kg	Kilogram	SW	Stone ware
q	quintal	SWG	Standard wire gauge

LIST OF MATERIALS BEARING ISI CERTIFICATION

(WITH REFERENCE FROM THE BUYERS GUIDE OF BUREAU OF INDIAN STANDARDS)

SL NO	IS NO	PRODUCT
Earth work		
(1)	IS:1307-1988	Aldrin emulsifiable concentrate
(1A)	IS:8944-1978	Chloropyrifos emulsifiable concentrate
Concrete Work		
(2)	IS:2645-1975	Integral cement water proofing compounds
RCC WORK		
(3)	IS:1566-1982	Hard drawn steel wire fabric for concrete reinforcement
WOOD WORK		
(4)	IS:303-1989	Plywood for general purpose
(5)	IS:1328-1996	Veneered decorative ply wood
(6)	IS:3087-1985	Wood particle boards(medium density)for general purpose
(7)	IS:1659-1990	Block boards.
(8)	IS:1658-1977	Fibre hard boards.
(9	IS:2191(Par1)1983	Wooden flush door shutters (cellular &hollow core type) ply wood face panels.
(10)	IS:2202(part1)1991	Wooden flush door shutters (solid core type) ply wood face panels.
(11)	IS:1341-1992	Steel butt hinges
(12)	IS:205-1992	Non ferrous metal butt hinges
(13)	IS:362-1991	Parliament hinges
(14)	IS:3818-1992	Continuous (piano)hinges
(15)	IS:206-1992	Tee & strap hinges
(16)	IS:208-1996	Door handles
(17)	IS:281-1991	Mild steel sliding door bolts for use with padlocks
(18)	IS:2681-1993	Non ferrous metal sliding door bolts (Aldrops) for use with padlocks.
(19)	IS:204(part 1)1991	Tower bolts (ferrous metal).
(20)	IS:204(part ii)1992	Tower bolts(Non-ferrous metal)
(21	IS:3564-1995	Door closers (Hydraulically regulated).

SL NO	IS NO	PRODUCT
STEEL WORK		
(22)	IS:7452	Hot rolled steel sections for doors windows & ventilators
(23)	IS:1038	Steel doors windows and ventilators
(24)	IS:6248	Metal rolling shutters & rolling grills.
(25)	IS:1161	Steel tubes for structural purposes.
FLOORING		
(26)	IS:1237-1980	Cement concrete flooring tiles
ROOFING		
(27)	IS:1322-1993	Bitumen felts for water proofing & damp proofing
(28)	IS:1626(part1)1994	Asbestos cement building pipes & pipes fittings gutters & gutter fittings and roofing-(part1)pipe & pipe fittings
(29	IS:1230-1979	Cast Iron rain water pipes & fittings.
FINISHING		
(30)	IS:341-1973	Black Japan type A B & C
(31)	IS:419-1967	Putty for use on window frames
(32)	IS:5410-1992	Cement pain Colour as required
(33)	IS:104-1979	Ready mixed paint brushing zinc chrome priming
(34	IS:123-1962	Ready mixed paint brushing finishing semi-gloss for general purpose to Indian standard colour No 445 446 448 449 451 473 & red oxide (colour unspecified).
(35)	IS:158-1981	Ready mixed paint brushing bituminous black lead free acid alkali & heat resisting
(36)	IS:164-1981	Ready mixed paint for road marking
(37)	IS:168-1993	Ready mixed paint air drying for general purposes
(38)	IS:9862-1981	Ready mixed paint brushing bituminous black lead free acid alkali water and chlorine resisting
(39)	IS:3537-1966	Ready mixed paint finishing interior for general purposes to Indian standard colours No 101 216 217 219,275, 281 ,352,353,358,to361,363,364,388,410,442,444,628,631,632 ,634 ,693,697,white and black.

SL NO	IS NO	PRODUCT
(40)	IS:3536-1966	Ready mixed paint brushing wood pink primer
(41)	IS:2339-1963	Aluminium paint for general purpose in dual container
(42)	IS:525-1968	Varnish finishing exterior & general purpose
(43)	IS:5411-(part1)1974	Plastic emulsion paint (part 1) for interior use
(44)	IS:2932-1993	Enamel synthetic exterior (a)under coating(b)finishing
(45)	IS:2933-1975	Enamel exterior (a)under coating (b)finishing
(46)	IS:133-1993	Enamel interior (a)under coating(b)finishing
(47)	IS:427-1965	Distemper dry colour as required
(48)	IS:428-1969	Distemper oil emulsion colour as required
Sanitary installations		
49	IS:4984-1987	HDPE pipes for potable water supplies sewage and industrial effluents
50	IS:3989-1984	Centrifugally cast (spun)iron spigot and sockets oil waste and ventilating pipes fittings and accessories
51	IS:1729-1979	Sand cast iron spigot and socket oil waste and ventilating pipes fittings and accessories
52	IS:771(part ii)1985	Glazed fire clay sanitary appliance (part 2)specific requirements of kitchen and laboratory sinks
53	IS:774-1984	Flushing cistern for water closet and urinals (other than plastic cistern)
54	IS:2326-1987	Automatic flushing cisterns for urinals
55 A	IS:2548-(part 1)1996	Plastic seats & covers for water closets (part 1) thermoset seats and covers
55 B	IS:2548-(part 2)1996	Plastic seats & covers for water closets (part 2) thermoplastic seats & covers
56	IS:1795-1982	
		Pillar taps for water supply purposes
Water supply		
57	IS:1592-1989	Asbestos cement pressure pipes
58	IS:4985-1988	Un plasticized PVC pipes for potable water supply

SL NO	IS NO	PRODUCT
59	IS:1536-1989	Centrifugally cast (spun)iron pressure pipes for water gas & sewage
60	IS:1537-1976	Vertically cast iron pressure pipes for water gas & sewage
61	IS:1538(part 1to24)1993	Cast iron fittings for pressure pipes for water gas and sewage
62	IS:778-1984	Copper alloy gate globe and check valves for water works purposes
63	IS:780-1984	Sluice valve for water works purposes (50 mm to 300 mm size)
64	IS:781-1984	Cast copper alloy screw-down bib taps & stop valves for water services
Drainage		
65	IS:458-1989	Precast concrete pipes (with and without reinforcements)
66	IS:651-1992	Salt glazed stone ware pipes and fittings
67	IS:1726-1991(part 1to 6)	Cast iron manhole covers and frames

LIST OF ADITIONAL MATERIALS BEARING ISI CERTIFICATION

(WITH REFERRENCE FROM THE LATEST LIST OF BIS)

Sr No	IS No	Products
Earth work		
(1)		
(2)	IS:6139-1978	Heptachlor emulsifiable concentrate
Concrete work	IS:2682-1984	Chlordane emulsifiable concentrate
(1)		
RCC WORK		
(1)		
	IS:9103-1979	Admixture for concrete
(2)		
(3)		
Wood work	IS:1786-1985	High strength deformed steel bars & wires for concrete reinforcement
(1)		
(2)	IS:7887-1992	M S wire rods for general Engineering purpose
(3)	IS:6522-1972	Specification for precast RCC door & window frames

Sr No	IS No	Products
(4)		
(5)	IS:1331-1971	Cut size timber
(6)	IS:2191(part ii)1983	Cellular & hollow core type particle board face panels
(7)	IS:2202(part ii)1983	Solid core type wooden flush door shutters particle board face panels & hard board face panels
(8)		
(9)	IS:4021-1995	Timber door window & ventilator frames
(10)	IS:4962-1968	Specification for wooden side sliding door
(11)	IS:6198-1992	Ledged braced & battoned timber door shutters
(12)	IS:5509-1980	Fire retardant plywood
(13)	IS:5539-1969	Specification for preservative treated plywood
(14)	IS:10394-1982	Wooden sleepers for railway track
(15)	IS:10701-1983	Structural plywood
(16)	IS:190-1991	Specification for coniferous sawn timber (baulks& scantlings)
(17)	IS:209-1996	Door handles
(18)	IS:452-1973	Door springs rat tail type
(19)	IS:453-1993	Double acting spring hinges
	IS:729-1979	Specification for drawer locks cup-board locks and box locks
20	IS:1823-1980	
21	IS:4992-1975	Floor door stoppers
22	IS:6315-1992	Specification for door handles for mortice locks
23		Specification for floor springs (hydraulically regulated) for heavy doors
24	IS:6343-1982	
25		Specification for door closet (pneumatically regulated)for light doors weighing up to 40 kgs
26	IS:7196-1974	
27	IS:7197-	Hold fasts
28	IS:1018-1982	Double acting floor springs for heavy doors
29	IS:1019-1974	Pad lock brass lever type machine made
30	IS:2009-1976	Rim latches
31	IS:3843-1995	Mortice locks

Sr No	IS No	Products
32	IS:3847-1992	Steel black flap hinges
33	IS:5899-1970	Mortice light latches
34	IS:5930-1970	Bathroom latches
35	IS:5999-1971	Mortice latch (vertical type)
36	IS:631-1971	Swing latches
37	IS:6607-1972	Specification for plastic window stays & fastners
38	IS:7540-1974	Specification for rebated mortice locks (vertical types)
39	IS:8760-1978	Mortice dead locks
40	IS:9106-1979	Mortice sliding door locks with lever mechanism
41	IS:10019-1981	Rising butt hinges
42	IS:12197-1987	Mild steel stays & fastners
43	IS:12303-1987	Pad locks pin tumbler type
STEEL WORK AND GLAZING	IS:12817-1989	Criteria for desing of RCC hinges
	IS:8756-1978	Stainless steel butt hinges
1	IS:9460-1980	Mortice ball catches for use in wooden almirah
	IS:207-1964	Specification for flush drop handles for drawer
2	IS:275-1992	Gate & shutter hooks and eyes
	IS:363-1993	Pad locks lever type hand made
3		Hasps & staple
4		
5		
6		
7	IS:1730-1989	
8		Steel plates sheets strips and flats for structural & general Engineering purposes
9	IS:3614(part 1)1966	Specification for fire check doors plate metal covered & rolling type
10	IS:3614(part ii)1992	Specification for metallic fire check doors resistant test & performance criteria
11	IS:4351-1976	

Sr No	IS No	Products
	IS:4384-1967	Specification for steel door frames
12	IS:7152-1992	Steel water tight & weather tight doors
13	IS:9796-1981	Book room doors specifications
14	IS:10521-1983	Non weather tight steel doors
15	IS:806-1968	Collapsible gates
16		Code of practice for use of steel tubes for general building construction
17	IS:808-1989	
18		Dimensions for hot rolled steel beam column channel and angle sections
19	IS:1081-1960	
20		Code of practice for fixing & glazing metal (steel & aluminium)doors windows & ventilators
21	IS:1361-1978	Steel windows for industrial buildings
22	IS:2835-1987	Flat transparent sheet glass
FLOORING	IS:3954-1991	Hot rolled steel channel section for general Engineering pp
1	IS:4923-1985	
2	IS:5437-1994	Hollow steel sections for structural use
3	IS:10451-1983	Figured rolled and wire glass
4	IS:11188(part1)1991	Steel sliding shutters (top hung type)
5	IS:11188(part ii)1991	Vault(strong room)doors part 1 specification
	IS:1188(part iii)1991	Vault (strong room)doors part ii test for burglary resistance
6	IS:1977-1996	
7	IS:2062-1992	Vault (strong room)doors part iii tests for fire resistance
8		Low tensile structural steels
9		Steel for general structural purposes
10	Is:1195-1978	
11	IS:1196-1978	
12	IS:1197-1970	Bitumen mastic for flooring
13	IS:1198-1982	Code of practice for laying bitumen mastic flooring
14	IS:5389-1969	Code of practice for laying rubber floors
15		Code of practice for fixing & maintenance of linoleum flooring
16	IS:5481-1992	

Sr No	IS No	Products
17	IS:653-1992	Code of practice for laying of hard wood parquet and wood block floors
18	IS:809-1992	
19	IS:1128-1974	Floor polish liquid
	IS:1130-1969	Linoleum sheets and tiles
20	IS:1478-1992	Rubber flooring materials for general purpose
	IS:3461-1980	Lime stone (slabs & tiles)
21	IS:3462-1986	Marble (blocks slabs & tiles)
	IS:3464-1986	Clay flooring tiles
22	IS:3583-1988	Specification for PVC asbestos floor tiles
	IS:3622-1977	Specification for un backed flexible PVC flooring
23	IS:3670-1989	Methods of test for plastic flooring & wall tiles
	IS:4457-1982	Burnt clay paving bricks
24	IS:13753-1993	Specification for stand stone slab and tiles
		Code of practice for construction of timber floors
25	IS:13754-1993	Ceramic unglazed vitreous acid resisting tiles
26		Dust pressed ceramic tiles with water absorption of E 10%(group B 111)
27	IS:13755-1993	
ROOFING		Dust pressed ceramic tiles with water absorption 60% E 10%(group B 11b)
1	IS:13756-1993	Dust pressed ceramic tiles with water absorption 3% E 6% (group b 11a)
2		
3	IS:9704-1980	Dust pressed ceramic tiles with low water absorption of E 3%9group b1)
4		
5	IS:13630-(parto sect 3 to part 15-1994	Method of test for linoleum sheets and tiles
6		
	IS:13801-1993	Ceramic tiles method of tests
7	IS:657-1982	Chequered cement concrete tiles
8	IS:658-1982	Materials for use in the manufacture of magnesium oxychloride flooring composition
9		
10		Code of practice for magnesium oxychloride composition floors
11	IS:5390-1984	

Sr No	IS No	Products
12	IS:277-1992	
	IS:459-1992	
13	IS:730-1978	Code of practice for the construction of timber ceiling
	IS:1239(part 1)1990	Galvanised steel sheet (plain and corrugated)
14	IS:1239(part 2)1992	Corrugated & semi-corrugated asbestos cements sheets
15		Hooks bolts for corrugated sheet roofing
16	IS: 1254-1991	Mild steel tubes and other wrought steel fittings mild steel tubes
17	IS:1346-1991	
18	IS:2690-(part 1)1993	Mild steel tubes tabular and other wrought steel fittings mild steel tabular and other wrought steel pipes fittings
	IS;2690(part 2)	Corrugated aluminium sheets
19	IS:3951(part 1)1975	
	IS:3951(part 2)1957	Code of practice for water proofing of roofs with bitumen felt
20		Burnt clay flat terracing tiles (machine made)
21	IS:6076-1971	Burnt clay flat terracing tiles (Handmade)
22		Specification for hollow clay tiles for floors and roofs filler types
23	IS:7193-1994	
24	IS:8869-1978	Specification for hollow clay tiles for floors and roofs structure type
25	IS:10388-1982	
26	IS:1580-1991	Specification for autoclaved reinforcements cellular concrete floor & roof slabs
27	IS:1626-(part2)1994	Glass fibre based bitumen pitch & bitumen felts
28		Washers for corrugated sheet roofing
	IS:1626(part 3)1994	Corrugated coir wood wool cement roofing sheets
29		Bituminous compounds for water proofing and caulking purposes
	IS:2096-1992	
30	IS:2098-1964	Asbestos cement building pipes & pipe fittings gutters & gutter fittings roofing fittings gutter & gutter fittings
	IS:2700-1987	
31	IS:2858-1984	Asbestos cement building pipes & pipe fitting gutter & gutter fittings & roofing fittings
32	IS:3087-1985	Asbestos cement flat sheets
33	IS:3097-1980	Asbestos cement building boards
	IS:3308-1981	

Sr No	IS No	Products
34	IS:6250-1981	Code of practice for roofing with wooden shingles
FINISHING	IS:6332-1984	Code of practice for roofing with mangalore tiles
1		Wood practice boards for general purposes
2	IS:7290-1979	Veneered particle boards
		Wood wool building slabs
3	IS:10505-1983	Specification for roofing slate tiles
4		Guide of practice for constructions of floor & roofs using pre-cast doubly curve shell units
5	IS:13008-1990	
6	IS:3348-1965	Recommendation for use of polythene film for water proofing of roofs
	IS:12506-1988	
7		Code of practice for construction of floors and roofs using pre-cast concrete waffle units
	IS:13000-1990	Shallow corrugated asbestos cement sheets
8		Specification for fibre insulation board
9		Code of practice for improved thatching of roof with rot & fire retardant treatment
10	Is:3709-1966	
11	IS:1232-1964	Silica asbestos cement flat sheets
12		
13	IS:5411(part 2)1992	
14	IS:2074-1992	Mastic cement or beddings of metal windows
15	IS:2075-1979	Ready mixed paint brushing yellow ochre semi-glose for general purpose
16	IS:3539-1996	
17		Plastic emulsion paint for exterior use
18	IS:3585-1966	Ready mixed paint air drying red oxide zinc chrome priming
19		Ready mixed paint storing red oxide zinc chrome priming
20	IS:3678-1966	
21	IS:5660-1970	Ready mixed paint undercoating for use under oil finished to Indian standard colours as required
22	IS:11883-1986	
23	IS:13183-1991	Ready mixed paint aluminium brushing priming water resistant for wood work
24	IS:14314-1995	
25	IS:14355-1996	Ready mixed paint thick white for lettering

Sr No	IS No	Products
26	IS:44-1991	Ready mixed paint brushing aluminium red oxide primer
27	IS:38-1976	Ready mixed paint brushing red oxide priming for metals
28	IS:40-1971	Aluminium paint heat resistant
29	IS:53-1988	Thinner general purpose for synthetic paints & vernishes
30	IS:54-1988	Zinc dust pigment for paint
31	IS:55-1970	Iron oxide pigment for paints
32	IS:56-1993	Antimony oxide for paints
33	IS:57-1989	Carbon black for paints
34	IS:58-1976	Branswick green for paints
35	IS:62-1950	Green oxide of chromium for paints
36	IS:63-1978	Ultramarine blue for paints
	IS:64-1972	Prussian blue (Iron blue) for paints
37	IS:66-1972	Red lead for paints & other purpose
	IS:67-1976	Litharge
38	IS:68-1979	Graphite for paints
	IS:70-1980	Whiting for paints & putty
	IS:75-1973	Burium sulphate pigments for paints
	IS:77-1976	Magnesium silicate pigments for paints
39	IS:79-1975	Silica for paints
	IS:80-1991	China clay (kaolin)for paints
40	IS:81-1989	Cuprous oxide for paints
	IS:102-1962	Linseed oil boiled for paints
41	IS:109-1968	Linseed oil boiled for paints
		Linseed stand oil for paints
42	IS:110-1983	Tung oil for paints
		Dehydrated castor oil for paints
43	IS:117-1964	Ready mixed paints brushing red lead non setting priming
44		Ready mixed paint brushing priming plaster to Indian standard colour No 361 & 631 white and off white

Sr No	IS No	Products
45	IS:120-1982	Ready mixed paint brushing grey filler for enamels for use over primers
46	IS:121-1962	Ready mixed paint brushing finishing exterior semi gloss for general purpose to Indian standard colour Nos 101 to 104 169 174 216 217 275 278 280 281 283 352 354 358 to365 384 to 388 397 410 442 to444
47	IS:122-1962	Ready mixed paint brushing finishing semi gloss for general purpose to Indian standard colour Nos 537 538 540 541 570 574
48	IS:124(part 1)1976	Ready mixed paint brushing finishing semi gloss for general purpose to Indian standards colour Nos 414
49	IS:124(part2)1979	Ready mixed paint brushing finishing semi gloss for general purpose to Indian standards colour Nos 411 412 413
50	IS:124(part3)1979	Ready mixed paint brushing finishing semi gloss for general purposes (part 1)
51	IS:126-1962	Ready mixed paint brushing finishing semi gloss for general purposes (part 1)
52	IS:127-1962	Ready mixed paint brushing finishing semi gloss for general purposes (part 3)
53	IS:128-1962	Ready mixed paint brushing finishing exterior gloss for general purposes to Indian standard colour No 671
54	IS:137-1965	Ready mixed paint brushing finishing exterior semi gloss for general purposes white
55	IS:144-1950	Ready mixed paint brushing finishing semi gloss for general purpose black
56	IS:145-1950	Ready mixed paint brushing mat or egg shell flat finishing interior to Indian standard colours as required
57	IS:146-1950	Ready mixed paint brushing petrol resisting air drying for interior painting of tanks & containers red oxide (colour unspecified)
58	IS:147-1950	Ready mixed paint slushing petrol resisting air drying for interior painting of tanks and containers red oxide (colour unspecified)
		Ready mixed paint brushing petro resisting stoving to

Sr No	IS No	Products
59	IS:148-1950	interior painting of tanks and containers red oxide(colour unspecified)
60	IS:149-1950	Ready mixed paint slushing petrol resisting stoving for interior painting of tanks and containers red oxide (colour unspecified)
61		
	IS:150-1950	Ready mixed paint brushing under coating stoving for enamels & general purposes colour as required
62		
63	IS:151-1986	Ready mixed paint spraying under coating stoving for enamels and general purposes colour as required
64		
65	IS:152-1950	Ready mixed paint spraying under coating stoving for enamels and general purposes colour as required
66		Ready mixed paint brushing storing lead free for general purposes colour as required
67	IS:153-1950	
68		Ready mixed paint spraying finishing storing enamels for general purposes colour as required
69	IS:155-1950	
70		Ready mixed paint brushing lead free for general purposes colour as required
71	IS:159-1981	
72	IS:162-1950	Ready mixed paint spraying stoving lead free for general purposes colour as required
Sanitary installations		Ready mixed paint brushing fire resisting silicate type for use on wood
1	IS:163-1978	
2	IS:290-1961	Ready mixed paint dipping fire resisting
	IS:337-1975	Ready mixed paint brushing fire resisting silicate type for use on wood colour as required
3	IS:342-1976	
	IS:344-1976	Ready mixed paint deeping fire resisting
4	IS:347-1975	Colour tar black paint
	IS:348-1968	Varnish finishing interior
5	IS:430-1972	Varnish acid resisting
6	IS:524-1983	Varnish stoving
7	IS:533-1973	Varnish shellac for general purposes
8	IS:870-1962	French polish
		Paint remover solvent type non flammable
9		Varnish finishing exterior synthetic air drying

Sr No	IS No	Products
		Gum spirit of turpentine (oil turpentine)
10	IS:771(part1)1979	Ready mixed paint brushing finishing egg shell gloss for interior use to Indian standard colours No 101 216 217 219 275 281 358
11	IS:771(part3/sec1)	
12	IS:771(part3/sec2)1985	
13	IS:771(part 4)1979	Glazed fire clay sanitary appliances part 1 general requirements
	IS:775-1970	Glazed fire clay sanitary appliances part 3 specific requirement of urinals section 1 slab urinals
	IS:777-1988	Glazed fire sanitary appliance part 3 specific requirements of urinals section 2 stall urinals
	IS:2556(part1)1994	
	IS:2556(part2)1994	Glazed fire clay sanitary appliances part 4 specific requirement to post mortem slabs
	IS:2556(Part 3)1994	Cast iron brackets & supports for wash basins
		Glazed earthen ware wall tiles
	IS:2556(part 4)	Vitreous sanitary appliances (vitreous china)gen requirements
	IS:2556(part 5)1994	Vitreous sanitary appliances (vitreous china)part 2 specific requirements of wash down water closets
	IS:2556(part6)1995	Vitreous sanitary appliances(vitreous china)part 3specific requirements of squatting pans
	IS:2256(part7)1995	Vitreous sanitary appliance (vitreous China)part 4 specific requirements of wash basins
		Vitreous sanitary appliances(vitreous china)part 5 specific requirements of laboratory sinks
		Vitreous sanitary appliances (vitreous china) part 6 specific requirements of urinal and partition plates
		Vitreous sanitary appliances (vitreous china)part 7 requirements of accessories for sanitary appliance
14	IS:2256(part 8)1995	Vitreous sanitary appliances (vitreous china)part 8 specific requirements of pedestal close coupled wash down and symphonic water closets

Sr No	IS No	Products
15	IS:2256(part 9)1995	Vitreous sanitary appliances (vitreous china)part 9specific requirements of pedestal type bidets
16	IS:2256(part 14)1995	Vitreous sanitary appliances (vitreous china)part 14 specific requirements of integrated squatting pans
17	IS:2256(part 15)1995	Vitreous sanitary appliances (vitreous china)part 15 specific requirements of universal water closets
18	IS:9758-1981	Flush valves & fittings for water closets & urinals
19	IS:1701-1960	Mixing valves for ablutionary and domestic purposes
20	IS:2963-1979	Specification for copper alloy waste fittings for wash basin &sink
21	IS:3311-1979	Waste plug &its accessories for sinks and wash basins
22	IS:4267-1967	Stands wash hand basins
23	IS:7231-1984	Specification for plastic flushing cistern for water closets & urinals
24	IS:8718-1978	Vitreous enameled steel kitchen sinks
25	IS:8727-1978	Vitreous enameled steel wash basins
26	IS:3489-1985	Specification for enameled bath tube
27	IS:6411-1985	Specification for gel coated glass fibre reinforced polyester resin bath tube
28	IS:13983-1994	Stainless steel sinks for domestic purposes
WATER SUPPLY		
1	IS:6163-1978	Centrifugally for sluice valves for water works purposes (350to 12 mm size)
2	IS:6163-1987	Centrifugally cast (spun)iron low pressure pipes for water gas &sewage
3	IS:7181-1986	Horizontally cast iron double flanged pipes for water gas & sewage
4	IS:5531-1988	Cast iron specials for asbestos cements pressure pipes for water gas & sewage
5	IS:8794-1988	Cast iron detachable joints for use with asbestos cement pressure pipes
6	IS:10299-1982	Cast iron saddle pieces for service connection from

Sr No	IS No	Products
		asbestos cements pressure pipes
7	IS:12987-1991	Cast iron detachable joint for use with asbestos cement pressure pipes (light duty)
8	IS:1701-1960	Mixing valves for ablutionary and domestic purposes
9	IS:1703-1989	Copper alloy float valves (horizontal plunger type)for water supply fittings
10	IS:1879-1987	Malleable cast iron fittings
11	IS:3004-1979	Specification for plug locks for water supply
12	IS:3076-1985	Low density polythene pipes for potable water supply
13	IS:3589-1991	Seamless or electrically welded steel pipes for water gas & sewage
14	IS:3950-1979	Surface boxes for sluice valves
15	IS:4038-1986	Foot valves for water-works purposes
16	IS:4346-1982	Specification for washers for use with fittings for water services
17	IS:4621-1975	Indicating bolts for use in public baths & lavatories
18	IS:4984-1995	High density polythene pipes for water supply
19	IS:5312(part 1)1984	Swing check type reflux valves single door pattern
20	IS:5312(part 2)1986	Swing check type reflex(non return)valves multi door pattern
21	IS:6392-1971	Steel pipe flanges
22	IS:6418-1971	Cast iron and malleable cast iron flanges for general Engineering purposes
23	IS:6631-1972	Steel pipes for hydraulic purposes
24	IS:7520-1974	Corrosion resistant high silicon iron castings
25	IS:7634(part 1)1975	Close of practice for plastic pipes work for potable water supplies part 1 choice of materials and general recommendations
26	IS:7834(part 2)1987	Injection molded PVC fittings with solvent cements joint for water supplies part 1 general requirements
27	IS:7834(part 2)1987	Injection moulded OVC fittings with solvent cement joint for water supplies part 2 specific requirement for

Sr No	IS No	Products
		45%elbows
28	IS:7834(part 3)1987	Injection moulded PVC socket fittings with solvent cement joint for water supplies part 3 specific requirement for 90% elbow
29	IS:7843(part 4)1987	Injection moulded PVC sockets fittings with solvent cement joint for water supplies part 4 specific requirement for 90% tees
30	IS:7834(part5)1987	Injection moulded PVC socket fittings for solvent cement joints for water supplies part 5 specific requirement for 45% tees
31	IS:7834(part 6)1987	Injection moulded PVC socket fittings with solvent cement joint for water supplies part 6 specific requirement for sockets
32	IS:7834(part 7)1987	Injection moulded PVC socket fittings with solvent cement joints for water supplies part 7 specific requirement for unions
33	IS:7834(part8)1987	Injection moulded PVC socket fitting with solvent cement joint for water supplies part 8 specific requirement for caps
34	IS:8008(part 1)1976	Injection moulded HDPE fittings for potable water supplies part 1 general requirements
35	IS:8008(part 2)1976	Injection moulded HDPE fittings for potable water supplies part 2 specific requirement for 90 bends
36	IS:8008(part 3)1976	Injection moulded HDPE fittings for potable water supplies part 3 specific requirement for 90 tees
37	IS:80089part iv)1976	Injection moulded HDPE fittings for potable water supplies part 4 specific requirements for reducers
38	IS:8008(part 5)1976	Injection moulded HDPE fittings for potable water supplies part 5 specific requirement for ferrule reducers
39	IS:8008(part 6)1976	Injection moulded HDPE fittings for potable water supplies part 6 specific requirement for pipe ends
40	IS:8008(part7)	Injection moulded HDPE fittings for potable water supplies part 7 specific requirement for sand witch flanges
41	IS:8329-1994	Centrifugally cast (spun)ductile iron pressure pipes for

Sr No	IS No	Products
		water gas & sewage
42	IS:8360(part1)1977	Fabricated high density polythene HDPE fittings for table water supplies part 1 general requirements
43	IS:8360(part2)1977	Fabricated high density polythene HDPE fittings for potable water supplies part 2 for 90 tees
44	IS:8360(part 3)1977	Fabricated high density polythene HDPE fittings for potable water supplies part 3 for 90 bends
45	IS:89311993	Copper allow fancy single tap assembly and stop levels for water service
46	IS:9338-1984	Cast iron screw down stop levels and stop and check valves for water works purposes
47	IS:9520-1980	Nominal size for valves
48	IS:9523-1980	Ductile iron fittings for pressure pipes for water gas and sewage
49	IS:9739-1981	Pressure reducing valves for domestic water supply system
50	IS:9762-1994	Polythene floats (spherical)for float valves
51	IS:9890-1981	General purpose ball valves
52	IS:10124(part 1)1988	Fabricated PVC fittings for potable water supplies part 1 general requirement
53	IS:10124(part 2)1988	Fabricated PVC fittings for potable water supplies part 2 specific requirement for sockets
54	IS:10124(part3)1988	Fabricated PVC fittings for potable water supplies part 3 specific requirements for straight reducers
55	IS:10124(part4)1988	Fabricated PVC fittings for potable water supplies part 4 specific requirement for caps
56	IS:10124(part5)1988	Fabricated PVC fittings for potable water supplies part 5 specific requirement for equal tees
57	IS:10124(part6)1988	Fabricated PVC fittings for potable water supplies part 6 specific requirement for flanged tail piece with metallic flanges
58	IS:10124(part7)1988	Fabricated PVC fittings for potable water supplies part 7 specific requirement for threaded adaptors

Sr No	IS No	Products
59	IS:10124(part 8)1988	Fabricated PVC fittings for potable water supplies part 8 specific requirement for 90 bends
60	IS:101249part9)1988	Fabricated PVC fittings for potable water supplies part 9 specific requirement for 60 bends
61	IS:10124(part x)1988	Fabricated PVC fittings for potable water supplies part 10 specific requirement for 45 bends
62	IS:10124(part 11)1988	Fabricated PVC fittings for potable water supplies part 11 specific requirement for 30 bends
63	IS:10124(part 12)1988	Fabricated PVC fittings for potable water supplies part 12 specific requirement for 22-1/2 bends
64	IS:10124(part 13)1988	Fabricated PVC fittings for potable water supplies part 13 specific requirement for 11-1/4 bends
65	IS:10292-1988	Dimensional requirements for rubber sealing rings for C1/D joint in asbestos cement piping
66	IS:12234-1988	Plastic equilibrium float valves for cold water service
67	IS:12701-1996	Rotational moulded polyethylene water storage tanks
68	IS:12709-1994	Glass fibre reinforced plastic (GRP)pipes joints and fittings for use for water supplies
69	IS:13095-1991	Butterfly valves for general purposes
70	IS:13114-1991	Forged brass gate globe and check valves for water works purposes
71	IS:13159(part 1)1993	Pipe flanges fittings part 1 dimensions
72	IS:14182-1994	Solvent cement for use with un plasticized polyvinylchloride plastic pipe fittings
73	IS:14329-1995	Malleable iron castings
74	IS:1795-1982	Specification for pillar tapes for water supply purposes
75	IS:2692-1989	Ferrules for water services
76	IS:9763-1988	Plastic bib taps & stop valves (rising spindle)for cold water services
Rain age		
1	IS:784-1978	Prestressed concrete pipes (including fittings)
2	IS:1729-1979	Sand cast iron spigot & ventilating pipes fittings &

Sr No	IS No	Products
		accessories
3	IS:3486-1966	Cast iron spigot & socket drain pipe
4	IS:3989-1984	Centrifugally cast (spun)iron spigot & socket soil waste & ventilating pipes fittings & accessories
5	IS:4350-1976	Specification for concrete porous pipes for under-drainage
6	IS:4885-1988	Sewer bricks
7	IS:5455-1969	Cast iron steps for manholes
8	IS:5600-1970	Sewage & drainage pump
9	IS:5961-1970	Specification for cast iron greeting for drainage purposes
10	IS:69081991	Asbestos cement pipes and fittings for sewage and drainage
11	IS:7319-1974	Perforated concrete pipes
12	IS:3006-1979	Specification for chemically resistant glazed stone ware pipes and fittings
13	IS:3271-1966	General requirement of steel cool ventilators with detectable components
14	IS:3272-1966	Dimension for oval-head steel cool ventilators
15	IS:3273-1966	Dimension for circular head steel cool ventilator
16	IS:3274-1966	Goose neck ventilators welded type
17	IS:3275-1966	Dimension for steel cowl ventilators accessories
18	IS:3278-1966	Dimensions for detachable coaming covers and wire mesh grids for steel cool ventilators
19	IS:6280-1971	Specification for sewage screens
20	IS:11925-1987	Specification for pitch impregnated fibre pipes and fittings for drainage purposes
21	IS:12592(part1)1988	Specification for pre-cast concrete manhole covers and frames part 1 covers
22	IS:12592-(part 2)1988	Specification for pre-cast concrete manhole covers and frames part 2 frames
23	IS:14333-1996	High density polythene pipes for sewage
24	IS:14402-1996	Glass fibre reinforced plastics (GRP) pipes joint and

Sr No	IS No	Products
		fittings for use for sewage industrial waste water (other than potable)
25	IS:13592-1992	Un plasticized polyvinylchloride (UPVC) pipes for soil and waste discharge system inside building including ventilation and rain water system

1.15 Earth Work

1.16 Definitions

Deadmen or Tell Tales : Mounds of earth left undisturbed in pits dug out for borrowing earth

Burjis : Short pillars of brick/stone having top surface finished with cement plaster for marking etc.

Formation or Profile : Final shape of the ground after excavation or filling up.

Foul Position : Filthy and unhygienic condition where physical movemens are hampered such as soil mixed with sewage or night soil.

Lead : The distance for removal, measured over the shortest practicable route and necessarily the route actually taken.

Liquid : Mud in liquid form or in a highly plastic state.

Lift : The vertical distance for removal with reference to ground level. The excavation upto 1.5 metres depth below the ground level and depositing the excavated materials upto 1.5 metres above the ground level are included in the rate of earth work. Lifts inherent in the lead due to ground slopes shall not be paid for.

Safety Rules : Safety rules as laid down by the statutory authority.

Payment for lift of 1.5 m and lift inherent due to ground slope are explained in Exhibit 2.1 below.

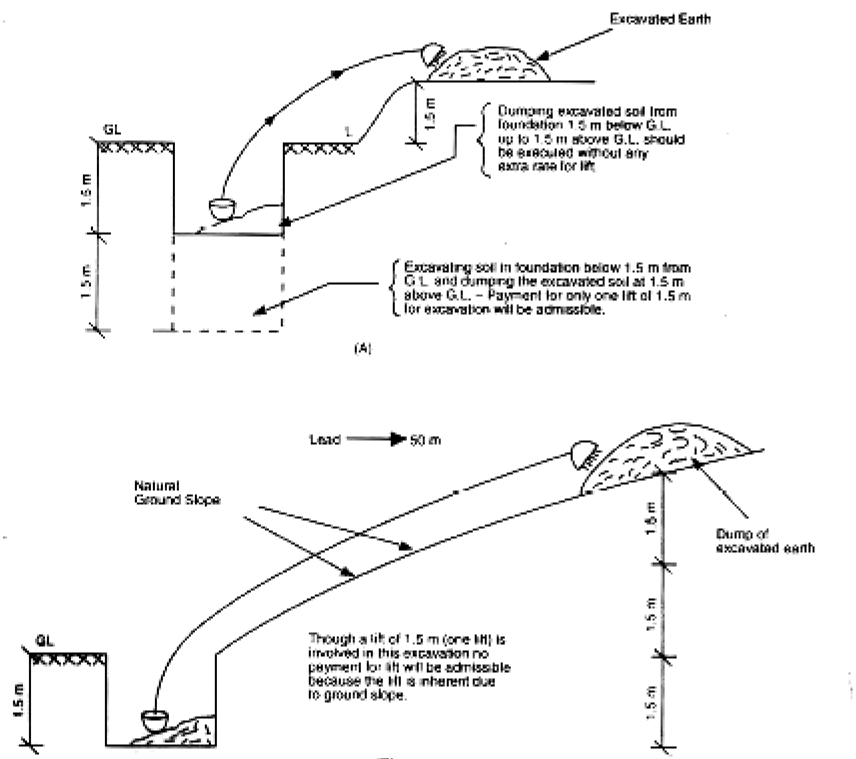


Exhibit 2.1 : Explaining Stipulation regarding Payment for extra Lifts in the Excavation Works

1.17 Classification Of Soils

1.17.1 The earthwork shall be classified under the following categories and measured separately for each category:

(a) All Kind of Soils: Generally any strata, such as sand, gravel, loam, clay, mud, black cotton moorum, shingle river or nallah bed boulders, soiling of roads, paths etc. and hard core, macadam surface of any description (water bound, grouted tarmac etc.), lime concrete, mud concrete and their mixture which for excavation yields to the application of picks, showels, jumper, sacrifiers, ripper and other digging implements.

(b) Ordinary Rock : Generally any rock which can be excavated by splitting with crow bars or picks and does not require any blasting, wedging or similar means of excavation such as lime stone, sand stone, hard laterite, hard conglomerate and unreinforced cement concrete below ground level.
If required light blasting may be resorted to, for loosening the materials but this will not any way entitle the material to be classified as 'Hard rock'.

(c) Hard Rock : Generally any rock or boulder for the excavation of which blasting is required such as quartzite, granite, basalt, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level and the like.

(d) Hard Rock (Blasting prohibited) : Hard rock requiring blasting as described under (c) but where the blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

1.18 Explanatory Notes And Comments

Classification of Soil [Clause 2.1.]

i. In fact the subject like classification soil is really a difficult task, encountered both by the site Engineer as well as the contractor, and for better understanding of the subject, it is advantageous to study the stipulations in the next authentic document, like Indian Standard specification.

ii. The provisions of IS : 1200 Part 1-1992 relating to classification of soil are given below:

Classification

The material to be excavated shall be classified as follows unless otherwise specified.

a) *Soft / Loose Soil* - Generally any soil which yields to the ordinary application of pick and shovel, or to phawra , rake or other ordinary digging implement such as vegetable or organic soil, turf gravel, sand, silt, loam, clay, peat, etc.

b) *Hard/Dense Soil* - Generally any soil which requires the close application of the picks or jumpers or sacrifiers to loosen ; such as stiff clay, gravel, coble stone, water bound macadam and soling of roads.

   Note: Coble stone is the rock fragment usually Rounded or semi-rounded having maximum diameter in any one direction between 80 and 300 mm.

c) *Mud* : A mixture of soil and water in fluid or weak solid state.

d) *Soft/Disintegrated Rock (Not required blasting):-* Rock or boulders which may be quarried or split with crowbars. This will also include laterite and hard conglomerate.

e) *Hard Rock (Requiring blasting) :-* Hard rock requiring blasting as described under (e) but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

Note – A broad classification soil and rock for earthwork suitable for conditions generally occurring in practice has been provided where necessary further sub-classification may be done to suit individual cases depending on the properties of the sub-strata.

i. In the term of earth work, classification of soil is a very important aspect. In case the classification is not done properly & judiciously either the contractor will loose heavily or the client/department will have to shell down heavy amount unnecessarily.

ii. The Site Engineer responsible for recording for measurements after due classification, has to bear tremendous responsibility on his shoulder especially when the large quantities of ordinary rock and hard rock are involved.

iii. If the CPWD and Indian Standard Specification relating to classification of soil is compared one can find remarkable contrast in selected items as pointed out below.

iv. /loose soil and hard/dense soil. The strata included in hard/dense soil are cobble stone (small boulders), water bound mechadam road, soiling of roads, interestingly the item of lean concrete is not included.

v. Under CPWD specification, all types of soil has been clubbed under the classification "Any kind of Soil". It, thus, includes soft/loose, to hard/dense soil, the predominant inclusion is river or nalah boulders soil of road, mechadam surface and also the lime concrete. As a matter of fact there is vast difference in the excavation in soft loose soils like organic soil, sand gravel etc. and one listed earlier. Appling one common rate for all kind of excavation is not justifiable & practical and this is done probably to save recording of some more items.

On the other hand the BIS specification is more practical and thoughtful in the sense, that a sub-division has been made in the item of soil as soft

vi. Under CPWD classification, "any type of soil" includes river and nalah boulders are also boulders in excavation of hard rock. It may be noted that even in river & nalah beds one can find huge boulders and also pebbles, and shingles. Hence, classifying excavation of boulders in the excavation of all kinds of soil makes absolutely no meaning, unless the very nature of boulder is analysed and explained.

vii. As compared to that, the I.S. specification follow a more practical approach, where the excavation of the cobble-stone (small boulders) is included in the excavation of hard dense soil. Also the meaning of cobble stone has been explained in detail. Accordingly a cobble stone is a rounded or semi-rounded fragment of a rock having maximum diameter in anyone direction between 80mm and 300mm. Thus the matter is very clear, and can be recorded without any hesitation.

viii. Similarly in the same specification the regular boulder is included in ordinary rock as well as, hard rock (requiring blasting), depending upon the fact that the removal was done by splitting with crow-bars or by blasting. Here also the nature of boulder has been explained in detail, such that any round or semi-round fragment of a rock over 300mm dia in any direction can be straight a way considered as boulder.

ix. Thus it may be noted that under CPWD specification, that classification of boulder rests entirely on the discretionary powers of the engineer recording the measurements. He may either classify the boulder in "any type of soil" or straight away classify the same under hard rock. This discretionary power may ruin the contractor if the quantity is considerable and the terms of the contractor with the engineer are not cordial. The department should make necessary amendments.

1.19 Antiquities And Useful Materials

1.19.1 Any finds of archaeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered to the engineer-in-charge and shall be the property of the Government.

1.19.2 Any material obtained from the excavation which in the opinion of the engineer-in-charge is useful, shall be stacked separately in regular stacks as directed by the engineer-in-charge and shall be the property of the government.

1.20 Protection

1.20.1 Excavation where directed by the engineer-in-charge shall be securely fenced and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights during the night to avoid accidents.

1.21.2 The contractor shall take adequate protective measures to see that the excavation operations do not damaged the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes and chambers, communication cables, power supply cables etc. met within the course of excavation shall be properly supported and adequately protected, so that this services remain functional.

1.20.1 Excavation shall not be carried out below the foundation level of the adjacent buildings until underpinning, shoring etc. is done as per the direction of the Engineer-in-Charge for which payment shall be made separately.

1.21 Site Clearance

1.21.1 Before the earth work is started, the area coming under cutting and filling shall be cleared of shrubs, ranks vegetation, grass, brushwood, trees and saplings of grith up to 30 cm measured at a height of 1 meter above ground level and rubbish remove up to a distance of 50 meters outside the periphery of the area under clearance. The roots of trees shall be removed to a depth of 60 cm below ground level or 30 cm below formation level or 15 cm below sub grade level, which ever is lower, and the holes, or hollows filled up with the earth, rammed and leveled.

1.21.2 The trees of girth above 30 cm measured at a height of one meter above ground shall be cut only after permission of the Engineer-in-Charge is obtained in writing. The roots of trees shall also be removed as specified in 2.4.1. Payment for cutting such trees and removing the roots shall be made separately.

1.21.2 Existing structures and services such as old buildings, culverts, fencing, water supply pipelines, sewers, power cables, communication cables, drainage pipes, etc. within or adjacent to the area if required to be delivered/removed, shall be delivered/dismantled as per direction of the Engineer-in-Charge and payment for such diversion/dismantling works shall be made separately.

1.21.1 Incase of Archaeological monuments within or adjacent to the area, the contractor shall provide necessary fencing all round such monuments as per the directions of Engineer-in-Charge and protect the same properly during execution of works. Payment for providing fencing shall be made separately.

1.22 Settings Out And Making Profiles.

1.22.1 A masonry pillar to serve as a bench mark will be erected as a suitable point in the area, which is visible from the largest area. This bench mark shall be constructed as per Fig.1 and connected with the standard bench mark as approved by the Engineer-in-Charge. Necessary profiles with strings stretched on pegs, bamboos or 'Burjis' shall be made to indicate the correct formation levels before the work is started. The contractor shall supply labour and material for constructing bench mark, setting out and making profiles and connecting bench mark with the standard bench mark at his own cost. The pegs, bamboos or 'Burjis' and the bench mark shall be maintained by the contractor at his own cost during the excavation to check the profiles.

1.22.2 The ground shall be taken at 5 to 15 meters intervals (as directed by the Engineer-in-Charge) in uniformly sloping ground and at closer intervals where local mounds, pits or undulation are met with. The ground 1[level shall be recorded] in filled books and plotted on plans. The plans shall be drawn to a scale of 5 meters to 1 cm or any other suitable scale directed by the Engineer-in-Charge. North direction line and position of bench mark shall invariably be shown on the plans. These plans shall be signed by the contractor and the Engineer-in-Charge or their authorized representatives before the earth work is started. The labour required for taking levels shall be supplied by the contractor at his own cost.

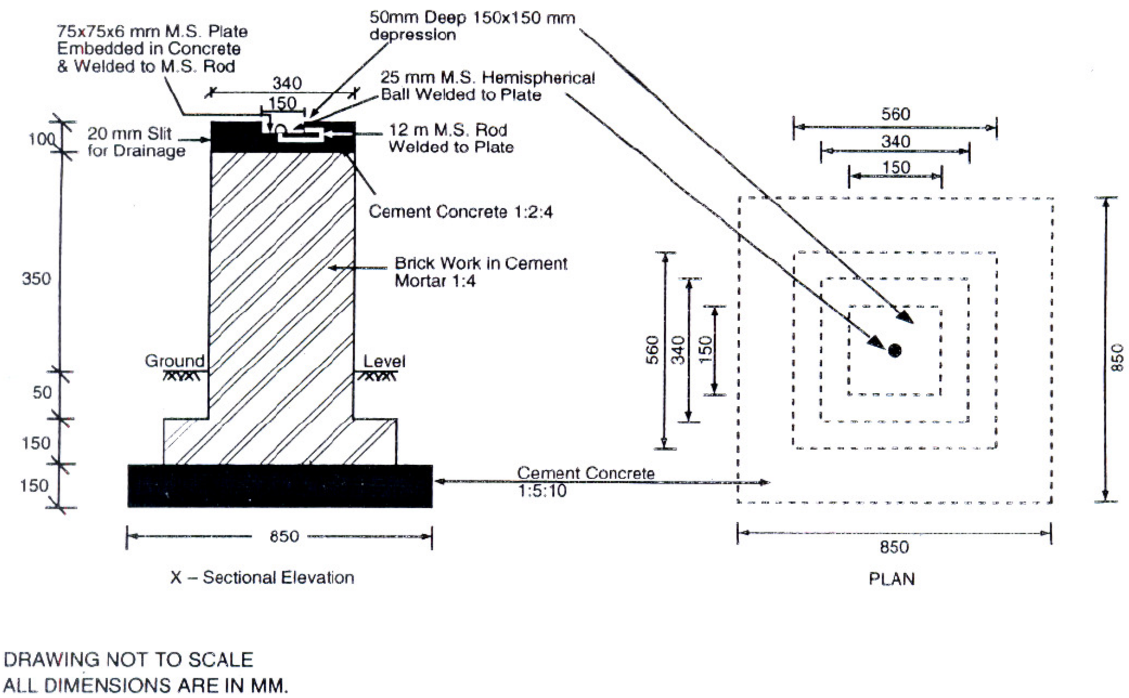


Fig. 1: The Design for Temporary Site Bench Mark.

(3) Setting a Road in straight Alignment

(A) List of Materials required for a Road marking (setting out)

(1) Boning rods:- These rods are useful to fix the intermediate levels. These are portable 'T' shaped rods having the same dimensions and used to furnish a line of sight, whereby from two given points other point at the same level or on the same gradient can be established.

(2) Slight rails and travelers:- These are similar to boning rods. These are used in a fixed position in Road work as well as drain work. The sight rails function as horizontal rails and the traveler which is cut to the

desired length is used to fix up the required level below that of sight line between the sight rails. The details of use of the sight rail and traveler are shown in Exhibits 2.12, 2.13 and 2.14.

(3) 100 mm Balli pieces as pegs.

(4) A dumpy level

(5) Hammer

(6) Cotton thread (Line Dori)

(7) Lime powder

(8) 30 m Steel tape

(9) 3 m to 5m steel tape

(10) Bricks

(11) Cement Mortar

(12) Theodolite

(B) Procedure of Setting out a Road

The procedure of setting out a road is quite easy when compared to buildings etc. Initially before taking up the road work spot levels of the ground where the proposed road is to be aligned should be recorded.

(**C) Fixing Sight Rails**

The next step is to drive wooden pegs along the centre line of the proposed road at every 15 mts. Distance. Now erect sight rails as shown in the figure at 1.00 m from the edge of the edge of the road. Construct brick pillars at the foot of the sight rails on which the R.L. of the proposed road at that particular point is noted. The height of the top of sight rail is adjusted to desired height before the sight rail is fixed in position.

(D) Traveller and it's Usage

The depth of excavation or for that matter the dradient of the road dan be checked during excavation with the help of the traveler as shown in Exhibit 2.13.

The above sight rail cannot be fixed where two or more roads meet in such cases one can use of boning rods, and maintain and check the excavation levels.

The use of sight rails and traveler is shown in Exhibit 2.13.

(E) Formation and Checking of Road Camber

In road work one has to maintain two separate levels as in the case of camber of road, one level at the crown and the other at the edge of Road. Hence, to check up the above level we can use two methods:

(1) Two sight rail and single traveler method (See Exhibit 2.12)

(2) Two traveler method. (See Exhibit 2.13)

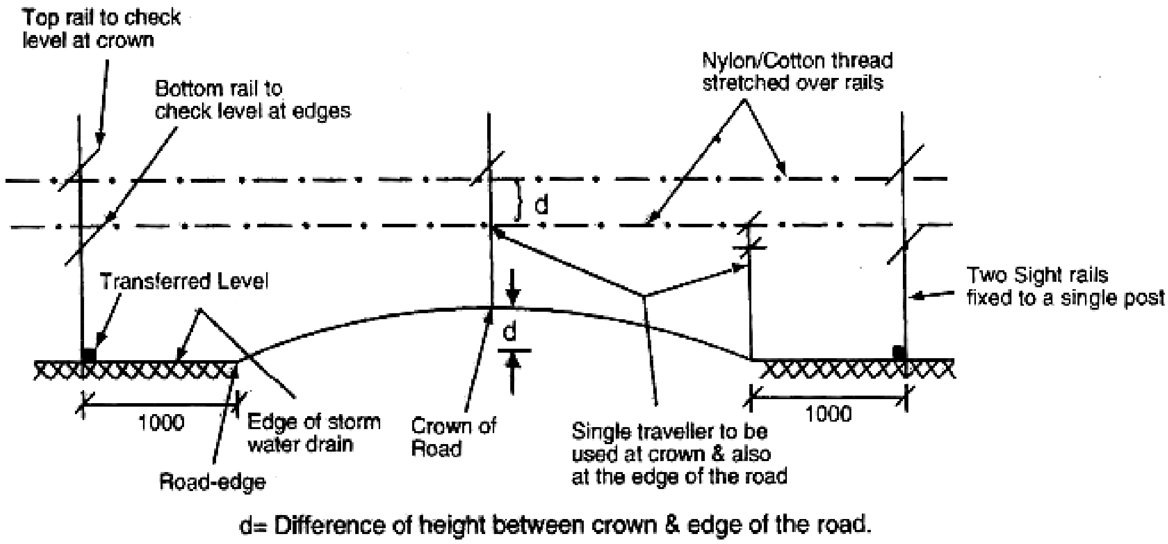


Exhibit 2.12: Single Traveller/two sight rail method

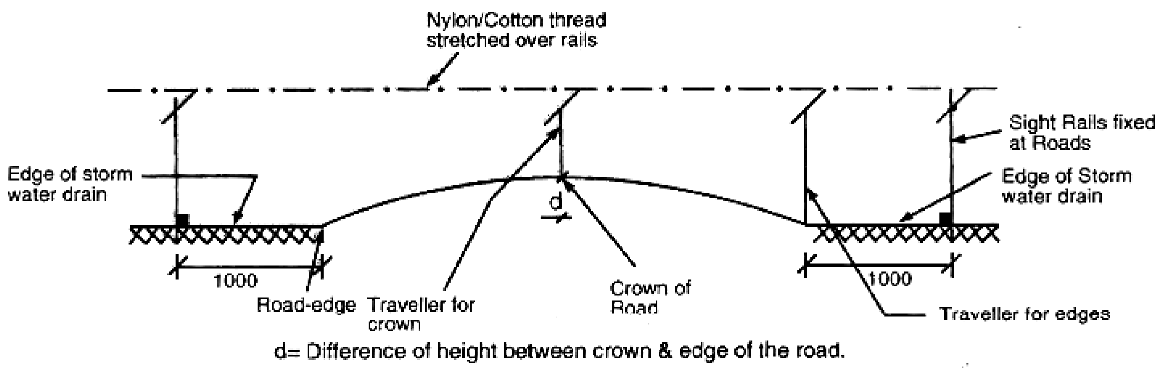


Exhibit 2.13: Two Trveller method

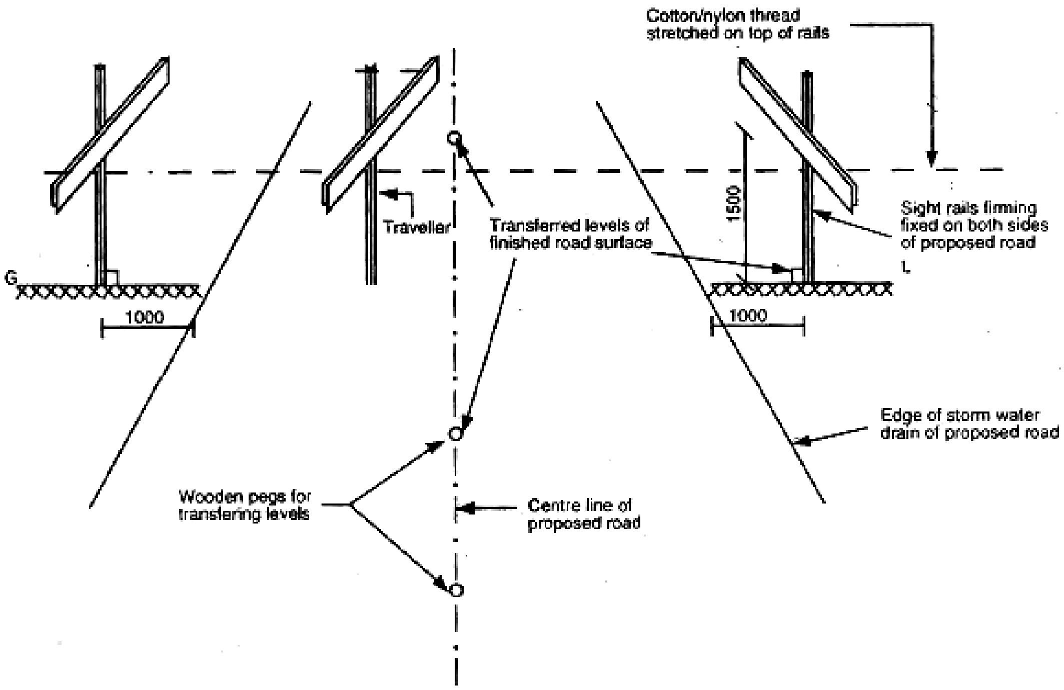


Exhibit 2.14: Details of Sight Rails and Traveller for Setting Out a Road

1.23 Setting Out A Drain

(A) Introduction

As a matter of fact, this is the most important item but totally neglected in practice. The reason being it is a covered item & not subject to rigorous checking. In practice they do not consider much importance for setting out a drain line. Sample pegs are drawn and demarcation completed by making two edges of drain & the Excavation work is started. There is no scope to check it the proper depth of Excavation is maintained. The Site Engineer will hold the Contractor responsible for any extra depth excavated, at the same time either the contractor would procure a leveling instrument and give spot levels or has to be after the Site Engineer to give levels when the work of Excavation is in progress and in the process sometimes the labour excavates more than actual required depth.

Hence, a method by which labourers themselves can check up the depths during excavations is to be adopted & this is a sight Rail traveler method, or use of vertical posts with special traveler.

The above two methods are explained in detail later in this section.

(B) Provision of primary reference points

Primary reference points should be provided in the form of pegs driven along the centre line of the proposed drain, as stated below:-

(a) At each end of the pipe line.

(b) At the centre of each intermediate manhole, inspection chamber etc.

(c) Each change of direction or gradient not having a manhole etc.

(d) At a point where the distance between the two pegs exceed 50.00 m.

(C) Method of Checking Depths: Method I – Sight Rail Traveller Method

After driving the pegs next step is to erect the sight rails because once the excavation is started either by machine or manually it would be difficult to erect the sight rails.

The work of erection of site rails can be as detailed in Exhibit 2.15.

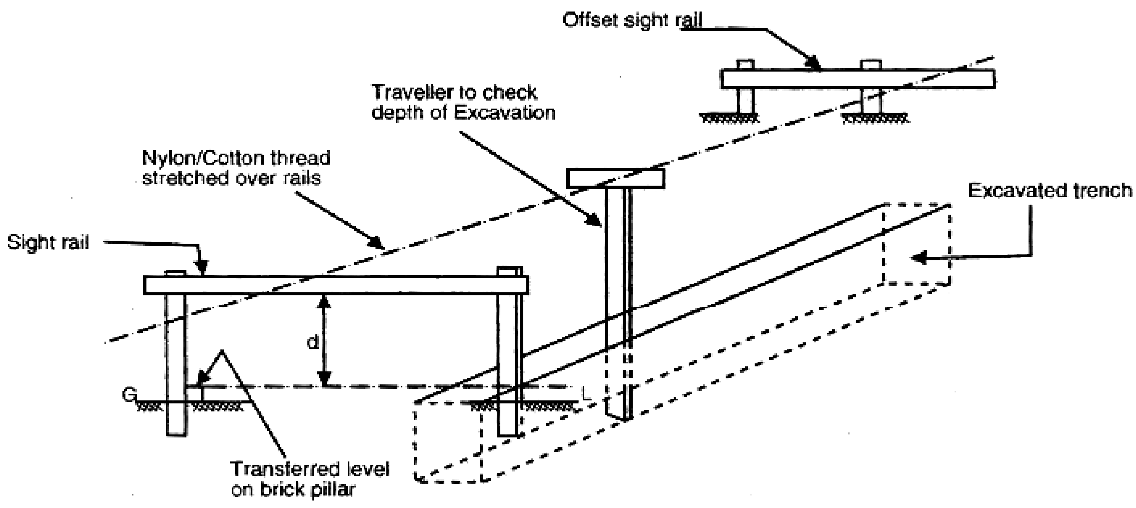


Exhibit 2.15: Sight Rails, Offset Sight Rails and Traveller used for the Excavation of Drain

The sight rails are erected at each man-hole & inspection chamber and if the length of the drain is over 10.00 m an immediate rail is set up at mid point.

The immediate rail helps in sighting over the length and also provides a check if any of the already erected sight rail is damaged during construction.

The rail is straddled on the centre line of the trench but care should be taken that the vertical post should not be placed on the path of the Excavation.

Sometimes due to space restriction it may not be possible to erect the posts on both the sides of the centre line of the trench in that case one can use an offset sight rail as shown in Exhibit 2.15.

The height of the site rail is determined from the level already transferred on the brick pillar at the base of Site rail & measuring up works to give a convenient height 'd' above the level on the brick pillar, & by adding the required depth of trench to the value 'd' the exact height of traveler at that point can be determined. For immediate heights the same methods is followed & traveler used to assure the correct depth of Excavation.

Some times it will not be possible to erect the vertical posts of the sight rail due to soil conditions in that case the vertical posts can be embedded in a pipe or barrel filled with ballast as shown in Exhibit 2.16.

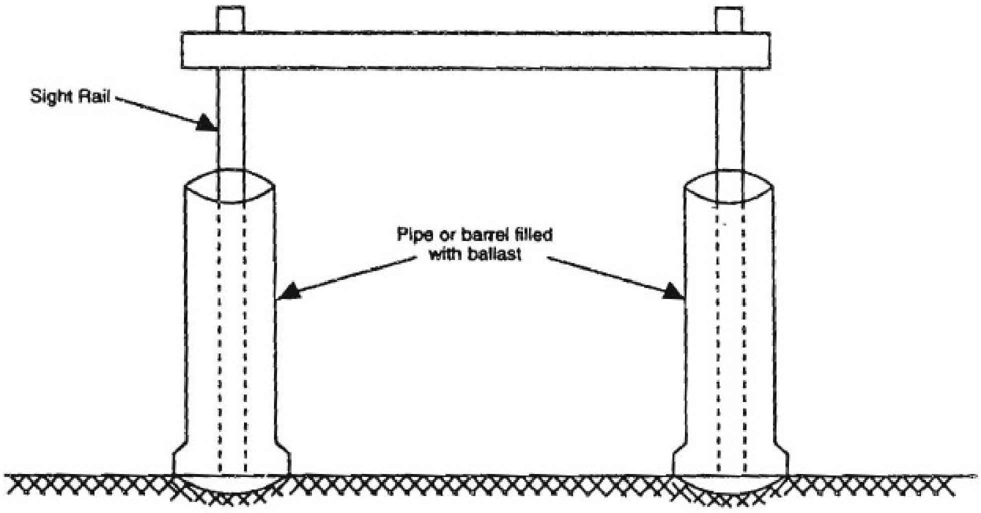


Exhibit 2.16 : Erection of Sight Rail on hard ground or very soft ground

(D) Method of Checking Depths: Method II – Vertical Posts with Special Traveller Method

In case instead of sight rail, Vertical posts say selected & straight ballies, are erected at about 5 to 10 metres apart on one side of the drain. Level Burji's are fixed at the base of alternate posts. A nail is driven at the desired height on the vertical post. Then a nylon or cotton thread is stretched over the nails.

A specially made traveler with an inbuilt sprit level is used to check the depth of Excavation of a pipe trench.

The details of erection of ballies and the special traveler is shown in Exhibit 2.17.

Note: The method of setting out for pipe laying will be dealt in detail later under item Sewage (in Vol. VI).

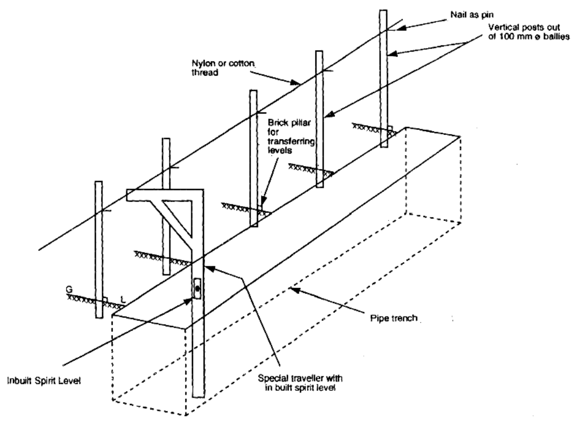


Exhibit 2.17: Vertical Posts and Line with Special Traveller

3-MORTARs

LIST OF MANDATORY TEST

Material	Clause	Test	Field/ Laboratory	Test Procedure	Minimum quantity of material for carrying out test	Frequency of testing
Water	3.1.1	(i) Ph value	Lab	I.S. 3025		Water from each source shall be got tested before the commencement of work and thereafter once in every three months till the completion of the work. Water from municipal source need be tested only once in six months. Number of Tests for each source shall be 3.
	(ii)	Limit of Acidity	Lab			
	(iii)	Limits of Alkality	Lab			
	(iv)	Percentage of Solids	Lab			
	(a)	Chlorides	Lab			
	(b)	Suspended matter	Lab			
	(c)	Sulphases	Lab			
	(d)	Inorganic solids	Lab			
	(e)	Organic solids	Lab			
Cement	3.1.2	Physical Requirement				
		(i) Fineness	Lab	I.S.4031 (Part II)	Each lot	Every 50 tonnes or part thereof
		(ii) Soundness		I.S.4031 (Part III)		
		(iii) Setting time (Initial & Final)		I.S.4031 (Part V)		
		(iv) Compressive strength	Lab	IS.4031 (Part VI)		
		(v) Consistency of standard cement paste	Lab	Test Procedure		
Lime	3.1.3	Chemical and physical properties of lime	Lab	Physical Properties (I to ix) as per Annendix 'A' I.S. 6932	5 M.T.	10 M.T. or part thereof as desired by Engineer-in-Charge
				Chemical properties (I to vi) I.S. 6932 (VII & VIII) I.S. 1514		
Sand	3.1.4.1	Organic impurities	Field	Appendix 'B'	20 cum	Every 20 cum or part thereof or more frequently as decided by Engineer-in-Charge.
	3.1.4.2	Silt content	Field	Appendix 'D'	20 cum	Do -
	3.1.4.4	Particle size distribution a, b, c, d & e	Field or Lab as decided by the Engineer-in-Charge	Appendix 'C'	40 cum	40 cum or part thereof
	3.1.4.5	Bulking of sand	Field	Appendix 'E'	20 cum	Every 20 cum or part thereof or more frequently as decided by Engineer-in-Charge

LIST OF BUREAU OF INDIAN STANDARD CODES

Sr.No.	IS. No.	Subject
1.	196	Atmospheric condition of testing
2.	269	Specification for 33 grade ordinary Portland Cement.

3.	383	Specification for coarse and fine aggregate from natural source for concrete.
4.	455	Specification for Portland slag cement.
5.	460 (Part –I)	Specification for test sieves : wire cloth test sieves.
6.	650	Specification for standard sand for testing of cement.
7.	712	Specification for building line.
8.	1344	Specification for Specification for calcined clay Pozzolana.
9.	1489	Specification for Portland Pozolana Cement.
10.	1542	Specification for sand for plaster.
11.	1727	Methods of Test for Pozzolanic materials.
12.	2116	Specification for sand for masonry mortar.
13.	2250	Code of Practice for preparation and use of masonry Mortar.
14.	2386 (Part I)	Method of test for aggregate for concrete (Particle size – and shape).
15.	2386 (Part II)	- do - Estimation of deleterious materials and organic impurities.
16.	2386 (Part III)	- do - specific gravity, density, voids, absorption and bulking.
17.	2580	Jute sacking bags for packing cement.
18.	2686	Specification for cinder aggregate for use in Lime Concrete.
19.	3025	Method of sampling and test for water.
20.	3406	Specification for masonry cement.
21.	3812	Specification for flyash for sue as Pozolana.
22.	4031 (Part I) to (Part XIII)	Method of Physical test for hydraulic cement.
23	4032	Method of chemical analysis of Hydraulic Cement.
24.	4098	Specification for Lime Pozolana mixture.
25.	6932 (Part 1 to 10)	Method of test for building lime.
26.	8041	Rapid hardening Portland cement.
27.	8043	Hydrophobic Portland cement.
28.	8112	Specification for 43 grade ordinary Portland cement.
29.	11652	Woven HDPE sacks for packing cement.
30.	11653	Woven polypropylene sacks for packing cement.
31.	12174	Jute synthetic unionbags for packing cement.
32.	12269	Specification for 53 grade ordinary Portland cement.

1.24 Mortars

1.25 Materials

1.26 Water

1.26.1 Water used for mixing and curing shall be clean and free from injurious quantities of alkalies, acids, oils, salts, sugar, organic materials, vegetable growth or other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The Ph value of water shall be not less than 6. The following concentrations represent the maximum permissible values: (of deleterious materials in water).

(a) *Limits of Acidity:* To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml of 0.02 normal NaOH. The details of the test shall be given in IS : 3025(part 22).

(b) *Limit of Alkalinity:* To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 H_2SO_4. The details of the test shall be given in IS: 3025(part 23).

(c) *Percentage of solids :* Maximum permissible limits of solid when tested in accordance with IS: 3025 shall be as under:

Organic	200 mg/litre
Inorganic	3000 mg/litre
Sulphates	400 mg/litre
Chlorides	500 mg/litre for RCC work and 2000 mg/litre for concrete not containing embedded steel.

Suspended matters 2000 mg/litre

The physical and chemical properties of ground water shall be tested along with soil investigation and if the water is not found conforming to the requirements of IS : 456:2000, the tender documents shall clearly specify that the contractor has to arrange good quality of water for construction indicating the source.

1.26.2 Water found satisfactory for mixing is also suitable for curing. However, water used for curing shall not produce any objectionable stains or unsightly deposit on the surface. The presence of tannic acid or iron compound in the water meant for curing is objectionable.

1.26.3 Sea water shall not be used for mixing or curing.

1.26.1 Water from each source shall be tested before the commencement of the work and thereafter once in every three months till the completion of the work. In case of ground water, testing shall be done for different points of drawdown. Water from each source shall be got tested during the dry season before monsoon and again after the monsoon.

1.27 Relevant Extracts From BIS Codes

IS: 456:2000 –CODE OF PRACTICE FOR PLAN AND REINFORCED CONCRETE

1.27.1 In case of doubt regarding development of strength the suitability of water for making concrete shall be ascertained by compressive strength and initial setting time tests specified in 5.4.1.2 & 5.4.1.3.

1.27.2 The sample of water taken for testing shall represent the water proposed to be used for concrete, due account being paid to several variation. The sample shall not receive any treatment before testing other than that envisaged in regular supply of water proposed for use in concrete. The sample shall be stored in clean container previously reinsed out with the same water.

1.27.3 Average 28 day compressive strength of at least three150mm concrete cubes prepared with water proposed to be used shall not less than 90 percent of the of the strength of three similar concrete cubes prepared with distilled water. The cube shall be prepared cured & tested accordance with the requirement of IS : 516.

1.27.4 The initial setting time of the test block made with the appropriate cement & the water proposed to be used shall not be less than 30 min & shall not deffer ±30 min from the initial setting time of control test block prepared with the same cement and distilled water.. The test block shall be prepared and tested in accordance with the requirements of IS : 4031 (Part 5).

1.27.1 The pH value of the water shall not be less than 6.

1.28 Explanatory Notes And Comments

1.28.1 Water

The description given under clause No. 3.1.1.1 (a), (b) & (c) 3.1.1.2 is exactly as given in IS : 456-2000.

The CPWD specification further states that "If the ground water is not found conforming to the requirements of IS : 456-2000 the contractor has to arrange good quality water".

Hence for the convenience of the reader, relevant extracts from IS : 456-2000 regarding the requirements of water for construction have been reproduced above.

Water is an important component of mortar or concrete. When mixed in for mortar it reacts with cement and forms a binding paste which in turn penetrates in the plenty, and shall voids of sand, which brings them to close cohesion, of sand particles.

In case of cement concrete the void formed between sand as well as coarse aggregates get filled with the paste in question thus forming a cohesive substance-concrete.

Though theoretically just enough water required for hydration should be used to prepare mortar or concrete, but such mix would be very dry and exceedingly difficult for placing. In practice it is seen that water is mixed at random to make the mix workable.

This is a bad practice and the additional water to be mixed should be kept to bare minimum because the use of too much water weakens the strength of cement paste. The undue dilution of glue weakens the adhesive quality.

The main disadvantages resulting in mixing too much water in mortar and also in concrete are:

(1) Water occupies the space in sand and as it evaporates it leaves void. The more the excess water the void will be more

(2) When excess water is used in concrete the excess water brings a misture of excess cement paste with water floating on the surface.

This material forms a thin layer of chalky material on the surface, making the surface very smooth. This smooth surface prevents the proper ponding of the next layer of concrete with the result the joint between the two layers become porous and especially in water tank works & dams it creates a plane of weakness and will effect the water-tightness of concrete.

(3) When concrete with excess water is used, in the shuttering normally used these days, even on the prestigious structures, the excess slurry through voids in shuttering escapes, which carries a certain amount of cement. This make the concrete of less cement content and ultimately the strength of the member gets reduced.

Hence, the Engineer supervising the work should be very careful not to use more than just required quantity of water both for preparing mortar or concrete. In fact, adding water in mortar and concrete should be strictly supervised to produce quality construction.

In normal course, the RCC structures built with sea water and exposed to atmosphere, especially in tropics, should not be encouraged or allowed, as the affect of reinforcements will be much more in these case.

Again under no circumstances the sea water should be used in pre-stressed concrete, and also in structures where high alumina cement in used. The use of high alumina cement with sea water creates adverse effect on the strength of reinforced concrete.

1.29 Use of Sand And Gravel From Sea

Here also the general opinion amongst Engineers is not to use sand or gravel obtained from sea, or washed in sea water for making concrete, though the amount of sea salt in such aggregates would not be more than one per cent of the weight of mixing water. Hence, if such aggregates are used with drinking water the effect of presence of salt in the aggregates will be very much less and will not be harmful, for the structure. Rather the concrete made with above method will be much harmless when compared to the concrete made of aggregates free of sea salts and mixed with sea water.

1.30 Using Of Sera Water for Curing

This is a debatable question. In fact, many specifications do not recommend the use of sea water for curing the Reinforced cement concrete works due to the fear of corrosion of reinforcement bars.

Tests conducted on the subject has proved that, one can use sea water for curing if ample cover to the reinforcements are provide. Also the salt crystals form only in the process of alternate wetting and drying. Hence, if the members is kept continuously wet while curing with sea water, no harm will be created to the structure.

1.31 Effect on Concrete Due To Different Types Of Waters

(a) Acid Water: No adverse effect on strength of concrete has been observed with the presence of hydrochloric, sulphuric and other common inorganic acids in concentration as high as 10,000 ppm.

(b) Alkaline Water: The presence of sodium hydroxide concentration of 0.5 per cent by weight of cement will not effect the strength of concrete provided no quick seting agents are used. The higher concentration may reduce the strength of concrete

(c) Industrial Waste Water: The industrial waste water that comprise the water from tanneries, paint facories, coke plants, galvanizing plants, etc. Should not be used for concrete work straightway without testing as even a few hundred ppm unusual solids in the water will be harmful for the strength of concrete.

(d) Water Carrying Sanitary Sewage: A typical sewage contains about 400 ppm of organic matter. However, if treated in a good disposal system the concentration gets reduced to just 20 ppm or less and this will not be harmful for concrete work in any way.

(e) Water with Sugar: It is proved that the concentration of sugar less than 500 ppm will generally not effect the strength of concrete, but if the concentration is more the tests for setting time and also strength must be done.

The following observations will show the real effect of sugar in water for concrete work:

(1) A small amount of sugar say 0.03 to 0.15 per cent by weight of cement usually retard the setting of cement and early strength but will improve the 28 day test.

(2) A quantity of sugar say 0.20 per cent by weight of cement in water when mixed in concrete will accelerate the setting time. On the other hand, water with sugar 0.25 per cent by weight of cement or more would accelerate rapidly the setting of concrete and a marked reduction of strength at 28 days test will be noticed.

(f) Presence of Silt or suspended particles in water: The presence of suspended clay or fine rock particles up to 2000 ppm is tolerable and will not have any effect on the strength of concrete, but though even higher amounts may not effect the ultimate strength of the concrete still there might be adverse effect on the other properties of the concrete mixture. Hence, it is advisable not to use very turbid water without allowing it to settle in a settling basin or otherwise clarified.

1.32 Presence of Oil In Water

There are two types of oils: Mineral oil and Animal or Vegetable oil

Water mixed with mineral oil used for mixing concrete will have hardly any effect on the strength of concrete. It has been observed that water mixed with 2 per cent engine oil, used to prepare concrete did not affect the strength of concrete in any way, whereas concrete prepared with water mixed with 2 per cent linseed oil lowered the 7 days tensile strength by 29 per cent.

It is observed that the water used for making concrete with oil concentration of more than 2%, may reduce the strength of concrete by about 20 per cent.

1.33 Presence Of Algae In Water

Algae when mixed in water for making concrete not only reduces the strength of concrete considerably but also reduces the bond between the cement paste and the aggregates. Algae is some times present on the surface of the aggregate, and the Engineer should take extra care to see that the presence of algae is totally eliminated.

The tolerable concentrations of some impurities is tabulated below:

ANNEXURE 3.1

CONCENTRATION OF IMPURITIES IN WATER

	Impurity	Tolerable Concentration
	Sodium and Potasium carbonates and bicarbonates	1000 ppm (total). In case this is exceeded test for both setting time and strength at 28 days should be undertaken
	Sodium Chloride	20,000 ppm
	Sodium Sulphate	10,000 ppm
	Calcium & Magnesium Bicarbonate	400 ppm of bicarbonate ion.
	Magnesium Sulphate & Magnesium	40,000 ppm
	Calcium Chloride	2 per cent by weight of cement in non pre-stressed concrete
	Iron Salts	40,000 ppm
	Sodium iodate, Sodium phosphate, Sodium	Very Low.
	Sodium sulphate	One should go in for testing even if presence seen is 100 ppm
	Hydrochloric, sulphuric and other Common	10,000 ppm
	Sodium hydroxide	0.5 per cent by weight of cement if no admixture for quick Setting is used.
	Silt & suspended particles	2000 PPM

1.34 Cement

1.34.1 The cement used shall be any of the following and the type selected should be appropriate for intended use.

(a) 33 grade ordinary Portland cement conforming to IS: 269.

(b) 43 grade ordinary Portland cement conforming to IS: 8112.

(c) 53 grade ordinary Portland cement conforming to IS: 12269.

(d) Rapid hardening Portland cement conforming to IS: 8041.

(e) Portland Slag cement conforming to IS: 455.

(f) Portland Pozzolona cement (flyash based) conforming to IS : 1489 (part 1).

(g) Portland Pozzolona cement (Calcined clay based) conforming to IS : 1489 (part 2).

(h) Hydrophobic cement conforming to IS: 8043.

(i) Low heat Portland cement conforming to IS : 12600.

(j) Sulphate resisting Portland cement conforming to IS: 12330.

Different types of cement shall not be mixed together. In case more than one type of cement is used any work, a record shall be kept showing the location and the types of cement used.

1.34.2 Caution in use of cement Grade 53 in construction: In case of Grade 33 cement, the gain in strength will continue beyond 28th day because, of early gain, gain of strength of other cements do not increase much beyond 28th day. In addition, because of the faster hydration process, the concrete also releases heat of hydration at a much faster rate initially and release of heat is the highest in case of Grade 53. The heat of hydration being higher, the chances of micro-cracking of concrete is much greater. Thus, during initial setting period of concrete, the higher heat of hydration can lead to damaging micro-cracking within the concrete which any not be visible at surface. This cracking is different from shrinkage cracks which occurs due to faster drying of concrete in windy conditions.

The situation can be worse when we tend to increase the quantity of the cement in concrete with a belief that such increases are better for both strength and durability of concrete. Thus, it is very essential to be forewarned that higher grade cement specially grade 53 should be used only where such use is warranted for making higher strength concrete and also

Where good quality assurances measures are in place, by which proper precautions are taken to relieve the higher heat of hydration through chilling of aggregates or by proper curing of concrete. Instances have come to our notice where higher grade cement is being used even for low strength concrete, as mortar or even for plastering. This can lead to unnecessary cracking of concrete/surfaces.

Another issue to be cautioned against is the tendency of the manufacturers to project grade 53 cement as a stronger cement, whereas grade 33 or 43 are enough to produce the concrete of desired characteristic strength. The scenario of method production of cement by various manufacturers should also be kept in mind while ordering various grades of cement. The ability to produce cements of various finness get fixed by the machinery installed by the manufacturers, and thus the ability to produce various grades of cement by a particular manufacturer also gets limited. Whereas tendency today is to supply the consumer what he orders for by the manufacturers by simply stamping such grades on the bags. Thus, it is often observed that cement bags marked as grade 33 or 43 may really be containing cements of much higher grade.

1.34.3 Compressive Strength : Compressive strength requirement of each type of cement for various grades when tested in accordance with IS: 4031 (part 6) shall be as under:

Sample	**Strength in N/mm^2 – not less than for**		
Age at testing	**Gr.33**	**Gr.43**	**Gr.53**
72 +1 hr	16	23	27
168+ 2 hrs	22	33	37
672 +4 hrs	33	43	53

1.34.4 Setting time: Setting time of cement of any type or any grade when tested by vicat apparatus method described in IS:4031 shall conform to the following requirement

(a) Initial setting time : Not less than 30 minutes

(b) Final setting time : Not more than 600 minutes

1.34.5 Supply: The cement shall be packed in jute sacking bags conforming to IS: 2580-1982, double Hessian bituminized (CRI type) or woven HDPE conforming to IS 11652:1986. Woven polypropylene conforming to IS:11653: 1986, jute synthetic union conforming to IS:12174:1987, or any other approved composite bags, bearing the manufacturer's name or his registered trade mark if any, and grade and type of cement.

Every delivery of cement shall be accompanied by a producer's certificate confirming that the supplied cement conforms to relevant specifications. These certificates shall be endorsed to the Engineer-in-Charge for his record.

Every consignment of cement must have identification marks on packages indicating date of manufacture and grade and type of cement. Cement brought to works shall not be more than 6 weeks old from the date of manufacture.

Effective precautionary measures shall be taken to eliminate dust – nuisance during loading or transferring cement.

1.34.6 Stacking and storage : Cement in bags shall be stored and stacked in a shed which is dry, leakproof and as moisture proof as possible. Flooring of the shed shall consists of the two layers of dry bricks laid on well consolidated earth to avoid contact of cement bags with the floor. Stacking shall be done about 150 to 20 mm clear above the floor using wooden planks. Cement bags shall be stacked at least 450 mm clear off the walls and in rows of two bags leaving in a space of at least 600 mm between two consecutive rows. In each row he cement bags shall be kept close together so as to reduce air circulation. Stacking shall not be more than 10 bags high to avoid lumping under pressure. In stacks more than 8 bags high, the cement bags shall be arranged in header and stretcher fashion i.e. alternately lengthwise an crosswise so as to tie the stacks together and minimize the danger of toppling over.

A typical arrangement for storing and stacking of cement is shown in Fig.1 of Chapter 3.

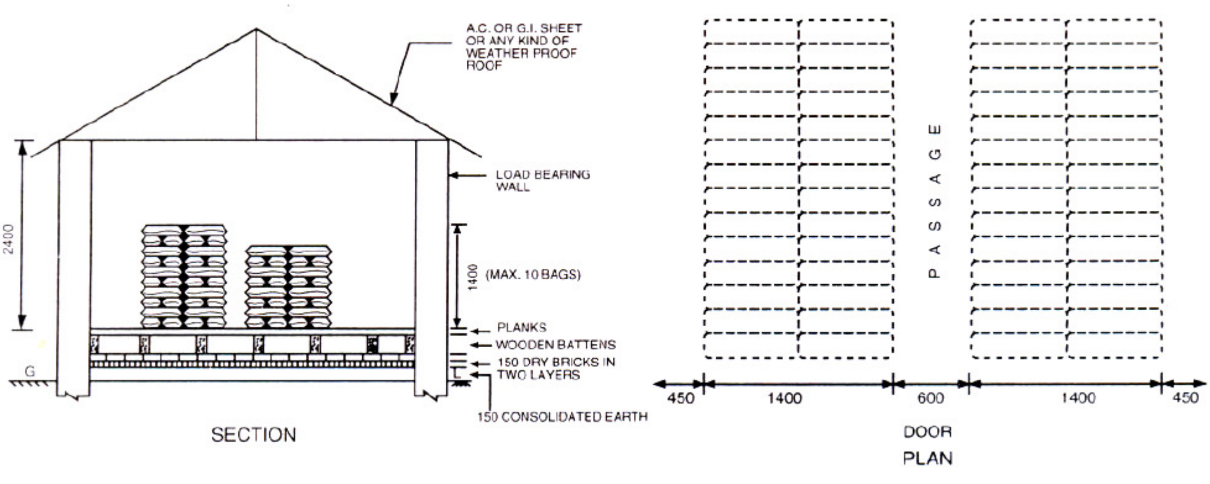


Fig.1: Typical Sketch For Cement Godown (Clause 3.2.1.6)

Different types of cement shall be stacked and stored separately.

Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received.

1.35 Concrete Work

1.36 Material

1.36.1 Water, cement lime, fine aggregate or sand, surkhi, cindde and fly ash shall be asspecified in Chapter 3 – Mortar.

1.36.2 Coarse Aggregate

1.36.4 General: Aggregate most of which is retained on 4.75 mm IS Sieve and contains only as much fin material as id permitted in IS : 383 of various sizes and grading is known as coarse aggregate. Coarse aggregate shall be specified as stone aggregate, gravel or brick aggregate and it shall be obtained from approved/authorized sources.

a) Stone Aggregate: It shall consist of naturally occurring (uncrushed, crushed or broken) stones it shall be hard strong, dense durable and clean. It shall be free veins adherent coatings, injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious sub-stances . it shall be roughly cubical in shape. Flaky and elongated pieces shall be avoided. It shall conform to IS : 383 unless otherwise specified.

b) Gravel: It shall consist of naturally occurring (Uncrushed, crushed or broken) river bed shingle or pit gravel. It shall be sound , hard and clean. It shall be free from flat particles of shale or similar laminated material, powdered clay, alit, loam, adherent coatings, alkali, vegetable, mater and other deleterious substances . Pit gravel shall be washed if it contains soil materials adhering to it. These shall conform to IS : 383 unless otherwise specified.

c) Brick Aggregate : Brick aggregate shall be obtained by breaking well burnt or over burnt dense bricks / brick bats . They shall be homogeneous in texture, roughly cubical in shape and clean. They shall be free from unburnt clay particles. Soluble slat, silt, adherent coating of soil, vegetable mate and other deleterious substances. Such aggregate should not contain more than one percent of sulphates and should not absorb more than 10% of their own mass of water, when used in cement concrete and 20% when used in lime concrete. It shall conform to IS : 306-1983 unless otherwise specified.

d) Light weight aggregate such as sintered fly ash aggregate may also be used provided the Engineer in-Charge is satisfied with the data on the proportion of concrete made them.

1.36.5 Deleterious Material : Coarse aggregate shall not contain any deleterious materials, such as pyrites coal, lignite, mice, shale or similar laminated materials, clay alkali, sift fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Coarse aggregate to be used for reinforced cement concrete. Coarse aggregate to be used for reinforced cement concrete shall not contain any materials liable to attack the steel reinforcement which are chemically reactive with alkalis of cement shall not be used. The maximum quantity of deleterious materials shall not be more than five per cent of the weight of coarse aggregate when determined in accordance with IS : 2386(I).

1.36.6 Size and Grading

i) Stone aggregate and gravel : it shall be graded or single sized as specified. Normal size and grading shall be as under :-

a) Nominal sizes of graded stone aggregate or gravel shall be 40,20,16, or 12.5 mm as specified. For any one of the nominal size, the proportion of other sizes as determinee by the method prescribed in Appendix “A” of Chapter 4 shall be in accordance with Table 1.

Table 1

GRADED STONE AGGREGATE OR GRAVEL

IS Sieve Designation	Percentage passing (by weight) for nominal size of 40 mm	20 mm	16 mm	12.5 mm
75mm	100	_	_	_
37.5mm	95 to 100	100	_	_
19mm	30 to 70	95 to 100	_	_
16mm	_	_	95 to 100	100
11.2 mm	_	_	_	95 to 100
9.5 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10

b) Nominal sizes of single sized stone aggregate or gravel shall be 63, 40, 20, 16, 12.5 or 10mm as specified. For any one of the nominal size, the proportion of other sizes as determined by the method prescribed in Appendix ‘A’ of chapter 4 shall be in accordance with Table 2.

Table 2

SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL

IS Sieve	Percentage passing (by weight) for nominal size of				
Designation	40mm	20mm	16mm	12.5mm	10mm
63mm	100	-	-	-	-
40mm	85-100	100	-	-	-
20mm	0-25	85-100	100	-	-
16mm	-	-	85-100	100	-
12.5mm	-	-	-	85-100	100
10mm	0-5	0-20	0-20	0-20	85-100
4.75mm	-	0-5	0-5	0-5	0-20
2.36mm	-	-	-	-	0-5

c) When stone aggregate or gravel brought to site is single sized (ungraded), it shall be mixed with single sizes aggregate of different sizes in the proportion to be determined by field tests to obtain grade aggregate of specified nominal size. For the required size, the proportion of other in mixed aggregate as determined by method prescribed in Appendix ‘A’ of Chapter 4 shall be in accordance with Table 1. Recommended proportions by volumes for mixing of different sized of sizes of single (upgraded) aggregate to obtain the required nominal size of graded aggregate are given in Table 3.

TABLE 3

SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL

Cement Concrete	Nominal size of graded aggregate required	Parts of single aggregate of size				
		50mm	40mm	20mm	2.5mm	10mm
1:6:12	63	9	-	3	-	-
1:6:12	40	-	9	3	-	-
1:5:10	63	7½	-	2½	-	-
1:5:10	40	-	7½	2½	-	-
1:4:8	63	6	-	2	-	-
1:4:8	40	-	6	2	-	-
1:3:6	63	4½	-	1½	-	-
1:3:6	40	-	4½	1½	-	-
1:3:6	20	-	-	4½	-	1½
1:2:4	40	-	2½	1	-	½
1:2:4	20	-	-	3	-	1
1:2:4	12.5	-	-	-	3	1
1:1½:3	20	0	0	2	-	1

Note :

i) The proportion indicated in table 3 above by volume when considered necessary, those proportion may be varied marginally by. Engineer-in-charge after sieve analysis of aggregate brought to site for obtaining required graded aggregate. No adjustments in rate shall be made for any variation in the proportion so ordered by the Engineer-in-charge. If single size coarse aggregate are not premixed at site to obtain the graded coarse aggregate requires for the mix the volume of single size aggregate required for the mix shall be suitably increased to account or reduction in total volume at the site pf mixing.

ii) Brick aggregate : Nominal size of brick aggregate shall be 40 mm and its grading shall be as specified in table 4 when tested for sieve analysis for the method prescribed in Appendix ‘A’ of Chapter 4.

TABLE 4

BRICK AGGREGATE

IS Sieve Designation	Percentage passing (by weight)
75mm	100
37.5mm	95-100
20.0mm	45-100
4.75mm	0-5

1.36.7 Stacking : aggregate shall be stacked on a hard, dry and level patch of ground. When stack piling the aggregate shall not form pyramids resulting is segregation of different sized materials. It shall be stacked separately according to nominal size of coarse aggregate. Stacking shall be done in regular stacks, of height not exceeding 100cm.

1.36.8 Testing " Coarse aggregate shall be tested for the following (as per IS : 2386 – 1963) :

a) Determination of particle size and shape (Appendix 'A' of chapter 4)

b) Estimation of organic impurities (as per IS : 2386-1963 Part II)

c) Surface moisture (appendix 'B' of chapter 4)

d) Determination of 10% fine value (Appendix 'C' of chapter 4)

1.36.9 Measurements: The aggregate shall be measured in stacks and paid for after making a deduction of 7.5% of the gross measurements of stacks in respect of aggregates of nominal size 40mm and anove. No deduction from the gross measurements of the stacks is to be made in respect of aggregates of nominal size below 40mm.

1.36.9 Chemical Admixtures :

a) Water – reducing Admixtures.

b) Retarding Admixtures

c) Accelerating Admixtures.

d) Water reducing and retarding Admixtures.

e) Water reducing and accelerating Admixtures.

f) Permeability reducing (water proffing) admixtures.

1.36.10 Liquid admixtures : admixtures introduced into the concrete as liquids generally fail into the following gategories.

a) Air entraining.

b) Water reducing.

c) Water reducing retarders.

d) Retarders.

e) Water reducing accelerators.

f) Accelerators.

1.36.14 Dosage of these admixtures may very according to manufactures specification.

1.36.15 Two or more admixtures may not be compatible in the same solution. It is therefore mandatory that when two admixtures manufactured by the same manufacturer is being used simultaneously, the manufacture shall certify their compatibility. In case the two or more admixtures are produced by different manufactures, then before their use in concrete, test shall be performed by the manufacturer to establish their capability, al such test reports shall be furnished to the Engineer-in-charge for his approval before their use in concrete.

1.36.16 Some admixtures may be in the form of powder, particle or high concentration liquids which may require mixing with water prior to dosing. Under these conditions water in solutions shall be considered as part of total water content in the batch in order to maintain the water-cement ratio.

1.36.17 Admixture manufacturer’s recommendation shall be carefully followed so as to ensure complete solution of the product or to prepare a standard solution of uniform strength for easier use.

1.36.18 Certain admixtures may contain significant amounts of finely divided insoluble material or active ingredients which may o not be readily soluble. It is essential for such admixture that precautions be taken to ensure that these constituents be kept in a state of uniform suspension before actual batching. When relative small amount of powder admixtures are to used directly, these shall be pre-blended with cement.

1.36.19 Admixtures re sold under various trade names and may be in the form of liquids or powder. The proprietary name and the net quantity of content shall be clearly indicated in each package or container of admixtures. The admixtures shall be uniform within each batch and uniform between all batches.

1.36.20 No admixtures shall accepted for use in concrete unless there are tested in accordance with I.S. 9103 and the test results are approved by the Engineer-in-charge.

1.37 Relevant Extracts From Bis Codes

Relevant Extracts from IS : 456-2000 pertaining to Aggregate and Admixtures for concreting

1.38 Aggregates

Aggregate shall comply with the requirements of IS : 383. As far as possible preference shall be given to natural aggregates.

1.38.1 Other types of aggregate such as slag and crushed over burnt brick or tile, which may be fond suitable with regard to strength, durability of concrete and freedom from harmful effects may be used for plain concrete members, but such aggregate should not contain more than 0.5 percent of sulphates as SO_3 and should not adsorb more than than 10 percent of their own mass of water.

1.38.2 Heavy weigh aggregate or light-weight aggregate such as bloated clay aggregate and sintered and sintered fly ash aggregate may also be used provided the engineer-in-charge is satisfied with the data on the properties of concrete made with them.

Note : Some of the provisions of the code would require modification when these aggregate are used ; specialist literature may be consulted for guidance.

1.38.3 **Size Of Aggregate**

The nominal maximum size of coarse aggregate should be as large as possible within the limits specified but in no case greater than one-fourth of the minimum thickness of the member, provides that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. For most work, 20 mm aggregate os suitable. Where there is no restriction to the flow of concrete into sections, 40mm or large size may be permitted. In concrete elements with thin sections , closely spaced reinforcement or small cover, consideration should be given to the use of 10mm nominal maximum size.

Plums above 160 mm and up to any reasonable size may be used in plain concrete work up to a maximum limit of 20 percent by volume of concrete when specifically permitted by the engineer-in-charge. The plums shall be distributed evenly and shall be not closer than 150mm from the surface.

1.38.4 For heavily reinforced concrete members as in the case of ribs of main beams, the nominal maximum size of the aggregate should usually be restricted to 5 mm less than the minimum clear distance between the main bars or 5 mm less than the minimum cover to the reinforcement whichever is smaller.

1.38.1 Coarse and fine aggregate shall be batched separately. All-in-aggregate may be used only where specifically permitted by the engineer-in-charge.

1.39 Admixtures

1.39.1 Admixture, if use shall comply with IS : 9103. Previous experience with and data on such materials should be considered in relation to the likely standards of supervision and workmanship to the work specified.

1.39.2 Admixtures should not impair durability of concrete nor combine with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.

1.39.3 The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

1.39.4 The relative density of liquid admixtures shall be checked for each drum containing admixtures and compared with the specified value before acceptance.

1.39.5 The chloride content of admixtures shall be independently tested for each before acceptance.

1.39.6 If two or more admixtures are used simultaneously in the same concrete mix, data should be obtained to assess their interaction an to ensure their compatibility.

1.40 Relevent Extracts From Cpwd, Quality Assurance Circulars

Central Public Works Department, Central Designs Organization

No. CDO/SE(D)/G/89/366 Dated 18.11.1985

Moisture air & salts are required for causing corrosion in reinforcements and absence of any of these can prevent corrosion almost completely. Such electro chemical reaction can set in when there is variation in the quality of concrete, when there is non uniform carbonation, when there is temperature difference due to exposure conditions, due to cracking of concrete, or due to permeability of concrete. Any heterogeneity in concrete can start such electro chemical action.

Prevention of electro-chemical reaction depends on laying good quality concrete of high PH value, mixing & laying it well to have uniform quality, using lower water cement ratio, and compacting it well to reduce porosity & permeability, curing it property to avoid micro-cracking due to drying. High density & low permeability concrete after increased resistence to such electrical activity.

Latest research/tests in G.B. indicate an interesting relationship in W/c Ratio and days of moist curing to obtain same permeability. For permeability of 25 x 10 – 15 M/S. number of wet curing days reduce from 23 to 2.4 when w/c ratio is reduced from 0.60 to 0.45. For w/c ratio of 0.70, the No. of days of moisturizing increase to 295.

Water used for concreting should not have soluble chlorides and sulphates. Such salts from water used in brick work, plastering curing also can get concrete work and hence even for such work water used in brick work, plastering, curing also can get concrete work and hence even for such work water used should be chloride and sulphate. Chloride ions can break down passive protective film around reinforcing bars even in concrete with high PH value Chloride ions are absorbed on metal surface and displace oxygen resulting in hydration of metal ions. Ionic charge of steel in good concrete is positive. But it changes to negative charge with high chloride and this change of charge sets in the electro chemical reaction of corrosion. It is thus necessary to test water used in concrete quite frequently to keep down the chloride and sulphate contents to levels which cannot be harmful. In raw concrete of M 15 grade (1:2:4) soluble chloride and sulphate contents beyond 50 & 500 ppm resp. are harmful. Considering the fact that after setting of concrete and sulphates are reduced to $1/5^{th}$ and $1/12^{th}$ resp. of raw concrete and considering 10% porosity, this gives limits of 100 ppm and 500 ppm for soluble chloride and sulphates (resp.) in the capillary water as tolerance values. Admixtures like accelerators (calcium chloride) or plasticisers containing chlorides are therefore harmful and should not be used.

Above paragraphs give brief, the factors that lead to corrosion and reduced durability of concrete. Considering our responsibility of constructing durable, long lasting structures, it is necessary to take following precautions in the works:

1. Water used in concrete work should be got tested. Merely that water is potable or is from municipal support is not adequate; initial tests could be carried out from two independent in the case of well water. Frequency of such tests should depend upon whether water is from potable municipal supply, from shallow wells or deep tude wells or it is brought in tankers from various sources. Quality of water drawn from change progressively. Tests should be more frequent in such cases and when water is brought in tankers and also when earlier tests show marginal or deteriorating values.

2. Sub –soil and ground water should be tested for chlorides and sulphates. Such aggregate soil and sub-soil water conditions, when encountered, need special precautions such as use of rich and dense concrete mix, sulphate resisting cement, protective surface treatments to concrete and special anti-corrosion treatment to reinforcement bars.

3. Use of low water cement ratio, so as to reduce porosity of concrete and make it as impermeable as possible. There is a common practice to use very high slump for thin sections like fins, drop walls perapet walls etc. Steel in such members has been found to corrode much faster. At the same time stiff mix can result in honey combing, Which is worst. Solution will probably in using non-chloride plasticisers. These are available in India and it is claimed, being used on major projects. These should conform containing plasticisers. There are available in India and it is claimed, being used on major projects. These should conform to IS : 9103-1979 and be chloride free. Some of the manufcaturees who claim such admixtures are:

1. FOSROC CHEMICAL (India) Ltd.
3/11, Kaveriappa Layout, Miller tank Bund Rd, Banglore – 560 052.
2. THE FERRO SITE CO.
2, Cockbum Lane, Royd Street, Calcutta-700 016.
3. ASIAN LABORATORIES (India),
88 New Okhla Industrial Complex, Phase –Ii, New Delhi –110 020.
4. SAHARA CHEMICALS, 12 BBD Bag East, Calcutta – 700 001.

These firms may be contacted by SSWs/Ces to get details of plasticisers, air-entraining agents, water proofing admixtures, to get names of projects/users etc. before using them. In CPWD these are not being used probably because there are no schedule items and rates. However, controller use on special works, particularly in high rise structured by proving specific items in such works. Such material should be selected after proper scrutiny and enquiry and local tests. To start with we could use in thin non-structural members. Experience gained could be shared with other zones and could lead to its acceptance in our schedules. Need to use minimum workable water cement ratio in emphasized in C.S No. 25 to CPWD Specifications 1977 Volume-1 and it was specified that to be used on the works should be decided by E.Es and should not be deviated from without his permission.

Quality Control wing C.D.O, CPWD

No. CDO/QCTA/6-IV/349-1400 Dated 31.12.1985

3.0 it is also observed that standard formats for recording results of mandatory tests issued vide circular No. CDO/QCTA/7-III/1564, dt. 27.11.84 are still not being utilised for recording rest. In some cases, samples taken were not entered in the register till the results was received. This can lead to omission of the test totally. If result is not favorable. In some cases results were not issued with the laboratories. The forms sent by CDO should be followed without fail and entries should be made right from the day samples are taken.

1.41 Cement Concrete

9.3.1 The concrete shall be in grade designated as under:

TABLE 5

GRADES OF CONCRETE

Group	Grade Designation	Specified characteristic Compressive Strength of 150 mm Cube at 28 Days in N/mm^2
(1)	(2)	(3)
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength Concrete	M60	60
	M65	65
	M70	70
	M75	75
	M80	80

Notes:

1. In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm2
2. For concrete of compressive strength greater than M55, design parameters given in the standard may not be applicable and the values may be obtained from specialized literatures and experimental results.

9.3.1.1 The characteristic strength is defined as the strength of material below which not more than 5 per cent of the test results are expected to fall.

TABLE 6

MINIMUM CEMENT CONTENT, MAXIMUM WATER –CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATES OF 20MM NOMINAL MAXIMUM SIZE

(Clauses 4.2.1.1)

Sl. No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m^3	Maximum Free Water Cement Ratio	Minimum Grade of Concrete	Maximum Cement Content kg/m^3	Minimum Free Water Cement Ratio	Maximum Grade of Concrete
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(i)	Mild	220	0.60	-	300	0.55	M20
(ii)	Moderate	240	0.60	M15	300	0.50	M25
(iii)	Severe	250	0.50	M20	320	0.45	M30
(iv)	Very Severe	260	0.45	M20	340	0.45	M35
(v)	Extreme	280	0.40	M25	360	0.40	M40

Notes ;

1. Cement content prescribed in this table is irrespective of the grades of cement. The addition such as fly or ground granulated blest furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS : 1489 (Part 1) and IS : 455 respectively.
2. Minimum grade for plain concrete under mild exposure condition is not specified.
3. The above minimum cement con tent and maximum water cement ratio apply only to 20mm nominal maximum size aggregate. For other of aggregate, these should be changed as per Table 6 of IS : 456:2000.

The minimum grade of concrete for plain and reinforced concrete shall be as per Table 6.

1.1.1 RELEVANT EXTRACTS FROM

Relevant Extracts from IS 456 : 2000

TABLE 6

ADJUSTMENT TO MINIMUM CEMENT CONTENTS FOR AGGREGATE OTHER THAN 20MM NOMINAL MINIMUM SIZE

S. No.	Nominal maximum Aggregate Size. Mm	Adjustments to Minimum Cement Contents in Table 6 Kg/cum
(i)	10	+40
(ii)	20	0

9.3.1.2 Concrete of grades lower than those given in Table 5 may be used for plain concrete constructions, lean concrete, simple foundations, foundation for masonary walls and other simple or temporary reinforced concrete construction.

1.42 Workability Of Concrete

9.4.1 The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS : 1199 are given below :

Placing Conditions	Degree of Workability	Slump (mm)
(1)	(2)	(3)
Blinding concrete : Shallow sections, pavements using pavers	Very low	See 4.2.2.2
Mass concrete : Lightly reinforced sections in slabs, beams, walls, Columns: Floors; Hand placed pavements; canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns;	Medium	50-100
Slipform work : Pumped concrete	Medium	75-100
Trench fill: In-situ piling	High	100-150
Tremie concrete	Very High	See 4.2.2.3

Note : For most of the placing condition, internal vibrators (needle vibratos) are suitable. The diameter of the needle shall determined based on the density and spacing of reinforcement bars and thickness of section. For tremie concrete, vibrators are not to be used (see also 4.2.7)

9.4.2 In the ‘very low’ category of workability where strict control is necessary, for example, pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (see IS : 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

9.4.3 In the ‘very high’ category of workability, measurement of workability by determination of flow will be appropriate (see IS : 9103).

TABLE 7
PROPORATIONS FOR NOMINAL MIX CONCRETE
(Clauses 4.2.3.2)

Grade of Concrete	Total quality of Dry aggregate by Mass per 50 Kg of cement to be taken as the sum of the Individual Masses of Fine and Coarse Aggregate, Kg Max	Proportion of fine Aggregate to Coarse Aggregate (by Mass)	Quantity of Water per 50 kg of Cement, Max 1
(1)	(2)	(3)	(4)
M 5	800	Generally 1:2 but subject	60
M 7.5	625	to an upper limit of 1:11/2	45
M 10	480	and a lower limit of 1:21/2	34
M 15	330		32
M 20	250		30

Note: The proportion of the fine to coarse aggregate should be adjusted from upon limit progressively as the grading of line aggregate becomes finer and the maximum size of coarse aggregate becomes large. Graded coarse aggregate shall be used.
Example :

For an average grading of fine aggregate (that is zone II of Table 4 of IS : 383), the proportions shall be 1:1½, 1:2½ for maximum size of aggregate 10mm, 20mm and 40mm respectively.

1.43 Concrete Mix Proportioning :

9.5.1 The determination of the proportion of cement, aggregate and water to attain required strengths shall be made as follows:

a) By designing the concrete mix: such concrete shall be called ‘Design mix concrete’. For details reference may be made to RCC Chapter.

b) By adopting nominal concrete mix : such concrete shall be called ‘Nominal mix concrete’.

Design mix concrete is preferred to nominal mix. If design concrete cannot be used for any reason on the work for grades of M20 or lower, nominal mixes may be used with the permission of Engineer-in-Charge, which, however, is likely to involve a higher cement content.

9.5.2 Nominal Mix concrete : Nominal Mix Concrete may be used for concrete of M20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with Table 7.

The cement content of the mix specified in Table 7 for any nominal mix shall be proportionately increased if the quality of water in the mix has to be increased to overcome the difficulties of placement and compaction, so that the water cement ration as specified is not exceeded.

1.44 Batching :

To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quality of both cement and aggregate shall be determined by mass admixture, if solid by mass, liquid admixture may however be measured in volume or mass ; water shall be weighed or measured by volume in a calibrated tank (see also IS : 4925).

Ready-mixed concrete supplied by ready-mixed concrete plant shall be preferred. For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants. (see IS : 4926).

9.6.1 Except where it can be shown to the satisfaction of the Engineer-in-charge that supply of properly graded aggregate of uniform quality can be maintained over a period work., the grading aggregate should be controlled by obtained the coarse aggregate in different sizes and blending them right proportions when required, the different sizes being stocked in separate stock-piles. The materials should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate be checked as frequently as possible, the frequency for a given job being determined by the Engineer-in-charge to ensure that the speficied grading is maintained.

9.6.1.1 The accuracy of the measuring equipment shall be within + 2 percent of the quality of cement being measured and within + 3 percent of the quantity of aggregate, admixtures and water being measured.

9.6.1.2 Proportion/Type and grading of aggregate shall be made by trail in such a way so as to obtain densest possible concrete. All ingredients of the concrete should be used by mass only.

9.6.1.3 Volume batching may be allowed only where weight-batching is practical and provided accurate *[bulk densities of materials to be actually] used in concrete have earlier been established. Allowance for bulking shall be made in accordance with IS : 2386 (Part 3). The mass volume relationship should be checked as frequently as necessary, the frequency for the given job being determined by Engineer-in-charge to ensure that the specified grading is maintained.

9.6.1.4 It is important to maintain the water-cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregate shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-in-charge according to weather conditions. The amount of the added water shall be adjusted to compensate for any variations in the moisture contents. For the determination of moisture content in the aggregate, IS : 2386 (Part 3) may be reference to. To allow for the variation in mass of aggregate due to variations in their moisture content, suitable adjustments in the masses of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table 8.

TABLE 8

SURFACE WATER CARRIED BY AGGREGATE

(Clause 4.2.4.5)

Sl No.	Aggregate	Approximate Quantity of Surface Water Percent by Mass	$1/m^3$
(1)	(2)	(3)	(4)
(i)	Very wet sand	7.5	120
(ii)	Moderately wet sand	5.0	80
(iii)	Moist sand	2.5	40
(iv)	[1]Moist Gravel or Crushed rock	1.25-2.5	20-40

[1]Coarser the aggregate less the water it will carry.

4.2.4.6 No substitutions in materials used on the work or alteration in the established proportions, except as permitted I 4.2.4.4. and 4.2.4.5 shall be made without additional test to show that the quality and strength of concrete are satisfactory.

EXPLANATORY NOTE

1. Mix Proportions for Different Grades of Concrete with Weight Batching

(a) Concrete with nominal Mix and with volumetric proportions

The grades and proportions of nominal mix concrete as prescribed in IS : 456-2000 are given under Table 7 in the revised CPWD Specification.

The terms nominal mix has not been properly understood a number of Engineers and Architects. They straightaway conclude that the concreting with Nominal mix is nothing but proportioning the various ingredients of concrete in the specified proportion as is being practiced from decades, with the help of mostly the single measuring boxes or some times even tokaris and term it as concreting with nominal-mix and volumetric proportion.

Through this is a total misinterpretation of the reality most of the specification proposed by various departments where even the CPWD is no exception and also the leading Architects base their stipulations on the same misconception.

It should be clearly understood that the nominal mix as designated in Table 7 Chapter 4 “Chapter” is not the nominal mix with volume batching, as prescribed in clause 5.4.8 chapter 5 Reinforced Concrete. The type of concrete prescribed in the above clause 5.4.8 can at the most be designated and called as ordinary concrete with volume batching.

The nominal mix as originally designated in IS : 456 and reproduced in the chapter 4 of the CPWD specification is a mix proportion approximately almost similar to Design mix but the weight of total quantity of aggregate per 50kg cement, for different grades of concrete, as prescribed in table – 7 Chapter-4 are proportioned, only by weigh, derived from the weight of total quantity of aggregate mentioned above, by the method suggest in the same Table 7.

In case of emergency as stipulated in clause 4.2.3.2 chapter 4 Concrete, when weight batching is not practicable the above derived proportion on weight can be converted in to the proportion by volume only after considering the unit weight of individual aggregate actually being used in the work and the mix proportions by volume thus calculated for the particular grade of concrete to be used, alone is called & designated as nominal mix volume batching.

Therefore the practice of designating the mix proportions 1:2:4, 1:1½:3 and 1:1:2 etc. as concreting under nominal mix and volume batching is not all correct all the same may be correctly termed only as ordinary concrete with volume batching so as to got the misconception cleared.

The misinterpreting is mainly due to condition of batching by volume as prescribed in IS : 456-200 and reproduced in CPWD specification under clause 4.2.4.4 that volume batching may e allowed only where batching is not practical and provided accurate bulk densities of materials to be actually used in concrete have earlier been established. Allowance for bulking shall be made in accordance with IS : 2386 (part 3). The mass volume relationship should be cheked as frequently as necessary, the frequency for the given being determined by Engineer-in-charge to ensure that the specified grading is maintained.

Her instead of consideration the complete matter in the above condition) clause 4.2.4.4) it is simply concluded that the nominal mix concrete with volume batching is nothing but the volume batching with mix proportions from ages.

The revised CPWD specification therefore has simply reproduced most of the stipulations of IS :456-2000 in chapter 4 and without much consideration and recommendation over the above stipulations, simple recommendation the “nominal mix concrete” on volume basis with mix proportions like 1:1½:3, 1:2:4, etc. in chapter 5 which mainly deal with the important reinforced cement concrete works.

It is shocking to note the clause 5.4.0 in chapter 5 of the specification which states that the “ the concrete shall e as specified under chapter 4 concrete work. The proportion by weight of ingredients shall be as specified”.

The matter in the above clause is surprising in the sense that when the stipulations in chapter 4 is to followed, where is the question of specifying the proportion by volume or by weight ? The proportion by weight for concrete that can be done under nominal mix is already specified in Table 7 b of chapter 4 and if volume batching has to be resorted to the proportions of the mix cannot be specified in advance as per the stipulation under clause 4.2.4.4, but decided onsite after conforming the unit weight of the individual ingredients as brought on site to be used on work.

Again in the same chapter clause 5.4.8 Table 5, for concrete mix (Nominal mix on volume basis) 1:1:2, 1:1½:3 and 1:2:4 the values of strength of concrete for these mix proportions is stipulated. Whereas in Chapter is absolutely no mention about these mix proportions, and the value as shown in Table 5. The strength of concrete mix as per Chapter 4 clause 4.2.1 Table 5 is reckoned with the grade of concrete specified and used hence if the concreting is to done as stipulated in Chapter 4 there is no question of stipulation strength of concrete separately in Chapter 5.

* These words appear to be missing in the Clause as per Govt. Publication and have been inserted by Nabhi's Board of Editors as per IS : 456.

The irony is as per clause 4.2.3.2 chapter 4 “ Concrete” Concrete grade M – 20, achieving a 28 days strength as 200 kg per sq cm and the lower grades achieving lower strength at 28 days, can only be executed under. Nominal mix.

Thus except the concrete grade M-20 all further higher grades like grades m-25, M-30 achieving the 28 days strength as 250 kg/sqcm and 300 kg/sqcm respectively must be executed only with Design mix.

On the contrary the clause 5.4.8 chpter-5 reinforced the use of nominal –mix with volume batching for mix proportions like 1:2:4. 1:1½:3 and 1:1:2 supposed to achieve a 28 days strength as 210 kg/sqcm. 256 kg/sqcm and 315 kg/sqcm respectively. Leaving apart the question of nominclature for the preparation of concrete i.e. nominal mix/ ordinary mix, it is strange to note that the clause 4.2.3.2 chapter 4 does not permit the use of nominal mix for grades of concrete archiving the 28 days strength higher than 200 kg/sqcm and recommends only concrete with design mix for grades of concrete achieving higher strength at 28 days, the same specification under clause 5.4.8 chapter 5 recommends the use of just ordinary concrete with volume batching for mix pro[potions supposed to achieve a strength as high as 210 kg/sqcm onwards, right up to 315 kg/sqcm.

The proving straightway that concreting with ordinary mix under volume batching is much more superior than the so called scientific method, the Design Mix – This is creating confusion.

The confusion is further aggravated when we go through the contents of the revised CPWD Specification including the valuable forward by the Director General (Works) CPWD wherein it is clearly mentioned that the revised Specification makes it mandatory to use Design mix/RMC in CPWD words provided the quantity of concrete is more than 25 cum. He has further expressed that the will go long way to improve the quality of concrete.

Surprisingly expect in the above forward no where in the text of chapter 4 or 5 of the revised Specification, even a small mention about the above mandatory provision is made. Instead in chapter 5 RCC under clause 5.4.8 the age old crude practice of doing concreting with ordinary mix and volume batching is recommended for all RCC works regardless of the quantity involved.

Further in chapter 5 R.C.C. under clause 5.4.10 the conditions of Standard Acceptance of concrete done with nominal mix is separately given, but the IS : 456-2000 does not differential between Standard Acceptance for concreting with design mix and nominal mix and the conditions of acceptance of concrete is common for doing work with any of the two procedures.

Thus one can easily conclude that by introducing the specifications of nominal mix under these additional clauses outside the provisions of IS : 456-2000 in chapter 5 of CPWD specification, the matte and the specification stipulated in Chapter 4 “Concrete almost gets nullified, and the good old practice of volume batching with mix proportions can be continued with a small mention of volume batching and specifying the proposed mix in the item of the tender, and thus the work would be executed almost without any detailed specification, and ultimately making the exercise of reproducing the stipulations of IS : 456-2000 in chapter 4, futile.

Therefore the correct method of deciding proportion by nominal mix for different grades of concrete by considering the weight of individual ingredients and the method as to how the same could be converted to volume batching for executing work with volume batching explained in detail, in the following pages.

Method of calculation Proportions by Nominal Mix on weight Basis for Different Grades of Concrete.

ANNEXTURE 4.1
UNIT WEIGHT OF STONE AGGREGATE AND SAND

Sl. No.	Source of information	Weight stone aggregate Kg/cum	Weight of sand kg/cum	Remarks
1.	IS : 875-(Pt. 1)	1600 to 1870	-	Dry well Shaken
		-	1540 to 1600	Dry Clean
2.	N.B.O. and Khanna’s Hand Book	1600 to 1840	-	Dry well shaken
		1400 to 1600	-	Loose
		-	1450 to 1600	Dry and clean
3.	Architect’s Hand Book	1600 to 1870	-	Dry well Shaken
		-	1540 to 1600	Dry and Clean

(a) Weight of stone Aggregate

Generally when the stone aggregate is taken for batching it is never taken in well shaken state. The N.B.O has given the normal weight of stone aggregate in loose state as 1400 kg to 1600 kg per cum. Hence only for illustration an average value of 1500 kg per cum is considered.

(b) Weight of sand

The weight of sand as prescribed in IS : 875 (Part 1) is 1540 kg to 1600 kg per cum. Therefore for illustration the weight of sand shall be taken as 1575 kg per cum.

Note : The Junior Engineer should note tat in actual practice the weight o stone aggregate and sand brought to site to be used on the work should b confirmed and only that value should be considered to fix the proportion of mix under concreting with Nominal mix and the values considered here for illustration should be taken for execution straightway.

(c) Explanation of Nominal; Mix as stipulated in Table 7

The table No 7 of the CPWD specification on nominal mix for concrete, specifies the proportion of the total quantity of fine aggregate and coarse aggregate to 50 kg of cement to be used for the particular grade of concrete. The proportions are as given in Annexure 4.2 below.

It is further added in the same table 7 that the proportion of the mix shall depend on the maximum size of coarse aggregate actually used on the work.

The stipulation is :

(i) A proportion of 1:1½ by weight (1 fine aggregate : 1½ Coarse aggregate) to be adopted if the maximum size of coarse aggregate to be used is 10 mm.

(ii) A proportion of 1:2 by weight (1 fine aggregate : 2 coarse aggregate) to be adopted if the maximum size of coarse aggregate to be used is 20mm.

(iii) A proportion of 1:2½ by weight (1 fine aggregate : 2½ coarse aggregate) to be adopted if the maximum size of coarse aggregate to be used is 40mm.

For fixing the correct proportion both coarse aggregate and fine aggregate (sand) have to be weighted. However in practice it is noticed that the weight of coarse aggregate and sand differ from quarry to quarry and place to place. Hence as per the general practice being followed all these days, i.e. ordinary mix with volume batching. Therefore, one cannot fix the proportions of the ingredients for doing work with nominal mix under weight batching in advance but the question of exact proportion has to be decided on site of work after taking in to account the actual weight of said and coarse aggregate brought on site to be used on the work.

PROPORTION OF TOTAL QUANTITY OD COAESE AND FINE AGGREGATE TO 50 KG OF CEMNET AS GIVEN IN TABLE 7 CHAPTER 4 CONCRETE.

S. No.	Grade of Concrete	Total Quantity of sum of the individual masses of fine and Coarse aggregate per 50 kg of cement to be used
1.	M-5	800
2.	M-7.5	625
3.	M-10	480

4.	M-15	330
5.	M-20	250

Note : The total quantity of aggregate specified in Annexure 4.2 above is the maximum quantity to be used per 50 kg cement. However keeping in view of the quantity of concrete & the production of dence mix the junior/site engineer can always make slight adjustments by increasing or decreasing the quantity of fine aggregate and coarse aggregate, keeping the total quantity specified intact.

Hence to fix up the individual weight of coarse aggregate and sand for the purpose of illustration, to show how the exact proportion of all ingredients are decided for the different grades of concrete, places refer to Annexure 4.1 where weights of coarse aggregate and sand as prescribed by different institutions and Authors is Tabulised. It can be seen that the is a good lot of variation even in the recommendation shown. Therefore we can just consider the average weights of aggregate at explained under the same annexure and consider the values thus arrived, only for illustration, and not for actual use on work.

(d) **Proportion for Different Grades of concrete by weight.**

(I) Concrete Grade M-5 – For Leveling course

(i) Weight of aggregate as per Annexure 4.1 considered for illustration : sand 1575 kg per cum. Coarse aggregate = 1500 kg per cum.

(ii) Maximum size of coarse aggregate to be used : 40 mm

(iii) Total quantity of sum of mass of individual aggregate as in Annexure 4.2 = 800 kg.

(iv) The proportion of coarse aggregate as prescribed in para c(iii) above = 1:2½

(v) Weight of cement per batch of concrete to be used = 50kg

Weight of sand in the combined quantity of coarse Aggregate and Sand – 800kg

= 800/3.5 = 22.857 kg say 230 kg.

And weight of coarse aggregate = 230 x 2.5 = 575 kg say 570 kg

The proportion of the mix by weight for concrete grade M-5

= 50kg cement : 230 kg sand : 570 kg coarse aggregate.

(II) Concrete Grade M-7.5 – For Levelling Course

(i) Weight aggregate as per Annexure 4.1 considered for illustration : sand 1575 kg per cum coarse aggregate = 1500 kg per cum.

(ii) Maximum size of coarse aggregate to be used : 401mm

(iii) Total quantity of sum of mass of individual aggregate in Annexure 4.2 = 625 kg

(iv) The proportion of sand to coarse aggregate as prescribed in para c(iii) above = 1: 2½

(v) Weight of cement per batch of concrete to be used = 50kg

Weight of sand in the combined quantity of coarse Aggregate and Sand – 625kg

= 625/3.5 = 179 kg say 180 kg

and weight of coarse aggregate = 180 x 2.5 = 450 kg or say 445 kg

The proportion by weight for concrete grade M-7.5

= 50 kg cement : 180 kg sand : 445 kg coarse aggregate

(III) Concrete Grade M-10 – For plain concrete work

(i) Weight of aggregate as per Annexure 4.1 considered for illustration : sand 1575 kg per cum, coarse aggregate = 1500 kg per cum

(ii) Maximum size of coarse aggregate to be used : 40 mm or 20mm

(iii) Total quantity of sum of mass of individual aggregate as in Annexure 4.2 = 480 kg

(iv) The proportion of sand to coarse aggregate as prescribed in para c(iii) & (ii) above = 1: 2½ when 40mm maximum size of cement aggregate is used and 1:2 when maximum size of coarse aggregate s used

(v) Weight of cement per batch of concrete to be used – 50 kg

(a) The proportion of the mix by weight using size of coarse aggregate

Weight of sand in the combined quantity of coarse aggregate and sand = 480 kg.

= 480/3.5 = 137.14 kg or say 140 kg.

and the weight of coarse aggregate = 140 x 2½ = 350 kg or say 340 kg

The proportion by weight for concrete grade M-10 using the maximum size of 40mm coarse aggregate = 50 kg cement : 140 kg sand : 340 kg coarse aggregate

(b) The proportion of the mix by weight using 20mm maximum size of coarse aggregate

The weight of sand in the combined quantity of coarse Aggregate and sand = 480 kg

= 480/3= 160 kg

and the weight of coarse aggregate = 160 x 2 = 320 kg

The proportion by weight for concrete grade M-10 using the maximum size of 20mm coarse aggregate = 50 kg cement : 160 kg sand : 320 kg coarse aggregate

(IV) Concrete Grade M-15 – For plain concrete work

(i) Weight of aggregate as per annexure 4.1 considered for illustration : sand 1575 kg per cum coarse aggregate = 1500 kg per cum

(ii) Maximum size of coarse aggregate to be used = 40mm, 20 mm or 12.5 mm

(iii) Total quantity of sum of the mass of indivual as in annexure 4.2 = 330 kg

(iv) The proportin of sand to coarse aggregate as prescribed in para c(iii), (ii) & (i)

= 1: 2½ when 40mm maximum size of coarse aggregate is used

= 1:2 when 20mm maximum size of coarse aggregate is used

= 1: 1½ when 10mm / 12.5 mm maximum size of coarse aggregate is used

(V) Weight of cement to be used per batch of concrete to be used = 50kg

(a) The Proportion of the mix weight using 40mm maximum size of coarse aggregate weight of sand in the combined quantity of coarse aggregate and sand 330kg.

= 330/3.5 = 94.28 say 95 kg

and the weight of coarse aggregate = 95 x 2½ = 237.5 or say 235 kg

The proportion by weight for concrete grade M-15 using 40mm maximum size of coarse aggregate = 50 kg cement : 95 kg sand : 235 kg coarse aggregate

(b) The proportion of the mix by weight using 20mm maximum size of coarse aggregate weight of sand in the combined quantity of coarse aggregate and sand 330kg

= 330/3 = 110kg

and the weight of coarse aggregate = 120 x 2 = 220 kg

The proportion by weight for concrete grade M-15 using 20mm maximum size of coarse aggregate = 50 kg cement : 110 kg sand : 220 kg coarse aggregate

(c) The proportion by weight of the mix using 10mm / 12.5mm maximum size of coarse aggregate weight of sand in the combined quantity aggregate & sand 330 kg

= 3330/2.5 = 132 kg

and the weight of coarse aggregate = 132 x 1.5 = 198 kg or say 200 kg

The proportion by weight for concrete grade M-15 using 10mm/12.5mm maximum size of coarse aggregate = 50 kg cement : 130 kg sand : 200 kg coarse aggregate

(VI) Concrete Grade m-20 – For reinforced concrete, only under mild environmental exposure

(i) Weight of aggregate as per annexure 4.1 considered for illustration:

Sand = 1575 kg per cum, coarse aggregate = 1500 kg per cum

(ii) Maximum size of coarse aggregate to be used = 20 mm

(iii) Total quantity of sum of the mass of individual aggregate as in Annexure 4.2 = 250 kg

(iv) The proportion of sand to coarse aggregate as prescribed in para c(ii) = 1:2

(VII) Weight of cement per batch of concrete to be used = 50 kg

The proportion by weight of the mix using 20mm maximum size of coarse aggregate

Weight of sand in the combined quantity of coarse aggregate and sand 250 kg

= 250/3 = 83.33 pr say 85 kg

and weight of coarse aggregate = 85 x 2 = 170 kg say 165 kg

The proportion by weight for M-20 grade of concrete by using 20mm maximum size of coarse aggregate = 50 kg cement : 85 kg sand : 165 kg coarse aggregate

The proportions as worked out for various grades of concrete are tabulated in Annexure 4.3

ANNEXURE 4.3

TABLE SHOWING MIX PROPORTIONS BY WEIGHT UNDER NOMINAL MIX FOR DIFFERENT GRADES OF CONCRETE

A.1.1.1.1.1. TABLE 7 CHAPTER 4 OF CPWD SPECIFICATIONS

S. No	Grade of concrete	Maximum size of Coarse aggregate	Nominal mix Proportion by weight Cement (Kg)	Sand (Kg)	Coarse aggregate (Kg)	Usage
1.	M-5	40 mm	50	230	570	lean Concrete Leveling coarse
2.	M-7.5	40 mm	50	180	445	- do –
3.	M-10	40 mm	50	140	340	Plain concrete
		20 mm	50	160	320	- do –
4.	M-15	40 mm	50	95	235	Plain concrete
		20 mm	50	110	220	- do –
		10 mm / 12.5 mm	50	130	200	- do –
5.	M-20	20 mm	50	85	165	Reinforced concrete work only under mild environmental exposure

1.45 Correction Or Moist Aggregate:

If the most aggregate is used in the mix proportion by weight the weight of the water in the aggregate also gets weighed, and to compensate the loss of the quantity of aggregate, the following method can be adopted.

Consider the mix proportion by weight with moist aggregate = 50 kg : 110 kg : 220 kg and if the percentage of moisture in the aggregate is 6% then the gross weight of fine aggregate in the above proportion should be = 110 + 6% of 110 = 110 + 606 =116.6 kg.

Therefore increse 6.6 kg of sand in the mix.

The surface water in coarse aggregate can e neglected. Also reduce the quantity of water by 6.6 kg.

(e) **Advantage of batching Concrete By Weight**

(i) Measure Accurate Quantity

Through weight batching is most scientific method of doing a correct job with advantages, the contractors including Architects and many Engineers does not seem to be interested in the system. However only if the departments/architect declare weight batching as obligator eliminating th age old practice will be difficult.

A major advantage in using weight batching instead of volume batching can be shown with the following simple example.

Fill up a 35 liters capacity measuring box with dry sand well packed and weight the contents this may weight 56 kg.

Similarly if the same box is filled loosely with sand to the capacity of the box and the contents weighed, it may just weight 45 kg.

Thus the sand considered in the first stage has weighted 1.25 times more than the later stage. Thus the sand contents in the second stage i.e. 45 kg is an uncertain quantity by weight.

On the other hand if we was take the 56 kg sand straightaway by weighment, the quantity is definite without any doubt about loose filling or well packed one. The moist condition of sand in weighment will not make much change in the ultimate weight of sand, which can be neglected. At the same time bulking of sand in volume basis would make a considerable change in the volume, and that is the reason even in clause No. 4.2.4.4 chapter 4 it is clearly mentioned that when volume batching is resorted to, the allowance for bulking shall be made.

Therefore if can be seen that the materials measured by weight batching will be accurate quantity.

(ii) Avoiding Honeycomb work

It is almost established fact that in any concrete work honey combing is noticed mainly when the moist sand is used, without making the correct allowance for bulk age. A number of junior Engineer/Site Engineers while getting the concreting work executed, either neglect the matter of bulk age totally, or ask the contractor to add few tasallas extra sand. In some cases they ask the contractor's representative to check the bulkage and make corrections and ultimately the concreting done will be without the required quantity of sand resulting a porous concrete.

Later when the from work is removed lot of honey combing would be seen on the exposed surface, which would be covered up immediately by the contractor and the matter goes un-noticed as the masons engaged on the job would be o smart that they make the exposed surface look as from finished. Thus the member would be seen from outside as perfectly cast, but would remain hollow from inside.

No contractor would take pains to rectify combed work as specified in chapter 5 under clause 5.4.7.2 on the other hand he will the risk of opening the from work after working hours, simultaneously engaging the services of expert mesons, specially for the job patching up honey combed surface and by the time the officials arrive on the subsequent day the whole surface would look neat and the contractor and the supervision staff get the compliments.

In case of weight batching this problem could be considerable avoided as the moist sand will not make much difference in the required of sand in mass and the rough formula of some junior Engineers of adding few Tasalla sand may solve the problem to a great extent. Also the correction of moist sand in weight batching s very simple and is explained after Annexure 4.3

Therefore by adopting batching of concrete ingredients by weight, one can avoid honey combing and improve the quality of work.

(iii) Checks on Tricks played by Unscrupulous Contractors

The volume batching is a grazing ground for an unscrupulous contractor. Normally when the concreting work is in full swing the contractor asks his labour to push one or two extra boxes of aggregate in each batch and as per normal practice even when he instructs the labour to help the boxes the excess quantity measured is considerable.

It is also noticed that even on sufficiently big work the contractors use half mixers and feed cement in loose state with tins, thus straightaway saving nearly 20% quantity of cement.\ Another very common factor one can come across on site is that the boxes of correct size is never prepared and used and if the mater is pointed out either by the Junior Engineer or his supervisors a mark would be made in the box to till aggregate to that level, but the instruction are rarely followed.

It is beyond anybody's imagination that with such working conditions, how the cube tests show, that the work executed is as per strength requirements.

In case of weight batching such mischief is difficult and using cement in loose condition is not of question as all ingredients including cement is weighed. The use of half bag gets eliminated automatically.

Thus batching materials for concreting by weight is a fool method to a great extent.

(f) **Convenient methods of Batching materials by Weight**

A number of departmental officials and Architects are scare to switch over to weight batching as they have been impressed by the interested contractors that the proposition would be too costly and they will not be in a position to do the work at the prevailing rates.

The junior engineer/Site Engineer are also of the opinion that by switching over to batching by weight responsibility will increase and they will be answerable doe any short comings.

However as early as in the year 1980 the Concrete Association of India have recommended easy method that can be adopted for batching by weight in one of their publications and the methods suggested can be easily implemented.

The methods suggested by them are :

(A) For contractors Executing woks worth Rs. 5 lakhs to 25 lakhs.

(1) Spring Dial Scale

In this system the spring dial scale can weight up to 200 kg material at a time. An ordinary spring dial scale is hung from a fixed support or frame which can easily be turned in all directions. From the hook of the scale a metal scoop is hung in to which the materials are weighed.

The whole system is so arranged that one can empty the scoop directly in to the hopper of the mixer, or to the wheel barrows.

The weighment can be done in two stages initially cement and sand can be weighed and then the coarse aggregate.

The initial cost will not be much but only think is one extra helper would be required to operate the scope hung from the dial. This system is very idea for small jobs.

(2) A platform Scale :

In this case the regular platform scale is used by widening the base to accommodate the wheel-barrows.

The wheel barrow are weighed empty and all the wheel barrows are brought to the weight of the heaviest of the wheel barrow by adding some weights. The platform is kept on the way to the mixer from stock piles and the weighment is done on the way and the materials thus weighed are unloaded in the mixer.

(3) Portable weight Batcher with single weigh Bucket

This type of weigh batcher is available in the market and the mechanism is very simple. This equipment consists of one weighbucket attached to spring loaded dial with levers.

The materials after weighing are discharged through a door with the help of catch and release type of leavers.

This equipment can be used on small works without much extra labour.

(B) For contractors Executing Works worth More than 25 lakhs.

(1) Portable Wight Batcher with Two Weight Buckets

Normally contractors executing works worth 25 lakhs or more will be owning their own concrete mixer and a person who can afford to own a mixer can definitely afford to purchase a weigh –batcher unless he is reluctant to switch over to weigh batching

In this type of weigh batcher two weigh buckets with separate dials are fixed in opposite direction, and with a special arrangement the buckets are made to swing completely round a circle. This arrangement allows considerable latitude in the weighing operation. With this type of weigh batcher one can continue the operation of weighing the ingredients in one bucket while the other bucket is getting unloaded in the hopper of the mixer thus saving a considerable.

A glaring fact with this type of machine is that except the initial investment which would be hardly Rs. 30,000/- on the purchase of weigh batcher, no other recurring expenditure or extra labour is required to use this machine.

(2) Mixers with attached Weigh Batcher.

This mechanism is a simple tubular frame attached to the mixer over which the skip rests. During weighing operation the skip resting on the cradle is automatically released from allconection with the mixer, thus recording accurate weights on the indicator dial. This machinery enables the complete mixer and weighter to be moved in the usual manner and eliminates the need for assembling or dismantling when arriving or leaving a location. This mixer with weigh batch attachment would be bit costly but persons executing works worth more than 50 lakhs can easily afford.

(g) ***Precautions While using a Weigh Batcher***

(i) *Calibration of Dial Regularly*

The Junior Engineer/Site Engineer should make sure that the reading shown on the dial is the real weight of the materials being weighed. This can be done by putting a known weight in the bucket say 2 to 3 bags of cement (100 to 150 kg) and see if the needle is showing the accurate weight. Necessary repairs may be attended if the reading is not correct. This exercise should be done daily before the work is started.

(ii) *Installation of the Machine in Perfect Level*

Any weigh batcher or for that matter even the platform scale should be fixed in perfect level. Even a slight tilt may result in incorrect values. The position of the weigh batcher if in level or not should also be checked as often as possible.

(iii) *Loading the Weigh Batcher Bucket*

While loading the bucket of the weigh batcher, care should be taken to load the materials in the centre of the bucket and then leveled. In case the bucket is not loaded evenly, the weight shown on the dial may not be correct.

(iv)..*Maintenance of Machine*

The machine should be kept clean, and all grease points should be greased regularly. One should make sure that the mechanism remains free moving. The bucket should be kept clean. Special care should be taken to see that the bucket does not get coated with hardened cement both both from inside as well as outside.

(h) ***Conclusions***

The general misconception that, out of the concrete grades specified in Table 5 Chapter 4 some of them are exactly same as the ordinary concrete with volumetric mix proportion as prescribed under clause 5.4.8 Table 5, Chapter 5 but with different values of strength at 28 days, is totally incorrect and misguiding. As per IS:456:2000 the two types of concretes are totally different and cannot be equated even remotely.

Specifying the same value for strength of concrete for the two types of mixes i.e., ordinary concrete with volume batching and Design mix concrete with weugh batching, or considering the volumetric mix proportions like mix 1:2:4, 1:1 ½:3, 1:1:2 etc and the designated grades as per IS:456, as same, but with different values of strength is prescribed under clause 5.4.8-Chapter 5 is not correct.

In case nominal mix proportion by weighment in Table 7 is to be used for volumetric batching the proportions with weighment, worked out for different grades shall be converted to volume by considering the individual weight of sand and stone aggregate per cum proposed to be used on site as prescribed in clause 4.2.4.4 chapter 4and then only the proportion for batching with volume shall be fixed.

The method to calculate mix proportions with volume batching for different grades of concrete i.e. M-5 to M-20 with nominal mix is worked out in detail in the following pages.

(II) Mix Proportions for Different Grades of Concrete with Nominal Mix and Volume Batching

(a) Restrictions for Taking up Volume Batching

As per the stipulation in Table 7 and also under clause 4.2.4.4 Chapter 4 of the volume batching should not be permitted to all grades and types of concrete, contrary to the stipulation recommended in Chapter 5 under clause 5.4.8 Table 5.

The volume batching under nominal mix should be taken up only for the following grades of concrete and under the circumstances mentioned below.

(1) The grades of concrete that can be taken up for volume batching under nominal mix are :

(a) Mix : M-5 Lean Concrete/ Levelling course

(b) Mix : M-7.5

(c) Mix: M-10 Plain Concrete

(d) Mix: M-15

(e) Mix: M-20 Reinfoeced Cement Concrete only under mild exposure conditions

All other grades of concrete shall be executed under desion mix and batching by weight.

(2) Volume batching with nominal mix can be taken up only when the space available on site to operate mixer weigh batcher etc. is not sufficient

(3) In case the quantity of concrete is so small that it may not be feasible to use weigh batching equipments, the volume batching may be taken up.

(4) The concrete grades mix M-5 and mix M-7.5 for nominal mix specified in Table 7 Chapter 4 are generally used for leveling coarse or lean concret4e. Concrete with these grades can be used with volume batching, mixed withmixer or hand mixing with 10% extra cement depending upon the quantity of work involved.

(5) The grades of concrete mix M-10 and Mix M-15 are to be used only for plain concrete work, and can be executed with volume batching, for portions of work which are not structurally important like floor concrete, concrete for steps, window cills, small precast items etc.

(6) As per Table 6 and clause 4.2.1.1 chapter 4 for all R.C.C. works only grade M-20 concrete can be used under nominal mix and volume batching, but for moderate exposure only concrete grade M-25 with design mix and volume batching will have to be used.

Hence the concrete grade M-20 with volume batching under nominal mix can only be used for the work of R.C.C. lintels, inside R.C.C. slabs and beams and all R.C.C. works covered under mild environmental exposure conditions as prescribed in Table 10 clause 4.2.14.1.1. Chapter 4 and for roof slabs, chajjas, fins and also works below ground has to be done only with grade M-25 concrete with design mix and weigh batching and definitely not with grade M-20 concrete under nominal mix and volume batching.

(7) Also clause 4.2.3.2 chapter 4 stipulates that concrete of grade higher than mix M-20 should not be used with nominal mix thus the question of using concrete of grade M-25 under nominal mix with volumetric basis does not arise.

(b) Method of Converting Mix Proportion by Weight to Mix Proportion by Volume for Concrete Grades Stipulated in Table 7 Chapter 4 Concrete

(1) Concrete Grade M-5 for Lean Concrete/Levelling Course

(i) Weights of Aggregates as per Annexure 4.1 considered for Illustration:

Sand = 1575 kg per cum coarse Aggregate 1500 kg per cum

(ii) Mix porporion worked out with maximum size of coarse Aggregate as 40 mm with weigh batching as tabulated in Annexure 4.3

= 50 kg Cement: 230 kg Sand: 570 kg Coarse aggregate

(iii) Considering the volume occupied by a bag of cement as 35 litres or = 0.035 cum: Volumetric proportion

$$= 0.035 \ : \ \frac{230}{1575} : \frac{570}{1500} \ : \ 0.04 \ : \ 0.04 \ : \ 0.146 \ : \ 0.38$$

i.e. 0.035 cum cement: 0.146 cum sand: 0.38 cum coarse aggregate

(a) Sizes for boxes to be used for concreting with mixer

Sand = 395 mm x 345 mm x 215 mm

Coarse aggregate = 400 mm x 345 mm x 275 mm

.: Feeding to mixer

= 1 Bag cement + 5 small boxes sand + 10 big boxes coarse aggregate

Note: The boxes should be got prepared to the correct sizes as specified above

(b) Size of pharma (Box) to be used for concreting by hand mixing

Sand = 750 mm x 750 mm x 260 mm

Coarse Aggregate = 1250 mm X 1250 mm x 245 mm

.: Batching on mixing platform

= 1 Big box coarse aggregate + 1 small box sand + 1 bag of cement

Note: The concrete with hand mixing should not be permitted without getting boxes of correct capacity.

(iv) Usage of this grade of concrete: Levelling course i.e. mud mat, for pipe work below C.C. pipe and to cover stone ware pipes.

(2) Concrete Grade M – 7.5

(i) Weights of Aggregates as per Annexure 4.1 considered for illustration:

Sand = 1575 kg per cum Coarse Aggregate = 1500 kg/cum.

(ii) Mix proportion worked out with maximum size of coarse aggregate as 40 mm with weigh batching as tabulated in Annexure 4.3

= 50 kg Cement: 180 kg Sand: 445 kg Coarse aggregate

(iii) Considering the volume occupied by a bag of cement as 35 litres or 0.035 cum: Volumetric proportion

$$= 0.035 : \frac{180}{1575} : \frac{445}{1500} : 0.035 : 0.114 : 0.297$$

i.e. 0.035 cum cement: 0.114 cum sand : 0.297 cum coarse aggregate

(A) Sizes for boxes to be used for concreting with mixer

Sand=390 mm x 340 mm x 215 mm

Coarse aggregate=390 mm x 340 mm x 280 mm

Feeding to mixer

=1 Bag cement +4 small boxes sand + 8 Big boxes coarse aggregate

(B) Size of pharma Box to be used for concreting with hand mixing

Sane=720 mm x 220 mm

Coarse aggregate= 1150 mm x 225 mm

Batching on mixing platform

=1 big box coarse aggregate + 1 small box sand + 1 bag cement

(iv) usage of this grade of concrete As lean concrete for foundations

Note before fixing up the volumetric proportion the junior Engineer /site Engineer should conform the actual weight per cum of sand and coarse aggregate brought to the site to be used in the work and only those values should be used to work out the proportion

(3) Concrete Grade M-10

(i) Weights of aggregates as per annexure 4 1 considered for illustration

Sand=1575 kg per cum coarse aggregate =1500 kg per cum

(ii)Mix proportion with weight batching as worked out and tabulated in annexure 4 3

(a)With 40 mm maximum sizes coarse aggregate

=50 kg cement 140 kg sand 340 kg coarse aggregate

(b) with 20 mm maximum size o coarse aggregate

=50 kg cement 160 kg sand 320 kg coarse aggregate

(iii)Considering the volume occupied by a bag of cement as 35 liters or 0 035 cum

(i) Volumetric proportion for concrete with 40 mm maximum size of coarse aggregate =

$$= 0.035 : \frac{140}{1575} : \frac{340}{1500} = 0.035 : 0.089:0.227$$

50 kg cement 0.089 cum sand 0.227 cum coarse aggregate

(a) size of boxes to be used for concreting with mixer

Sand =345 mm x 345 mm x 250 mm

Coarse aggregate = 400 mm x 350 mm x 270 mm

Feeding to mixer

=1 bag cement + 3 boxes sand + 6 big boxes coarse aggregate

(ii) Volumetric proportion for concrete with 20 mm maximum size of coarse aggregate

=0.035:160/1575:320/1500=0.035:0.102:0.21

50 kg cement 0.102 cum sand 0.21 cum coarse aggregate

(b) Sizes of to be used for concreting with mixer

Sand = 400 mm x 350 x 245 mm

Coarse aggregate = 400 mm x 350 mm x250 mm

Feeding to mixer

=1 big cement + 3 box sand + big box coarse aggregate

(iv) Usage of this grade of concrete base concrete for floor for water tanks basements as sub grade for CC pavement

Note In the case of volumetric proportion with 20 mm maximum size of aggregate as worked out above the proportion has come to exactly 1 3 6 but this may not be same in every case as the weight of aggregate change from quarry to quarry

(4) Concrete Grade M-15

(i) Weight of aggregate a per annexure 4 1 considered for illustration

Sand= 1575 kg per cum coarse aggregate = 1500 kg per cum

(ii) Mix proportion with weight batching as worked out and tabulated in annexure 4 3

(a) With 40 mm maximum size of coarse aggregate

=50 kg cement 95 kg sand 235 kg coarse aggregate

(b) With 20 mm maximum size of coarse aggregate

=50 kg cement 110 kg sand 220 kg coarse aggregate

(c) With 10/12.5 mm maximum size of coarse aggregate

=50 kg cement 130 kg sand 200 kg coarse aggregate

(iii) considering the volume occupied by a bag of cement as 35 liters or 0.035 cum

(i) Volumetric proportion for concrete with 40 mm maximum size of coarse aggregate

=0.035:95/1575:235/1500=0.035:0.06:0.157

=50 kg cement 0.06 cum sand 0.157 cum coarse aggregate

(a) Sizes of box to be used for concreting with mixer

Sand =350 mm x 350 mm x 245 mm

Feeding to mixer

=1 bag cement + 2 small boxes sand + 4 big boxes coarse aggregate

(ii) Volumetric proportion for concrete with 20 mm maximum size stone aggregate

=0.035:110/1575:220/1500=0.035:0.07:0.0147

=50kg cement 0.07 cum sand 0.147 cum coarse aggregate

(b) Size of boxes to be used for concreting with mixer

Sand =400 mm x 350 m mx 250 mm

Coarse aggregate =400 mm x 365 mm x 250 mm

Feeding to mixer

1 bag of cement +2 small box sand + 4 big box coarse aggregate

(iii) Volumetric proportion for concrete with 10 mm/12.5 mm maximum size of coarse aggregate

=0.035: 130/1575 :200/1500 =0.035 :0.083 :0.133

50 kg cement: 0.83 cum sand :0.133 coarse aggregate

(c) Sizes of boxes to be used for concreting with mixer =sand = 400 mm x 297 mm

Coarse aggregate =350 mm x 350 mm x 272 mm

Feedi9ng to mixer

1 bag cement +2big boxes sand +4 small boxes coarse aggregate

(iv) usage of this grade of concrete

Till Indian standard 465 was revised in the year 2000 this mix proportion concrete was very widely used on all important items of plan and reinforced concrete works except in tall structures and water retaining structures throughout the country

However after studying the past experience all these days not only in this country but also in other countries the bureau of Indian standard decided to limit the usage of this grade to only plain concrete and prohibited the usage in reinforced concrete

The usage of the concrete of this grade is further restricted only to moderate environmental exposure and all these stipulations of IS 456-2000 have been introduced in table 6 and other clauses in chapter 4 of CPWD specification Thus ultimately the concrete of this grade I e M-15 shall be used only in every few items of work only in plain concrete and not for even minor R C C work

Therefore in general this concrete can be used for plain cement concrete pavements PCC bends kerbs etc where no reinforcement is used and the area of usages are only in plains of northern India and central portion of south India

(5) Concrete Grade M-20

(i) Weight of aggregate as per annexure 4 1 considered for illustration

Sand= 1575 kg per cum coarse aggregate =1500 kg per cum

(ii) Mix proportion for weight batching as worked out and tabulated in annexure 4 .

(a) With 20 mm maximum size of coarse aggregate

=50 kg cement 85 kg sand 165 kg coarse aggregate

(iii) Considering the volume occupied by 1 bag of cement as 35 liters or 0.035 cum

Volumetric proportion for concrete with 20 mm maximum size of coarse aggregate

=0.035:85/1575:165/1500=0.035:0.054:0.11

=50 kg cement 0.054 cum sand 0.11 cum coarse aggregate

Size of boxes to be used for concreting with mixer

Sand =300 mm x 300 mm x 300 mm

Coarse aggregate =400 mm x 360 mm x 255 mm

Feeding to mixer

(iv) Usage of this grade of concrete

Out of all the concrete grades permitted to be laid under nominal mix as per table 7 under clause 4 2 3 2 chapter 4 this is the only grade of concrete which can be used for reinforced concrete work with nominal mix but on limited scale Further as per clause 4 2 4 4 all these grade of concrete including this grade can be used with volume batching further as per table 6 chapter 4 and the foot not below this grade of concrete can be used in RCC works only in mild environmental exposure with the result the usage of concrete of this grade has also become very much limited

Again the condition of mild environmental exposure has been explained in table 10 clause 4 2 14 1 1 as the concrete surface protected against weather or aggressive conditions and this condition can be seen only in the concrete items not exposed to external atmosphere and surfaces non in contact with earth or water

Therefore concrete of this grade i.e. M-20 with Nominal mix under volume batching can only be used on inner RCC columns, beams, slabs, except roof slab, lintels inside the building etc., in plains of Northern India and non-coastal areas of south India. Again in places like hilly areas of Northern India, Andaman and Nicobar islands, Lakshdweep islands, Kutch and coasts of Saurashtra region in Gujarat, and Western and Eastern coastal belt, this grade of concrete shall noly be used for plain concrete work and not for reinforced concrete work.

The quality conscious Engineers/ Architects are really encouraged and happy that the Additional Director General (TD) has prescribed in the preface of the revised CPWD Specification, that the use of concrete Grade M-25 and higher grades has been made mandatory for all RCC works, thus eliminating completely the use of concrete Grade M-20 from all RCC works.

This mandatory provision is rightly imposed inspite of the fact that Table 6 Chapter 4 recommends the use of Grade M-20 concrete for mild exposure conditions i.e. mostly the items inside the building, but not even the items below ground.

It is very correctly envisaged by the Authorities that it would be very difficult to differentiate the use of the concrete Grade M-20 for the RCC items inside the building and concrete Grade M-25 for RCC items situated outside the building, and also for foundations, of the structures, except for particular RCC members where concrete Grade M-30 or of higher grades will have to be used.

Therefore the decision of restricting the use of not less than grade M-25 concrete for all RCC works, which would cover most of the items in a building including the work in foundation, is more practical and commendable.

However, it is beyond anybody's imagination, as to how the stipulations in chapter 5 RCC under clause No. 5.4.0, 5.4.8 & 5.4.10 are formed, which imparts totally contradictory meaning when compared to the mandatory provisions as stipulated in the Foreward and Preface of the Revised CPWD Specifications chapter 3,4 & 5

The clause 5.4.8 of Chapter 5 RCC recommends the use of ordinary concrete with volume batching for all RCC works with volumetric mix proportions 1:2::4, 1:1 ½:3 and 1:1:2 with minimum cement consumption as 320 kg/cum, 400 kg/cum and 610 kg/cum respectively, and the strength at 28 days as 210 kg/sq.cm.,265 kg/sq.cm. respectively.

It is practically impossible to compare the types of concrete specified as above with concrete Grade M-25 with minimum cement content as 300 kg/cum achieving a strength of 250 kg/sq.cm. at 28 days, the usage of which has been made mandatory in all RCC works mainly to improve the quality of concrete.

(c) *Conclusion*

The result of the entire analysis is that the usage of concrete with nominal mix and weigh-batching or volume batching has only limited scope. If the stipulations as detailed in chapter 4 "Concrete" is to be scrupulously followed most of the plain and RCC works in the country will have to be executed only with design mix and weigh batching and definitely not with nominal mix and volume batching. This can be conformed from the following concluding observations.

(i) Out of the total 15 Nos. of different grades of concrete with varying strengths as detailed in Table 5 clause 4.2.1 Chapter 4 only 3 Nos. lower grades of concrete are termed in the said Table 5 as ordinary concrete" and the concrete grade M-5 and grade M-7.5 generally used only in levelling course and mud mat but not included in the 15 No. of grades in Table 5 are permitted to be used with nominal mix as per Table 7 clause 4.2.3.2 Chapter 4

(ii) Out of the three Grades of ordinary concrete namely Grade M–10 Grade M-15 and Grade M-20, the concrete Grade M-10 is always used as plain concrete for base courses etc. but as per Table 6 clause 4.2.1.1 under Chapter 4 the concrete Grade M-15 is also brought under the category of plain concrete, only to be used under moderate environmental exposure. Thus this concrete grade M-15 which was normally used for all important RCC works till IS : 456 was revised in the year 2000 cannot be used even for plain concrete work under severe and very severe environmental exposures like, hilly regions of North India, Andaman & Nicobar Islands, Lakshdweep Islands, Kutch and coasts of Saurashtra region in

Gujarat, Western & Eastern coastal belts where only the concrete Grade M-20 has to be used for plain concrete work.

(iii) Therefore due to the environmental exposure conditions as stipulated in Chapter 4, Table 10, Clause 4.2.14.1.1, the Nominal mix on volumetric basis can be used only for covered items inside the building and for all other items either exposed to atmosphere or constructed below ground, only the concrete Grade M-25 with design mix and weigh batching will have to be used. Thus there is absolutely no point in using the nominal mix with volume batching for the items of work to be constructed inside the building and design mix with weigh-batching for items of work below ground and exterior portion of the building. On the other hand the entire work can be conveniently done with Design mix.

(iv) Another most important problem that may arise while executing concrete with nominal mix and volume batching is the contractor will have to alter the sizes of measurement boxes whenever the unit weight of aggregates change. The Junior Engineer/Site Engineer will also have to put in extra effort to fix up the mix proportions, whenever the contractor changes the source of materials.

(v) It is already explained that the weigh batching is not only convenient but also economical. It does not require extra labour as feared and once the system of weigh batching is established, the weigh batchers will be available on hire basis in all major towns. The department also in the interest of maintaining the quality of work purchase a few weigh batchers and issue them on hire basis.

(vi) Getting mix design prepared is also not a problem. We can find Civil Engineer laboratories and the Civil Engineering Consultants on the subjects, in most of the cities in the country, where from the mix design can be got prepared. In addition the Department/client can save on the cost of the project as the saving on cement with design mix process will be considerable, without in any way compromising on the strength of the structure, because the minimum cement content for the concrete of Grade M-25 is 300 kg/cum as per table 6 Clause 4.2.1.1 Chapter 4 and to achieve the same strength the department is executing 1:1 ½:3 concrete using cement @ 400 kg/cum and thus a clear saving of 25% in the cost of cement could be achieved, which may result in lowering the overall cost of project by minimum 10%

(vii) The department need not have different standards of acceptance of quality of concrete for design mix and nominal mix and the standard of concrete already framed in the specification can be relevant for the concreting work with design mix.

(viii) The contractor can be asked to produce the design mix calculations from the recognized laboratories or consultants and the departmental officials can check and approve the same. Thus it is high time that the crude method of concreting being followed all these days is discarded and the most scientific method practiced in most of the countries in the world is adopted as early as possible without giving any twist to the stipulations so a so suit the continuation of the crude method being followed from ages.

(ix) Lastly the contractors are hereby cautioned before submitting their tenders in which the quantity of plain/RCC concrete is considerable they should confirm from the authorities inviting the tenders as to whether they have to execute the plain/RCC works with Design mix as stipulated in chapter 4 of the

Specification, and also the mandatory provisions of using the concrete Grade-25 for all RCC works as specified in the foreword & preface of the revised chapters 3,4 & 5 of the Specifications, or with ordinary mix under volume batching as stipulated in clause 5.4.8 chapter 5

The main reason being if the contractor quotes his rates for the grades of the concrete with Design Mix as per chapter 4, where the consumption of cement is very much less & later after the acceptance of the tender if he is asked to execute the work as per

The stipulation in clause 5.4.8 of chapter 5 RCC in CPWD Specification, he will loose heavily as the consumption of cement for the mix specified is much more.

Similarly if he quoted his rates considering the mix proportions as described in clause 5.4.8 of chapter 5 in CPWD specification, where the mix proportions are to be executed with higher quantity of cement & if his competitor quotes his rates considering the provisions of chapter 4 of CPWD specification with Design mix where the consumption of cement is on a lower scale, he will loose the work as his rates will work out to be on higher side.

List of BIS Codes Chapter 5 – Reinforced Cement Concrete Work

LIST OF BUREAU OF INDIAN STANDARD CODES

Sl. No.	IS No.	Subject
1.	IS : 226	Structural Steel
2.	IS : 432 (Part I)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part I mild steel and medium tensile steel bars.
3.	IS : 432 (Part II)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part II Hard drawn steel wire.
4.	IS : 456	Code of Practices for Plain and Reinforced concrete.
5.	IS : 516	Method of test for strength of concrete.
6.	IS : 716	Specification for Pentachlorophenol.
7.	IS : 1199	Method of sampling and analysis of Concrete.
8.	IS : 1200	Method of measurement of building and civil engineering work-concrete work.
9.	IS : 1200	Method of measurement of building and civil engineering work-concrete work.
10.	IS : 1566	Specification for hard-drawn steel wire fabric for Concrete requirement.
11.	IS : 1599	Method for bend test.
12.	IS : 1343	Code of Practice for Prestressed Concrete.
13.	IS : 1608	Method for tensile testing of steel products.
14.	IS : 1786	Specification for high strength deformed steel and wires for concrete reinforcement.
15.	IS : 1791	Specification for batch type concrete mixes.
16.	IS : 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
17.	IS : 2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
18.	IS : 4925	Batch Plants Specification for concrete batching and mixing plant.
19.	IS : 6523	Specification for precast reinforced concrete door, window frames.
20.	IS : 10262	Recommended guidelines for concrete mix design.
21.	IS : 13311	Indian Standard for non-destructive testing of concrete Method of test for ultrasonic pulse velocity.
22.	IS : 13311	Indian Standard for non-destructive testing of concrete Method of testing by rebound hammer.

LIST OF OTHER BIS CODES THAT MAY BE REFERRED

Sl. No	IS No	Subject
1.	269-1989	Specification for ordinary Portland cement , 33 grade (fourth revision).
2.	383-1970	Specification for coarse and fine aggregates from natural sources for concrete (second revision)
3.	432(Part 1)-1982	Specification for mild steel and medium tensile

steel bars and hard-drawn steel wire for concrete reinforcement : Part 1 Mild steel and medium tensile steel bars (third revision).

Specification for Portland slagcement(fourth revision)

5.	516-1959	Method of test for strength of concrete.

Code of practice for design loads (other than earthquake) for buildings and structures:

(Part 1)-1987 Dead loads- Unit weights of building material and stored materials (second revision).

	(Part 2)-1987	Imposed loads (second revision)
	(Part 3)-1987	Wind loads (second revision)
	(Part 4)-1987	Snow loads (second revision)
	(Part 5)-1987	Special loads and load combinations (second revision)
7.	1199-1959	Methods of sampling and analysis of concrete.
8.	1343-1980	Code of practice for prestressed concrete (first revision)
9.	1489	Specification for Portland pozzolana cement:
	(Part 1)-1991	Fly ash based (third revision)
	(Part 2)-1991	Calcined clay based (third revision)
10.	1566-1982	Specificationfor hard-drawn steel wire fabric for concrete reinforcement (second revision)
11.	1641-1988	Code of pratice for fire safety of buildinds(general):General principles of fire grading and classification (first revision)
12.	1642-1989	Code of pratice for fire safety of buildinds(general) : Details of construction (first revision).
13.	1786-1985	Specification for high strength deformed steel bars and wires for concrete reinforcement (third revision)

14. 1791-1968 Specification for batch type concrete mixers (second revision)

15. 1893-1984 Criteria earthquake resistant design of structures (fourth revision)

16. 1904-1986 Code of practice for design and construction of foundations in soils: General requirements (third revision)

17. 2062-1992 Steel for general structural purposes (fourth revision)

18. 2386 (Part 3)-1963 Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking.

19. 2502-1963 Code of practice for bending and fixing of bars for concrete reinforcement.

20. 2505-1980 Concrete vibrators- Immersion type- General requirements.

21. 2506-1985 General requirements for screed board concrete vibrators (first revision)

22. 2514-1963 Specification for concrete vibrating tables.

23. 2751-1979 recommended practise for welding of moild steel plain and deformed bars for reinforced construction (first revision)

24. 3025 Methods of sampling and test (physical and chemical) for water and waste water:

(Part 17)-1984 Non- filterable residue (total suspended solids) (first revision)

(Part 18)-1984 Volatile and fixed residue (total filterable and non-filterable) (first revision).

(Part 22)-1986 Acidity (first revision)

(Part 23)-1986 Alkalinity (first revision)

(Part 24)-1986 Sulphates (first revision)

(Part 32)-1988 Chloride (first revision)

25. 3414-1968 Code of practice for design and installation of joints in buildings.

26. 3812-1981 Specification for fly ash for use as pozzolana and admixture (first revision)

27. 3951 (Part 1)-1975 Specification for hollow clay tiles for floors and roofs: Part 1 Filler type (first revision)

28. 4031 (Part 5)-1988 Methods of physical tests for hydraulic cement: Part 5 Determination of initial and final setting times (first revision)

29. 4082-1996 Recommendations on staking and storage of construction materials and components at site (second revision).

30. 4326-19993 Code of practice for earthquake resistant design and construction of buildings (second revision)

31. 4656-1968 Specification for form vibrators for concrete.

32. 4845-1968 Definitions and terminology relating to hydraulic cement.

33. 4925-1968 Specification for concrete batching and mixing plant.

34. 4926-1976 Specification for ready-mixed concrete (second revision)

35. 5816-1999 Method of test for splitting tensile strength of concrete (first revision)

36. 6061 Code of practice for construction of floor and roof with joists and filler blocks:

(Part 1)-1971 With hollow concrete filler blocks.

(Part 2)-1971 With hollow clay filler blocks (first revision)

37. 6452-1989 Specification for high alumina cement for structural use.

38. 6461 Glossary of terms relating to cement:

(Part 1)-1972 Concrete aggregates.

(Part 2)-1972 Materials.

(Part 3)-1972 Concrete reinforcement.

(Part 4)-1972 Types of concrete

(Part 5)-1972 Formwork for concrete.

(Part 6)-1972 Equipment, tool and plant.

(Part 7)-1973 Mixing, laying, compaction, curing and other contruction aspect.

(Part 8)-1973 Properties of concrete.

(Part 9)-1973 Structural aspects.

(Part 10)-1973 Tests and testing apparatus.

(Part 11)-1973 Prestressed concrete.

(Part 12)-1973 Miscellaneous.

Commentary on CPWD Specifications – Civil Works

1.46 Reinforced Cement Concrete Work

1.47 General

Reinforced cement concrete work may be cast-in-situ or Precast as may be directed by Engineer-in-charge according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work.

(a) Form work (Centring and Shuttering)

(b) Reinforcement

(c) Concreting : 1 (Cast-in-situ 2) Precast

1.48 Materials

10.1.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of chapter 03-mortars and chapter 04-concrete work as applicable. Portland Pozzolona Cement at (f) & (g) page 22 shall not be used for RCC Work.

1.49 Steel for reinforcement

10.1.2.1 The steel used for reinforcement shall be any of the following types :

(a) Mild steel and medium tensile bars conforming to IS: 432 (Part I)

(b) High strength deformed steel bars conforming to IS: 1786

(c) Hard drawn steel wire fabric conforming to IS: 1566

(d) Structural steel conforming to Grade A of IS: 2062

(e) Thermo-mechanically treated bars TMT bars refer Correction slip No. 6 of the Chapter .*

1.50 Types and Grades:

Reinforcement supplied in accordance with this standard shall be classified into the following types :

(a) Mild steel bars : It shall be supplied in the following two Grades

(i) Mild steel bars grade I designated as Fe 410-S

(ii) Mild steel bars grade II designated as Fe 410-O

(b) Medium tensile steel bars, grade II designated as Fe 540-W-HT.

10.1.2.3 Mild steel and Medium tensile steel : Physical requirement are given in the following Table 1.

TABLE – 1

Sl. No.	Type and nominal size of bar	Ultimate tensile Stress N/mm^2 Minimum	Yield stress N/mm^2 minimum	Elongation percent
1.	Mild steel grade I			
	For bars upto and including 20mm.	410	250	23
	For bars over 20 mm upto and including 50 mm	410	240	23
1	Mild steel grade II			
	For bars upto and including 20mm	370	225	23
	For bars over 200mm, upto and including 50mm	370	215	23
3.	Medium tensile steel			
	For bars upto & including 16mm	540	350	20
	For bars over 16mm, upto and including 32mm	540	340	20

Elongation Percent on gauge length 5.65 so where ‘so’ is the cross sectional areas of the test piece.

Note

1. Grade (II) Mild steel bars are not recommended for the use in structures located in earthquake zone subjected to severe damage and for structures subjected to dynamic loading (other than wind loading) such as railway and highway bridges.

2. Welding of reinforcement bars covered in this specification shall be done in accordance with the requirements f IS : 2751.

Nominal mass/weight: The tolerance on mass/weight for round and square bars shall be the percentage given in Table 2 of the mass/weight calculated on the basis that the masses of the bar/wire of nominal diameter an of density 0.785 kg/cm^3 or .00785kg/mm^3.

TABLE 2

TOLERANCE ON NOMINAL MASS

Nominal size In mm		Tolerance on the nominal mass percent Batch	Individual Sample +	Individual sample for Coil (-x-)
(a)	upto and including 10	+ 7	+8	+8
(b)	over 10, upto and including 16	+5	-6	+6
(c)	over 16	+3	-4	+4

\+ for individual sample plus tolerance is not specified

(x) for coil batch tolerance is not applicable

Tolerance shall be determined in accordance with method given in IS : 1786.

Tests – Following type of lab test shall be carned out

(1) Tensile Tests : This shall be done as per IS : 1608

(2) Bend Test : This shall be done as per IS : 1599

(3) Re-test : This shall be done as per IS : 1786

(4) Rebend Test : This shall be done as per IS : 1786

Should any one of the test pieces first selected fail to pass any of the tests specified above, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the materials represented b the test samples shall be deemed to comply with the requirement of the particular test. Should the test piece from either of these additional samples fail, the material represented by the test samples shall be considered as not having complied with standard.

10.1.2.4 High strength deformed bars & wires shall conform to IS : 1786. The physical properties for all sizes of steel bars are mentioned below in Table 3.

TABLE 3

Sl. No.	Property	Grade Fe 415	Fe 500	Fe 550
1.	0.2% proof Stress/yield stress, min N/mm^2	415	500	550
2.	Elongation, percent min. on gauge Length 5.650A, Where A is the X-Sectional Area of the test piece.	14.5	12	8
3.	Tensile strength	10% more than actual 0.2% proof stress but not less than 465 N/mm^2	8% more than actual 0.2% proof stress but not less than 545 N/mm^2	6% more than actual 0.2% proof stress but not less than 585N/ mm^2

Tests: Selection and preparation of Test sample. All the tests pieces shall be selected by the Engineer-in-Charge or his authorized representative either –

(a) From cutting of bars

or

(b) If he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer-in-Charge or his authorized representative.

The test pieces obtained in accordance with as above shall be full sections of the bars as rolled and subsequently cold worked and shall be subjected to physical tests without any further modifications. No deductions in size by machining or otherwise shall be permissible. No test piece shall be enacted or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

Tensile test: This shall be done as per IS: 15599.

Re-test: This shall be done as per IS: 1786.

Rebend test: This shall be done as per IS: 1786.

1.51 Stacking and storage

Steel for reinforcement shall be stored in such a way as to prevent distorting and corrosion. Care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable methods. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause minimum wastage in cutting from standard length.

1.52 Form Work (Centring & Shuttering)

1.53 Form work

Form work shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

1.54 Design & Tolerance in construction

Form work shall be designed and construction to the shapes, lines and dimensions shown on the drawings with the tolerance given below:

(a) Deviation from specified dimension of cross section of columns and beams + 12 mm - 6mm

(b) Deviation from dimensions of footings

(i) Dimension in Plan +50mm -12

(ii) Eccentricity in plan 0.02 times the width of the footings in the direction of deviation but not more than 50 mm.

(iii) Thickness + 0.05 times the specified thickness.

(Note - Tolerance apply to concrete dimensions only, and not to positioning of vertical steel or dowels.)

1.55 General Requirement

It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

Forms shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections. Care shall be taken to see that no piece is keyed into the concrete.

10.2.3.1 Material for Form Work

(a) Propping and centring

All propping and centring should be either of steel with extension pieces or built up sections rolled steel.

10.2.3.2

(a) Centering/Staging : Staging should be as designed with required extension pieces as approved by Engineer-in-Charge to ensure proper slopes, as per design for slabs/beams etc. and as per levels as shown in drawings. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.

(b) In case of structures with two or more floors, the weight of concrete, centring and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

(c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set atleast for 14 days.

10.2.3.3 Shuttering: Shuttering used be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of material as approved by the Engineer-in-charge shall be provided in the joints.

Steel shuttering used for concreting should be sufficiently stiffened. The steel shuttering should also be properly repaired before use and properly cleaned to avoid stains, honey combing, seepage of slurry through joints etc.

(a) Runner joists: RSJ, MS Channel or any other suitable section of the required size shall be used as runners.

(b) Assembly of beam head over props. Beam head is an adopter that fits snugly on the head plates of props to provide wider support under beam bottoms.

TYPICAL SET UP OF STEEL WALL FROM WORK (CLAUSE 5.2.3.6)

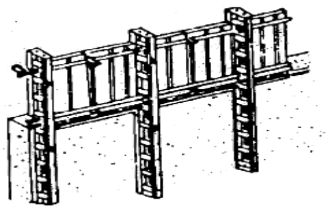


Fig. 1A : Single Side Wall Form (Adjustable)

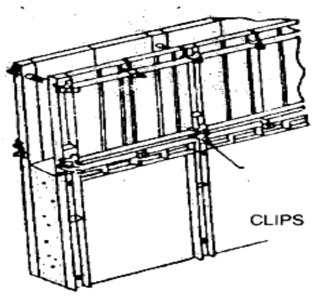
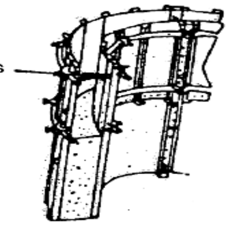


Fig. 1B : Double Sided Wall Form

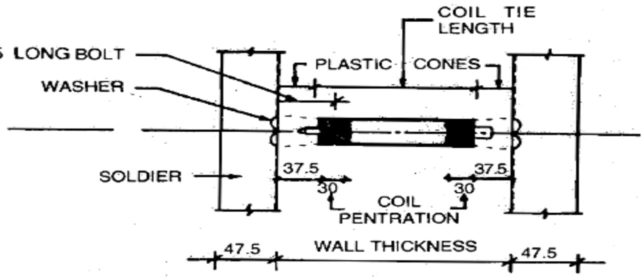
WALL FORM (Clause 5.2.3.6)



All members are of steel

Fig. 2 : Adjustable Curved Wall Form (Double Sided)

TYPICAL FIXING DETAILS OF WALL TIES
(Clause 5.2.3.6.2)



ALL MEMBERS IN STEEL

Fig. 3A : Wall Tie for Two Sided Shuttering

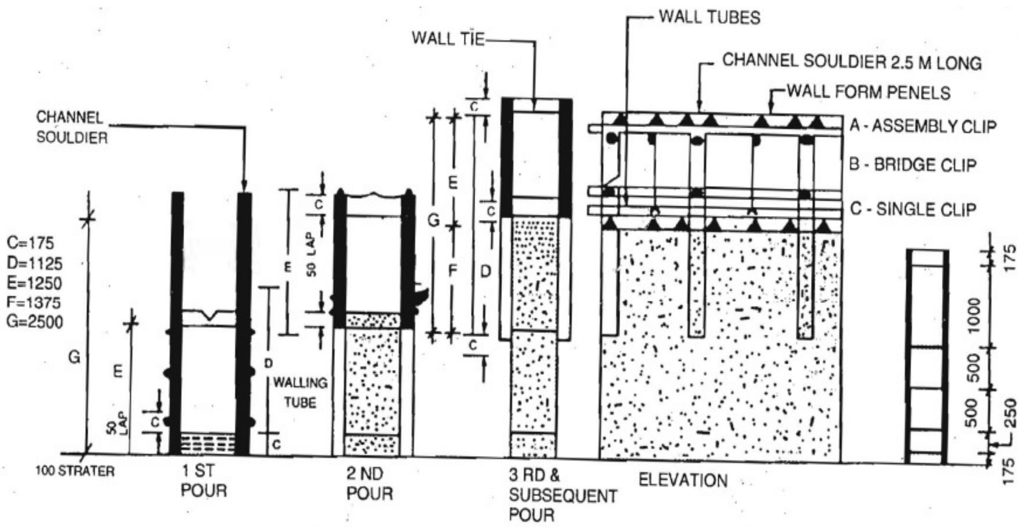


Fig. 3B : Position of Wall Ties & Waling Tubes
(Shuttering for Ist Pour should be properly Strutted by Rakers)

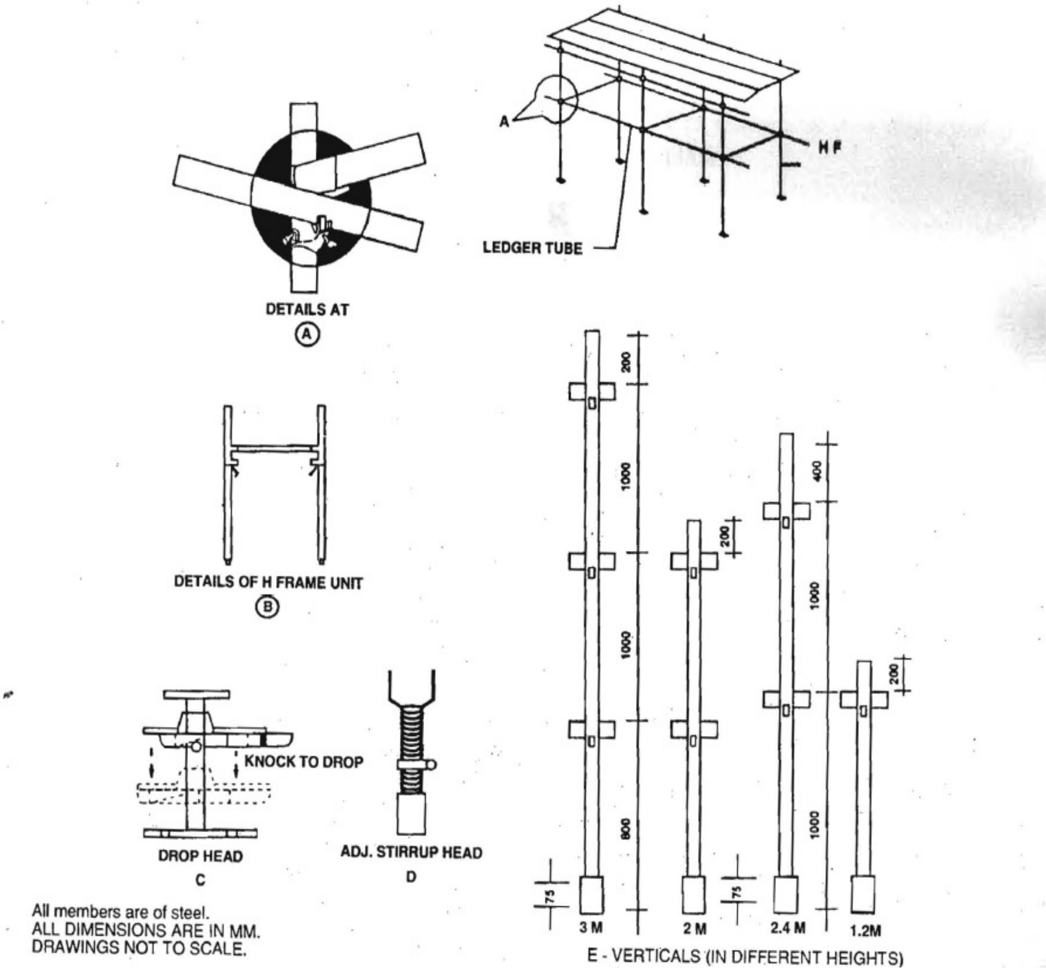


Fig.4: Typical Standard Units of Form Work (Centring & Shuttering)
(Clause 5.2.3)

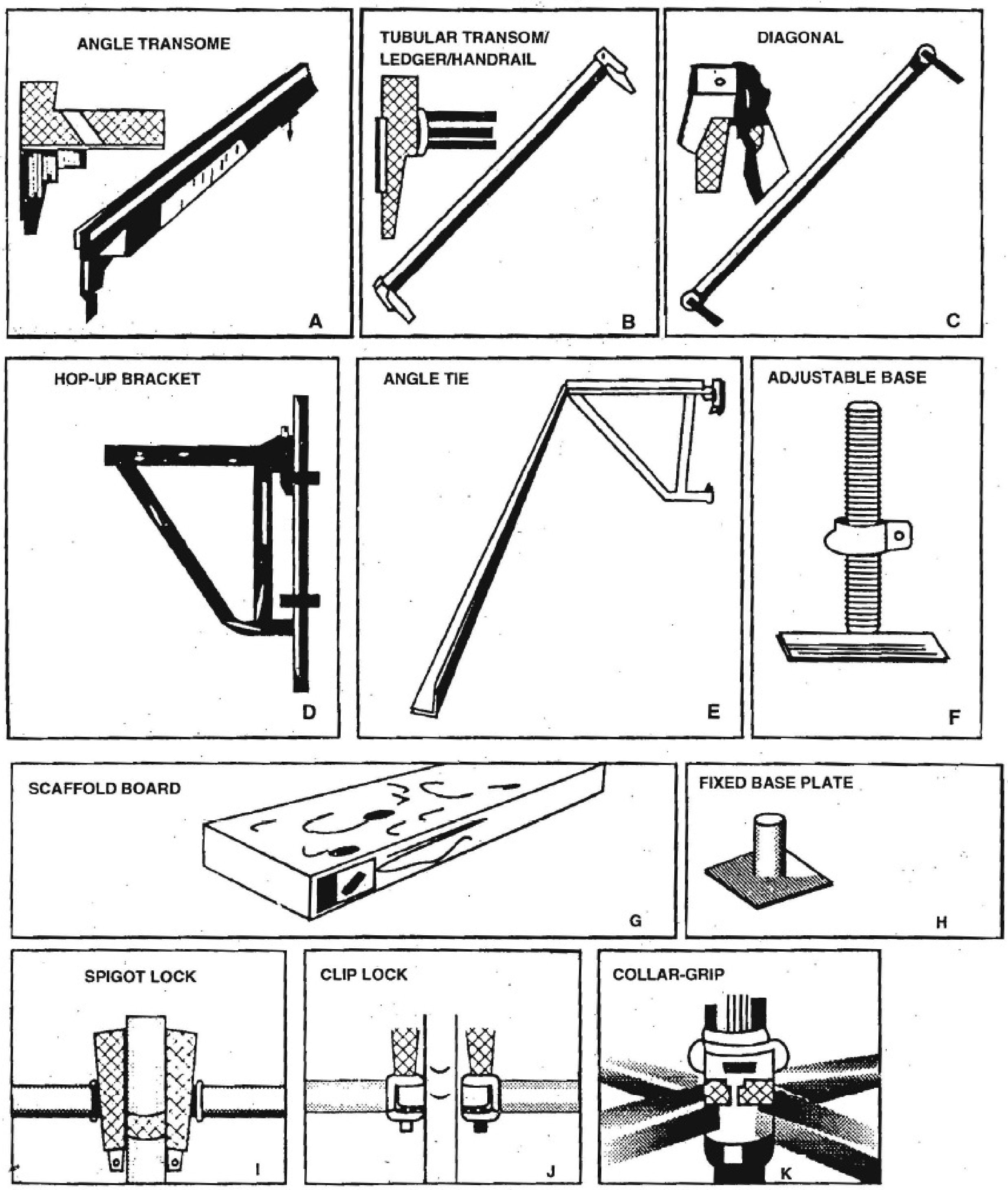


Fig.: Typical Components of Form Work (Clause 5.2.3.2)

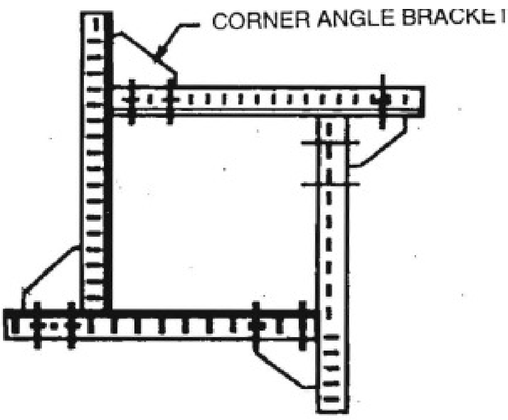


Fig. 6A : Four Sides Adjustable Column Form

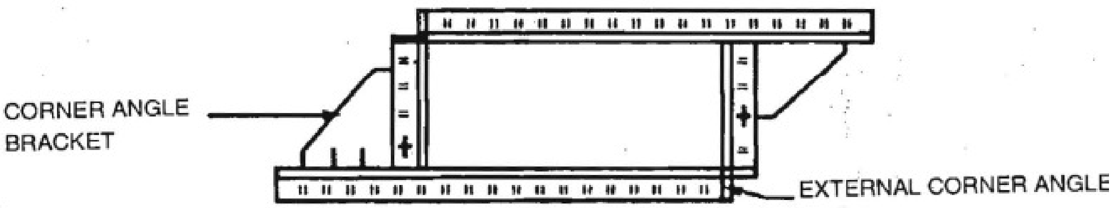


Fig. 6B : Two Sides Adjustable Column Form

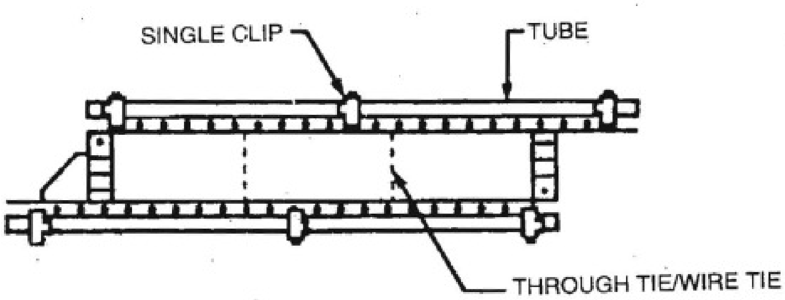
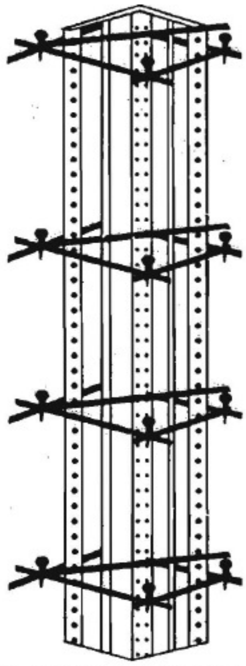


Fig.6: Typical Arrangement of Column Form Work (Clause 5.2.3.2)



All Members are of steel

Fig. 7 : Typical Column Shuttering
(Clause 5.2.3.2)

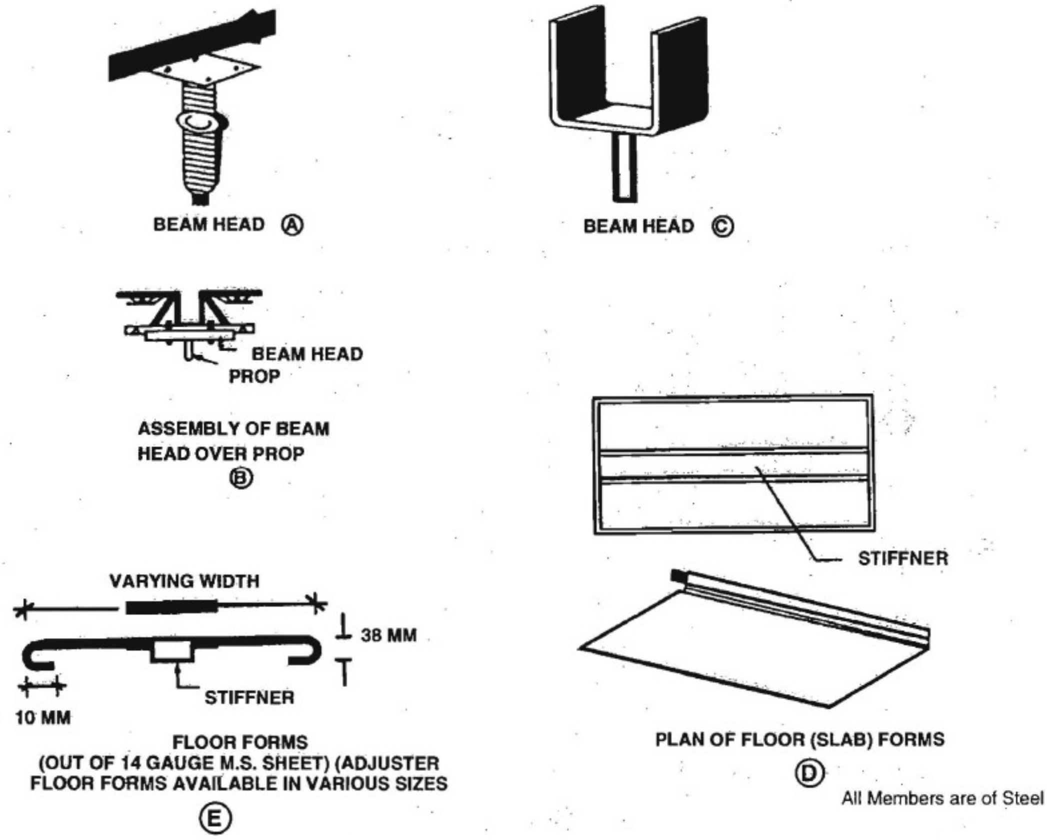


Fig.8: Typical Detail of Beam Head and Stiffner (Clause 5.2.3.3)

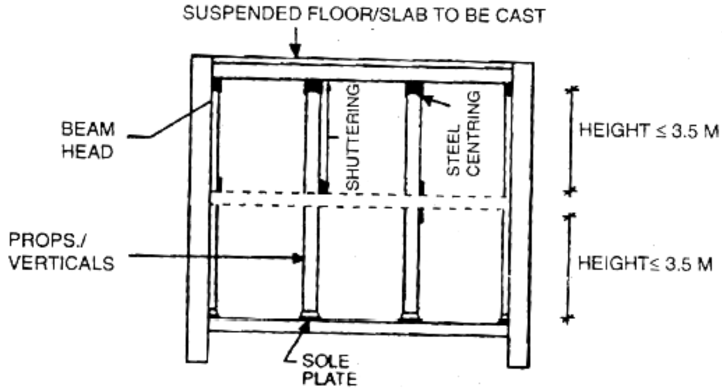
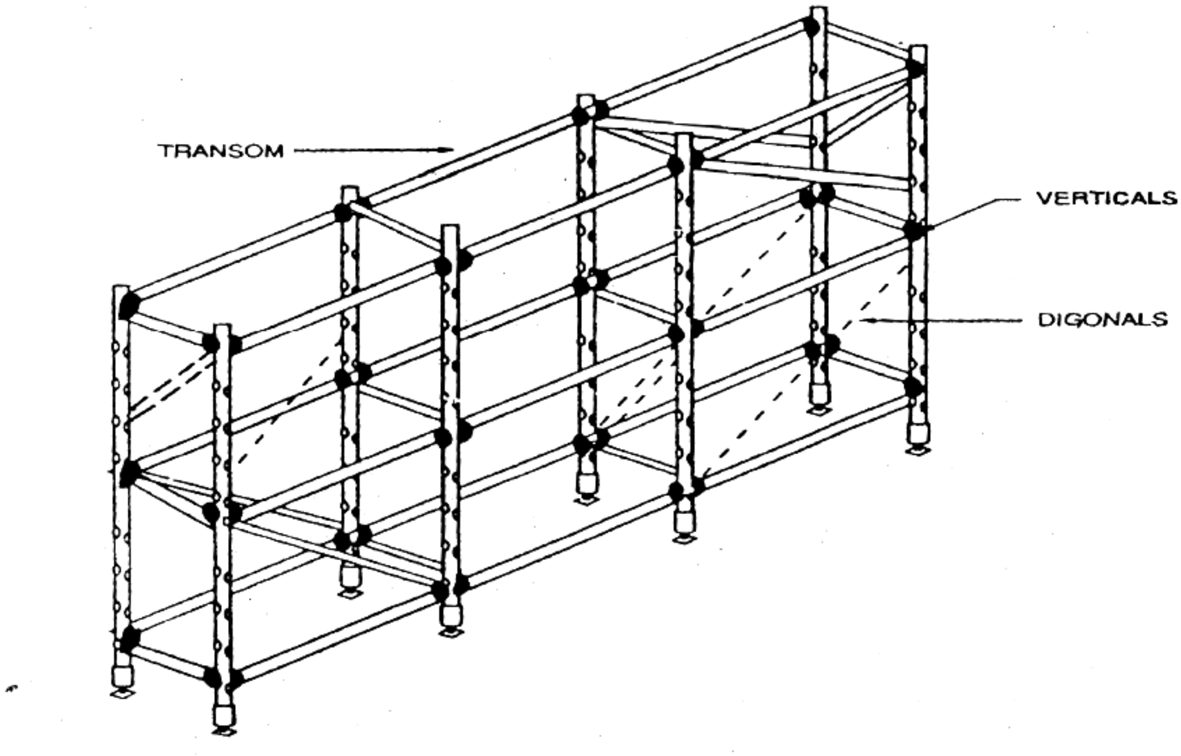


Fig. 9A : Suspended Floor – Multi stage shuttering (Vertical Section)



All Members are of Steel.

Fig. 9B : Typical Details of Multi Stage Shuttering (Clause 5.2.3.2)

10.2.3.4 Form work shall be property designed for self weight, weight of reinforcement, weight of fresh concrete, and in addition, the various live loads likely to be imposed during the construction process (such as workmen, materials and equipment). In case the height of centring exceeds 3.50 metres, the prop may be provided in multi-stages. Atypical detail of multistage shuttering is given in Fig. 9.

10.2.3.5 Camber : Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and stabs shall be 4mm per metre (1 to 250) or as directed by the Engineer-in-Charge, so as to offset the subsequent deflection. For cantilevers the camber at free end shall be 1/50th of the projected length or as directed by the Engineer-in-Charge.

10.2.3.5.1 Typical arrangement of form work for ‘Beams, columns and walls’ are shown in Figure 1 to 8 and form secured by wall ties is shown in Fig. 3.

10.2.3.6 Walls :The form faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts is considered best. A typical wall form with the components identified is given in Fig. 1,2,& 3. The two shutters of the wall are to be kept in place by appropriate ties, braces and studs. Some of the accessories used for wall forms are shown in Fig. 3.

10.2.3.7 Removal of Form work (Stripping time) : In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods :

Type of Formwork	Minimum Period Before Striking Formwork
(a) Vertical Formwork to columns, walls, beams	16-24 h
(b) Soffit formwork to slabs (Props to be refixed Immediately after removal of formwork)	3 days
(c) Soffit formwork to beams (Props to be refixed Immediately after removal of formwork)	
(d) Props to slabs :	
(1) Spanning upto 4.5m	7 days
(2) Spanning over 4.5m	14 days
(e) Props to beams and arches :	
(1) Spanning upto 6m	14 days
(2) Spanning over 6m	21 days

Note 1 : For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. If Portland pozzolana or low heat cement has been used for concrete, the stripping time will be 10/7 of the period stated above.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the stabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Note 3: For rapid hardening cement, ¾ of above periods will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for atleast 24 hours.

Note 4: In case of cantilever slabs and beams, the centring shall remain fill structures for counter acting or bearing down have been erected and have attained sufficient strength.

Note 5: Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement of cement in cold weather and accordingly stripping time shall be increased.

Note 6: Work damaged through premature or careless removal of forms shall be reconstructed.

1.56 Surface Treatment

10.2.4.1 Oiling the Surface: Shuttering gives much longer service life if the surfaces are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

A typical mould oil is heavy mineral oil or purified cylinder oil containing not less than 5% pentachlorophenol conforming to IS : 716 well mixed to a viscosity of 70-80 centipoise.

After 3-4 uses and also in cases when shuttering has been stored for a long time , it should be recoated with mould oil before the next use.

10.2.4.2 The design of form work shall conform to sound Engineering practices and relevant IS codes.

1.57 Inspection of Form Work

The completed form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discoloration of concrete etc. Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing by proper designing and erection of form work which will be approved by Engineer-in-Charge.

Shuttering surface before concreting should be free from any defect/deposits and fully cleaned so as to give perfectly straight smooth concrete surface. Surface should be therefore checked for any damage to its surface and excessive roughness before use.

10.2.5.1 Erection of Form Work (centring and shuttering). Following points shall be borne in mind while checking during erection.

(a) Any member which is to remain in position after the general dismantling is done, should be clearly marked.

(b) Material used should be checked to ensure that, wrong items/rejects are not used.

(c) If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.

(d) (i) The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.

(ii) Sole plates shall be properly seated on their bearing pads or sleepers.

(iii) The bearing plates of steel props shall not be distorted.

(iv) The steel parts on the bearing members shall have adequate bearing areas.

(e) Safety measures to prevent impact of traffic, scour due to water etc. should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.

(f) Bracing, struts and ties shall be installed along with the progress form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be a adequately restrained against tilting, over turning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.

(g) The stacked materials shall be placed as catered for, in the design.

(h) When adjustable steel props are used, they should :

1. Be undamaged and not visibly bent.

2. Have the steel pins provided by the manufacturers for use.

3. Be restrained laterally near each end.

4. Have means for centralizing beams placed in the forkheads.

(i) Screw adjustment of adjustable of adjustable props shall not be over extended.

(j) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/elastic shortening of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightended/clamped down after adjustment to prevent their shifting.

(k) No member shall be eccentric upon vertical member.

(l) The number of nuts and bolts shall be adequate.

(m) All provisions of the design and/or drawings shall be complied with.

(n) Cantilever supports shall be adequate.

(o) Props shall be directly under one another in multistage constructions as far as possible.

(p) Guy ropes or stays shall be tensioned properly.

(q) There shall be adequate provision for the movement and operation of vibrators and other construction plant and equipment.

(r) Required camber shall be provided over long spans.

(s) Supports shall be adequate, and in plumb within the specified tolerances.

RELEVANT EXTRACTS FROM CPWB, QUALITY ASSURANCE CIRDULARS
CPWD,CDO

No. SE (D)/G-48/391 Dated 10.11.1982

Subject : Propping and centering for R.C.C. Stabs & Beams

During the inspection of works, one of the common defects noticed is that no supports are being provided one floor below the top floor already cast while casting the upper floor R.C.C. slabs & beams and that even where, the supports are so provided, they are being removed before the period stipulated for striking the formwork. In this connection para 5.2.2.2 if C.P.W.D. Specifications 1977 Vol. 1* , clearly states that centering and shuttering of any upper floor being cast shall be suitably supported on floor below the topmost floor already cast, Specifications giving the striking period of centering & shuttering do not give different period for removal of the supports in the lower floor. It, therefore, follows that non-provision of such supports or their removal before due date for removal of centering & shuttering are in contravention of the specifications and also may be structurally undesirable.

These instructions are brought to the notice of all concerned for strict compliance.

Quality Control & Technical Audit Wing (CDO), CPWD

No. CDO/QCTA/28/1051-1100 **Dated 29.10.1983**

3. As per para 5.2.2 of CPWD Specification Vol. 1, 77 (P-102) "in case of structures with two or more floors the weight of concrete, centring and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast. In such cases normal props as per para 5.2.2.1 shall be provided for supporting the floor to be cast on the top most floor already cast. Suitable supports below this floor shall be provided preferably to come below the props of the upper floor ……………… in case of balconies and cantiever beams, coming one above the other, the members being cast shall be supported by props on two floors below, the floor where initial supporting has been done."

In this office No. SE (D)/G-46/391 dated 2.12.82, Circulated to all C.Es & E.Es, it was pointed out that the above provision was not being followed. It was also mentioned that specifications giving the striking period of centering & shuttering do not give different period for removal of the supports in the lower floor. It, therefore, follows that non provision of centring and shuttering are in contravention of the specifications and also may be structurally undesirable.

In spite of such clear instructions issued for strict compliance, it is found that the instructions are not followed in most of the works visited by the Core Unit.

4. Figure 5 of C.P.W.D. Specifications Vol. 1, 77 (page 399) (Clause 5.2 page 101) giving details of form work is practically not being followed anywhere.

8. Ballies being used for form work are found to be of lesser diameter.

9. As per para 5.2.2.3 of CPWD Specifications Vol. 1.77 details of form work of spans exceeding 4.5 m and height exceeding 3.5 m are required to be properly designed .

Director General of Works. CPWD

No. 13(1)/83-WI (DG)/Cir. No. 4/84 **Dated 28.2.1984**

Subject : Centring and Shuttering for R.C.C. Work

The provisions under para 5.2 of CPWD Specifications, 1977, Vol. I clearly indicate the various aspects of providing for a work for Reinforced Cement concrete Work. If these provisions are strictly followed, there should be no cause for any mishaps

Due to failure of centring. Para 5.2.2.3 stipulates that in case of spans exceeding 4.5 Mts. & height beyond 3.5 Mts. The formwork shall be designed properly for the self weight, weight of reinforcement, weight of fresh concrete, various imposed improved during the construction process (such as workmen & equipment). It is important to ensure that suitable & adequate horizontal as well as diagonal bracings are provided to resist lateral forces.

3. In case of long spans and high roof buildings, it is advisable to use steel centring as indicated in the this office Memo No. 28/26/77-7 (M) Cir. No. 18/78 dated 21.6.78.

4. It has been observed that in spite of repeated instructions. Adequate care is not being exercised in the design & erection of centering and propping. During inspection of works, the Superintending Engineer and Executive Engineers should pay special attention to this item of work.

Office of Chief Engineer S.P.G. Project. CPWD

No. MSSC/CE/SPGP/91 Dated 8.7.1992

Subject : Avoidance of use of Timber in Centering and Shuttering

As you are aware that use of wood in CPWD works has been banned with effect from 1.4.93 Therefore earnest effort be made to reduce the use of timber right now. One of the major item where timber is used centering and shuttering. In order to avoid the use of timber and to get better finish surface of concrete, please discourage use of timber in the ongoing projects/ works. In the case of new projects/works suitable provision in the N.I.T. be made to ensure that timber is not used for centering and shuttering. Preferably steel centering and shuttering may be specified.

Quality Control & Technical Audit Wing, SPG, CPWD

No. CDO/SPG/QCTA/G-2/932-CDO Dated 7.7.1995

Subject : Centering and Shuttering for R.C.C. Works – Span exceeding 4.5 mtrs. And Height beyond 3.5 mtrs.

From time to time instructions have been issued to preferably use steel centering for long spans and higher roof heights. CPWD Specifications '77 Vol. I in para 5.2.2.3 stipulates that for spans exceeding 4.5 m and hights 3.5 m, the formwork has to be properly designed with horizontal and diagonal bracings to withstand various loads. Further, at paras 5.2.1 and 5.2.2 the specification provides steel as one of the alternatives to be used for formwork and centering.

In the light of the above, it is a matter of serious concern that the formwork, even for long spans and higher roof heights continues to be used without proper design, particularly when timber members are used. This has resulted in failure of centering and shuttering and consequent collapse of R.C.C. members in few cases, recently.

It is, hereby decided that henceforth for spans exceeding 4.5 mtrs. And for heights beyond 3.5 mtrs. Only steel formwork shall be used. Necessary stipulation to this effect shall be made in all the NITs. For current agreements, if for some reasons, the use of steel centering and shuttering has not been specified, the staging shall have adequate horizontal and inclined bracings to ensure rigidity in both the directions as specified in para 5.2.2.3 ibid.

The JE/AE/EE incharge of the work will be held personally responsible for violation of the above instructions.

CEs shall bring the content of this circular to the notice of all concerned for immediate necessary action.

5.2.6 Measurements

5.2.6.1 General

The form work shall include the following :

(a) Splayed edges, notchings, allowance for overlaps and passing at angles, sheathing battens, strutting, bolting nailing, wedging, easing, striking and removal.

(b) All supports, struts, braces, wedges as well as mud sills, piles or other suitable arrangements to support the form work.

(c) Bolts, wire ties, clamps, spreaders, nails or any other items to hold the sheathing together.

(d) Working scaffolds, ladders, gangways, and similar items.

(e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20 mm wide to beams, columns and the like.

(f) Where required, the temporary openings provided in the forms for pouring concrete, inserting vibrators, and cleaning holes for removing rubbish from the interior of the sheathing before pouring concrete.

(g) Dressing with oil to prevent adhesion and

(h) Raking or circular cutting

5.2.6.2 Classification of Measurements : Where it is stipulated that the form work shall be paid for separately, measurements shall be taken of the area of shuttering in contact with the concrete surface. Dimensions of the form work shall be measured correct to a cm. The measurements shall be taken separately for the following :

(a) Foundations, footings bases of columns etc. and for mass concrete and precast shelves,

(b) Walls (any thickness) including attached pilasters, butteresses, plinth and string courses etc.

(c) Suspended floors, roofs, landings, shelves and their supports and balconies.

(d) Lintels beams, girders, bressummers and cantilevers.

(e) Columns, pillars, posts and struts.

(f) Stairs (excluding landings) except Spiral staircase.

(g) Spiral staircases (including landings)

(h) Arches.

(i) Domes, vaults, shells roofs, archribs and folded plates.

(j) Chimneys and shafts.

(k) Well steining

(l) Vertical and horizontal fins individually or forming box, louvers and bands.

(m) Waffle or ribbed slabs.

(n) Edges of slabs and breaks in floors and walls (to be measured in running metres where below 200 mm in width or thickness).

(o) Cornices and mouldings.

(p) Small surfaces, such as cantilevers ends, brackets and ends of steps, caps and boxes to pilasters

(q) Chullah hoods, weather shades, chajjas, corbels etc. including edges and

(r) Elevated water reservoirs.

10.2.6.3 Centring, and shuttering where exceeding 3.5 metre height in one floor shall be measured and paid for separately.

10.2.6.4 Where it is not specifically stated in the description of the item that work shall be paid for separately, the rate of the RCC item shall be deemed to include the cost of form work.

10.2.6.5 No deductions from the shuttering due to the openings/obstructions shall be made if the area of such openings/obstructions does not exceed 0.1 square metre. Nothing extra shall be paid for forming such openings.

10.2.7 Rate

The rate of the form work includes the cost of labour and materials required for all the operations described above.

1.58 Relevant Extracts From Bis Codes

Relevant Extracts from IS : 14687 – 1999 – Guidelines on false work for Concrete Structures

Note : This is the only code published by B.I.S. on Form Work – i.e. Centering and Shutteing

1.59 Scope

11.1.1 These guidelines cover the common requirements of materials, design and construction of false work, as applied to general building ann ordinary civil engineering constructions excluding bridges and special structures. General building construction for the purpose of this code, means structures up to 4 storeys or 15 m height and dead load of formwork and concrete not exceeding 20 kN/m^2. The provisions of these guidelines can be applied to other building and structures with additional with additional requirements.

11.1.2 The requirements of special falsework systems , such as moving forms, climbing forms, slipforms, flying forms etc. are not covered in these guidelines. It also does not govern many requirements of moulds for precast and prestressed concrete components, architectural concrete and lost forms.

1.60 References

The Indian Standards listed in Annex A Contain provisions which through reference in this text. Constitute provision of this standard At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed in Annex A.

1.61 Terminology

For the purpose of this code, the definitions, given in IS : 6461 (Part 5) shall apply.

1.62 Requirements of falsework

1.63 Safety and Integrity

The falsework shall be planned with safety of permanent constructions and workers. It shall be adequately laterally and diagonally.

1.64 Rigidity and Deflection

Falsework shall be rigid enough so that the deflections under the dead load and live loads and forces caused by ramming and vibration of concrete and other incidental loads imposed upon it during and after casting of concrete are well within permissible limits (see 7.5) The rigidity can be achieved by suitable number of ties and braces. Screw jacks or hard board wedges, where required shall be provided to control falsework settlement.

1.65 Strength and Stability

The falsework shall be of adequate strength and so detailed as to withstand all enticipated loads including lateral loads, vibrations and small accidental loads. The system shall be such as to prevent progressive failure due to minor causes.

1.66 Functional Requirements

11.5.1 Erection and Release

Falsework shall be so designed and constructed that they can be removed in parts in the desired sequence without damaging the surface of concrete or disturbing other sections or causing collapse of the formwork systems. The connections joining various components of the formwork should be capable of being easily removed while formwork stripping.

11.5.2 Ease of Inspection

The scheme of falsework should facilitate adequate and safe access to all areas for inspection.

11.5.3 Shape and Size

The falsework shall be erected such that the shape and dimensions of the concrete structures are conforming to the drawings, the specifications and tolerances. Chamfers, beveled edges and mouldings if specified, should be provided in the forms.

11.5.4 Finish

The formwork should be hard enough so as to not to get damaged due to operations of reinforcement fixing, pouring and vibrating of concrete and removal of forms. The materials of formwork shall depend upon the final finished surface required.

11.5.5 Reuse

It shall be designed and planned to permit maximum reuses, reducing the cost of concrete work. While avoiding unsafe or poor practices, adequate planning shall be done right from initial stages to develop a viable reuse plan, utilizing member sections and sizes that will involve minimum material cutting, wastage and minimum assembly.

1.67 Type of falsework

11.6.1 Falsework may be fabricated at site, or partially or wholly pre-fabricated.

11.6.1.2 Commercially available falsework systems may be used, provided those meet the requirements of these guidelines and detailed information as necessary in furnished, unless otherwise it is specifically agreed between the supplier and agencies executing and supervising the construction.

When propriety systems of falsework are employed, it is recommended that the designer may obtain the information as per Annex B from the suppliers.

1.68 Materials and Accessories for False work

1.69 General

The false work may consist of timber, plywood, steel, aluminum, PVC, plastics ferro-cement or any engineering material General requirements and specific use of these materials are given in 6.1.1 to 6.1.4

11.7.2 Timber

Timber should be softwood of partially seasoned stock to avoid swelling or warping. Timber which may be used for making strong scaffolding, beams, columns, props and bracing shall conform to IS : 883

11.7.3 Plywood

Plywood conforming to IS : 4990 may be used for form lining, sheathing and panel.

11.7.4 Steel

Steel sheet plates conforming to IS : 2062 or IS : 1977 may be used for form and form lining and rolled sections and tubes conforming to IS : 2062 or IS : 8500 or IS : 1161 may be used for steel forming and bracings.

Whenever proprietary systems are intended to be used, technical information as per Annex B should be obtained form the manufacturer beforehand. Steel clamps and couplers shall conform to IS : 2750.

11.7.5 Other Materials

Other materials which may be used in falsework include alluminium , PVC reinforced plastics, high density polyethylene, polypropylene, ferro-cement and polythene sheet for lining, etc. In certain applications, masonry, concrete and earthwork may be used as part of falsework.

1.70 False work Accessories

1.71 Form Ties

Form tie (see Fig. 1) may be used in the form of variety of threads and nuts having varying diameter from 10 to 30mm and of a suitable length as per the requirements of each job. A plastic tube. A plastic tube may be used covering the tie for easy removal of the tie after concrete is set.

The form ties may be fitted with plastic or wooden sleeving cones at each end. Ties may also be used in association with concrete blocks with central holes.

The part of form tie, if left inside the concrete, shall have minimum cover as specified for reinforcement.

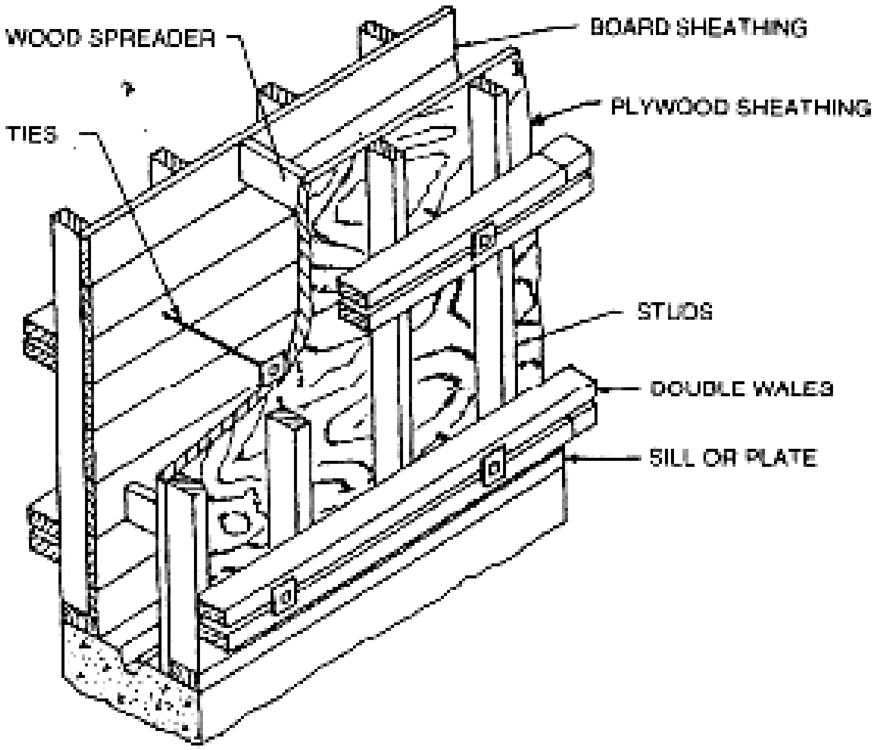


Fig.1: Typical Wall Form Showing Wall Ties

11.8.2 Form Anchors

Form anchors should be embedded during concrete placement at specified locations in case formwork for the next lift is to be secured to the concrete being placed. The securing of formwork should be done only after the previously placed concrete has gained adequate strength.

11.8.3 Form Hangers

Form hanger (see Fig. 2) devices may be used for hanging formworks loads form structural steel or precast concrete structural members or other members.

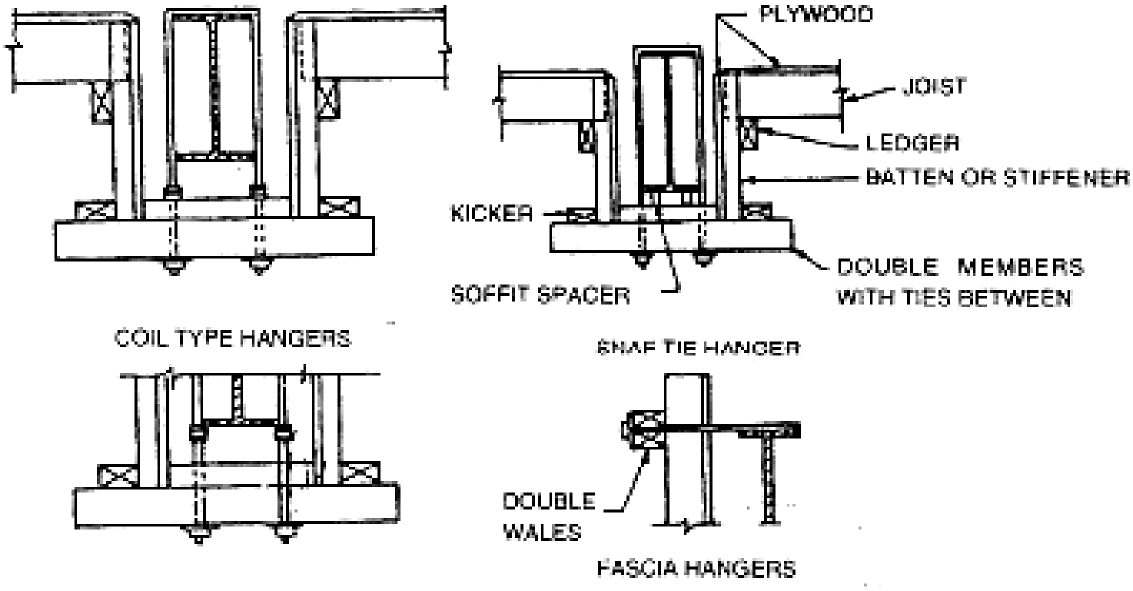


Fig. 2: Typical Beam Encasement Forms, Showing Both Coil and Snap Type Hangers

11.8.4 Form Jacks

These proprietary systems may be used to facilitate supporting of the formwork from the lower flanges of steel beams (as an alternate to hanging the forms)

11.8.5 Spreaders, spacers

These devices may be used to keep forms in the proper position and to maintain a correct spacing between vertical form and reinforcing bars. These may be made of high strength mortar (vibrated or pressed), concrete, various grades of plastic, steel etc.

11.8.6 Column Clamps

The column clamps may be used to hold the column form together and to resist the lateral pressure of the freshly poured concrete.

11.8.7 Sealing Strip

T-strips made of PVC sections and dimensions ranging from 15mm to 40 mm may be used for sealing the joints between the faces of formwork against leakage of mortar or slurry.

11.8.8 Chamfer Fillets

Proprietary fillets made of PVC to provide chamfers of various dimensions from 10 to 30mm may be used

11.8.9 Adjustable Steel Props

Adjustable steel props may be used.

1.72 Formwork Coatings and Releasing Agents

Formwork in contact with concrete may be treated with a coating or releasing agent of approved composition. The type of coating and its composition depends upon the type of shuttering material used and its surface which would be in contact with concrete. Coating and release agent should :

(a) Provide a clean easy release or strike without damage to either the concrete face or the form.

(b) Contribute to the production of blemish free concrete surface.

(c) Have no adverse effect upon either the form or concrete.

(d) Be easy to apply evenly at the recommended coverage, and

(e) Not inhibit adhesive of any finish applied to the formed surface.

11.9.1 Shuttering should be coated with suitable form release agents for easy stripping, before each use. The form release agents are temporary coatings consisting of fatty acids which react which react with the alkali in cement and leave behind a soap like substance on the contract surface. This helps release of the form. These may be oils, emulsified wax, oil based emulsions with water globules, petroleum based products. Catalysed polyurethane form, etc.

11.9.2 Careful consideration should be given to the choice of release agent taking account of the type of surface to which it is to be applied , the conditions under which it is to be used, the type of concrete, the quality of finish, the area of form and the ease of application.

The conventional use of waste oil as release agent should not be encouraged since it dose not contain fatty acids.

1.73 Design of Falsework

1.74 General

Falsework shall be designed to meet the requirements of the permanent structure using relevant Indian standards for materials selected for falsework. The design should take into account the conditions of materials to be actually used for the falsework, environment and site consideration.

The checks for safety, overturning, overall stability and progressive collapse shall be implicit in design.

The falsework scheme shall preferably be so designed that the vertical members are subjected to compressive force only under the action of combined horizontal and vertical loads. The design should also take into account the sequence of concreting, specially in construction of cantilevers, domes, etc.

1.75 Design Information

Before proceeding to the design, all the relevant design information should be obtained from the relevant sources. The design information includes the site investigation report, expected loading scheme of load transfer, sequence of erection and releasing, procedure of concreting and time frame.

11.12.1 Loads on Falsework and Combination of Loads

11.12.2 General

Falsework shall designed to resist the expected dead load, imposed load, environmental load and construction load. Loads on falsework are any combinations of the following:

(a) Dead Loads,

(b) Imposed loads,

(c) Environmental loads,

(d) Incidental loads during erection and operation, and

(e) Lateral pressure

11.12.3 Dead Loads

11.12.4 Dead loads shall include ;

(a) Falsework structure, self weight of formwork and any ancillary temporary work connected or supported by formwork, and

(b) Weight of freshly placed concrete for the permanent structure directly supported by the formwork, self load shall be determined either by actual measurement or in accordance with IS : 875 (Part 1). The unit weight o wet concrete including reinforcement shall be taken as 26 kN/m2.

Additional weights of fittings shall be included in the self weight calculation.

11.12.5 Actual load of formwork shall be evaluated for use in design. However, in absence of the date, load may be assumed as 500 N/m2 for the purpose of initial calculations.

11.12.6 Imposed Loads

11.12.7 General

11.12.8 Loads during constructional operation shall constitute the imposed load [see IS : 875 (Part 2) for falsework design. Such loads may occur due to construction personnel, plat and equipments, vibration and impact of machine delivered concrete, lateral pressure of fresh concrete, unsymmetrical placement of concrete, concentrated load and storage of construction materials. Imposition of any construction load on the partially construes shall not be allowed unless specified in the drawings or approved by the engineer-in-charge. Allowance shall be made in the falsework design to accommodate force or deformation in the post tensioned members.

11.12.9 For this loading allowance to be valid, the concrete should not be dropped from a free height greater than 11 m nor should be concrete allowed to keep and accumulate on the formwork to a height more than three times the depth of the slab, with a limit in area of 1 m^2 for any such situation to this height. If it be necessary to exceed these limitations, allowances for the additional loading should be made in design.Where allowance has only to be made for access and inspection purposes, a loading of 750 N/m^2 should be adequate.

11.12.10 Load from the permanent works shall be assessed from the self weight of the permanent structure to be supported by the formwork including the weight of plastic concrete which may actually be determined or taken as per IS : 875 (Part 1). The effect of impact or surge wherever it may occur shall be suitably considered and catered for. Where pumping resorted to, additional loads should be considered in design.

11.12.11 Lateral pressure due to fresh concrete

The lateral pressure due to fresh concrete on the temperature of concrete as placed, the rate of placing concrete and the concrete mix proportion. A set of curves giving typical values of pressure p max for unit height, on formwork are given in Fig. 3 for guidance.

For variation in the parameters appropriate correction factors as indicated in Table 1 are applicable for working out values from Fig. 3

(a) Workability – correction factors as given in Table 1 should apply

Table 1 Correction Factors for Different Degree of Workability of Concrete

Degree of workability	Rate of Placement of Concrete m/h		
	Up to 1	1.5 – 2	2.5 – 4
Very low	0.70	0.75	0.80
Low	0.80	0.85	0.90
Medium	1.00	1.00	1.00
High	1.10	1.30	1.50

(b) Cement Content – For every 50 kg increase in cement beyond 350 kg/ m^3 , the rate of placement of concrete may be reduced 0.5 m/h for obtaining the correction to pressure.

(c) Density of Concrete – The curves are based on concrete density of 24 kN/m3. For other densities the values of P max shall have to be pro-rated.

(d) Type of Cement – Where cement other than 33 grade ordinary Portland cement in used, appropriate allowance can be made for increasing or decreasing the value of P max as the case may be, depending on the relative setting times of concrete.

(e) Admixture - The curves are valid for concrete without use of any admixture, where admixtures are contemplated, trials or manufacturers data will be required to determine the effect of admixtures on the values of pressure. The pressure distribution along the height of formwork can be assumed as given in Fig. 4. For normal concrete, the maximum pressure may occur at a height h_m below the top as given by the following formula :

Hm = Pmax ID

Where

H^m is in m, P_{max} is in kN/m^2, and

D^m is density of fresh concrete in kN/m^3 .

The pressure exerted on back form (that is top form on inclined surfaces) can uplift the formwork. Such situation should be designed and detailed for anchorage and pressure containment without movements.

11.13.1 Environment Loads

These loads include:

(a) Wind or seismic loads,

(b) Earth pressure,

(c) Water pressure,

(d) Snow load, etc.

11.13.1.2 Wind loads should be taken for design in accordance with IS 875 (Part 3) subject to a minimum horizontal load equal to 3 percent of the vertical loads at critical level.

11.13.1.3 Snow loads should be assumed in accordance with IS : 875 (Part 4).

11.13.1.4 Ice loads are required to be taken into account in the design of members in zones subjected to ice formation. The thickness of ice deposits may be taken to be between 3mm and 10 mm depending upon the locations of the formwork. The maximum density of ice may be assumed to be 900 kg/ m3.

11.13.1.5 Earth pressure can occur on falsework as in the case of retaining walls and these shall be catered for. The rise in the water table may increase pressure on the falsework.

11.13.1.6 .Shrinkage and early thermal movements in the freshly placed concrete should be assessed and accommodated in the design of formwork.

1.76 Permissible Stresses

Permissible stresses shall not exceed the values specified in the relevant Indian Standards for permanent structures.

In case of reusable components of steel, timber, etc., the values of permissible stresses shall be suitably reduced depending upon the number of uses and extent of deterioration (see 7.4.4)

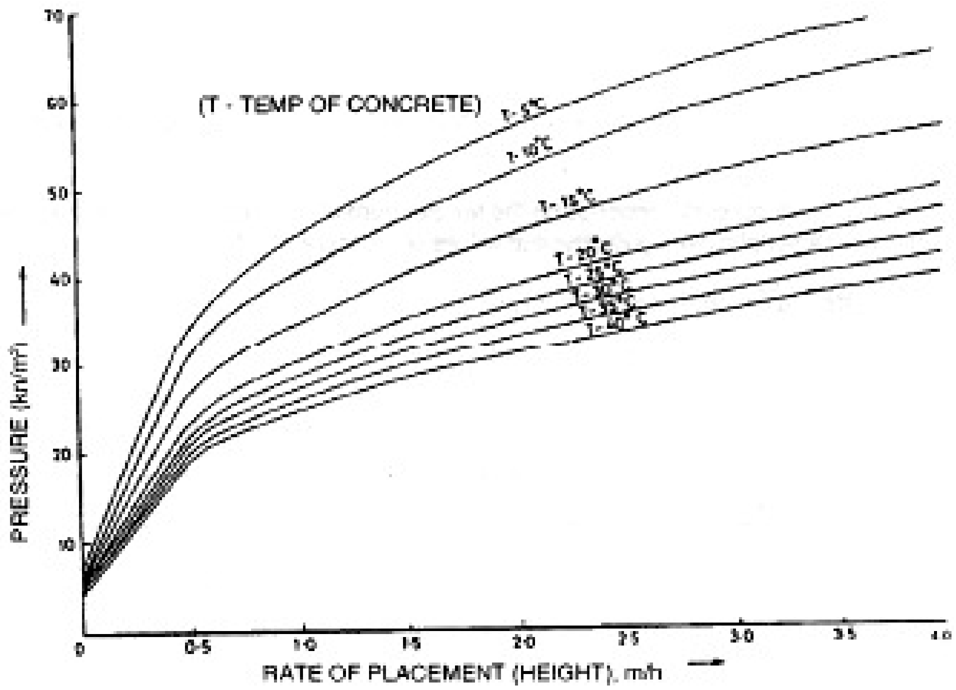


Fig.3: Maximum Pressure on Formwork Due to Fresh Concrete

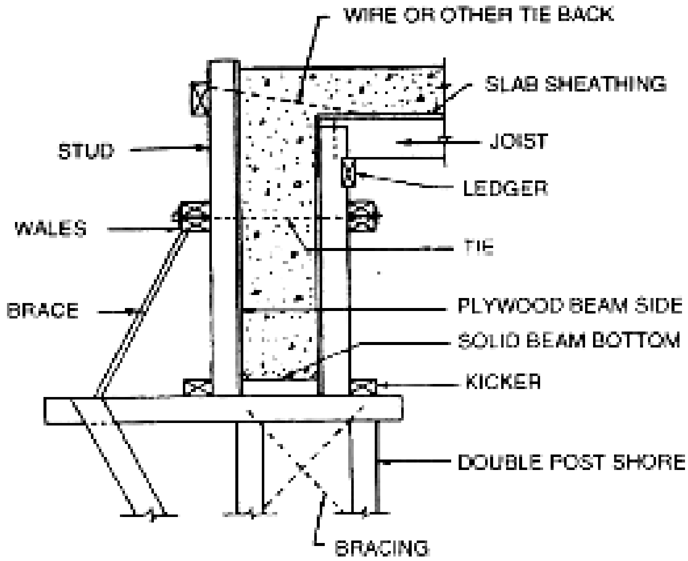


Fig.4: Typical Stud and Wale Forming for Spandrel Beam with Bracing

11.14.1 Timber

Basic permissible stresses of different species of timber selected out of timbers listed in IS : 399, shall be taken in accordance with the stresses given in IS : 883.

11.14.2 Plywood

Maximum permissible stresses and modulus of elasticity shall be in accordance with the provisions of IS 4990.

11.14.3 Steel

The permissible stresses shall be assumed as given in IS 800 and IS 2750, as applicable.

11.14.4 Tubular Section

The permissible stresses shall be assumed in accordance with IS : 806, in case of reused steel tubes the permissible compressive stresses may be reduced by 15 percent provided the maximum reduction in nominal mass (see IS : 1161) is 7.5 percent and the deviation in length is not more than 1/600 of the length.

11.14.5 Brickwork – Stone

The properties of brickwork, stone masonry and blockwork shall be as per IS : 1905, IS : 1597 (Part 1) and IS : 2212.

11.14.6 Concrete

The concrete should in general comply with the requirements of IS : 456 as appropriate to a concrete member.

Blinding concrete, where used shall have a minimum thickness of 50 mm of grade m 10. If concrete of lower strength is used minimum thickness shall be 75 mm.

1.77 Reflection Limit

The formwork shall be designed so as to remain sufficiently rigid during placing and compaction of concrete. The total calculated deflection (s) of false work including the initial imperfection in the members shall not exceed the following:

(a) For beam span < 3000 mm

(b) For beam length > 3 mm

is the least of

(1) 30 mm

(2) L/1000

1.78 Stability

The formwork shall be designed to check against overturning and sliding. A factor of safety of 1.5 may be used in design against overturning and sliding.

1.79 Forces Resulting from Erection Tolerances

The acceptable erection tolerances on a nominally vertical members result in horizontal erections in association with the applied vertical forces.

Provided the maximum permissible erection tolerances are not exceeded, and the centroid of the member applying the vertical forces is not more than 25 mm in plan from the centroid of the foot of the supporting vertical member, provision should be made for a horizontal reaction equal to 1 percent of the applied vertical forces. These recommendations relate to individual tubes, props and structural steel sections and to proprietary components used as support towers.

1.80 Forces Resulting from Members Out of Vertical Design

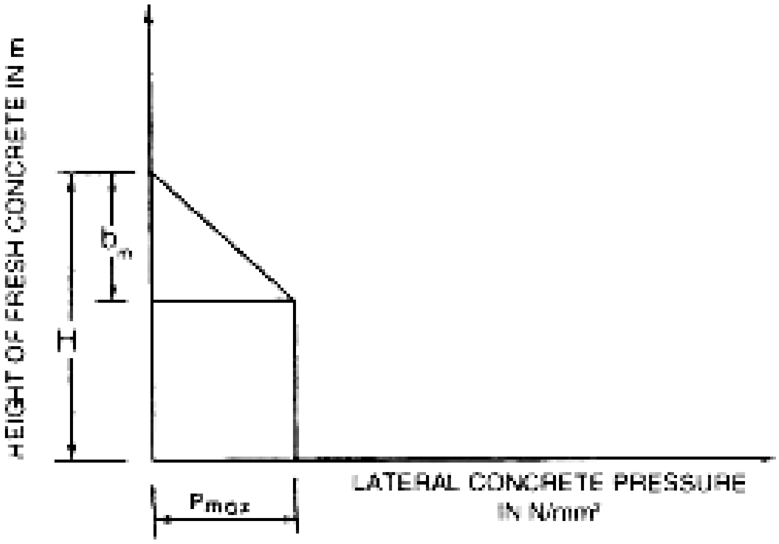
Falsework members (for example beams of supports) may be designed to follow gradients of profiles and the members installed out of vertical by design. The vertical forces transmitted by the members will give horizontal components that require to be resisted in addition to other force.

1.81 Bracing

11.19.1 The formwork system should be designed to transfer all horizontal loads to the ground or the completed construction in such a manner as to ensure safety during construction. Diagonal bracings (see

Fig. 5) should be provided in vertical and horizontal plane to resist lateral loads and to prevent instability of individual members.

11.19.2 Bracing should be provided where restraint is actually required and should be as close to the point of application of vertical and horizontal forces and at the intersection of vertical and horizontal members.



1.82 Foundation

11.20.1 Proper foundations on ground such as mudsills, spread footings or pile footings shall be provided depending upon the support conditions. It soil under mudsills is or may become incapable of supporting superimposed loads without appreciable settlement, it should be stabilized or other means of support should be provided.

11.20.2 Falsework should be so designed and constructed that vertical adjustment can be made to compensate for taking up any foundation settlement.

Where the vertical load from the formwork are transferred to a permanent work such as slab, foundation, etc. a check should be made that these permanent structures can safely receive, this loading without uneven ground pressure, deflection and statement.

11.20.3 The loads from the formwork supported on the ground shall be applied to the ground through distribution members made of timber, steel base plate or precast concrete.

11.20.4 When it is required to proceed with the upper storey construction before the floor below has developed required strength or its strength is not enough to withstand the construction loads including dead and live loads, the falsework below the lower floors should be retained or it should be repropped ensuring that the props are directly one under the other so as to stress the lower floors to the minimum and within the permissible limits. In any event, shock loading through the falsework to the structure below shall be avoide. Also the lower props shall be checked against buckling.

Common Deficiencies in Design

Following common design deficiencies leading or contributing to failure should be avoided :

(a) Lack of allowance in design for such loadings as wind, power buggies placing equipment and temporary material storage;

(b) Inadequate anchorage against uplift due to battered form faces ,

(c) Insufficient allowance for eccentric loading due to placement sequence,

(d) Failure to investigate bearing stresses in members in contact with shores and struts,

(e) Failure to provide proper lateral bracing or lacing of shoring,

(f) Failure to investigate the slenderness ratio of compression members,

(g) Inadequate provisions to tie corners of intersection cantilevered form together,

(h) Failure to account for loads imposed on anchorages during gap closure in aligning formwork,

(i) Inadequate reshoring, and

(j) Overstressed reshoring.

1.83 Shuttering for concrete and other Detailing

1.84 Footings

Slopped footings will normally require formwork for vertical sides only. If the slope of the top faces exceeds angle of repose of the vertical concrete, formwork may be required for the top face.

Stepped footings may be provided to avoid the top form

1.85 Columns

Coumn forms (see Fig. 6) should be capable of being stripped easily. In tall forms it is desirable to provide windows at appropriate levels on the least one face to facilitate inspection, concrete placement and vibration.

Any method (standard or patented) such as adjustable clamps, bolts, purpose made yokes, etc. to hold the panels in place may be used. The spacing and size of these clamps shall depend upon the lateral pressure of fresh concrete.

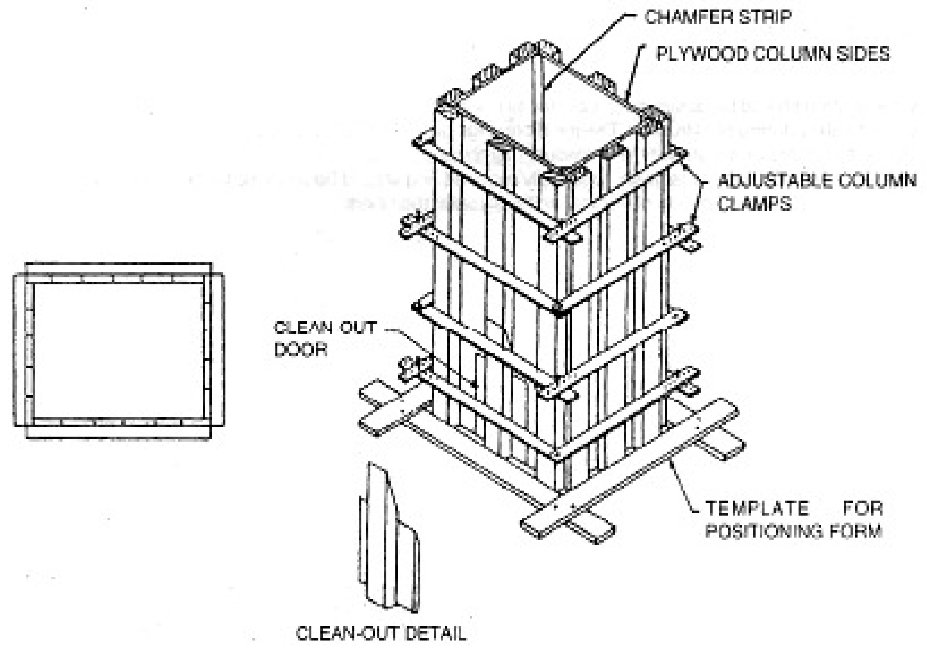


Fig.6: Typical Construction of Heavier Column

1.86 Walls

The shuttering shall be fixed at required distance equal to the required wall thickness. The two faces of shutters of the wall should be kept in place by appropriate ties with spacer tubes or bolts, braces and studs (see Fig 1)

1.87 Beams and floor slabs

When single post prop is used, it should be adequately braced and connected to the nearest props (see Fig. 7 and Fig 8).

1.88 Inclined Members

Members inclined to horizontal may have a single bottom shuttering is the angle of inclination is less than or equal to 400. Otherwise double shuttering shall be required.

1.89 Timber connections

Bolting is preferred to nail foints to avoid damage to formwork material. The splices can be made by using a pair of mild steel or timber fishplates connected with bolts in timber. The splice piece should be at least 600 mm long, 50 mm mm thick with width not less than the width of the prop.

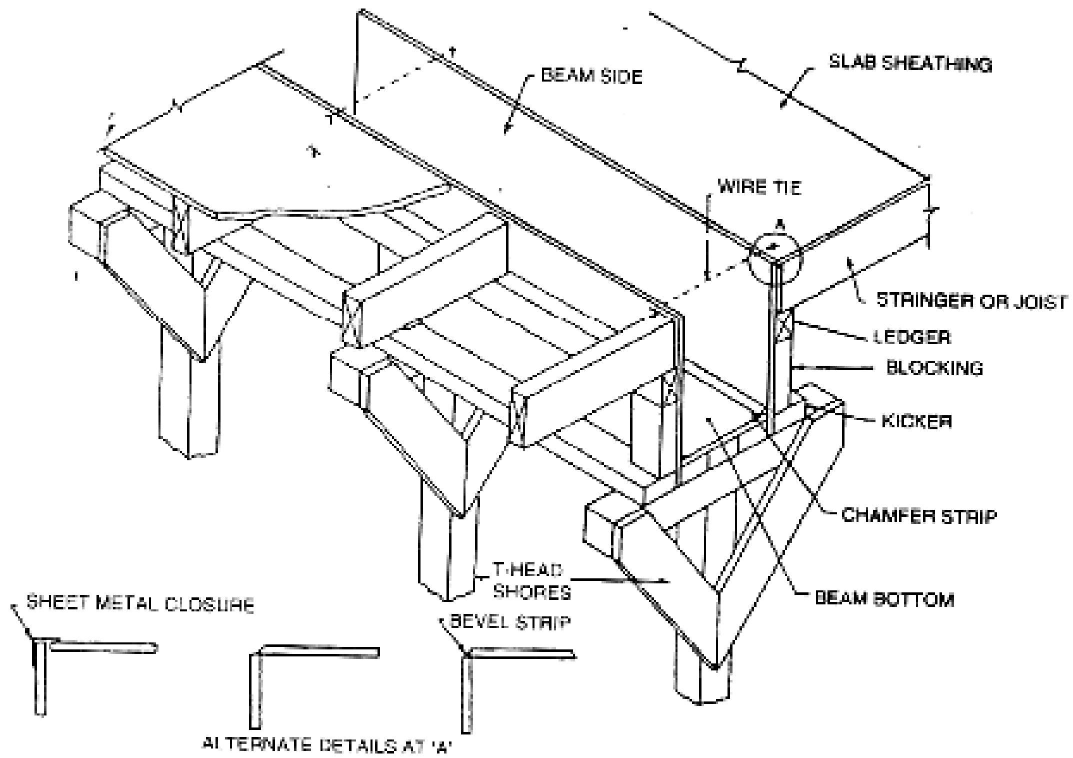


Fig.7: Typical Components of Beam form Work with Slab Framing

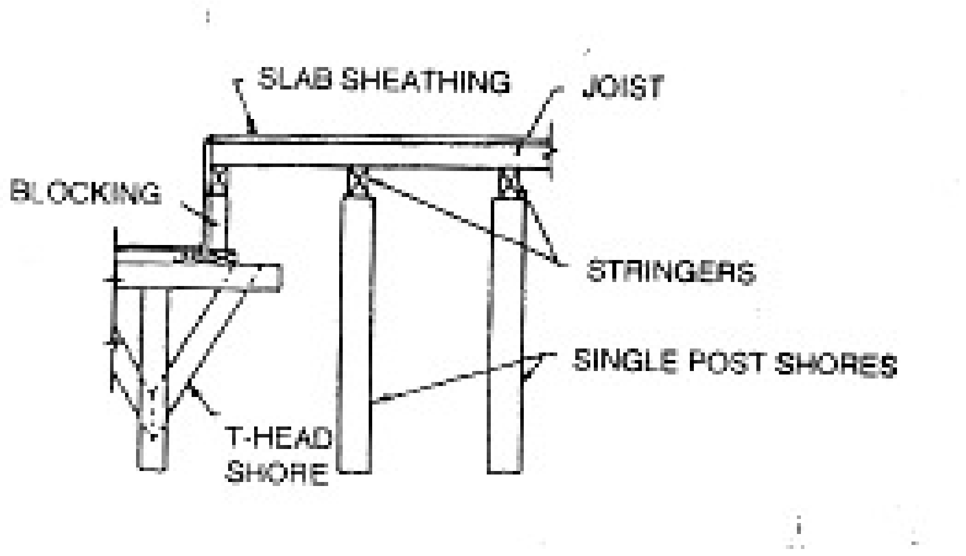


Fig.8: Typical Slab form Resting on beam Ledger and Stringers

1.90 Site Operation

1.91 Safety Precaution

Construction procedures should be planned in advance to ensure the safety of personnel and equipments and the integrity of the finished structure. Some of the safety provisions which should be considered are:

(a) Erection of safety signs and barricades to keep unauthorized personnel clear of areas in which erection. Concrete placing. Or strippling is under way.

(b) Providing experienced form watchers during concrete placement to assure early recognition of possible form displacement or failure. A supply of extra shores or other material and equipment that might be needed in an emergency should be readily available.

(c) Provision for adequate illumination of the formwork and work area.

(d) Inclusion of lifting points in the design and detailing of all forms which will be crane handled. This especially important in flying forms or climbing forms. In the case of wall formwork, consideration should be given to an independent scaffold bolted to the previous lift.

(e) Incorporation of scaffolds, working platforms, and guard rails into formwork design and all formwork drawing

(f) A programme of field safety inspections of rormwork.

(g) In case structural elements such as cantilever, beams/slabs, wher overturning is an important parameter, stripping of formwork shall be done only after mobilization of full restraining forces.

1.92 Erection of falsework

Following should be checked during erection of falsework.

(a) All provisions of the design and drawings should be complied with

(b) Any member, which has to remain in position during or after the general releasing of falsework, should be clearly marked.

(c) The materials used should be checked to ensure that undesibable or rejected items are not used.

(d) Any excavations nearby which can influence the safety of the falsework, should be accounted for the planning.

(e) The bearing soil should be sound and suitably prepared. The sole plates should fully bear on the ground, without possible settlement.

(f) Safety measures should be taken to prevent impact of traffic, scour due to water, etc.

(g) Adequate bracings, struts and ties should be installed with the progress of erection to ensure strength and stability of falsework at intermediate and final stages.

(h) Inclined forms, which give rise to very high horizontal forces should be taken care of by trussing and diagonal bracing (see Fig. 9)

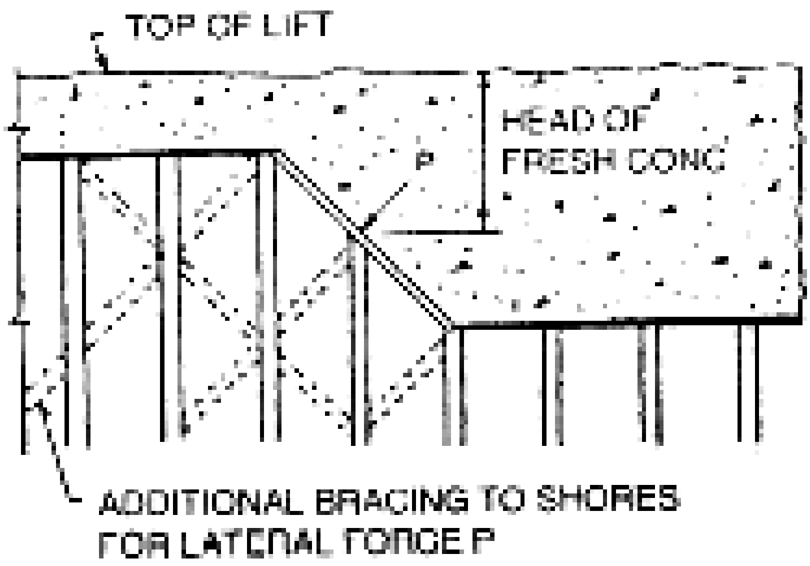


Fig.9: Simplified Drawing of Inclined Slab form with Supporting Shores

(i) The places of stacking of materials should be marked as per provision in falsework design and it should be ascertained that the stacking is done only at proper places.

(j) The deterioration of materials due to storage, reuse and misuse should be checked and corrective steps taken for safety.

(k) Wedges should be provided for adjustment of the falsework to the required position, after any settlement or elastic shortening of props occur.

(l) The inclined plane of the wedges should not be too steep and the pair should be nailed down after adjustment to prevent their shifting. A pair of two matched and equal wedges should be used in opposition. And not one wedge only by itself. The wedges should not induce eccentricity.

1.93 Reuse and Maintenance of Formwork

13.3.1 Timber Formwork.

Timber should be generally examined for any visible damage during use and be discarded or its safe capacity suitably reduced if any of the following is present :

a) Signs of rot.

b) Cuts of the edge greater than 1/20 of the thickness of the section.

c) Bolt holes in the two outer third lengths or width.

d) Undue distortion of shape.

e) Any other mechanical damage.

f) Splitting.

1.94 Metal Formwork

Forms which are to be reused shall be carefully cleared and properly repaired between uses. Concrete or mortar film sticking to the form face or the joining surface shall be completely removed after each use when not required for use, the formwork material shall be properly stored. The component shall be cleaned and painted periodically. Threaded parts shall be oiled greased after thorough clearing and removal of dirt or slurry. Free movement of the telescopic components shall be ensured by periodic cleaning/oiling.

1.95 Concreting Operations and the Application of Loads

Following shall be checked, before and during concreting operations or load application:

(a) Adequate access ramps, gangway, etc. in the proper positions are provided for the smooth flow of men, materials and machines.

(b) All precautions are taken to prevent accidental impact, scouring or flooding of foundations. Adequate precautions should also be taken to keep unauthorized people away from the falsework.

(c) The forms shall be clean and free from wood shavings. Grit, etc.

(d) Forms and joints are such that they prevent leakage of mortar and slurry.

(e) Only approved coating of form release agent are applied, and the reinforcement are clean from the same.

(f) The sequence, rate of concreting, and method of placement and position of construction joints are as per the design brief. In some cases, the load of fresh concrete and the live load at one place may cause uplift of the forms at another place and thus result in displacement of the forms and danger to the props by sousing wedges, etc. Positions of such possibilities be checked.

(g) The reinforcement and falsework have permission to commence the placement of concrete has been accorded.

(h) The thickness of the concrete are maintained all along the member as per drawing, even when camber have been provided.

(i) The props are bracings should be watched during the placement of concrete and its vibration. Any members or wedges which may tend to become loose or shift should be attended immediately. An agreed system of communication between the man below and the man in charge of concrete operations should be established so that corrective actions as required may be taken and concreting can be stopped instantly if at all it becomes necessary to do so.

(j) Platforms for the movement of workers and mechanized concrete buggies are separate and are not placing load upon the reinforcing steel. If this is unavoidable, steel chairs should be placed under the reinforcement at adequate spacing to prevent deformation of the reinforcement.

1.96 Stripping of Falsework

Also releasing or dismantling or removing or de – shuttering of formwork.

9.5.1 Soffit falsework shall not be released unit the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected, at the time of removal. The strength referred to shall be that of concrete using the same cement, aggregates and admixture, if any with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work.

While the above criteria of strength be the guiding factor for removal of formwork, in normal circumstances where ambient temperature does not fall below 150 C and where ordinary Portland cement is used and adequate curing is done, following strucking period may deem to satisfy the guidelines:

Vertical formwork to columns, walls beam	16-24 h
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
Soffit formwork to beams (props to be refixed immediately after removal of formwork	7 days
Props to slabs :	
(a) Spanning up to 4.5 m	7 days
(b) Spanning over 4.5 m	14 days
Props to beams and archer	
(a) Spanning up to 6 m	14 days
(b) Spanning over 6 m	21 days

For other cements and lower temperature, the stripping time, recommended above may be suitably modified. When formwork to vertical surface, such as beam sides, walls and columns, is removed at early ages, care should be exercised to avoid damage to the concrete especially to arises and features. If necessary, the provision of relevant curing methods should immediately follow the removal of the vertical formwork at such age and the concrete should be protected from low or high temperatures by means of suitable insulation.

Supporting forms and shores must not be removed from the beams, floors and walls unit these structures/ units are strong enough to carry their own weight and any approved superimposed load. Supporting forms and shores should not be removed from the horizontal members before concrete strength is at least 70 percent of design strength.

As a general rule, the forms for columns and piers may be removed before those for beams and slabs. Formwork and supports should be so constructed that each can be easily and safely removed without impact or stuck to permit the concrete to carry its share of the load gradually and uniformly.

13.4.1 Following should be checked before and during release of falsework :

(a) The person concerned and the workers are in the knowledge of the sequence of releasing of forms and the props to be left in position.

(b) All falsework material are properly stacked and maintained in good condition. Any items which may be damaged or wrecked while stripping are segregated. Any member should not be allowed to be dropped from a height but should be carefully brought down.

(c) Forms are eased off from concrete faces such as to prevent damage to both concrete and forms.

(d) The sequence of dismantling, as laid down, are adhered to. If not laid down the sequence are planned by the agency doing falsework, and that are safe for the workers and the permanent construction.

1.97 Telerance in Formwork

The formwork shall be such that the finished concrete shall be in the proper position in space measured with respect to certain predefined reference points. Formwork should be of the proper dimensions and shape as per drawings. The tolerances on the shape, lines and dimensions shown in the drawing shall be within the specified limits given below :

(a) Deviation from specified dimensions of cross-section of columns and beams	-6 mm +12 mm
(b) Deviation form dimensions of footings	
(1) Dimensions in plan	-12 mm +50 mm
(2) Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm ± 0.50 times the specified thickness

1.98 Accuracy of Falsework

Unless otherwise specified, the limiting criteria recommended in 9.7.1 and 9.7.2 should not be exceeded on site.

13.4.2 Adjustable Steel Props and Forkheads

The following limiting factors are appropriate to adjustable steel props :

(a) Props should be undamaged and not visibly bent.

(b) Props should be plumb within 1.5^0 of vertical (that is, not exceeding 25 mm out of vertical over a height of 1 m).

(c) Props should be placed centrally under the member. To be supported and over any member supporting the prop, with no eccentricity in excess of 25 mm.

Tube and Coupler Falsework

In case of tube and coupler falsework the following factors should apply :

(a) The tubes used in false work should be undamaged, not visibly bent or creased and have smooth square cut ends. Other components should also be undamaged.

(b) Vertical should be plumb within 15 mm over 2 m of height, subject to a maximum displacement for the vertical of 25 mm.

(c) Vertical members should be placed centrally under the members to be supported and over the member supporting them with no eccentricity exceeding 25 mm.

(d) Adjustable fork head and base plates should be adequately laced or baced where their extension 300 mm, unless an alternative figure is specified. The bracing tubes should be attached close to the fork or base plate and to an adjacent vertical member, close to the lacing.

(e) Tubes should have end-to-end joints in adjacent tubes staggered. Sleeve couplers should be used in preference to joint pins for axial connections.

(f) The centerlines of tubes at node point should be as close together as possible, and never more than 150 mm apart.

(g) Sole plates used to distribute falsework loads on the foundation soils should normally be set horizontally within a tolerance not exceeding 25 mm in a length of 1 m.

13.4.3 Fabricated Steel Works

The following tolerances should be adopted for purposely fabricated steelwork:

(a) Inclination of a column from vertical (see Fig.10)

(1)	For column of length, L_S	< 1450 mm
(2)	For column of length L_S	5 mm >1450 mm $\Delta_v 0.0035\ L_s$ Or 25 mm Which ever is the lesser

Where

L_s = clear length of strut or column (in mm), and

Δ_v = inclination from vertical (in mm)

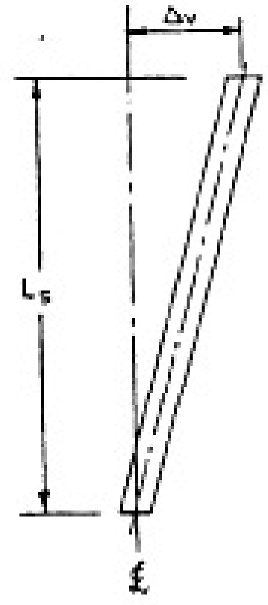


Fig. 10: Inclination of column from Vertical

(b) Out of straightness of a strut or column (see Fig. 11)

(1) for a column or strut of length L_s < 3350 mm

$\Delta_s \not> 5$ mm

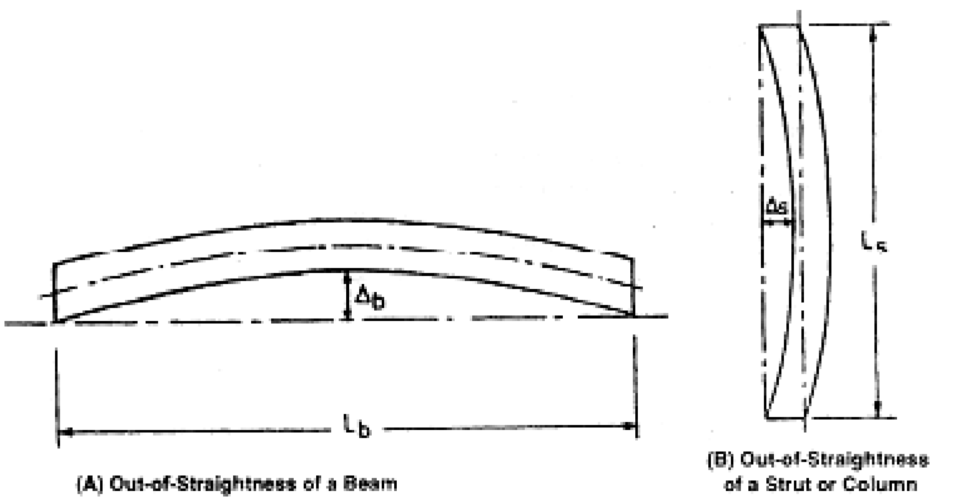


Fig.11: Points of Measurement of Tolerances for Purposely Fabricated Steel Work

f strut of length L_S

$L_s > 3350$ mm

$\Delta_s \not> 0.0015$ L_s or 25 mm, whichever is lesser

Where

= clear length of strut or column (in mm), and

= out of straightness of the column or strut (in mm)

(c) Eccentricity of beam bearing

The eccentricity of beam bearing

The eccentricity of any beam should not exceed 5 m

9.8 Checking

9.8.1 Format checks are recommended

(a) When the proposed founding level for the falsework is in preparation :

(b) When the false work has attained a height to 10m or a height equal to 1.5 times the minimum of its plan dimensions :

(c) When the false work reaches its support level ,

(d) At intermediate stages, when the strength or stability of the falsework may have been adversely affected by environmental or other loading conditions or unauthorized interference.

(e) Where equipment is being continually reused and periodic checks are appropriate and

(f) Immediately prior to load being applied.

9.8.2 At the stages indicated in 9.8.1 through inspection of the false work is necessary to ensure that the completed structure will function as indicated.

The inspection should be undertaken with direct reference to any drawing or specification that has been issued, and checks subsequently to the first should inspect every feature that could have altered in the intervening period.

(a) General

(1) All the drawing and written instructions have been strictly complied with :

(2) Only the correct materials in serviceable conditions have been employed, specially of specific types of qualities required as will normally be the case with structural steel or timber.

(b) At ground level

(2) The setting out is correct;

(3) The ground has been adequately prepared and at a satisfactory level (foundations appearing sound in dry or freezing conditions can be quite inadequate following rain or thaw;

(4) Suitable sole plates or other bases have been provided and have been properly leveled;

(5) Sole plates or other bases have not settled;

(6) Sole plates have been properly bedded down (no cavities underneath), and steps taken to prevent erosion;

(7) Sole plates and other load-distributing members laid on the slope are adequately prevented from movement down the slope;

(8) Any checks or other supports are of the correct shape, and are adequately secured;

(9) Base plates have been used and are properly spaced and centeed on the sole plates; and

(10) The extension of each screw or adjustable base is within the permitted limits, and braced, if necessary.

(c) Above ground level

All the points applicable for the falsework above the ground, mentioned in 9.2, shall be checked.

6-BRICK WORK

LIST OF MANDATORY TESTS

Material	Clause	Test	Field/ Laboratory Test	Test Procedure	Minimum quantity of material For carrying out test	Frequency of testing
Bricks/ Brick Tiles	6.1.3 to 6.1.3.6	Testing of Bricks/Brick Tiles for dimensions compressive water absorption and efflorescence	Laboratory	Appendix A,B,C &D of Chapter 6		As per Table 3 and 4

LIST OF BUREAU OF INDIAN STANDARD CODES (ISI)

SI. NO.	IS. NO.	Subject
1.	712-1984	Building lime (3rd Revision) Reaffirmed 1991.
2.	1077-1992	Common burnt clay building bricks (5th Revision).
3.	1200(Part 3)-1976	Method of measurements of building and civil engineering works: Part 3 Brick work (3rd Revision) Reaffirmed 1992.
4.	2212-1991	Code of practice for brick work (1st Revision).
5.	3102-1971	Classification of burnt clay solid bricks (1st Revision) (Superseded by Common burnt clay building bricks) (5th Revision).
6.	3495-1976	Method of test for building bricks. (Part 1 to 4 in one volume)

(Part 1-4) (3^{rd} Revision).

7. 3812-1981 Fly ash for use as pozzolana and admixture. (1^{st} Revision) Reaffirmed 1992.

8. 5454-1978 Methods of sampling of clay building bricks.

9. 12894-1990 Fly ash-lime bricks.

LIST OF OTHER BIS CODES THAT MAY BE REFERRED

I.S. NO.	Subject
195-1963	Specification for fire clay mortar for laying fire clay refractory bricks. (Second revision).
702-1961	Specification for industrial bitumen (revised).
1077-1986	Specification for common burnt clay building bricks(Fourth revision).
1526-1960	Sizes and shapes for fire bricks(230 mm series).
	Specification for bituminous compounds for water proofing and caulking purposes(first revision).
	Specification for sand for masonry mortars (first revision) (second revision).
2116-1980	Specification for send for masonry mortars(first revision). (second revision).
2386(part 11)-1963	Methods of test for aggregates for concrete. Part II-Estimation of deleterious materials and organic impurities.
2508-1984	Specification for low density polyethylene film (second revision).
2691-1972	Specification for burnt clay facing bricks (first revision)
	Specification for bitumen primer for use in water proofing and damp proofing.
4832(Part II)-1969	Specification for chemical resistant mortars, Part II, Resin type.
4832-(Part III)-1968	Specification for chemical resistant mortars, Part III, Sulphur type.
5454-1978	Methods for Sampling of clay building brick (first revision).
4860-1968	Specification for acid resistant bricks.
6165-1971	dimension for special shapes of clay bricks.
10440-1983	Code of practice for construction of R.B. and R.B.C. floor and roof.

6.BRICKS WORK

1.99 Terminology

Bond: The arrangement of the bricks in successive courses to tie the brick work together both longitudinally and transversely. The arrangement is actually designed to ensure that no vertical joint of one course is exactly over the one in the next course Above or below it, and there in greatest possible amount of lap.

Bed Joint: Horizontal joint in brick work or masonry.

Closer: Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course(see fig.3)

Coping a Weathering: the cover applied over or the geometrical from given to a part of structure to enable it to shed rain water.

Corbel: A cantilever projecting from the face of wall to form a bearing(see Fig.1D)

Cornice: Horizontal or ornamental feature projecting from the face of a wall(see Fig.1d)

Course: A layer of bricks including bed mortar.

Cross Joint: A joint other than a bed joint normal to the wall face.

Efflorescence: A powdery incrustment of salt left by evaporation. This may be visible on the surface or may be below the surface.In the later case, this is termed as crypto Efflorescence.

Header: A brick laid with its length across the wall.

Indenting: The leaving recesses into which future work can be bonded.

Jamb: The part of the wall at the side of an opening.

Joint: A junction of bricks.

Jointing: The operation of finishing joints as the masonry works proceeds.

Pier: A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or the wall or to carry a vertical concentrated load. The thickness of a pier is the over all thickness including the thickness of the wall, or when bonded into leaf of a cavity wall the thickness obtained by treating this leaf as an independent wall [see Fig. (1A, 1B)].

Pillar: Pillar means a detached masonry support. This can be rectangular, circular, elliptical etc. In case of rectangular pillar, the breadth shall not exceed three times the thickness and thickness itself shall not exceed more than thrice the length of brick (see Fig. 1C).

Quoin: An external corner in brick work, the term may also denote the brick used to form the quoin.

Scaffolding: A temporary erection of timber or steel work used in the construction, alternation, demolition or repairs of a building to support or to attend of the hoisting or lowering of workmen, their tools and materials.

Still: A brick work forming the lower boundary of door or window opening (see Fig. 1D).

Spandrel: The space between the haunches and the road decking of an arch.

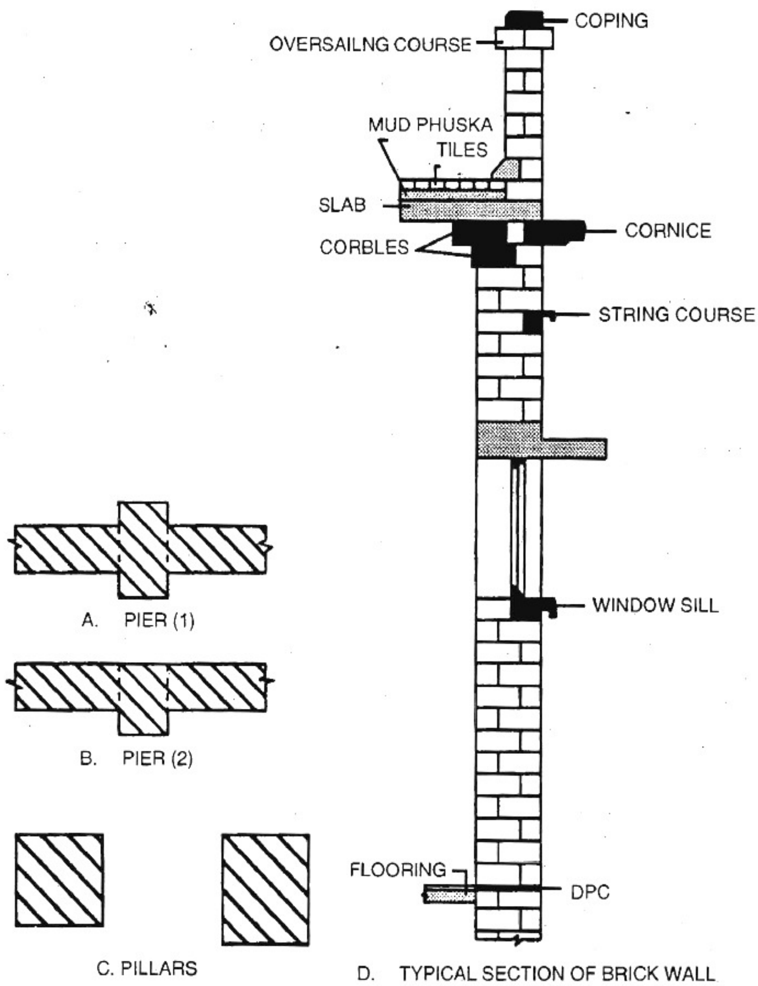
Strecher: A brick laid with its length in the direction of the wall.

String course: A horizontal course projecting from a wall usually introduced at every floor level or window or below parapet for imparting architectural appearance to the structure and also keeping off the rain water.(see Fig. 1D).

Templet: A pattern of sheel metal used as a guide for setting out specific section and shape.

Toothing: Bricks left projecting in alternate courses to bond with future work.

Wall joint: A joint to the wall face.



THE BREADTH SHALL NOT EXCEED THREE TIMES
THE THICKNESS AND THICKNESS ITSELF SHALL NOT
EXCEED MORE THAN THREE BRICKS

Figure 1: Brick Work (Clause 6.08)

1.100 Explanatory Notes and Comments

Terminology

(1) Arrises: The edge of a brick are formed by the inter section of the plain of the brick. The edges thus formed are called arrises should be form any damage & square. See Exhibit 6.1.

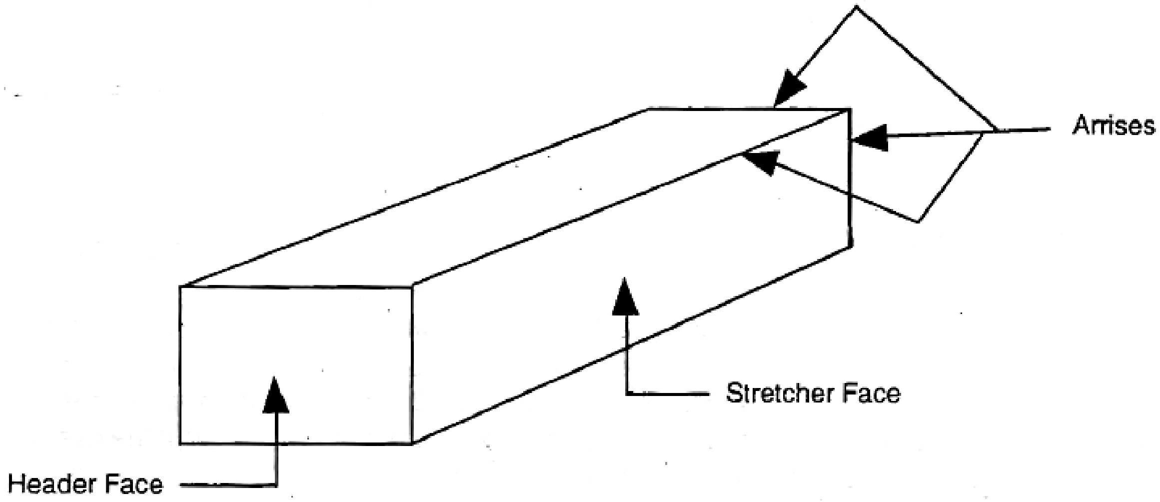


Exhibit 6.1 : A Common Building Brick

(2) Bed: When the brick is laid flat the lower surface of the brick is called the bed.

(3) Bed joint: The horizontal layer of mortar which should not be less than 10 mm in thickness is termed as bed joint.

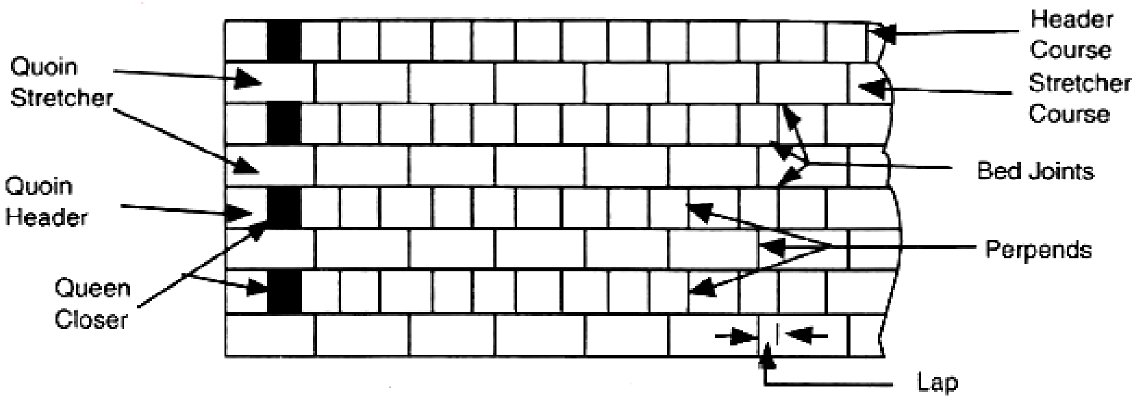


Exhibit 6.2: Brick-Work English Bond

(4)Perpends: The vertical joint of the bricks on header course stretcher course are called as perpends. These perpends should be one above the other in alternate course. See **Exhibit 6.2**.

(5) Lap: Lap is a horizontal distance between the joint of stretcher course with header course in case of brick-work in EnglishBond. For a good brick work the length of the lap should be equal to one fourth of the length of brick. See Exhibit 6.2.

(6) Racking Back: When a brick wall has to be terminated instead of terminating the same in a vertical position if the sameis terminated in stepped fashion it is known as racking batch.

(7) Toothing: When a brick wall has to be terminated and then continued after a considerable time, the wall its terminated vertically but to secure bondage with the new construction, alternate layer bricks are projected beyond the face of termination, and this projection of alternate bricks is called toothing.

(8) Closer: The CPWD Specification states that any portion of brick used in constructing a wall, to close up the bond next to the end brick of a course. Figure 3 of the Specification is also not clear as no details are given except "Queen Closer". The specification thus permits unscrupulous contractors to use brick bats freely, since it clearly states that any portion of the brick can be treated as a closer. In fact , probably this is the main reason that most of the contractors doing the Government works freely use brick bats and broken bricks without reservation.

On the other hand, there are many types of closer and each type of closer is to preferred out of the regular solid brick and not the brick bats, and unless the different types of closers are mentioned in the specification neither the contractor will follow the correct method not the site engineering will be in a position to insist upon getting the getting the correct work done. Hence, a queen closer prepared out of a solid brick is introduced next to the quoin. This introduction of the Vertical line and prevents the same falling in one vertical position of the joint of the successive layer.

There are several types of closers used for various purposes. Some of the closers are given below:

(a) Queen Closer: A solid brick is cut longitudinally in two equal parts and the above half brick is called queen closer. Instead of cutting the brick longitudinally we can cut the same breadth wise in quarter length and in that case two closers one from each face will have to used. However, a single piece is preferable. The queen closer is normally placed next to quoin header as shown in Exhibit 6.2.

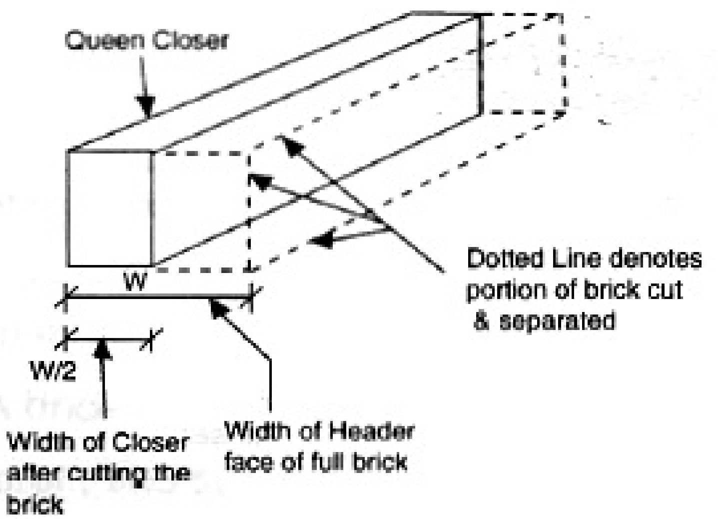


Exhibit 6.3 : Queen Closer

(b) King closer: While doing work on jambs during the fixing of doors or windows, brickbats are freely used to get the Satisfactory arrangement of mortar joints, at such places one can use these closers very conveniently. The king closer is obtained by cutting half portion of header face half portion of stretcher face in triangular position, as shown in Exhibit 6.4.

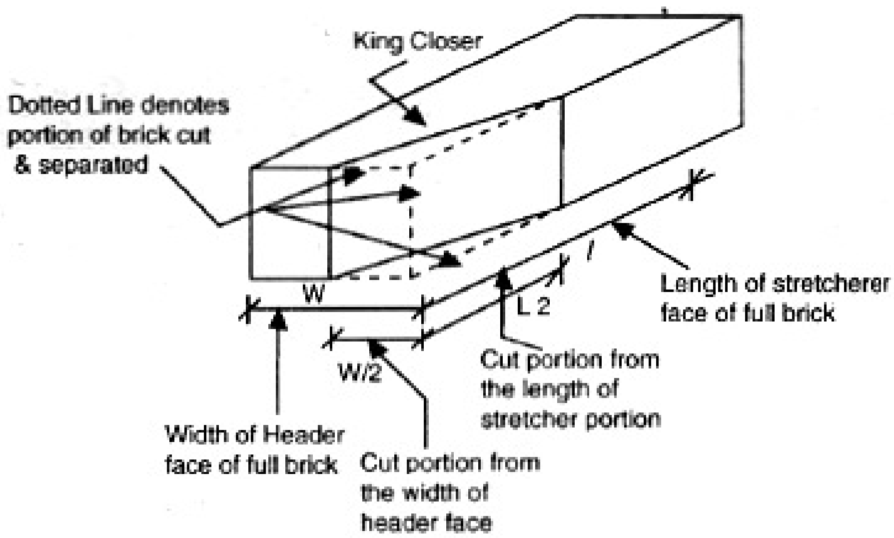


Exhibit 6.4 : King Closer

(c) Bevelled Closer: To construct splayed brick work the mason takes resort brick to bats but use of bevelled closer which appears as closer at one face and a header at other face is most convenient.

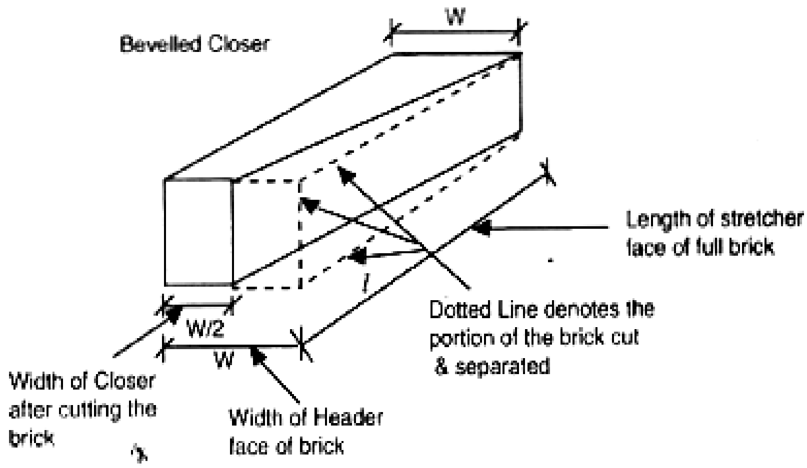


Exhibit 6.5: Bevelled Closer

The beveled closer is obtained by cutting a triangular portion of the brick, from half the width of the brick to the end of length side, as shown in Exhibit 6.5. Any good mason will be in a position to prepare these closers neatly.

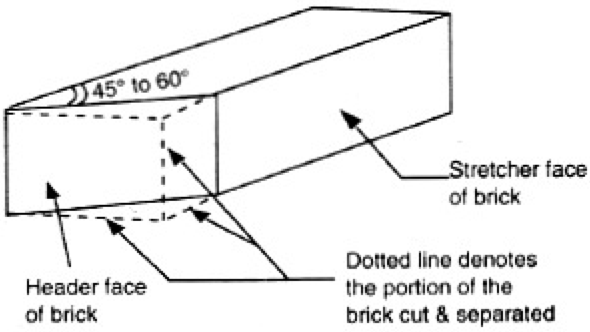


Exhibit 6.6: Mitred Closer

(d) Mitred Closer: It has been seen that when a wall is being closed at corners or near pillars the necessity of closer arises and mostly the mason takes resort to brick bats and completes the job but the method of using brick bats so freely is not a healthy practice. The real solution is to use regular closers and these closers are called mitred closers. These closers are called mitred closers. These closers are made by cutting a triangular portion of the brick through its width at an angle of 45° to 60° with length of the brick, as shown in Exhibit 6.6.

1.101 Bricks/Brick Tiles/Brick Bats

Bricks used in the masonry may be of the following type:

(a) Common burnt clay bricks: Shall be hand moulded or machine moulded. They shall be free from nodules of free lime, visible cracks, flaws warpage and organic matter, have a frog 100 mm in length 40 mm in width and 10mm to 20mm deep of one of its flat sides. Bricks made by extrusion length process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufactures identification mark or initials.

(b) [Fly Ash Lime Bricks (FALG Bricks): The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS: 12894-1990. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side.
Fly Ash: Fly Ash conform to grade 1 or grade 2 of IS: 3812-1981.

Note: This item will be operated only for load bearing structure upto 2 storeys and for non-load bearing walls 23 cms thick for multi-storeyed building's.]
Bottoms ash used as replacement of sand shall not have more than 12% on ignition when tasted.
Sand: Deleterious materials, such as clay and sit in the sand shall preferably be less than 5%.
Lime: Lime shall conform to class "C' hydrated lime of IS : 712.
Additives: Any suitable additive considered not detrimental to the durability of bricks may be used.

(c) [1]**[Clay Fly Ash Bricks:** The clay fly ash bricks shall conform to IS: 13757-1993. Thed bricks shall be Sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square Corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free time and organic matter, the brick shall be hand or machine moulded. The bricks shall have frog of 100mm in length 40mm width and 10 to 20mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs.

Fly ash shall conform to grade II of IS : 3812-1981.]

(d) Fly ash shall conform to grade I or grade II of IS:3812.

[1][Calcium Silicate Bricks: The bricks shall conform to IS: 4139-1989. The Calcium Silicate Bricks shall be sound, compact and uniform in shape. Bricks shall be free from visible cracks, warpage organic matter, large pebbles and modules of free lime. Bricks shall be solid and with or without for. The bricks shall be made of finally grounded sand siliceous rock and lime. In addition limited quantity of fly ash confirming to IS: 3812-1981 may be used in the mix. These bricks are also known as Fly Ash Sand Lime bricks in the construction industry.]

(e) **Tile Brick:** The Brick of 4 cm heath shall be moulded without frogs. Where modular tiles are not freely available in the market, the tiles bricks of F.P.S. thickness 44mm(1-3/4") shall be used unless otherwise specified.

(f) **Brick Bats:** Bricks bats shall be obtained from well burnt bricks.

1.102 Dimensions

The bricks may be Modular or non-modular. Sizes for both types of bricks\tiles shall be as per Table1.hile use of modular bricks /tiles is recommended, non modular (FPS) bricks/tiles can also be used where so specified. Non-modular bricks/tiles of size other than the sizes mentioned in Table may also be use where specified.

Table 1

Types of bricks/Tiles	Nominal Size Mm	Actual Size mm
Modular bricks	200 x 100 x 100 mm	190 x 90 x 90 mm
Modular tile bricks	200 x 100 x 40 mm	190 x 90 x 40 mm
Non-modular tile bricks	229 x 114 x 44 mm	225 x 111 x 44 mm
Non-modular bricks	229 x 114 x 70 mm	225 x 111 x 70 mm

1.103 Classification

Bricks/brick tiles shall be classified on the basis of their minimum compressive strength as given below:

Table 2

Class/ Designation	Average compressive strength Not less than		Less than	
	N/mm^2	(kgf/cm^2)	N/mm^2	(kgf/cm^2)
10(10)	10	(100)	12.5	125
7.5(75)	7.5	(75)	10	100
5(50)	5	(50)	7.5	75
3.5(35)	3.5	(35)	5.0	50

The bricks shall have smooth rectangular faces with sharp corner shall be uniform in colour1[and emit clear ringing] sound when struck.

(Note: Upper limits specified in Table 2 are for calculating the average compressive strength in accordance with appendix B of Chapter 6).

1.104 Sampling and Tests

Samples of bricks shall be subjective to the following tests:

(a) Dimensional tolerance.

(b) Water absorption.

(c) Efflorescence.

(d) Compressive strength.

1.105 Sampling:

For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random according to the size of lot as given in Table 3 below. The samples thus taken shall be stores in a dry place until test are made. For the purpose of sampling, the following definition shall apply:

(a) Lot: A collection of bricks of same class and size, manufactured under relatively similar conditions of production. For the purpose of sampling a lot shall contain a maximum, of 50,000 bricks. Incase a consignment has bricks more than 50,000 of the same classification and size and manufactured under relatively similar conditions of production, it shall be divided into lots of 50,000 bricks or part thereof.

(b) Sample: A collection of bricks selected for inspection and/or testing from a lot to reach a decision regarding the acceptance or rejecting of the lot.

(c) Defective: A brick failing to meet the one or more of the specified requirements.

1.106 The samples shall be taken as below:

(i) **Sampling from a Stack:** When it is necessary to take a sample from a stack, the stack shall be divided into a number of real or imaginary sections and the required number of bricks drawn from Clause 6.1.3.2 each section. For this purpose bricks in the upper layers of the stick shall be removed to enable units to be sampled from places within the stack.

Note: For other methods of sampling that is sampling in motion and sampling from lorries or trucks, IS: 5454 may be referred.

Scale of sampling and criteria for conformity for visual and dimensional characteristics:-

Visual characteristics: The brick shall be selected and inspected for ascertaining their conformity to the requirement of the relevant specification.

The number of bricks to be selected from a lot shall depend on the size of lot and shall be in accordance of Col. 1 and 2 of Table 3 for visual characteristics in all cases and dimensional characteristics if specified for individual bricks.

(ii) **Visual Characteristics:** All the bricks selected above in accordance with Col. 1 and 2 of Table 3 shall be examined for visual characteristics. If the number of defective bricks found in the sample is less then or equal to the corresponding number as specified in Col. 3 of Table 3 the lot shall be considered as satisfying the requirements of visual characteristics, otherwise the lot shall be deemed as not having meet the visual requirements.

(iii) **Dimensional Characteristics:** The number of bricks to be selected for inspecting the dimensions and tolerance shall be in accordance with Col. 1 and 4 of Table 3. These bricks will be divided into groups of 20 bricks at random and each of the group of 20 bricks thus format will be tested for all the dimensions and tolerances. A lot shall be considered having found meeting the requirements of dimensions and tolerance if none of the groups of bricks inspected fails to meet the specified requirements.

TABLE 3

SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVE FOR VISUAL AND DIMENSION CHARACTERISTIC

No. of bricks in the lot	For characteristic specified for individual bricks		For dimensional characteristics for group of 20 bricks- No. of bricks to be Selected
	No. of bricks to be selected	Permissible no. of defective in the sample	
(1)	(2)	(3)	**(4)**
2001-10000	20	1	**40**
10001 – 35000	32	2	**60**
35001 – 50000	50	3	**80**

Note: In case the lot contains 2000 or less bricks the sampling shall be as per decision of the Engineer-in-Charge.

(iv) Scale of Sampling and Criteria for Physical Characteristics: The lot which has been found satisfactory in respect of visual and dimensional requirements shall be next tested for physical characteristics like compressive strength, water absorption, efflorescence as specified in relevant material specification. The bricks for this purpose shall be taken at random from those already selected above. The number of bricks to be selected for each of these characteristics shall be in accordance with relevant columns of Table 4.

TABLE 4

SCALE OF SAMPLING FOR PHYSICAL CHARACTERISTICS

Lot size	Sample size for compressive strength, water absorption and efflorescence	Permissible No. of defectives for efflorescence
(1)	(2)	(3)
2001 – 10000	5	0
10001 – 35000	10	0

35001 – 50000	15	1

Note: In case the lot contains 2000 or less bricks, the sampling shall be as per decision of Engineer-In-Change.

(v) A lot shall be considered having satisfied the requirements of physical characteristics if the condition stipulated here in are all satisfied.

(a) From the test results for compressive strength the average shall be calculated and satisfied the requirements specified and relevant material specification.

Note: In case any of the test results for compressive strength exceed the upper limit for the classes of bricks, the same shall be limited to upper limit of the class for the purpose of averaging.

(b) Wherever specified in the material specifications, the compressive strength of any individual bricks tested in the sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 per cent.

(c) From the test results for water absorption the average for the bricks in the sample shall be calculated and shall satisfied the relevant requirements specification in material specification.

(d) The number of bricks failing to satisfied the requirements of the efflorescence specified in the relevant specifications should not be more than the permissible no. of defectives given in Col. 3 of Table 4.

1.107 Dimensional tolerances:

The dimensional of modular bricks when tested as described above as per procedure described in Appendix A of Chapter 6 shall be within the following limits per 20 bricks:

Length 372 to 388 cm (380+8cm)

Width 176 to 184cm (180+ 4cm)

Height 176 to 184 cm (180 +4cm) for 90 mm high bricks.

Brick Tiles

76 to 84 cm(80+4) for 40 mm high brick tiles.

In case of non-modular bricks, % age tolerances will be +2% for group of 20 numbers of class. 10 bricks, and +4% for other class of bricks.

1.108 Compressive strength:

The bricks, when tested in accordance with the procedure laid down in Appendix B of Chapter 6 shall have a minimum average compressive strength for various classes as given in Table 2. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%. In case compressive strength of any individual brick tested exceeds the upper limits specified in Table 2 for the corresponding class of bricks, the same shall be limited to upper limit of the class as specified in Table 2 for the purpose of calculating the average compressive strength.

1.109 Water absorption:

The average water absorption of bricks when tested in accordance with the procedure laid down in Appendix C of Chapter 6 shall be not more than 20% by weight.

1.110 Efflorescence:

The rating of efflorescence of bricks when tested in accordance with the procedure laid down in Appendix D of Chapter 6 shall be not more than moderate.

1.111 Brick Work

1.112 Classification

The brick work shall be classified to class designation of bricks used.

1.113 Mortar

The mortar for the brick work shall be as specified, and conform to accepted standards. Lime shall not be used where reinforcement is provided in brick work.

1.114 Soaking of Brick

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks hall be stacked on a clean place where they are not again spoiled by dirt earth etc.

Note I: The period of soaking may be easily found at site by a filed test in which the bricks are soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in construction work.

Note II: If the bricks are soaked for the required time in water that is frequently change the soluble salt in the bricks will be leached out, and subsequently efflorescence will be reduced.

1.115 Laying

2.1 Bricks shall be laid in English bond (Fig. 2,3,4) unless otherwise specified. For brick work in half brick wall Bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment.

Note: Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top courses of footing shall be headers

3.1 All loose materials, dirt and set lumps of mortar which may be lying over the surface on which brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on a full bed of mortar, when laying, each brick shall, be properly dabbed and set in position by gently pressing with the handle of a trowel. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow space are left inside the joints.

4.1 The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joins shall be truly vertical. Vertical joins in the alternate course shall come directly one over the other. Quoin, Jambs and other angles shall be properly plumbed as the work proceeds. Care shall be taken to keep the perpends properly a aligned within following maximum permissible tolerances :

(a) Deviation from vertical within a storey shall not exceed 6 mm per 3m height.

(b) Deviation in verticality in total height of any wall of building more than one storey in highest shall not exceed 12.5 mm.

(c) Deviation from position shown on plan of any brick work shall not exceed 12.5 mm.

(d) Relative from displacement between load bearing wall in adjacent storey intended to be vertical alignments shall not exceed 6mm.

(e) A set of tools comprising of wooden straight edge, Masonic spirit levels, square, 1 metre rule line and plumb shall be kept on the site of work for every 3 masons for proper check during the progress of work.

5.1 All quoin shall be accurately constructed and the height of brick courses shall be kept uniform. This will be checked using graduated wooden straight edge or storey road indicating height of each course including thickness of joints. The position of damp proof course, window silles, bottom of linthels, top of the wall, etc. along the height of the wall shall be marked on the graduated straight edge or storey road. Acute and obtuse quoins shall be bonded, where practicable in the same way as square quoins. Obtuse quoins shall be formed with squint showing three quarters brick on one face and quarter brick on the other.

6.1 The brick work shall be built in uniform layers.

7.1 No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degrees or less with the horizontal. Toothing shall not be permitted as an alternative to raking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

8.1 All pipe fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified, in their correct position as the work proceeds unless otherwise directed by the Engineer –in-charge.

9.1 Top courses of all plinths, parapets, steps and top of walls below floor and roof slabs shall be laid with brick on edge, unless specified otherwise. Brick on edge laid on the top courses at corner of walls shall be properly radiated and keyed into position to form cut (maru) corners as shown in Fig. 4. Where bricks cannot be cut to the required shape to form cut (maru) corners, cement concrete 1:2:4 (1 cement :2

coarse sand :4 graded stone aggregate 20mm nominal size) equal to thickness of course shall be provided in lieu of cut bricks.

10.1 Bricks shall be laid with frog (where provided) up. However, when top course is exposed, bricks shall be laid with frog down. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the bricks position.

11.1 In case of walls one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

12.1 To facilitate taking service lines later without excessive cutting of completed work, sleeves (to be paid separately) shall be provided, where specified, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

13.1 Top of the brickwork in coping and sills in external walls shall be slightly tiled. Where brick coping and sills are projecting beyond the face of the wall, drip course/throating (to be paid separately) shall be provided where indicated.

14.1 Care shall be taken during construction that edges of jambs, sills and projections are not damaged in case of rain. New built work be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Engineer– in–Charge.

15.1 : Vertical reinforcement in the form of bars (MS o r high strength deformed bars), considered necessary at the corners and junction of wall and jamb opening doors, windows etc. shall be incased with cement mortar not leaner than 1:4 (1 cement : 4 coarse sand), or cement concrete mix as specified. The reinforcement shall be suitably tied, properly embedded in the foundation and at roof level. The dia. of bars shall not be less than 8mm and concrete grade shall be minimum (1cement:3coarses sand : 6 graded stone aggregate 20mm nominal size).

16.1 In reining walls and the like, where water is likely to accumulate, weep holes, 50 to 75 mm square shall be provided at 2m vertically and horizontally unless otherwise specified. The lowest weep hold shall be at about 30 cm above the ground level. All weep holes shall surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

(Note: Work of providing loose stone will be payable extra)

17.1 Work of cutting chases, wherever required to be made in the walls for housing G.I. pipe, CI pipe or any other fixtures shall be carried out in various locations as per guidelines given below:

(a) Cutting of chases in one brick thick and above load bearing walls.

(i) As far as possible services should be planned with the help of vertical chases. Horizontal chases should be avoided.

(ii) The depths of vertical chases and horizontal chases shall not exceed one-third and one-sixth of the thickness of the masonry respectively.

(iii) When narrow stretches of masonry (or sort length of walls) such as between doors and windows, cannot be avoided they should not be pierced with openings for soil pipes or waste pipes or timber joints, etc. Where there is a possibility of load concentration such narrow lengths of walls shall be checked for stresses and high strength bricks in mortar or concrete walls provided, if required.

(iv) Horizontal chases when unavoidable should be located in the upper or lower one-third of height of storey and not more than three chases should be permitted in any stretch of a wall. No continuous horizontal chase shall exceed and kept within the permissible limits.

(v) Vertical chases should not be closes than 2 m in any stretch of a wall. These wall be kept away from bearings of beams and lintels. If unavoidable, stresses in the effected area should be checked and kept within permissible limits.

(vi) Masonry directly above a recess, if wider than 30 cm horizontal dimension should be supported on lintel. Holes in masonry may be provided upto 40 cm in diameter.

(b) Cutting of chases in half brick load bearing walls:

No chase shall be permitted in half brick load bearing walls and as such no recessed conduits and concealed pipes shall be provided with half brick thick load bearing walls.

(c) Cutting of chases in half brick non-load bearing walls: services should be planed with the help of vertical chases. Horizontal chase should be provided only when unavoidable.

1.116 Explanatory Notes And Comments

Mortar

A lot of has been written manufacturing bricks, quality of bricks, laying etc. but unfortunately, the most important facto in masonry, that is, the bonding agent of mortar, has not been dealt in required detail. The specification does not insist on the necessity of using gauge boxes for measuring sand to prepare the mortar.

It has become a general practice to take sand in iron pots and the foreman or maistry guides as to the number of pots of sand to be taken for mixing a particular lot. The supervising staff is, generally particular about maintaining proportions in cement concrete work, but in masonry works the matter is totally entrusted to the foreman. Unscrupulous contractors take undue advantage of it and many a items it is seen that a bag of cement is unloaded on a portion of heap of sand and the mortar prepared for use in masonry.

If the use of boxes is insisted by an Engineer to mix the mortar the contractors will generally get the usual measuring box used for concrete work. As the labour is not willing to go on the job of measuring the small sand boxes, he simply measures one or two loads of mix and discontinues the practice. Also no one bothers about allowance for bulkage etc. and almost a forman's specification is freely followed.

To keep proper check on quality, it is necessary that a suitable box for measuring sand to proper mortar of one full bag cement should be made available so that the labour will not have any excuse. Also it has been shown in chapter 4 that preparing mortar by taking loose cement means straight away consuming less cement.

Normally, the proportions adopted for masonry cement mortar are 1:6 (one cement: 6 coarse/fine sand) or 1:4 (one cement coarse/ fine sand).

Thus, if we have separate boxes for measuring sand for the above two proportions the matter can be solved.

A bag of cement contains 0.035 cum. of cement. The quality of sand required for 1:6 proportion will be 6*o.o35=0.210 Cum, for which we should provide a box of size 830mm*830mm*305mm. The box can be manufactured out of steel or timber.

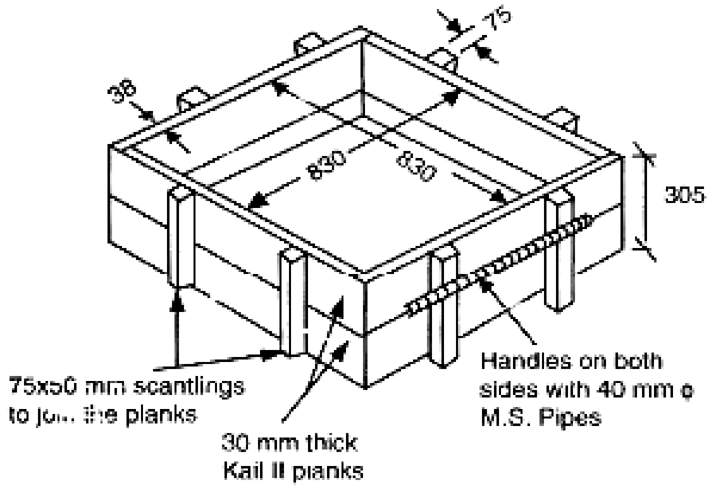


Exhibit 6.7: Box for Measuring Sand to get 1.6 Mortar with One full Bag of Cement

A typical box is shown in Exhibit 6.7 .One box of sand will be sufficient for one full bad of cement. The Site Engineer should calculate the bulkage in sand if sand is moist and add the extra quantity by measuring the same with small size boxes. The labour should be asked to fill the box and the top face of sand should be leveled by using 1.00 mm long scraper. If this method is scrupulously followed use of cement can be regulated and we can get the quality work.

Similarly, for cement mortar 1:4 (one cement : 4 coarse/ fine sand) we need a separate box. One bag contains 0.035 cum cement 4 we require 4 * 0.035=0.14 cum of sand, for which a box of size 750 mm* 750 mm* 250 mm can serve the purpose. One box full of sand will be efficient to mix with one bag cement to get cement mortar of 1:4 proportion. In this case also the scraper should be used to level top sand surface after the box is filled. The above method will help doing a quality job and the mischief of any sort can be checked to a great extent.

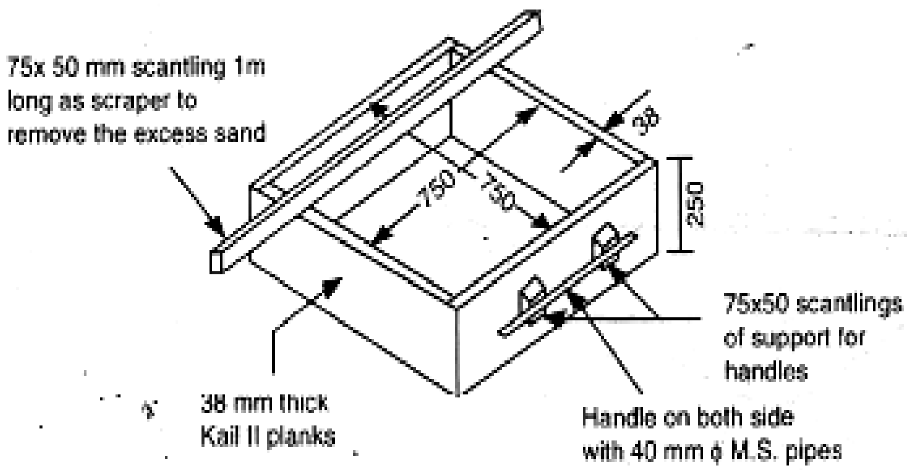


Exhibit 6.8: Box for Measuring Sand to get 1.4 Mortar from One Full of Cement

Another most important factor is the platform to mix the mortar. Generally, it is seen that either some sheets or some bricks are spread and the mortar in mix on the same. The most important factor in preparing the mortar is the mixing should be done on a water proof Platform so that the cement water does not get wasted. The site Engineer should insist on the constructing a suitable platform to mix the mortar. If the mortar is mixed with the help of mixer, the same should be done by adding sand with measuring boxes and not by tokaries. The very purpose of getting good mortar is frustrated, if sand is not added accurately and added on approximate basis. It is advisable to use fixed quality of water for each bag mix.

1.117 Setting Out Or Marking:

Though this is the most important item, rather it is the foundation of total construction. In practice, setting out is limited at the most up to excavation job. Once the excavation is complete and the foundation concrete is laid the masons doing brick work are entrusted with the job of transferring the line from the page to the foundation. The corner are marked with the help of a masons right angel and the job taken up .For doing line out, the mason does not require all he pages at all. He does not bother about the missing pegs, and he does not require it at all. If he can mark centre line and with that he will set out the entire structure. However, the Site Engineer should not allow the above method shown in Exhibit 6.9, but try and guard all the pegs during excavation. If any peg is missing the same should be replaced immediately. He should himself take initiative to take up the setting out work as showin in Exhibits 6.10, 6.11 & 6.12.

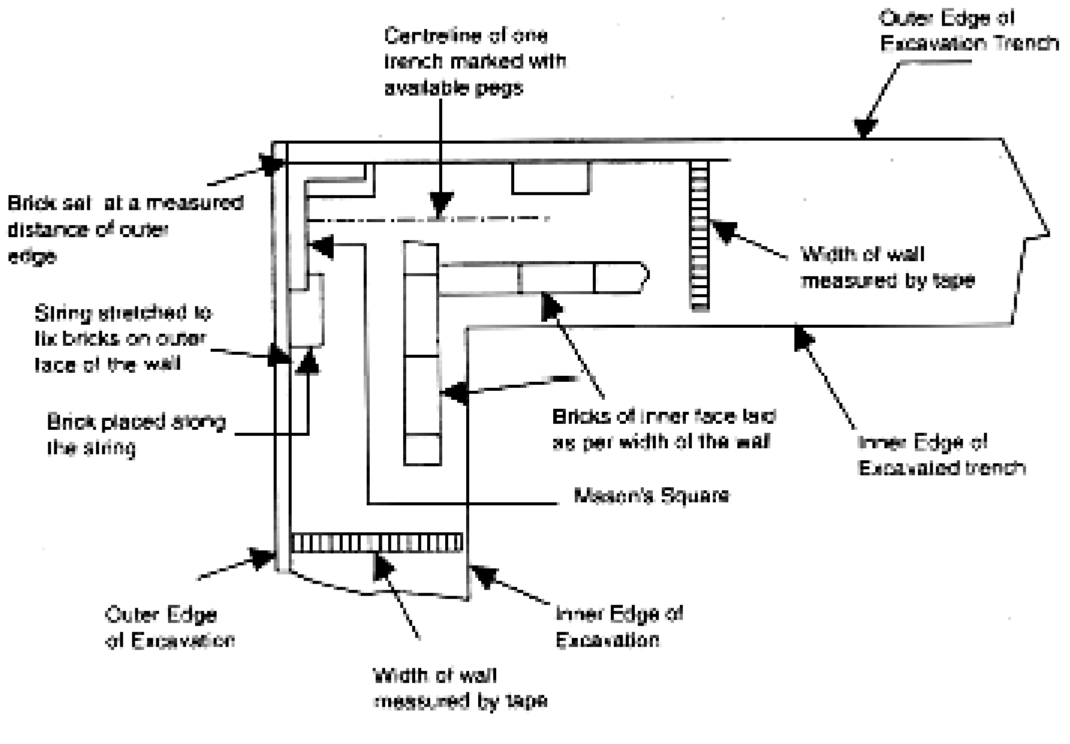


Exhibit 6.9: Method of Setting out Generally Followed by Masons (A very bad method of setting out and should not be permitted)

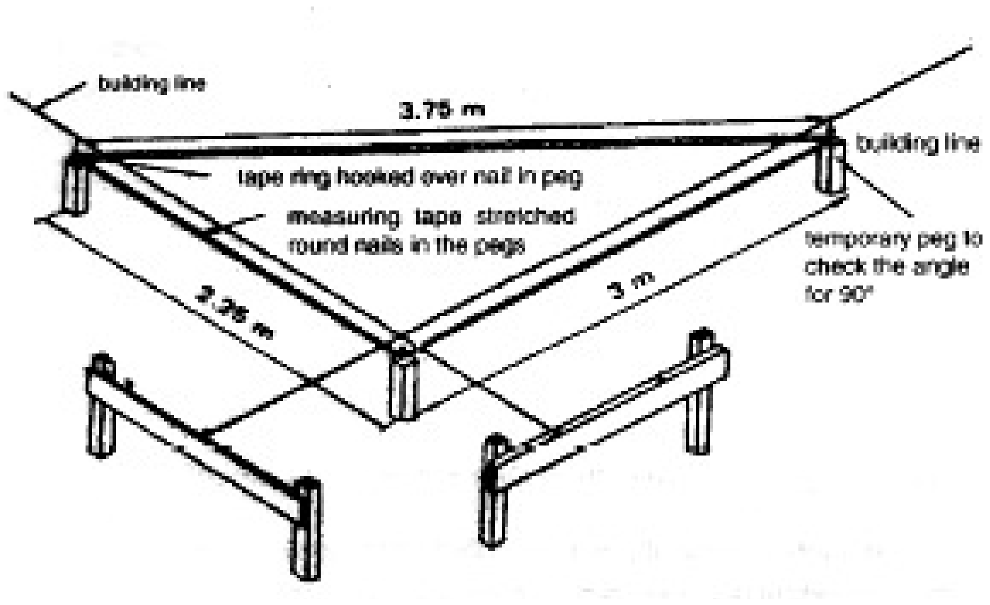


Exhibit 6.10: Practical Application of the 3.4.5 Rule

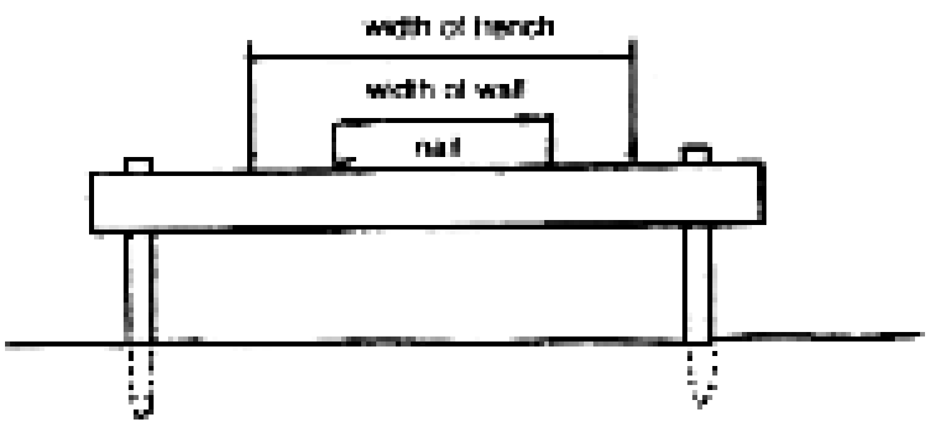


Exhibit 6.11: A Typical Timber Profile Showing Widths of Wall and Trench

1.118 Soaking Of Bricks

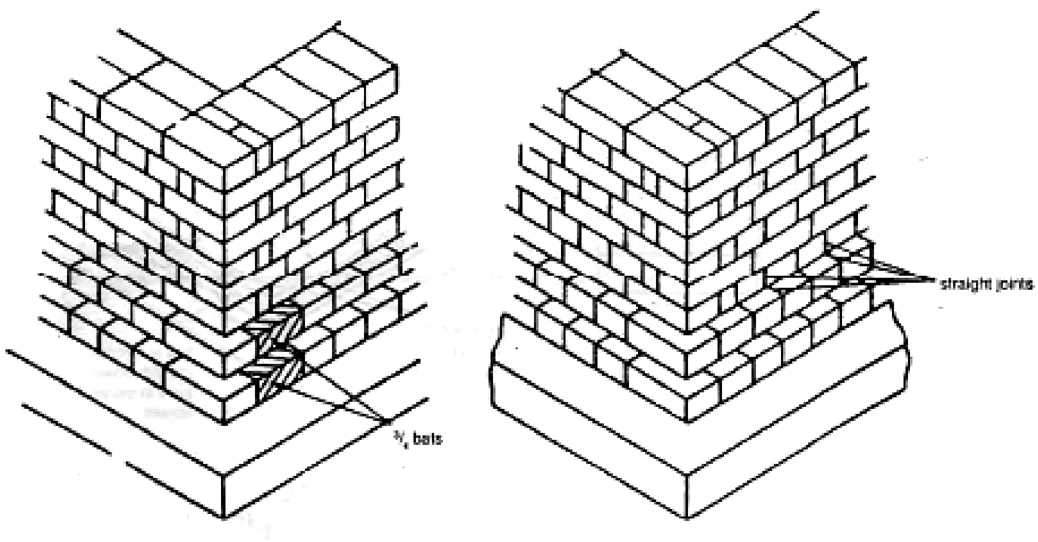
CPWD Specification specifies either soaking the bricks in tanks till the water penetrates the full depth of brick or by profusely spraying clean water on brick stacks at regular intervals for a periods of 6 hours. This second alternative condition is a clean chit for the labour of the contractor not to soak the bricks at all as required. The bricks when soaked will weigh more and no labour or mason will be willing to handle the heavy bricks. The supervision of sprinkling water for 6 hours is very difficult and the labour will just sprinkle some water on lower layer and sufficient water on top layers and since it is very difficult to check every layer, the unsoaked bricks will be used on the job under the nose of the supervisory staff. A condition in specification should be fool proof and not capable of being twisted to the benefit of the contractors. A contractor will also avoid soaking bricks in a tank as only quality bricks will sustain the water absorption and lot of wastage will occur if inferior quality bricks are soaked for one or two hours.

Sometimes it is permitted to soak bricks in water in drums or barrels but this does not serve the purpose as the bricks procured by this method are not sufficiently soaked. Thus, the only alternative is to construct either two tanks or tank with two compartments so that bricks in one tank can be arranged for soaking while the bricks in other tank are kept in water for soaking. A small platform should be constructed by the side of the tank where the soaked bricks can be stacked for usage.

1.119 Laying

1.120 Types of Bond

There is an infinite number of possible bonding arrangements but in our country the English bond is mostly adopted. In every department the stretcher bond is used for partition walls, Header bond is used for curved walls and also the footing course as shown in Exhibit 6.16 and 6.17.



(a) Three-quarter bats are introduced to avoid straight joints

(b) Straight joints are introduced between the top course of footings and the first course of the wall. This method is generally used on site

Exhibit 6.16: Bonding Footing Courses

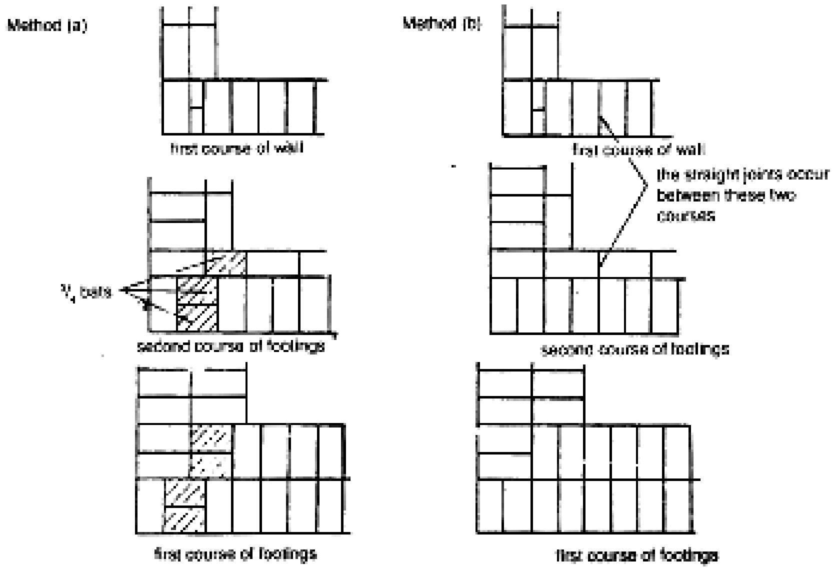


Exhibit 6.17: Plans showing Alternative Method of Bonding Footing Courses

1.121 Methods of Construction:

To sell an article you must make it attractive to the customer. In production, engineering firms go to great lengths to ensure that their products have a finished that is both durable and attractive to the eyes. The same thing applies to the building industry. A site Engineer and the staff supervising the work must realize that their work should be well made and pleasing to the viewers.

Brick-work done by a good mason using first class bricks under sticks supervision, shall have attractive appearance which ill not only last for long time but also we learn appreciation of higher authorities. On the other hand , if the work has been carried out in a slipshod manner it will be a thoroughly bad advertisement both for the mason and Site Engineer and will earn a bad reputation to the supervising stuff. The site Engineer should ,thus, make up his mind to turn out a perfect job by using suitable methods to do a first class quality job.

The Essential of good brick work construction are:

(1)Be vertical

(2)Be truly horizontal

(3)Have perpends in line and truly vertical

(4)Have true surface along it's face.

1.122 Plumbing :

It is seen that this matter is generally left to the mason or the maistry. There are not trained to construct the corner first and then proceeds with the middle portion. The method generally adopted these days is shown in 6.42 in this case initial full layer is laid and to lay the second layer the header Quoin is fixed by plumbing with the lower layer on both sides. Then the beginning of 11 layer is laid till a little distance on which a brick surrounded with a string placed projecting little away from the face of the wall. Another brick is placed on top so that the initial brick will remain firm when the string is stretched. On the other end at a considerable distance or till next corner again the same procedure is adopted and a brick tied with other end of the string is placed. Here also additional brick is placed as an extra weight. Then the brick-work in the portion below the string and first layer is laid.

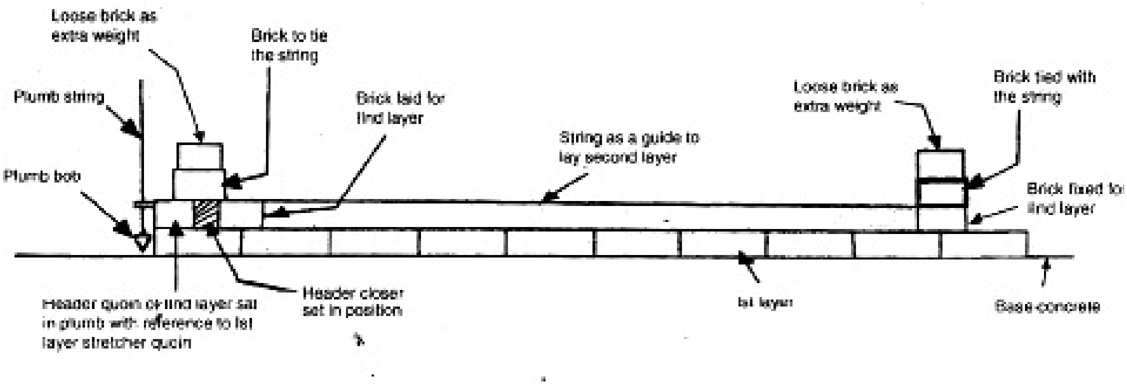


Exhibit 6.42: Method of Brick work usually done. This is a bad type work and should be discouraged.

This method no doubt assists the worker to do a fast job as he has not to wait much to construct the comers but there are many flaws in this method, namely, since the plumbing is done from brick, even a slight mistake in handling the plumb will multiply the mistake in subsequent layers. Besides, maintaining the level of course is difficult because no level bottle is used for every layer. As a result, the brick work will remain with certain non-rectifiable defects.

The quality of brick work can be greatly improved under the following method.

Under this method the corners should be constructed up to a particular height first, carefully and accurately.

For a wall to be vertical it is vital to ensure that the corners or quoins are truly perpendicular or plumb as each quoin brick is laid it should be plumbed with the aid of plumb rule and plumb bob. It is better to use vertical spirit level. The corner should be laid as shown in Exhibit 6.43

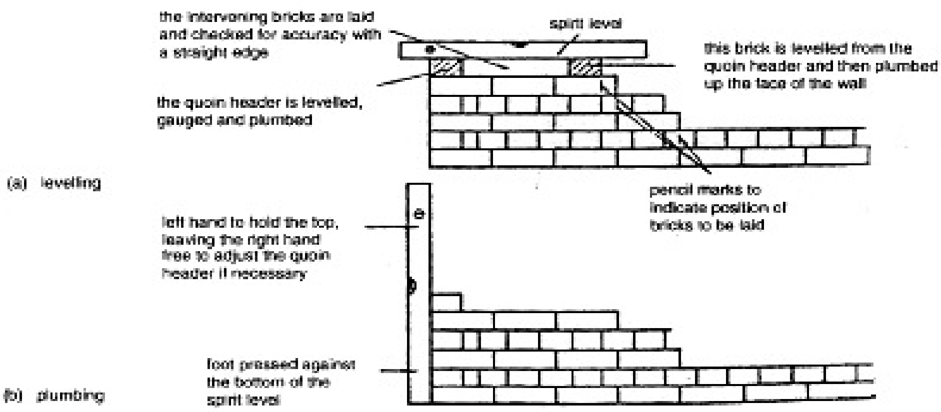


Exhibit 6.43: Method of plumbing and leveling a corner.

In a good quality face work the perpends should be kept vertical, and this is achieved by plumbing the perpends with the aid of spirit level, and pulling mark where the bricks are to be laid. This is shown in Exhibit 6.44.

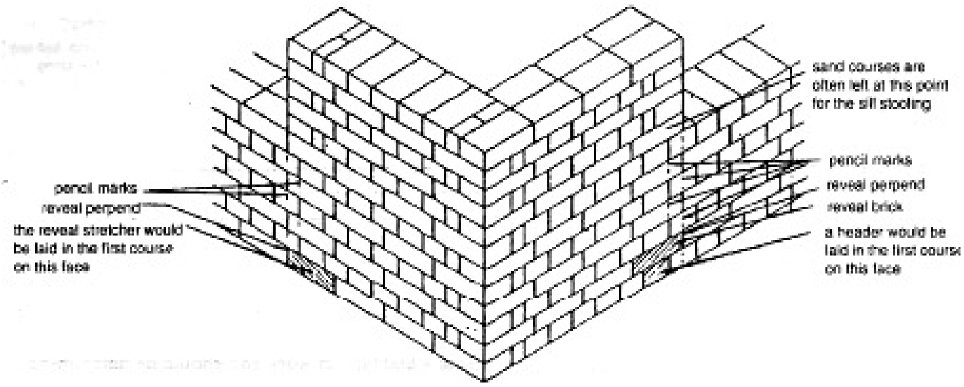


Exhibit 6.44: An isometric view showing the setting out of face bonds on adjoining faces.

The above method may be a bit costlier; as the labour will not be able to turn out the quantity of work, which they can do under the conventional method, but quality of work should not be compromised for the sake of undesirable economy or speed.

1.123 Levelling

A wall out of level is commonly said to have a pig in it and such a wall is rather unsightly. Even if a wall has been built out of level for a part of the height, and than corrected either by grinding down the head which is high, using very thin bed joints, or bringing up the end which is low, it will stand out as uneven piece and give a poor appearance. It is therefore necessary to keep a constant check on the work throughout its constructions which is the main responsibility of the Site Engineer.

1.124 Erecting a Corner

To erect a corner it is advisable to use a gauge road. This gauge road can be out of 75mm into 50mm timber scantling and of a convenient length. This gauge road be set out to so the height of the brick courses. These courses should be made to suite the thickness of the bricks plus the required thickness of the joint. This is called keeping the work to gauge, and is commonly four course to 305mm or according to the size of bricks used. To keep the gauge roads in use for quite for a long time, it is better to make small show cuts at the course marks. For convenience the gauge can be used as storey roads and the length of the rod can be the height of storey so that datum pegs can be fixed at each floor level.

In addition to the courses various other height can be marked on one of the plain faces of the rod, such as height of sills, arches, air bricks, plinths and string courses. These marks on the gauge rod serve as a reminder to the supervising staff and the mason during the building operations so that no special feature is forgotten. This will eliminate the contingency of pulling down and rebuilding which is expensive and most uneconomical.

The corners should not be too large since it is more economical to run a wall with the aid of a line than to build up large portions of walling in the form of corners. The corners should be preferably raked back as shown in Exhibit 6.45, since toothing is frowned upon by many engineers because of difficulty of ensuring a solid joint when the bricks are placed, to fill up the toothings. In such work a line of weakness can occur, and if there is any slight movement in foundations, the defect may emerge and cause cracks.

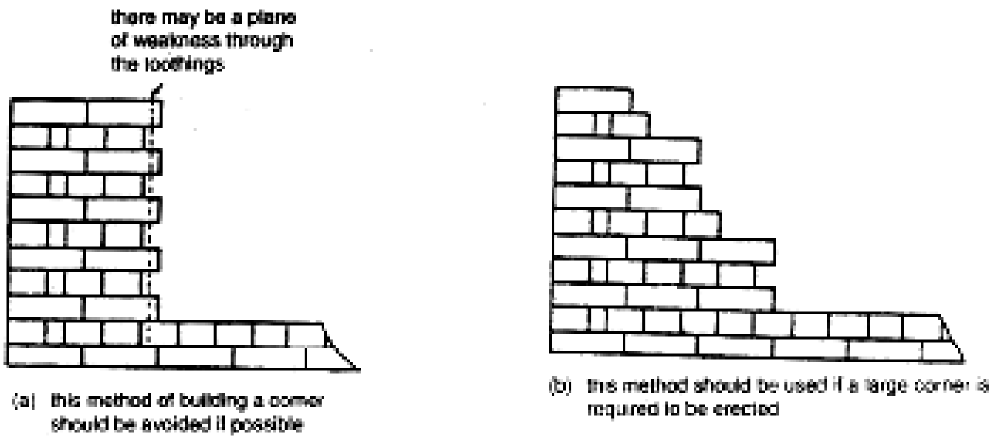


Exhibit 6.45: Alternative methods of corner construction

1.125 Working along the line

When the corners are built the waiting in between can be worked with the aid of early either blocks and lines or a line and pins. These are shown in exhibits 6.46 and 6.47. Corner blocks are far more satisfactory than line and pins because no pin holes are made in the wall and the pins get bent on being hammered into hard mortar. Once the line has been set to the length of the wall no further adjustment is necessary, since it is simply a case of sliding the corner block up the wall to the height of its course.

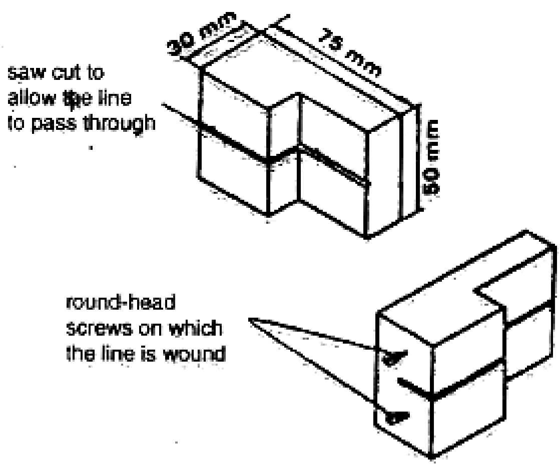


Exhibit 6.45: Detail of a typical corner block

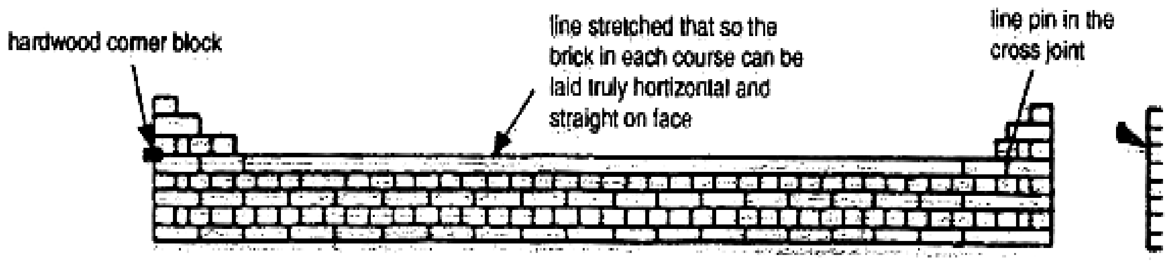


Exhibit 6.47: Alternative methods of supporting a line at 'the end' of wall Corner Profile

1.126 Conclusion

As most of the brick work constructed is plastered both from inside and outside no one bothers about maintaining the quality of bond etc. but the main reason for resorting to plaster exterior faces is that the unplastered faces look shabby due to negligience in construction. Infact when ordinary first class bricks are available and used, one can totally avoid external plaster. The contractor will have to spend little extra amount for labour and the Site Engineer will have to take some extra pains. The contractor can be compensated for the extra labour from the amount saved on plastering.

1.127 Joints

The thickness of all types of joints including brick wall joints and cross joints shall be such that four course and three joints taken consecutively shall be measure as follows:

(i)In case of modular bricks conforming to IS: 1077-1986 specification for common burnt clay buildings bricks, equal to 39 m.

(ii) In case of non-modular bricks, it shall be equal to 31 cm.

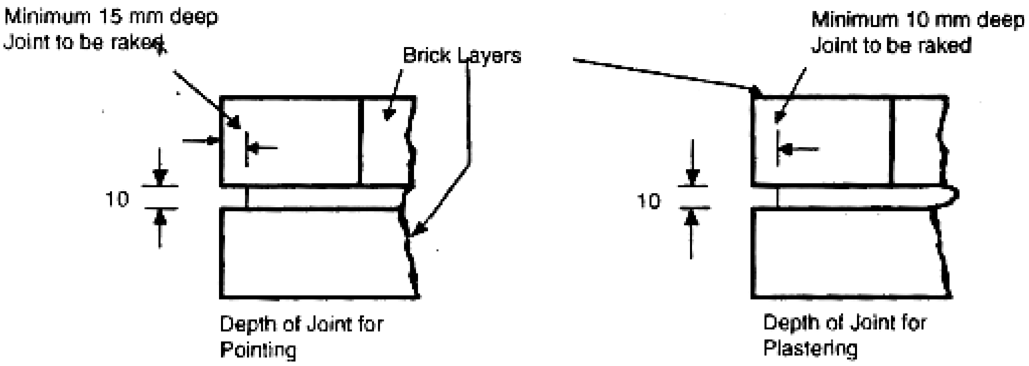
Note: Specified thickness of joints shall be of 1 cm. Deviation from the specified thickness of all joints Shall not exceed one-fifth of specified thickness.

1.127.1 Finishing of Joints: The face of brick work may be finished flush or by pointing. In flush finishing either The face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequently plastering. The faces of brick work shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brick work. In pointing, the joints shall be squarely raked out to a depth of 1.5 cm while the mortar is still green and raked joints shall be brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give ruled finish. Some such finishes are 'flush', 'weathered', ruled, etc.

1.128 Joints

The CPWD specification states that the joint should be 10mm but in practice this not it all followed. On works like drains etc. almost no joint is provided whereas on regular building work the thickness of joint varies 8mm to event 15mm. This is mainly because the brick work is done without making the layer properly.

Almost all specifications insist that if the surface is to be plastered the joint should be raked when green is to a minimum depth of15mm but the problem is no one bothers to do the raking while the work is green.On the other hand, these days mansons so train that they simultaneously fill up the joint almost as if flush pointing is done. This serves the purpose of labour that any visible defects will not be noticed easily It also serves the purpose of the contractor that he will save on plastering materials. The site Engineer also is not bothered as he to would be happy that the defects in constructions are covered and remain unnoticed.



The site Engineer should not allow this practice of filling the joints while doing the brick work instead he should see that all joint rae raked up by 10mm for plastering and 15mm pointing before the work is close for the day. If the raking is done simultaneously it is not cost anything and can be done very quickly whereas, you will not be able to rake the joint without cutting corners of brick one the mortar is set, and you will have to do the plastering and pointing without any proper key, as no one do raking to the required depth once the mortar is set.

1.129 Curing

The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the date on which the work as done so as to kept a watch on the cutting period.

1.130 Scaffolding

Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work.

1.130.1 Single Scaffolding: Where plastering, pointing or any other finishing has been indicate for brick work, single scaffolding may be provided, unless otherwise specified. In single scaffolding one end of the put-logs/pole shall rest in the hole provided in the header course of brick masonry. Not more than more header for each put-log/pole shall be left out. Such holes shall not be allowed in the case of pillars bricks work less than one meter in length between the opening or near the structure members supported by the walls. The holes for put-logs/pole shall be made good with brick work and wallfinishing as specified.

1.130.1 Double Scaffolding: Where the brick work or tile work is t be exposed and not to be finished with plastering etc. double scaffolding having two independent supports, cler of the work shall be provided.

1.131 Measurements :

1.131.1 Brick work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to nearest 0.01 m i.e 1 cm. Areas shall be calculated to the nearest 0.01 cubic metres.

1.131.2 Brick work shall be measured separately in the following stages:

(a) From foundation to floor level (plinth level).

(b)Plinth (floor one)level to floor two level.

(c)Between two specified floor levels above floor two level.

Note: (1)Brick work in parapet walls, mumty, lift machine room and water tanks constructed on the roof up to 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

1.131.3 . No deductions or additions shall be done and no extra payment made for the following :

Note: Where minimum area is defined for reduction of an opening, void or both, such area shall refer only opening or void within the space measured.

(a)Ends of dissimilar materials (that is joists, beams, lintels, posts, rafters, purlins, trusses,corbels, steps,etc up to 0.1 m2 in sections.

(b)Opening up to 0.1m2in area (see Note);

(c) Wall plates, bed plates, and bearing of slabs, chhajjas and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

(d) Cement concrete blocks as for hold fasts and holding down bolts;

(e) Iron fixtures, such as wall ties, pipes upto 300mm diameter and hold fasts for doors and windows;

(f)Chases of section not exceeding 50cm in girth; and

(g)Bearing portion of drip course, bearinfg of molding and cornice.

Note: In calculating area of an opening, any separate lintel or sills shall be include with the size of the opening but end portions
of lintel shall be excluded. Extra width of rebated reveals, if any , shall also be excluded.

1.131.4 Walls half brick thick and less shall each be measured separately in square metres stating thickness.

1.131.5 Walls beyond half brick thickness shall measured in multiples of half brick which shall be deemed to be inclusive of mortar joints. For the sizes of bricks specified in 6.1.1, half brick thickness shall mean 100 mm for modular and 115mm for non-modular bricks.

Where fractions of half brick occur due to architectural or other reasons, measurement shall be as follows:

(a) Upto $1/4^{th}$ brick –actual measurements and

(b) Exceeding ¼ brick-full half bricks.

1.131.6 String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running meters stating dimensions of each projection.

1.131.7 Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick.

1.131.8 Circular pillars shall be measured separately in cubic metres as per actual dimensions.

1.131.9 Brick work curved on plan shall be measured like the brick work in straight walls and shall include all cutting and wastage of brick, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls.

Nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.

1.131.10 Tapered walls shall be measured net as walls and extra payment shall be allowed for making tapered surface for brick work in walls.

1.131.11 Brick work with brick tiles shall be measured and paid for separately

1.131.12 Rate

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rate shall also include the following:

(a) Raking out joints or finishing joints flush as the work proceeds;

(b) Preparing tops of exisiting walls and the like for raising further new brick work;

(c) Rough cutting and waste for forming gables, splays at eaves and the like;

(d) Leaving holes for pipes upto 150 mm dia. And encasing hole fast, etc;

(e) Rough cutting and waste for brick work curved in plan and for backing to stone or other types of facing;

(f) Embedding in ends of beams, joists, slabs, lintels, sill, trusses, etc;

(g) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc. in or walls if not covered in respective items;

(h)Leaving chases of section not exceeding 50 cm in girth or 350 sq cm in cross-section; and

(i)Brick on edge courses, cut brick corners, splays reveals, cavity walls, brick works curved on plan to a mean radius exceeding six metres.

1.132 Specification for Random Rubble Masonry

1.133 Random Rubble Masonry

1.134 Stone

The stone shall be of the type specified such as granite, trap, limestone, sand stone, quartzite, etc. and shall be obtained from the quarries, approved by the Engineer in-Charge. Stone shall be hard, sound, durable and free from weathering decay and defects ljke cavities, cracks, flaws, sand holes; injurious veins, patches of loose or soft materials and other similar defects that may adversely affect its strength and appearance. As far as possible stones shall be of uniform colour, quality or texture. Generally stone shall not contain crypst crystalline silica or chart, mica and other deleterious materials like iron oxide organic impurities etc.

Stones with round surface shall not be used.

The compressive strength of common types of stones shall be as per Table 1 and the percentage of water absorption shall generally not exceed 5% for stones other than specified in Tab1e 1. For laterite this percentage is 12%.

Table

Type of stone	*Maximum Water Absorption percentage by weight*	*Minimum Compressive strength kg/sq.cm*
Granite	0.5	1000
Basalt	0.5	400
Lime stone (Slab & Tiles)	0.15	200
Sand Stone (Slab & Tiles)	2.5	300
Marble	0.40	500
Quartzite	0.40	800
Laterite (Block)	12	35

1

Note1: Test for compressive strength shall be carried out as laid down in IS: 1121 (Part I}.

Note 2: Test for water absorption shall be carried out as laid down in IS: 1124.

1.135 Size of Stones

Normally stones used should be small enough to be lifted and placed by hand, Unless otherwise indicated, the length of stones for stone masonry shall not exceed three times the height arid the breadth or base shall not be greater than three-fourth the thickness of wall, or not less than 15 cm. The height of stone may be upto-30 cm.

Random Rubble Masonry shall be un coursed or bought to courses as specified (Fig 8 and 9). Uncoursed random rubble masonry shall be constructed with stones of sizes as referred to in para. 7.1.2 and shapes picked up random from the stones brought from the approved quarry. Stones having sharp corners or round surfaces shall, however, not be used.

Random rubble masonry brought to the course is similar to uncoursed random rubble masonry except that the courses are roughly levelled at intervals varying from 30 cm to 90 cm in height according to the size of stones used.

1.136 Dressing:

Each stone shall be hammer dressed on the face, the sides and the bed. Hammer dressing shall enable the stones to be laid close to neighbouring stones such that the bushing in the face shall not project more than 40 mm on the exposed face and 10 mm on the face to be plastered.

1.137 Mortar

The mortar used for joining shall be as specified.

1.138 Laying

All stones shall be wetted before use. Each stone shall be placed close to the stones already laid so that the thickness of the mortar joints at the face is not more than 20 mm. Face stones shall be arranged suitably to stagger the vertical joints and long vertical joints shall be avoided. Stones for hearting or interior filling shall be hammered down with wooden mallet into the position firmly bedded in mortar. Chips or sprawls of stones may be used for filing of interstices between the adjacent stones in heartening and these shall not exceed20% of the quantity of stone masonry. To form a bond between successive courses plum stones projecting vertically by about 15 to 20 cm shall be firmly embedded in the heartening at the interval of about one metre in every course. 1\10 hollow space shall be left any where in the masonry.

The masonry work in wall shall be carried up true to plumb or to specified batter.

Random rubble masonry shall be brought to the level courses at plinth, windowsills, linthel and roof levels. Levelling shall be done with concrete comprising of one part of the mortar as used for masonry and two parts of graded stone aggregate of 20 mm nominal size.

The masonry in structure shall be carried uniformly. Where the masonry of one part is to be delayed the work shall be raked back at. an angle-not steeper than 45°.

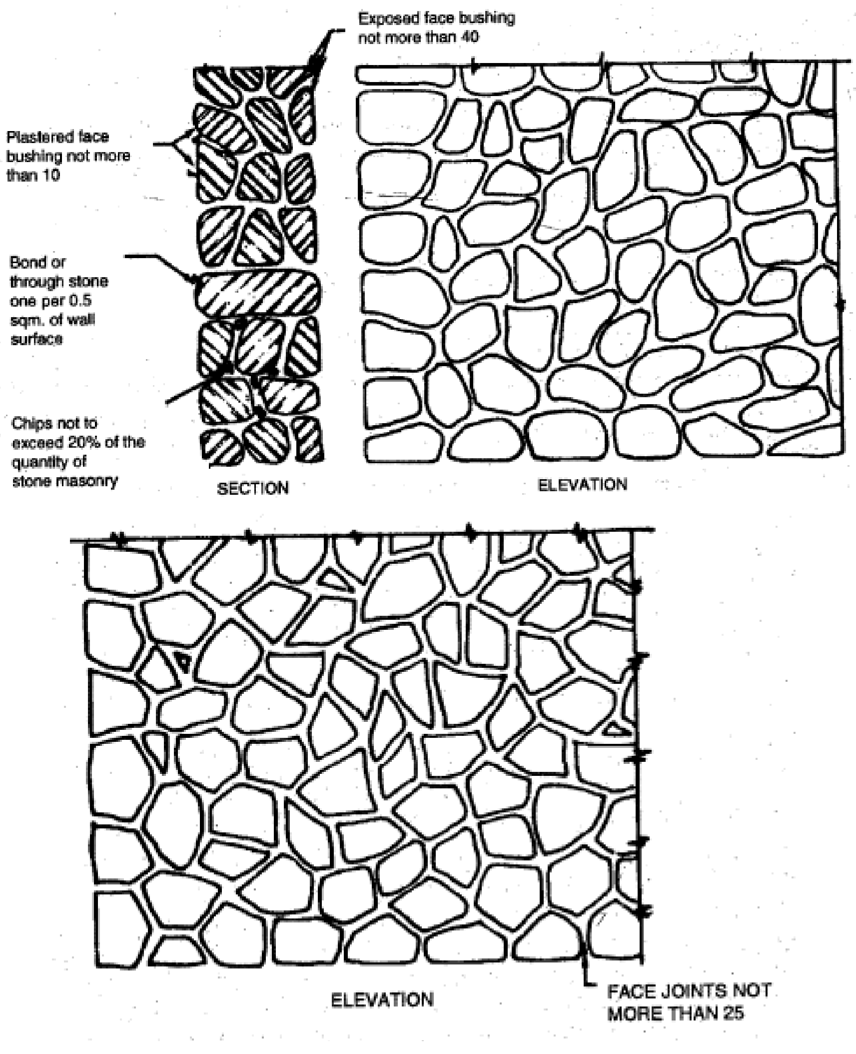


Fig-8 Random Rubble Masonary

1.139 Bond Stones

Bond or through stones running right through the thickness of walls, shall be provided in walls up to 60 m thick and in case of wa11s above 60cm'thickness, a set of two or more bond stones overlapping each other by at least 15 cm shall be provided in a line from face of the wall to the back.

In case of highly absorbent types of stones (porous lime stone and sand stone etc.) single piece bond stones may give rise to dampness..For all thicknesseS1)f such walls a set of two or more bond stones overlapping each other by at least 1.5 cm shall be provided. Length of each such bond stone shall not be less than two-third ·of the thickness of the wall.

Where bond stones of suitable lengths are not available precast cement concrete block of 1: 3: 6 mix (1 cement: 3 coarse sand: 6 graded stone aggregate 20mm nominal size) of cross section not less than 225 square centimetres and length equal to the thickness of wall shall be used in lieu of bond stones. (This shall be applicable only in masonry below ground level and where masonry above ground teve1 is finally required to be plastered).

At least one bond stone or a set of bond stones shall be provided for every 0.55 Sqm. of the area of wall surface. All bond stones shall be marked suitably with paint as directed by the Engineer in-Charge.

1.140 Quoin and Jamb Stones

The quoin and' jamb stones shall be of selected stones neatly dressed with hammer or chisel to form the required angle. Quoin stones shall not be less than 0.01 cum in volume, Height of quoins and jamb stones shall not be less than 15cm.Quoins sh~1l be laid header and stretcher altenatively.

1.141 Joints

Stones shall be of laid so laid that all joints are fully packed with mortar and chips. Face joints shall not be more than 20 mm thick.

The joints shall be struck flush and finished at the time of lying when plastering or pointing is not to be done. For the surfaces to be plastered or pointed, the joints shall be raked to a minimum depth of 20 mm when the mortar is still green.

1.142 Scaffolding

Single scaffolding having one set of vertical support shall be allowed. The supports shall be sound and strong, tied together by horizontal pieces, over which the scaffolding planks shall be fixed. The inner end of the horizontal scaffolding member may rest in hole provided in the masonry. Such holes, however, shall not be allowed in pillars under one metre in width or near the skew back of arches. The holes left in masonry work for supporting scaffolding shall be filled and made good with cement concrete1: 3: 6 (1cement: 3 coarse sand: 6 stone 'aggregate 20 mm nominal size).

1.143 Curing:

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In case of masonry the lime mortar curing shall commence two days after laying of masonry and shall continue for at least seven days thereafter.

1.144 Protection

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

1.145 Measurements

The length, height and thickness shall be measured correct to a cm. The thickness of wall shall be measured at joints excluding the bushing. Only specified dimension shall be allowed; anything extra shall be ignored. The quantity shall be calculated in cubic metre nearest to two places of decimal.

The work under the following categories shall be measured separately:

(i) From foundation to plinth level (level one).

(a) Work in or under water and. or liquid mud.

(b) Work in or under foul positions.

(ii) From plinth level (Level one) to floor two level.

(iii) From floor two level to floor three level and so on.

(iv) Stone masonry in parapet shall be measured together with the corresponding item in the wall of the storey next below.

No deduction shall be made nor extra payment made for the following:

(i) Ends of dissimilar materials (that is joists, beams, linthels, posts, girders, rafters , purlins trusses

corbels, steps etc.) up to 0.1 sqm. in section.

(ii) Openings each upto 0.1 sqm in area. In calculating the area of openings, any separate lintels or sills shall be included along with the size of opening but the end portions of the lintels. shall be excluded and the extra width of rebated reveals, if any. shall also be excluded.

(iii) Wall plates and bed plates, and bearing of chhajjas and the like, where the thickness does not

exceed 10 cm and the bearing does not extend over the full thickness of the wall.

Note: The bearing of floor and roof shall be deducted from wall masonry.

(iv) Drain holes and recesses for cement concrete blocks to embed hold fasts for doors, windows etc.

(v) Building in masonry, iron fixture, pipes up to 300 mm dia hold fasts of doors and windows etc.

(vi) Forming chases in masonry each up to section of 350 sq cm.

Masonry (excluding fixing brick work) in chimney breasts with smoke of air flues not exceeding 20 sq dm (0.20 sq m) in sectional area shall be measured as solid and no extra payment shall be made for pargetting and coring such flues. Where flues exceed 20 sq dm (0.20sq m) sectional area, deduction shall be made for the same and pargetting and coring flues shall be measured in running metres stating size of flues and paid for separately. Aperture for fire place shall be deducted and no extra payment made for splaying of jambs and throating.

Apertures for fire places shall not be deducted and extra labour shall not be measured for splaying of jambs, throating and making arch to support the opening.

Square or Rectangular Pillars: These shall be measured as walls, but extra payment shall be allowed for stone work in square or rectangular pillars over the rate for stone work in walls. Rectangular pillar shall mean a detached masonry support rectangular in section, such that its breadth does not exceed two and a half times the thickness.

Circular Pillars (Columns): These shall be measured as per actual dimensions, but extra payment shall be allowed for stone work in circular pillars over the rate for stone work in walls. The diameter as well as length shall be measured correct to a cm.

Tapered walls shal.1 be measured net, as per actual dimensions and paid for as other walls.

Curved Masonry*:* Stone masonry curved on plan to a mean radius exceeding 6 metres shall be measured and included with general stone work. Stone work circular on plan to a mean radius not exceeding 6 metres shall be measured separately and shall include all cuttings and waste and templates. It shall be measured as the mean length of the wall.

1.146 Rate

The rate shall include the cost of materials and labour required for all the operations described above and shall include the following

(a) Raking out joints for plastering or pointing done as a separate item, or finishing flush as the work .proceeds

(b) Preparing tops and sides of existing walls for raising and extending.

(c) Rough cutting and waste for forming gables cores, skew backs or spandrels of arches, splays at eaves and all rough cutting in the body of walling unless otherwise specified.

(d) Bond stones or cement concrete bond blocks.

(e) Leading and making holes for pipes etc.

(f) Bedding and pointing wall plates, linthels, sills etc. in or on walls, bedding roof tiles and corrugated sheets in or on walls.

(g) Building in ends of joists, beams, linthels etc

1.147 Coursed Rubble Masonry-First Sort

1.148 Stone

Shall be as specified in

1.149 Size of Stone

Shall be as specified in

1.150 Dressing

Face stones shall be hammer dressed on all beds, and joints so as to give them approximately rectangular block shape. These shall be squared on all joints and beds. The bed joint shall be rough chisel dressed for at least 8 cm back from the face, and side joints for at least 4 cm such that no portion of the dressed surface is more than 6 mm from a straight edge placed on it. The bushing on the face shall not project more than 4 cm as an exposed face and one cm. on a face to be plastered. The hammer dressed stone shall also have a rough tooling for minimum width of 2.5 cm along the four edges of the face of the stone, when stone work is exposed.

1.151 Mortar

The mortar for jointing shall be specified.

1.152 Laying

All stones shall be wetted before use. The walls shall be carried up truly plumb or to specified batter. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The height of each course shall not be less than 15 cm nor more than 30cm.

Face stones shall be laid alternate headers and stretchers No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one third of the stones shall tail into the work for length not less than twice their height.

The hearting or the interior filling of wall shall consist of stones carefully laid on their proper beds in mortar; chips and spalls of stone being used where necessary to avoid thick beds of joints of mortar and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stone to bring these up to the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up uniformly but where breaks are unavoidable, joints shall be raked back at angle not steeper than 45°.Toothing shall not be allowed.

1.153 Bond Stones

Shall be as specified in 7.1.8 except that a bond stone or a set of bond stones shall be inserted 1.5 to 1.8, metres apart, in every course.

1.154 Quoins

The quoins shall be of the same height as the course in which these occur. These shall be at least 45 cm long and shall be laid stretchers and headers alternatively. These shall be laid square on the beds, which shall be rough-chisel dressed to a depth of at least 10 cm. In case of exposed work, these stones shall have a minimum of 2.5 cm wide chisel drafts at four edges, all the edges being in the same plane.

1.155 Joints

All bed joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar, face joints shall not be more than one cm thick. .

When plastering or pointing is not required to be done the joints shall be struck flush and finished at the time of laying. Otherwise, joints shall be raked to a minimum depth of 20 mm by raking tool during the progress of work, when the mortar is still green.

15.2.9 Curing, scaffolding, measurements and rates shall be as specified under 7.1.

Coursed Rubble Mason Y-Second Sort (Fig. 9)

Stone: Shall be .as specified in 7.1.1.

***Size* of *Stone*:** Shall be as specified in7.1.2.

Dressing

Shall be as specified in 7.2.3 except that no portion of dressed surface shall exceed 10 mm from a straight edge placed on it

Mortar

The mortar for jointing shall be as specified.

Laying

Shall be as Specified in 7.2.5 except that the use of chips shall not exceed 15% of the quantity of stone masonry and stone, in each course need not be of the same height but not more than two stones shall be used in the height of a course.

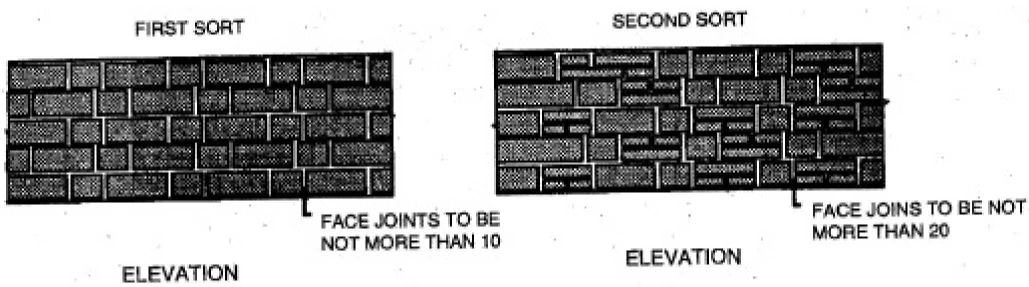
Bond Stone, Quoins

Shall be as specified in 7.2.6 and 7.2.7 respectively.

Joints

All bed joints shall be horizontal and all side vertical. All joints shall be fully packed with mortar, face joints shall not be more than 2 cm thick. When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise the joints shall be raked to a minimum depth of 20 mm by raking tool during progress of work, where the mortar is still green.

Curing, Scaffolding, measurement and rates. Shall be as specified under 7.1.



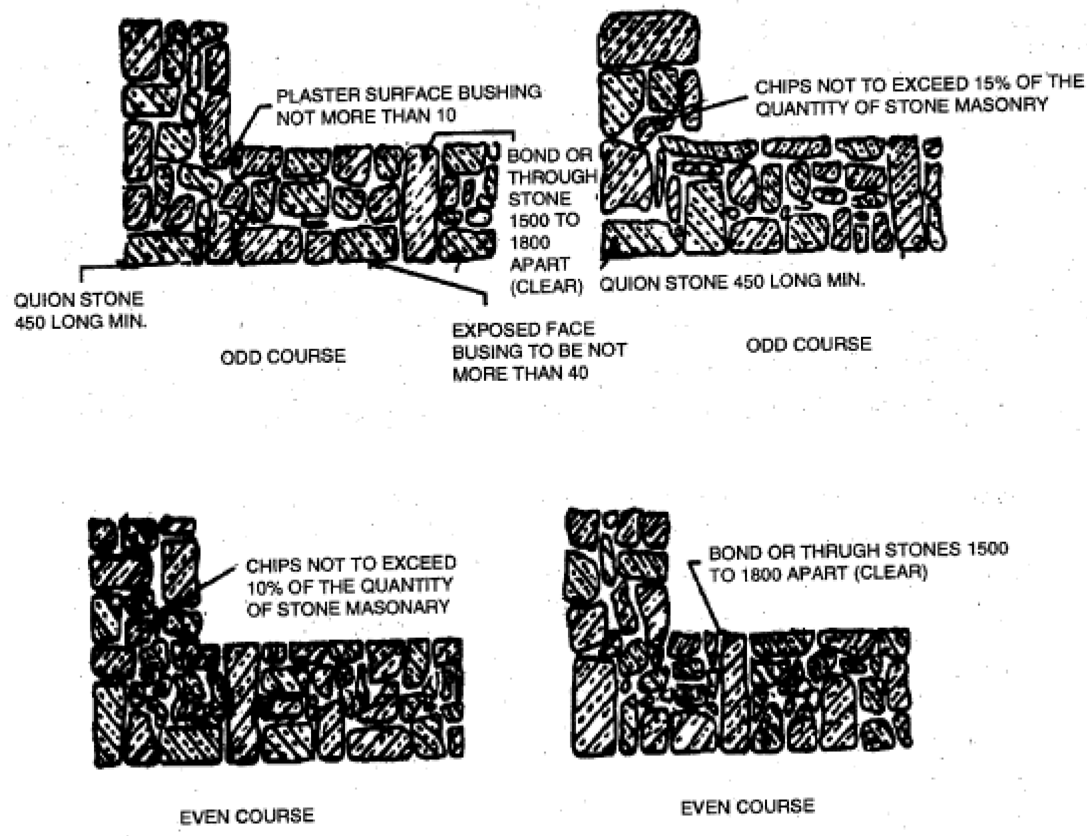


Fig. 9 : Rubble Stone Masonry - Coursed

Random Rubble Masonry.

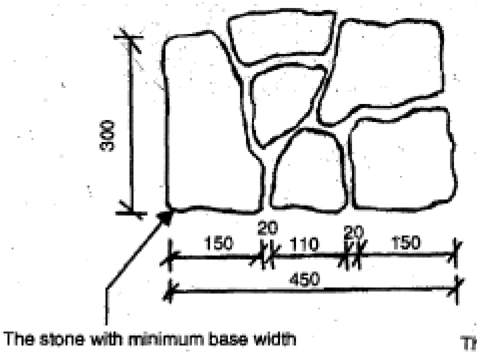
The stone masonry work is mainly restricted to works below ground level but in some cases the same is used in superstructure as well. However, there is no uniformity in specification for execution of stone masonry, by different departments/agencies.

Breadth or Base of Stone (Size of stone)

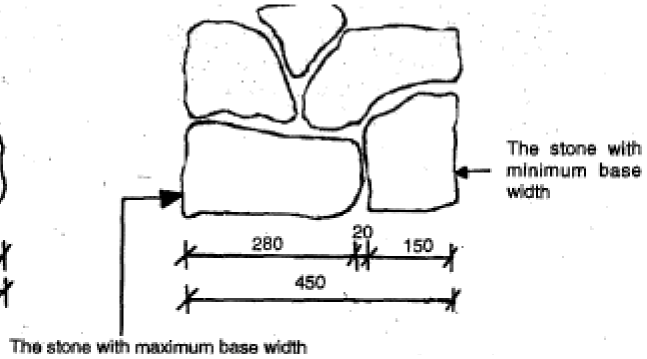
According to Clause 7.1.2 of CPWD specifications “The breadth or base shall not be greater than three fourth the thickness of wall or not less than 15 crn. The height of stone may be upto 30 cm.

The Correct method of executing the work (If RR Masonry by just slightly modifying the condition of dimension of individual stones is shown in Exhibits7.1 arid 7.2.)

Exhibit-7.1 **Exhibit-7.2**



Constructing R.R. Masonry with Minimum Base-Width



Constructing R.R. Masonry with Maximum and Minimum Base Width

Rather, when the work is actually executed, the above condition is twisted by the contractors to their advantage as shown in Exhibit 7.a. It is a known fact that a considerable quantity of mortar can be saved by using large stones. Thus the contractors have a tendency to use stones with maximum base and in case of walls with lesser widths both the above conditions i.e. the use of stone with maximum and minimum base widths together In one layer cannot be adhered to. This is clear from Annexure 7.1 and also Exhibit 7.3.

Consider a wall with 450 mm width. In this case the maximum base width of an individual stone as per specification should be 450 x 3/4 =337.5 mm and in that case on the opposite side a stone with a base width of just less than 100 mm only will have to be used. The Site Engineer may not be In a position to stop the contractor from using a larger stone as the condition IS vague. Thus, many a times in actual construction we find the work being done as shown in Exhibit 7.3. Hence, the contractor profitably uses the large stone with say 385 mm base width on one face of the wall and in the remaining space on the opposite face uses a thin tall slate type stone and fills the gap between the two stones by small chips and mortar. This method is suitable for the contractor because by use of large stones, he gets a considerable saving in the mortar and in addition the work turnout is more and fast. The Site Engineer also cannot interfere as one of the conditions is being strictly followed.

MAXIMUM AND MINIMUM WIDTH OF INDIVIDUAL STONE WITH REFERENCE TO THE THICKNESS OF WALL

Sl. No.	*Thickness of Wall*	*Maximum base of an individual stone*	*Minimum base of an individual stone*	*Joint Thickness*	*Maximum Height of Individual stone*
1.	380 mm	210 mm	150 mm	20 mm	300 mm
2.	450 mm	280 mm	150 mm	20 mm	300 mm
3.	530 mm	360 mm	150 mm	20 mm	300 mm
4.	600 mm	430 mm	150 mm	20 mm	300 mm
5.	760 mm	570 mm	150 mm	20 mm	300 mm

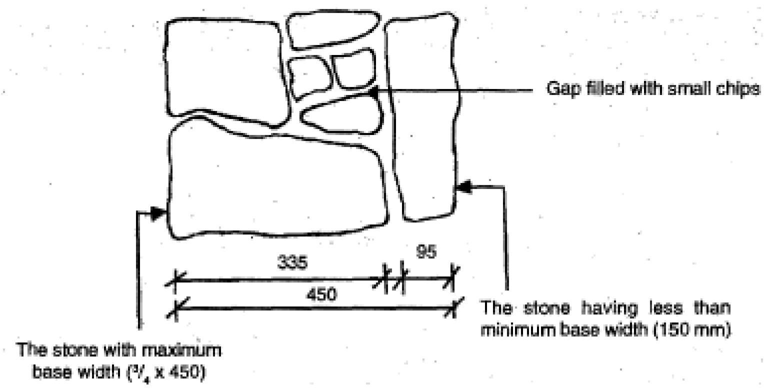
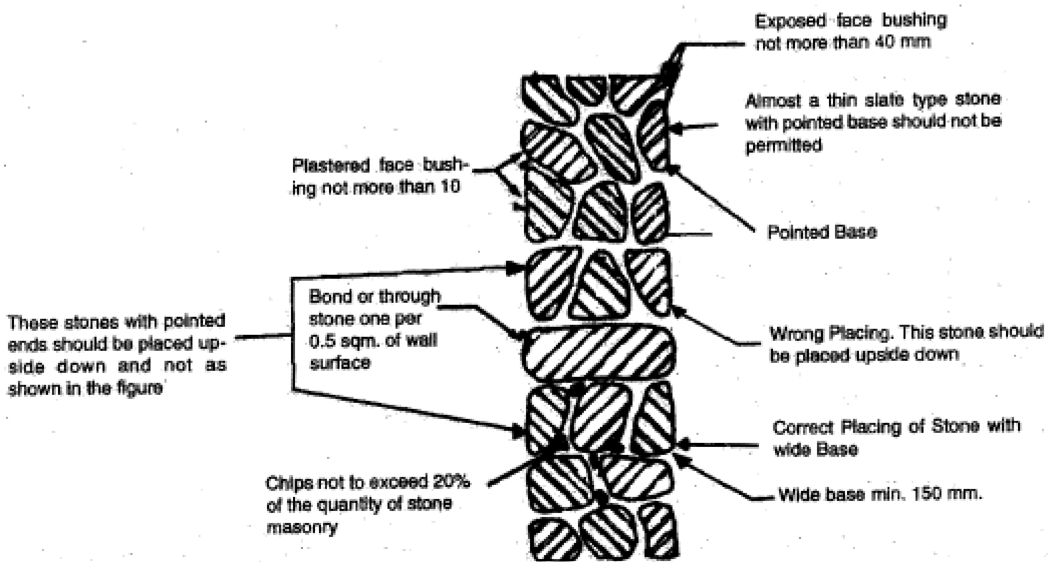


Exhibit 15.3 R.R Masonry work generally executed by Adopting only one of the conditions of the Dimension of Stones as stated in the CPWD Specifications (Clause 7.1.2) (A VERY BED PRACTICE)

Hence, the condition regarding the size of stones in RR masonry as given in the CPWD specifications should be modified especially for the usually adopted .walls of 600mm or less thickness as shown in Annexure 7.1. The size of stone given in the Specification is suitable for walls with thickness of 760 mm or more but for walls with lesser thickness the condition is vague and misguiding and any unscrupulous contractor is bound to take the full advantage.

A section of RR Masonry wall shown in figure 8 of the CPWD specification is also incorrect and confusing. See Exhibit 7.4 (a).The section of wall shown in figures of CPWD specification clearly shows the stones with pointed base being used. The Specification clearly mentions that the minimum base of an individual stone should be 150rnm whereas stones with pointed base and also small thin chips have been shown being used as face stones, and normally figures are followed by the contractors and the Site Engineer becomes helpless.

The figure 8 of CPWD is reproduced here to clarity the above point under Exhibit7.4 (a).



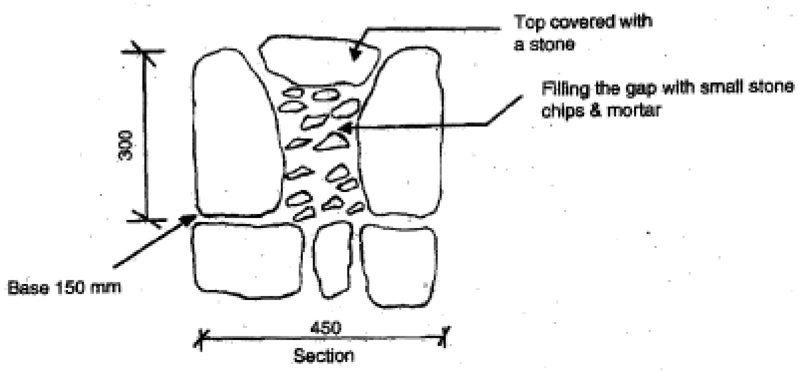


Exhibit-15.4 Work normally executed by following the specifications regarding size of stones (VERY BAD PRACTICE)

The CPWD specifications allow the height of individual face stone as 300 mm. Thus a face stone of 150 mm width and 300 mm height would be acceptable for R.R. Masonry walls as per CPWO specifications. The contractor takes the advantage, of this condition as shown in Exhibit 7.4 (b). Hence the mason Promptly erects two vertical stones of base 150rnm or less and height 300 mm on both faces of the wall & also is so quick in filling the gap with chips and mortar and closes the top with a regular stone giving an. impression that only stones are packed. It is very difficult for a Site Engineer to control the masons when the condition itself is very much favorable to the contractor. The, contractor can always argue that he is using stones as prescribed in the CPWD specifications.

Conclusion

(1) The CPWD Specification needs to be modified by Introducing Annexure 7.1 of this chapter, indicating the maximum size of stone to be used in walls, with smaller thickness.

(2) The stones with pointed base should not be used. The base should be wide enough.

(3) The condition of maximum height of stone which is prescribed as 300 mm irrespective of the thickness of wall should be modified and a condition that the base width should not be less than the height of an individual stone should be introduced. This will prohibit the masons from erecting two thin and tall verticals on both faces and filling the gap with chips and mortar. Exhibits 7.5 and 7.6 show the correct method of selecting size of stones.

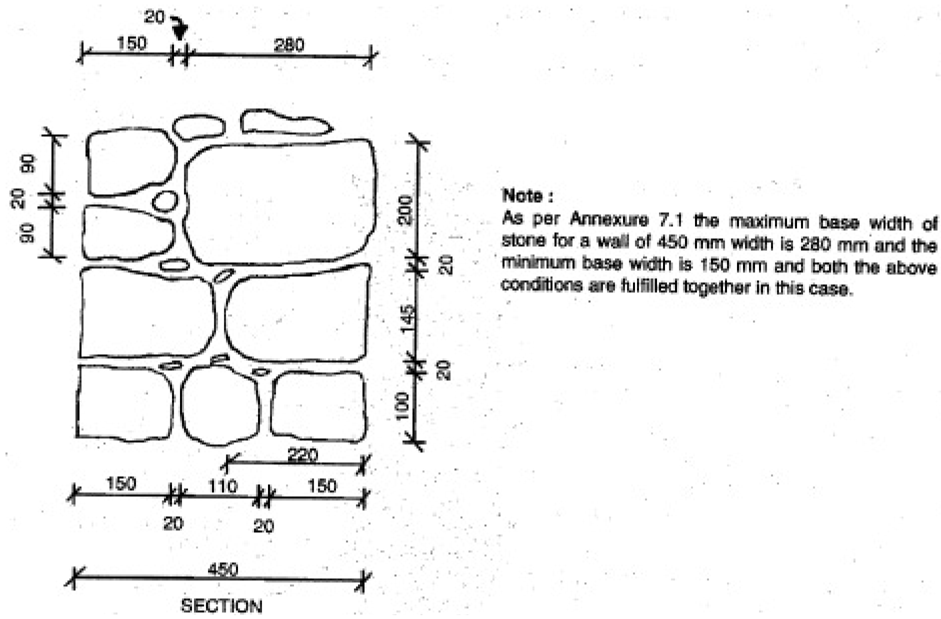


Exhibit 15.5 The correct method of Execution of work by strictly following the specification for Sizes of stones as described in Annexure 7.1.

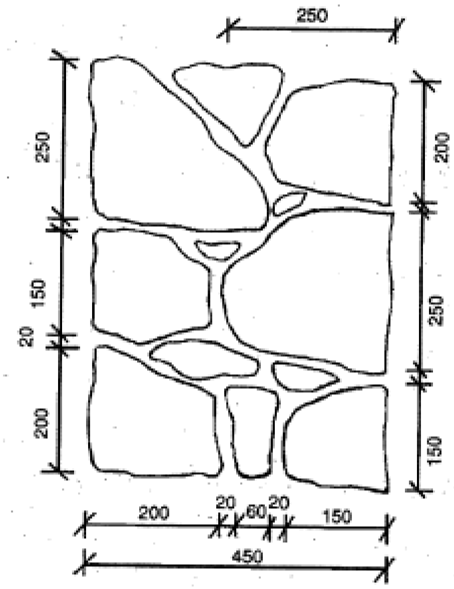


Exhibit 15.6 Alternative Correct, Method of Execution of Random Rubble Masonry using stones, of size as prescribed in Annexure 7.1

Random Rubble Masonry brought to Course.

Mortar: The mortar for stone masonry should be prepared by using measuring boxes as explained in Chapter 6 Brick Work. The usual practice of measuring sand approximately should not be allowed. The sand for stone masonry work must be screened otherwise it will be very difficult to get the uniform size of joints.

Laying: Though every specification provides that the stones should be wetted before use so as to avoid dry stones absorbing water from the mortar but no one cares for this condition and the works are carried out even on very important projects without wetting the stones. The Site Engineer should take special precaution in this case and should not allow construction unless proper arrangement is made to wet the stones before use.

Bringing Stones* to *Shape: In practice the mason starts work especially on uncoursed or coursed random rubble masonry straight away from the lot of stones brought from quarry. The result is the mason uses the stone as supplied. One can improve the quality of work if the stones are rough dressed and selected before starting the actual laying. At the time of laying the mason can give final touch of dressing with chisel while fixing. This method will help avoiding use of stones with less bearing.

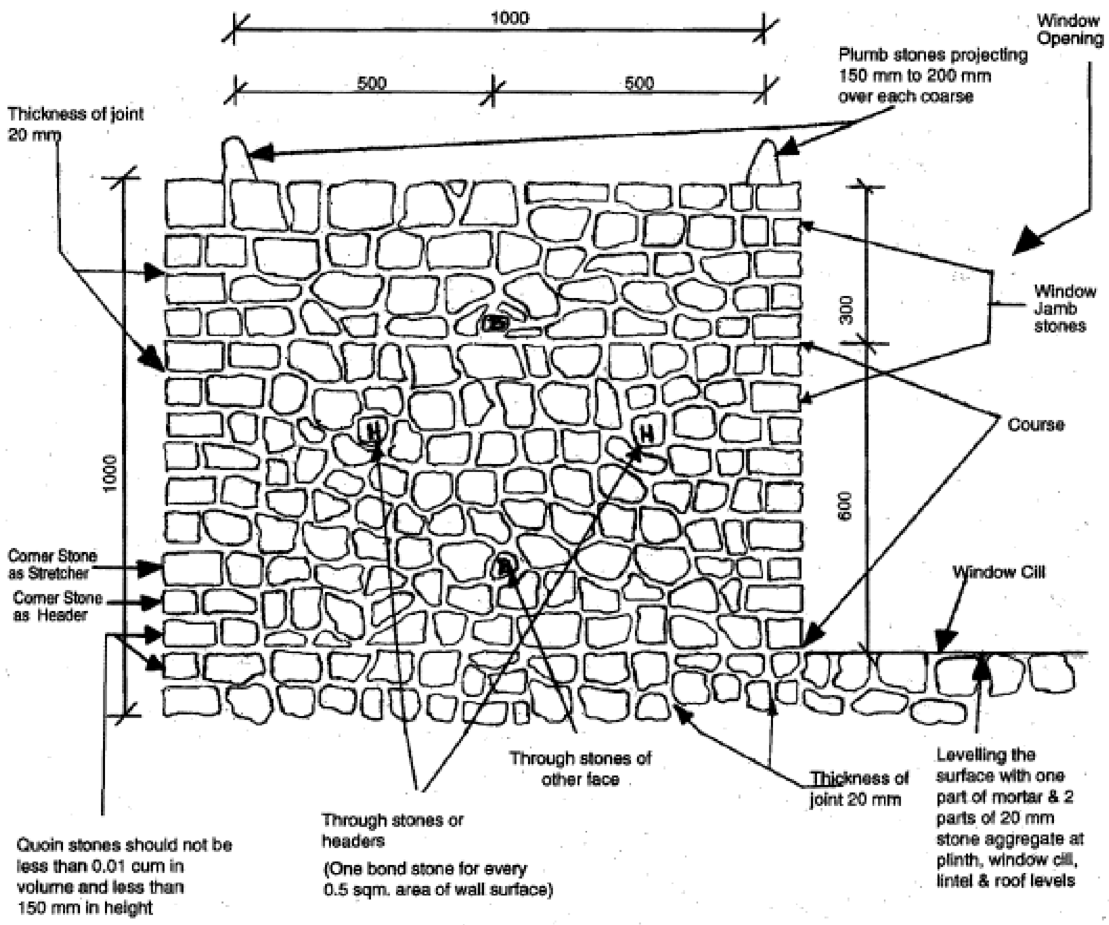


Exhibit 15.7 Random Rubble Masonry Brought to Course (Clause 7.1.3)

Plum Stone: Though the specifications insist that plum stones should be used at intervals of 1.00 m and well embedded in the lower course projecting 150 to 200 mm over the course, (the method of providing plum stone is shown in Exhibit 7.7.), it is observed that many Site Engineers have no knowledge of it. It should be noted that, the plum stones would join the courses firmly and the Site Engineer should take special care in using the same.

Levelling* at *different stages: The masonry should be levelled with stone aggregate mixed with mortar in the proportion of one part of mortar that is used on the job and two parts of stone aggregate. It is not advisable to use stone chips in the process and all gaps should be filled with above mix only. The method of levelling the course at cill level is shown in Exhibit 7.7.

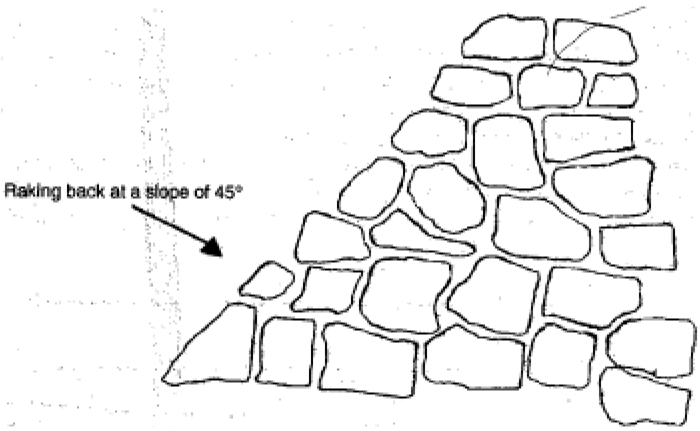


Exhibit 15.8 Where the masonry of one part is to be delayed the work shall be raked back at an Angle not steeper than 45°

Raking Back: When the work a portion of waif is to be stopped for a certain period the wall should not be left constructed vertically. It should be raked back to at an .angle not steeper than 45^0 and the wall may be left constructed as shown in Exhibit 7.8

Different Methods of Providing Headers (Bond Stones) in a Stone wall

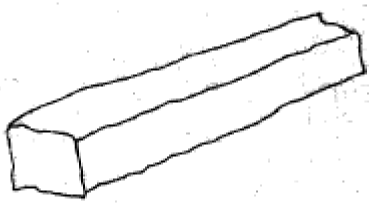


Exhibit 7.9 : Header or Bond Stone (Through Stone)

Method of placing Bond Stones for Walls lesser than 600 mm Thick

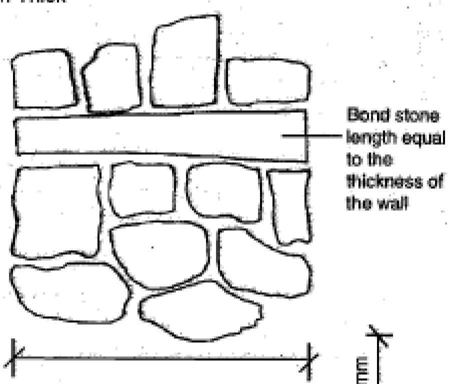


Exhibit 7.10 : Bond Stone

Method of Placing Bond Stones in Walls Thicker than 600 mm

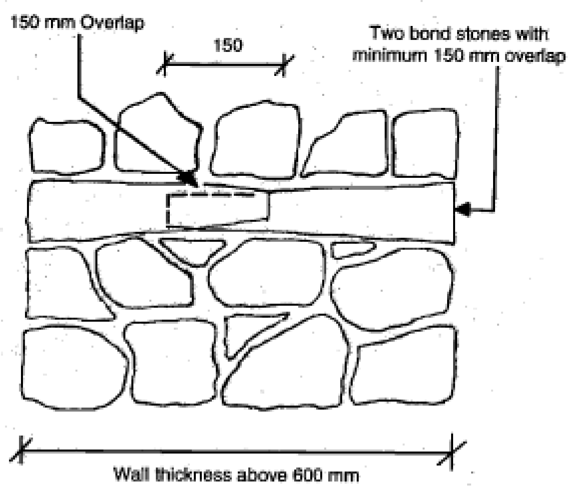


Exhibit 7.11 : Bond Stones with overlap

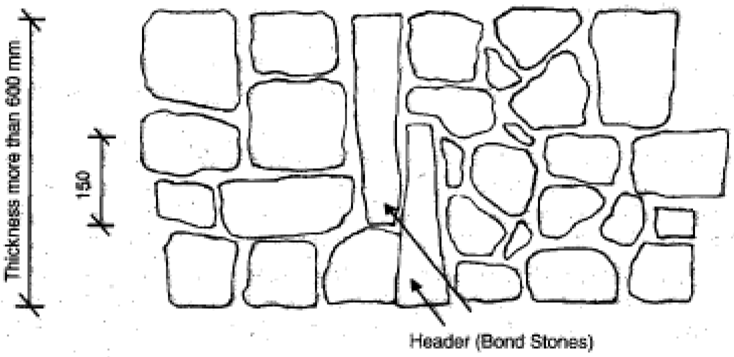


Exhibit 7.12 : Header (Bond Stones)

Bond Stones: Bond stones are called header in some parts of the country. Exhibit 7.9 shows the shape of a bond stone. The bond stones are to be provided for every 0.5 sqm. of the area of wall surface. On opposite surface also a bond stone has to be provided. However, the CPWD specifications in this regard are not clear. The bond stones with pointed edges should not be permitted. The method of providing bond stones (marked H) and staggering the same is shown in Exhibit 7.7. The bond stones marked B in the Exhibit are the bond stones of other face.

Size* of *Sand Stones: The CPWD specification prescribes the minimum area of 225 sqms for bond stones. However in practice the dimension at face 01 bond stone can be 150 x 150 mm to 200 x200 mm. The bond stones with pointed ends should be totally rejected. Exhibits 7.10, 7.11 and 7.12 show the shape of a usual bond stone and also it's usage in walls of thickness less than 600 mm and in walls of thickness more than 600 mm.

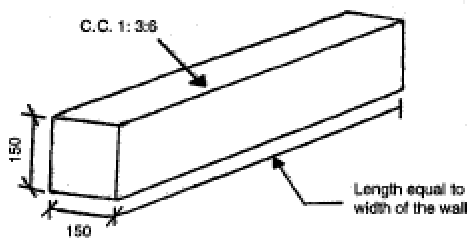


Exhibit 7.13 Concrete Bond Stone with C.C. 1: 3: 6 (However it Is advisable to use 6 mm dia. longitudinal bars 4 Nos. with 6 mm stirrups at 150 mm c/c*)*

Concrete Bond Stones: The CPWD specification prescribes the use of concrete bond stones where natural bond stones are not available. The proportion prescribed for the concrete is 1:3:6 but this should be 1:2:4 because a long header (say 600 mm Bond Stone) with weak proportion will not be strong enough. Moreover, bond stones should be lightly reinforced to take the temperature and shrinkage stresses. It is advisable to use 4 Nos. 6 mm dia. rods longitudinally with stirrups at 150 mm *c/c.* The P.C.C. Bond stone may break while placing. A concrete Bond Stone is shown in Exhibit 7.13.

Quoins* & *Jamb Stones: As per CPWD specifications the quoins should be from selected stones, hammer or chisel dressed and should not be less than 0.01 cum. Also the height of the stone should not be less than 150 mm. Thus, normal size of corner stone should be 350 mm long, 200 mm wide and minimum 150 mm high; and the height and width are interchangeable This gives a stone with a volume of 0.0105 cum. However, in practice the selected corner stones are never ordered and brought from quarry but the same are selected from the lots of stones brought for the masonry. This practice should be stopped and the, corner stone's of suitable dimensions ordered from the quarry directly should be allowed to be used. The method of using the quoins for corners and jambs is shown in Exhibit 7.7. Besides, additional chisel dressing of the beds and joints to the extent of 5 and 2.5ems respectively for granite or trap stones and8 cm and 4 cms, respectively, for other stones should be done to improve the workmanship.

Joints: The CPWD specification prescribes maximum thickness of face joints as 20 mm, whereas Fig· 8 of the specification shows tile size of joint as 25 mm. However, in practice the size of joints maintained is much more, because it is very difficult to maintain 20 mm thick joint. Thus, a joint of 25 mm thickness can be safety permitted. Except where the Random Rubble masonry work is constructed below ground, the surface of masonry is treated with pointing and in some selected cases, with plastering. For doing pointing or plastering, the joints must be raked up to a depth of 20 mm. However, it is observed that the joints are not at all raked when the mortar is green, but filled carefully and completely to hide the defects and also to save on the materials of pointing or plastering. Therefore, the Site Engineer should insist on raking the joints.

Scaffolding: The scaffolding can be either with Ballies or M.S. pipes.

Protection of Masonry

It is *very* important to protect the facial appearance of stone masonry when the work is finished with pointing. In practice, the facial appearance is never kept clean and free of cement markings. Many a times it is seen that the cement slurry from concrete lintel/cill when cast, flows on the exposed masonry leaving a dirty mark on the surface of stones and as it is impossible to clean the surface later, the work is accepted as it is, with ugly surface due to cement slurry markings.

The best practice win be before taking up the work of concreting get the surface washed in the evening itself or the next day morning or apply pure cow dung in a thick layer over the surface. This can remain till the entire work on the portion is executed and then the cow dung coating can be washed clean. The above method will give a clean stone surface. This method can be followed for any type of masonry work and will be useful even later when painting work would be taken up.

16. STEEL WORK

16.0 Definitions

Bead: A single run of weld metal deposited on surface.

Butt weld: A weld in which the weld metal lies substantially within the extension of the planes are the surfaces of the parts joined.

Crater: A depression left in weld metal where the arc was broken or the flame was removed.

End crater: A crater at the end of a weld or at the end of a joint.

Fillet weld: A weld of approximately triangular cross-section joining two surfaces approximately at the right angles to each other in a lap joint, tee joint or corner joint. It is of two types:

(1) Continuous

(2) Intermittent

Fusion Welding: Any welding process in which the weld is made between metals in a state of fusion without hammering or pressure.

Non-fusion Welding: A term applied to the deposition, by the Oxy-Acetylene process of filler metal on parent metal without fusion of the latter.

Oxy-Acetylene Pressure welding: Pressure welding in which any Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.

Run: The metal deposited during one passage of the electrode or blow pope in the making of a joint.

Throat thickness: See fig. 1

Weld: A union between two pieces of metal at faces rendered plastic or liquid by heat or pressure, or both. Filler metal may be used to effect the union.

16.1 Materials

16.1.1 Steel

All finished steel shall be well and cleanly rolled to the dimensions and weight specified by BIS subject to permissible tolerances as per IS: 1852. The finished materials shall be reasonably free from cracks, surface flaws laminations, rough and imperfect edges and all other harmful defects.

Steel Sections, shall be free from excessive rust, scaling and pitting and shall be well protected. The decision of the Engineer-in-Charge regarding rejecting any steel section on account of any of the above defects shall be final and binding.

Structural steel work shall conform to the following requirements. The mechanical and chemical properties of the structural steel shall be as per Appendix A of Chapter 10. The following varieties of steel should be used for structural purposes:-

16.1.1.1 S.T. 42-S: The standard quality steel designated as SD.T. -42-S, conforming to Is: 226 shall be used for all types of structure (riveted or bolted) including those subject to dynamic loading and where fatigue, wide fluctuation of stresses and reversal of stresses are involved, as for example crane gantry, as for example crane gantry girders, road and rail bridges etc. It is also suitable for welded structures provided that the thickness of materials does not exceed 20 mm.

16.1.1.2 S.T. 42-W: The fusion welding quality steel designated as S.T. 42-W, conforming to IS: 2062 shall be used for structures subject to dynamic loading (Wind load is not to be considered as dynamic load for this purpose) where welding is employed for fabrication and where fatigue, wide fluctuation of, stresses reversal of stress and great restraint are involved as example, crane gantry girders and road and rail bridges.

16.1.1.3 S.T. 42-0: The ordinary quality steel designated as S.T. 42-0 conforming to IS: 1977 shall be used for structures not subjected to dynamic loading other than wind loads where welding is not employed or/and structures not situated in earth quake zones or/and design has not been based on plastic theory.

16.1.1.4 S.T. 32-0: The ordinary quality steel designated as S.T. 43-0 conforming to IS: 1977 shall be used for doors, window frames, window bars, grills, steel gates, hand railing, builders hardware, fencing post, tie bars etc.

16.1.2 Rivets

Rivets shall be made from rivet bars of mild steel as per IS : 1148.

16.1.3 Bolts

These are of two types namely turned and fitted bolts and black bolts. Turned & bolts are turned to exact diameter in automatic lathe. For these bolts, whether reamed or drilled bolts, the same unit stresses are allowed as fro rivets. In case of black bolts which are not finished to exact sizes, a lower working stress other than for turned bolts is adopted. They shall conform to IS: 1367 Technical supply conditions for threaded steel fasteners.

16.1.4 Electrodes

The electrodes required for metal arc welding shall be covered electrodes and shall conform to IS : 814.

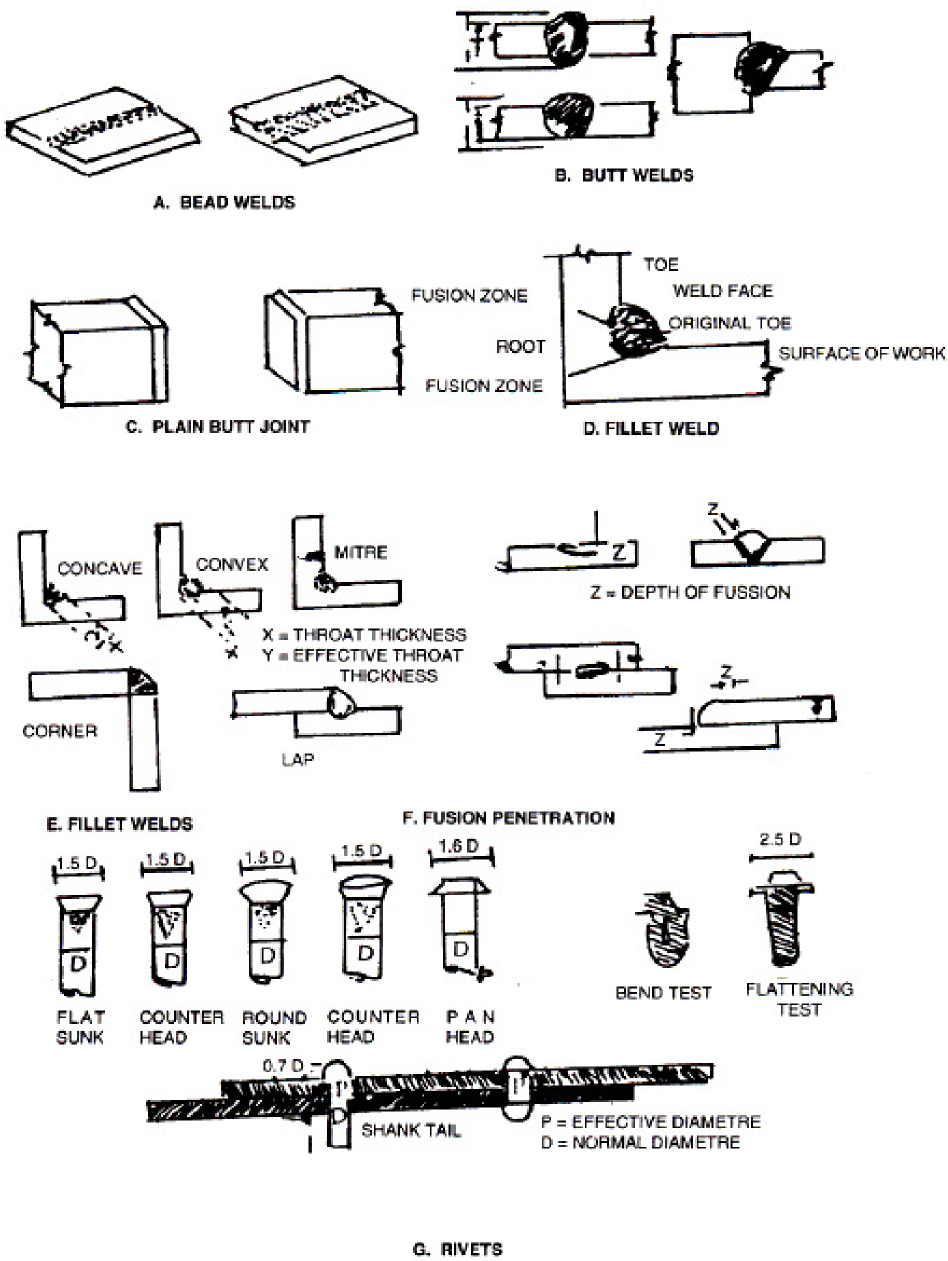
16.2 Steel Work in Single Section Fixed Independently With Connecting Plate

16.2.0 The steel work in single sections of R.S. Joists, flats, Tees Angles fixed independently with or without connecting plate, is described in these clauses.

16.2.1 Fabrication

16.2.0 The steel sections as specified shall be straightened and cut square to correct lengths and measured with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member.

All straightening and shaping to form, shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of the metal.



ALL DIMENSIONS ARE IN MM

DRAWINGS NOT TO SCALE

Fig. 1: Welds and Rivets

16.2.2 Painting

All surfaces which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust. Surfaces not in contact but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections. Part to be encased in concrete shall not be painted or oiled. A priming coat of approved steel prime i.e., Red Oxide Zinc chrome primer conforming to IS : 2074 shall be applied before any member of steel structure are placed in position or taken out of workshop.

16.2.3 Erection

Steel work shall be hoisted and placed in position carefully without any damage to itself and other building work and injury to workmen. Where necessary mechanical appliances such as lifting tackle winch etc. Shall be used. The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of the Engineer-in-Charge.

16.2.4 Measurements

The work as fixed in place shall be measured in running meters correct to a millimeter and weights calculated on the basis of standard tables correct to the nearest kilogram.

Unless otherwise specified, weight of cleats, brackets, packing pieces, bolts, buts, washers, distance pieces, separators, diaphragm gussets (taking overall square dimensions) fish plates, etc. shall be added to the weight of respective items. In riveted work, allowance is to be made for weight of rivet heads. Unless otherwise specified an addition of 2.5 per cent of the weight of structure shall be made for shop and site rivet heads in riveted steel structures.

No deduction shall be made for rivet/or bolt holes(excluding holes for anchor or holding down bolts).

Deduction in case of rivet or bolt hole shall however be made if its area exceeds 0.02 sqm.

The weight of steel sheets, plates and strips shall be taken from relevant Indian Standards based on 7.85 Kg/m^2 for every millimeter sheet thickness. For rolled sections, steel rods and steel strips, weight given in relevant Indian Standards shall be used.

16.2.5 Rate

Rate includes the cost of labour and materials required for all the operations described above.

16.3 Steel Work in Built Up Sections (Riveted and Bolted)

The steel work in built up sections (Rivetted and bolted) such as in trusses, framed work etc. is specified in this clause.

16.3.1 Laying Out

A figure of the steel structure to be fabricated shall be drawn on a level platform to full scale. This may be done in full or in parts, as shown on drawings or as directed by the Engineer-in-Charge. Steel tape shall be used for measurements.

16.3.2 Fabrication

Fabrication shall generally be done as specified in IS : 800.

In major works or where so specified, shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details of rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer-in-Charge. The drawings shall indicate the shop and field rivets, bolts and welds. The steel members shall be distinctly marked or stenciled with paint with the identification marks as given in the shop drawings.

Great accuracy shall be observed in the fabrication of carious members. So that these can be assembled without being unduly packed, strained or forced into position and when built up, shall be true and free form twist, kinks, buckles or open joints.

Wooden or metal sheet templates shall be made to correspond to each member, and position or rivet holes shall be marked accurately on them and holes drilled. The templates shall then be laid on the steel members, and holes for riveting and riveting and bolting marked on them. The ends of the steel members shall also be marked for cutting as per required dimensions. The base of steel columns and the positions of anchor bolts shall be carefully set out at the required location.

16.3.2.1 The steel section shall be straight or be straightened or flattened by pressure unless required to be of curvilinear form and shall be free from twists. These shall be cut square either by shearing or sawing to correct length and measured by steel tape. No two pieces shall be welded or joined to make up for the required length of member.

16.3.2.2 Making Holes: Holes through more than one thickness of materials for members, such as compound stanchion and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 3 mm less in diameter then the required size and reamed after assembly to the full diameter. The thickness of material punched shall be not grater than 16 mm.

Rivet Holes: The diameter for rivets and black bolts holes shall be taken as the nominal diameter of a rivet plus 1.5 mm for rivets of nominal diameter less than or equal to 25 mm and 2.0 mm for rivets of nominal diameter exceeding 25 mm, unless specified otherwise. Holes for turned and fitted bolts shall not be formed by gas cutting process.

Holes shall have their axis perpendicular to the surface bored through. The drilling or reaming shall be free from burrs, and the holes shall be clean and accurate. Holes for rivets and bolts shall not be formed by gas cutting process.

Holes for counter sunk bolts shall be made in such a manner that their heads sit flush with the surface after fixing.

16.3.2.3 Assembly : Before making holes in individual members, for fabrication and steel work intended to be rivette or bolted together shall be assembled and clamped properly and clamped properly and tightly so as to ensure close abutting, or lapping of the surfaces of the different members. All stiffeners shall bear tightly both at top and bottom without being drawn or caulked. The abutting joints shall be cut or dressed true and straight, and fitted close together.

Web plates of girders, which have no cover plates, shall have their ends flush with the tops of angles unless otherwise required. The web plates when spliced, shall have clearance of not more than 5 mm. The erection clearance for cleated ends of members connecting steel to steel shall preferably be not grater than 1.5 mm. The erection clearance at the ends of beams without web cleats shall not be more than 3 mm at each end but where for practical reasons, greater clearance is necessary suitably designed seating shall be provided.

Column splices and butt joints of struts and compression members depending on contact for stress transmission shall be accurately, machined and close butted over the whole section. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc. after riveting together shall be accurately machined so that parts connected, but against each other over the entire surfaces of contact. Connecting angels or channels shall be fabricated and placed in position with great accuracy so that they are not unduly reduced in thickness by machining.

The ends of all bearing

16.3.2.4 Rivetting: Rivets shall be sued, where the connection is such that slip under load has to be avoided.

Preliminaries before riveting: Members to be riveted shall have all parts firmly drawn and held together before and during riveting, and special care shall be taken in this respect for all single rivetted connections. For multiple rivetted connections, a service bolt shall be provided in every third or fourth hole.

Process of riveting: The riveting shall be carried out by using machines of the steady pressure type. However, where such facilities are not available hand riveting may be permitted by the Engineer-in-Charge. The rivets shall be heated red hot, care being taken to control the temperature of heating so as not to burn the steel. Rivets of diameter less than 10 mm may be driven cold. Rivets shall be finished neat, with heads full and of equal size. The heads shall be central on shanks and shall grip the assembled members firmly. All loose, burnt, or badly formed rivets with eccentric or deficient heads shall be cut out and replaced. In cutting out rivets, care shall be taken so as not to injure the assembled members. Caulking and recuping shall not be permitted.

For testing rivets, a hammer weighing approx. 0.25 kg shall be used and both heads of the rivet (specially the machine head) shall be tapped. When so tested, the rivets shall not give a hollow sound and a jar. Where so specified, other tests shall be carried out to ensure the soundness of rivets.

All rivets heads shall be painted with approved steel primer paint within a week of their fixing.

16.3.2.5 Bolting: The nominal length of the bolt shall be the distance form the underside of the head to the further end of the shank. The nominal diameter of the bolt shall be the diameter at the shank above the screwed threads, Bolts, nuts and washers shall be thoroughly cleaned and dipped in double boiled linseed oil, before use. All Bolts heads and nuts shall be hexagonal unless specified otherwise. The screwed threads shall conform to IS :1363 and the threaded surface shall not be tapered. The bolts shall be of such length as to project at least two clear the\reads beyond the nuts when fixed in position, and these shall fit in the holes without any shake. The nuts shall fit in the threaded ends of bolts properly.

Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut at least two thread. In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nuts to avoid any threatened portion of the bolt being within the thickness of the parts bolted together.

Where there is a risk of the nuts being removed or becoming loose due to vibrations or reversal of stresses, these shall be secured from slackening by the use of lock nuts, spring washers as directed by the Engineer-in Charge.

16.3.3 Erection

16.3.3.0 Steel work shall be hoisted and erected in position carefully, without any damage to itself other structures and equipment and injury to workmen. The method of hoisting and erection proposed to be adopted by the contractor shall be fully responsible for the work being carried out in a safe and proper manner without unduly stressing the various members and proper equipment such as derricks, lifting tackles, winches, ropes etc. shall be used.

16.3.3.1 The work may be erected in suitable units as may be directed by the Engineer-in-Charge. Fabricated members shall be lifted at such points as to avoid deformation or excessive stress in members. The structure or part of it placed in position shall be secured against over-turning or collapse by suitable means.

During execution, the steel work shall be securely bolted or otherwise fastened and when necessary temporarily braced to provide for all loads to be carried safely by the structure during erection including those due to erection equipment and its operations. The steel work shall be placed in proper position as per approved drawing, final riveting or permanent bolting shall be done only after proper alignment has been checked and confirmed.

16.3.3.2 Trusses shall be lifted only at nodes. The trusses above 10 m in span shall not be lifted by slinging at two mid points of rafters, which shall be temporary braced by a wooden member of a suitable section. After the trusses are placed in position, purlins and wind bracings shall be fixed as soon as possible.

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the other end kept free to move. In case of trusses of spans up to 10m the free end of the truss shall be laid on lead sheet or steel plate as per design ,and the holes for holding down bolts shall be made in the form of oblong slots so as to permit the free movements of the truss end. For large spans the truss shall be provided with proper bearing as per design .

16.3.3.3 columns and stanchions shall be erected truly vertical with the necessary cross bracing etc. and the base shall be properly fixed with the foundation concrete by means of anchor bolts etc, as per drawing.

16.3.3.4 Anchor bolts to be placed in the concrete foundation should be held in position with a wooden template. At the time of concreting anchor bolt locations shall be provided with suitable timber mould or pipe sleeve to allow for adjustment which shall be removed after initial setting of concrete. The spaces left around anchor bolts shall be linked to a stopping channel in the concrete leading to the side of the pedestal and on the underside of the base plate to allow the spaces being grouted up after the base plate is fixed in position along with the column footing. Grouting shall be of cement mortar 1:3 (1 cement : 3 coarse sand) or as specified.

16.3.3.5 Bedding of column, Stanchions etc.: Bedding shall not be carried out until the steel work has been finally leveled, plumbed and connected together. The stanchion shall be supported on steel wedges and adjusted to make the column plumb. For multistoried buildings, the bedding shall not be done until sufficient number of bottom lengths of stanchions have been properly lined, leveled and plumbed and sufficient floor beams are fixed in position. The base plates shall be wedged clear of the bases by M.S. wedges and adjusted where necessary to plumb the columns. The gaps under the base plate may be made upto 25 mm shall then be pressure grouted with cement grouts.

With small columns, if permitted by the Engineer-in-Charge, the column base shall be floated on a thick cement grout on the concrete pedestal. The anchor bolt holes in the base plate may be made about 10 to 15 mm larger than the bolts. In such cases suitable washers shall be provided.

16.3.4 Painting

Before the members of the steel structure are placed in position or taken out of the workshop these shall be painted as specified in 10.2.2.

16.3.5 Measurements

To work as fixed in place shall be measured in running metres correct to a millimeter and their weight calculated on the basis of standard table correct to the nearest kilogram.

Unless otherwise specified, weight of cleats, brackets, parking pieces, bolts nuts, washers, distance, pieces, separators diaphragm gussets (taking overall square dimensions) fish plates etc. shall be added to the weight of respective items. No deductions shall be made for skew cuts. In rivetted work, allowance is to be made for weight of rivet heads. Unless otherwise specified an addition of 2.5 per cent of the weight of structure shall be made for shop and site rivet heads in rivetted steel structures. No deduction shall be made for rivet/or bolt holes (excluding holes for anchor or holding down bolts). Deduction in case of rivet or bolt hole shall, however, be made if its area exceeds 0.02 m^2

The weight of steel sheets and strips shall be taken from relevant Indian Standards based on 7.85 kg/ m^2 for every millimeter sheet thickness. For rolled sections, Steel roads and steel strips, weight given in relevant Indian Standards shall be used.

16.3.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

EXPLANATORY NOTES AND COMMENTS

Steel Work- Methods of Fastening

The three methods used for fastening structural steel components together are riveting, welding, and bolting. Even on the same connection, these are not necessarily independent of one another, since one method may be used in the shop and another in the field on the same connection. In any one structure all three methods may be present. for example, beams may be field bolted, major girder-to-columns connections rivetted,and smaller columns welded directly to their base plates to avoid the use of clip angles. Furthermore during the process of riveting, plates are often tack welded to hold them in position while the holes are being drilled and the rivets; and in a welded job, the members are temporarily bolted in position until the welder can get at them.

In the near future, special cold glues may be used to fasten components in lieu of the above methods. For the present, however, let us discuss the three methods being practiced.

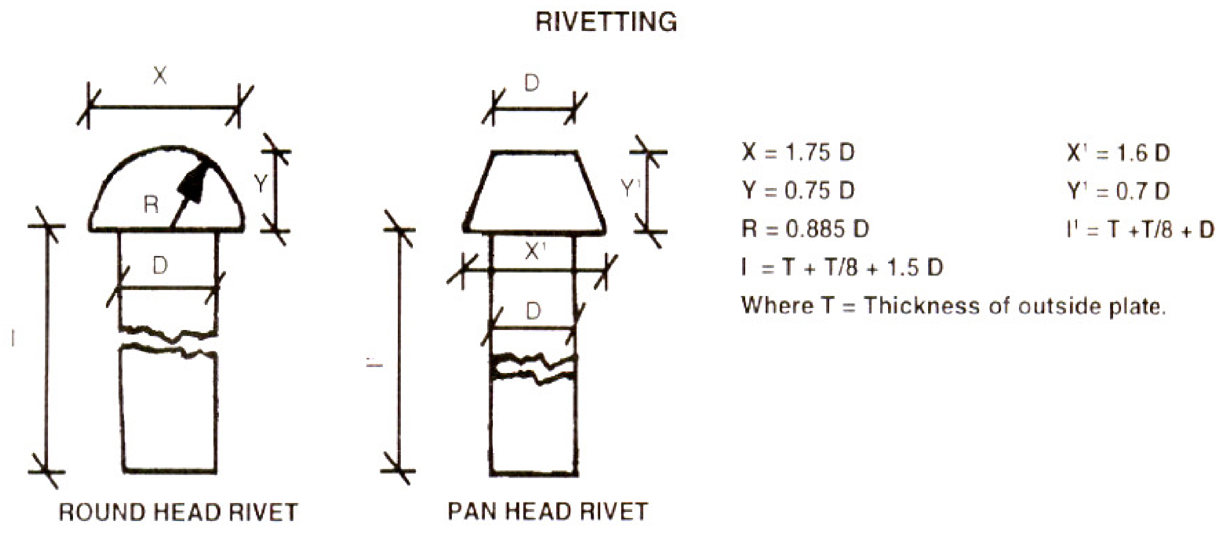


Exhibit 10.1 : Standard Proportions of Rivets

Shop Riveting

Rivets may be driven either cold or hot, although mostly they are heated. However, as per CPWD specification, rivets of less than 10 mm dia. can be rivetted cold. The rivets are brought up to the heating equipment by an apprentice. When they reach the proper temperature, a man called a heater tosses them to a catcher who inserts them shank first into the prepared holes. The rivet head is then formed with the riveting equipment.

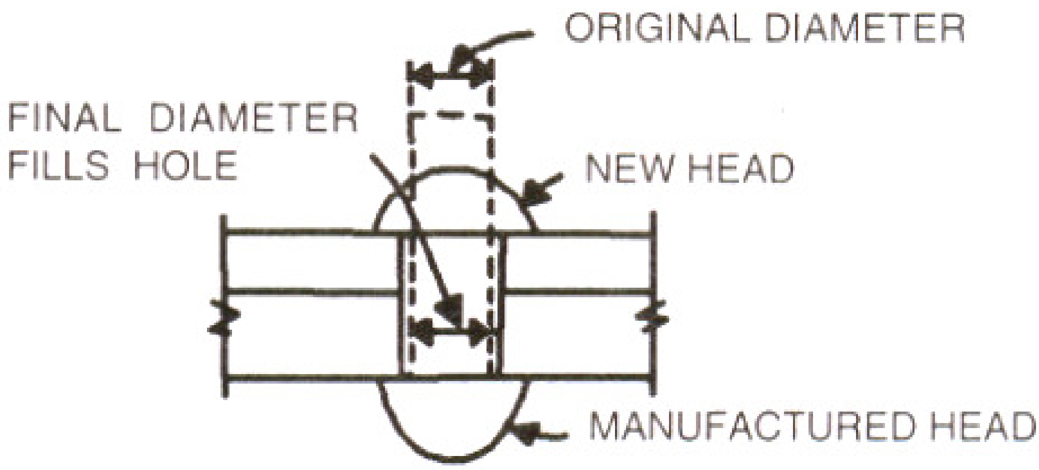


Exhibit 10.2: Cross Section of Rivet Before and after being Driven

Generally, this process is similar for both shop and field operations. The heating equipment in most shops is either oil or gas fired, although some shops use electric furnaces in which the current passing through the rivets raises them to the proper temperature. The heater removes them from the fuel-type furnaces when they reach a cherry red colour.

In some shops the heater may take the red hot rivet directly to the work, while in others he will toss it with a pair of tongs to the catcher. This man catches the rivet in an open metal cone and then, with a pair of tongs, puts it into the proper hole. Rivets in a group are driven in such a pattern as not to throw stresses due to temporary concentric loading into the joint.

The rivet is driven either by pressure or impact equipment, both of which operate on compressed air at 5.62 to 7 kgs/cm^2 pressure. Both types of equipment are taken up to the work; stationary, hydraulically-operated equipment is sometimes used, but is not common. The pressure equipment using compressed air, known as a bull riveter, is a good sized machine with a C-shaped frame. The open side of the C is positioned on the rivet, which is then completely driven with one stroke. Pressure machines must be provided with some sort of auxiliary traveling equipment, the larger ones being hung from overhead cranes.

Portable riveting guns – Portable riveting guns (see Exhibit 10.4) are often used in the shop to drive up a few scattered rivets, or sometimes to drive tapered dirff pins into holes when fitting material. The guns are also operated on compressed air, and form a second rivet head by pounding on the shank end of the rivet (see Exhibit 10.2). In this case, besides the riveter, a fourth man is required on the riveting team for holding the rivet head in place while the shank is being driven. This man called the bucker-up, does his job with the aid of a dolly, which is a lever that operates in a manner that the more pressure is put against it, the harder it grips. At times the bucker-up will use a pnenumatic dolly.

A well driven rivet will completely fill the rivet hole, which is made 1.5 mm larger than the rivet diameter. Both a bull riveter and a portable gun will do a good job. In fact the gun, when being driven. With the one stroke pressure riveter, the rivet is still hot after being driven, and as it cools it shrinks away from the hole. Fortunately, the shrinkage is also longitudinal and results in initial tension in the rivet, thus gripping the plates by friction.

Inspection, Before leaving the shop, all materials are inspected for length and size and all joints are tested. Rivets are tested by hitting them tightly with a hammer and listening to the sound or feeling the back side of the rivet. A poorly driven rivet will have a hollow ring and will feel loose, and must be removed and replaced.

When a bull riveter has been used, it is probably not necessary to check every rivet on the job. Perhaps one at each joint, or for large joints, one of each ten rivets may be tested.

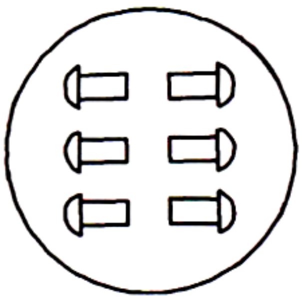


Exhibit 10.3 : Rivets in charcoal brazier.

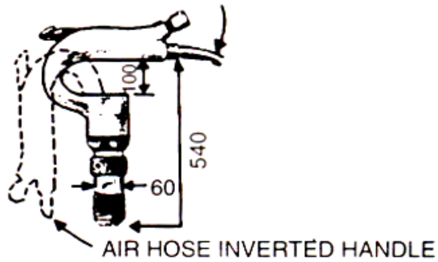


Exhibit 10.4 : Rivetting Gun

Field Rivetting

Rivetting in the field is done of necessity with portable tools and heating equipment. A four man crew and an apprentice or labourer are used. The heater does his job with the aid of a charcoal brazier, placing four or six rivets in the brazier (see Exhibit 10.3) with the shank ends toward the centre of the fire. When the rivets are hot he tosses them with a pair of tongs to the catcher. Thereafter, the work is the same as done in a shop when a riveting gun is used. It is inconvenient for the heater to move his furnace too often, so he sets it up on the floor above the crew and pitches the rivets down to them. When they reach his level, he throws them horizontally. Finally he tosses the rivets one floor up and then moves his equipment three floors up.

On larger jobs, several riveting crews are used to speed up the work. One air compressor with a tender can service all of them simultaneously.

As per CPWD specification, hand riveting may be permitted where facilities for riveting with machines are not available.

Normally, for hand riveting the crew will be a holder up, two riveters and one or two helpers for heating and supporting the rivets. The hammer required for riveting shall be1 to 3 kg in weight, and the holding up hammer shall be 5 to 18 kg.

With the help of above crew roughly 80 to 90 rivets can be done in an 8 hour shift. Joints by riveting are stronger than joints by bolting because when the rivet is hammered hot, they contract on cooling, thus causing frictional resistance between the plats, which adds considerably to the rigidity of the joint.

The rivet joints can be classified as : (1) Lap Joint, (2) Single Cover, (3) Double Cover. Lap and single cover joints should not be adopted for joining tension members.

BOLTING

The preparation of material for bolting is identical to that for rivetting. The various pieces are punched, sub-punched and reamed, or drilled according to the thickness of the plate and the nature of the job. In all cases the holes are larger in diameter than the bolt diameter to be used.

Basically there are two kinds of bolts in common usage on structural joints, The unfinished or common bolt, and the so-called high tensile bolt. No special tools are required with the common bolt and it can be applied by one man. The shank end of the bolt is slipped through the holes, after which the nut is put on and drawn up snugly by hand. To put the assembly tightly together a long handled wrench may be used on permanent fittings, although shorter wrenches are often used on minor framing pieces. Inspection is mostly visual. It is a very simple mater to test the tightness of a nut, if desired. On the flanges of I-beams and channels a beveled washer should be used.

Tensile Bolting

Those bolts, nuts, and washers whose material composition conforms with I.S. specification are called high tensile. Such bolts can be identified by three radial lines on top of the head as shown in Exhibit 10.5.

The bolts are ordered by size and length, the size being the diameter of the threaded shank, and the length being the sum of the thicknesses of the plates joined by the bolt (called, as for rivets, the grip), plus and allowance for two flat washers, nut, and bolt point. The total length should be adjust to the next full 6 mm increment up to 125 mm in length and to the next longer 12 mm increment for lengths over 125 mm. When beveled washers are used, an additional 3 mm should be added for each.

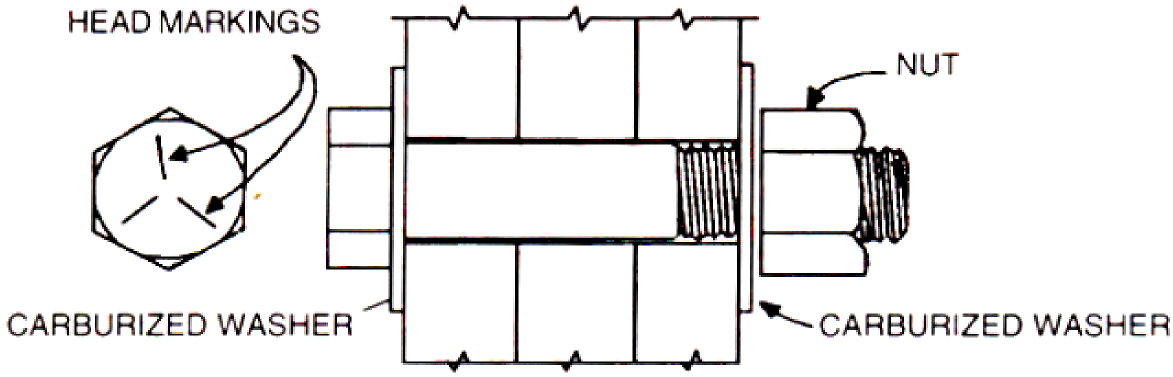


Exhibit 10.5 : High Tensile Bolt

Washers. A different washer is used with each bolt size. The washers are all specially hardened. They have an inside diameter equal to that of the hole into which the bolt is to be inserted, and an outside diameter approximately twice the bolt size plus 12 mm. Square-beveled washers used with Indian Standard Beams and Channels have a universal mean thickness of 8 mm and a slope of one to six. Their width is 45 mm for all bolts except the two largest sizes, where the width becomes 55 mm.

The material to be assembled may carry the normal tight mill scale, but all loose scale should be removed. The contact surface should be clean and free of oil, burns, pits and other defects that will prevent solid seating of the parts. A shop coat of protective paint or lacquer is not objectionable, provided the joints are not subjected to stress reversal, impact, or vibration. Paint should also not be applied where stress redistribution due to joint slippage would be undesirable.

Bolt Installations

Bolts are connected by two men crew. Each man carries with him a pocketful of bolts, nuts, and washers. After the holes have been paired up with enough drift pins to maintain dimensions and plumbness of the structure, one of the men slip a bolt through a washer and the holes, the other puts a washer over the exposed threads and hand tightens a nut. A hand torque wrench is used to tighten up the bolts. Either the head or the nut may be driven up. After each bolt has been tightened sufficiently, making sure that the connected parts are properly fitted, the pins are removed and replaced with bolts.

To avoid the use of expensive air compressors, pipes, manifolds, and torque wrenches, it is better to tighten the bolts with a long handled socket or spud wrench to produce the equivalent torque for required minimum tension.

Inspection: Bolted connections can be inspected both visually and mechanically. Not every bolt need be tested. With joints containing less than 10 bolts, it is sufficient to check only 1 bolt. With joints containing more than 10 bolts. 1 out of every 10 is tested.

17. WELDING

For comments on welding see later under Clause 10.4.

17.4 Steel Work in Built up Section (Welded)

17.4.1 Laying out

It shall be as specified in 10.3.1

17.4.2. Fabrication

17.4.2.1 Straightening, shaping to form, cutting and assembling, shall be as per 10.3.2 as far as applicable, except that the words “rivetted or bolted” shall be read as “Welded” and holes shall only be used for the bolts used for temporary fastening as shown in drawings.

17.4.2.2 Welding: Welding shall generally be done by electric arc process as per IS : 816 and IS : 823. The electric arc method is usually adopted and is economical. Where electricity for public is not available generators shall be arranged by the contractor at his own cost unless other specified. Gas welding shall only be resorted to using oxyacetylene flame with specific approval of the Engineer-in-Charge. Gas welding shall not be permitted for structural steel work. Gas welding requires heating of the members to be welded along with the welding rod and is likely to create temperature stresses in the welded members. Precautions shall therefore be taken to avoid distortion of the members due to these temperatures stresses.

The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used. Symbol for welding on plane and shops drawings shall be according to IS : 813.

As far as possible every efforts shall be made to limit the welding that must be done after the structure is erected so as to avoid the improper welding that is likely to be done due to heights and difficult positions on scaffolding etc. apart from the aspect of economy. The maximum dia of electrodes for welding any work shall be as per IS : 814 and Appendix “B” of IS : 823. Joint surfaces which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter, which adversely affect the quality of weld and workmanship.

17.4.2.3 Precautions: All operations connected with welding and cutting equipment shall conform to the safety requirements given is IS : 818 for Safety requirements and Health Provision in Electric and gas welding and cutting operations.

17.4.2.4 Operation, Workmanship and Process of Welding is described in Appendix B, of Chapter 10.

17.4.2.5 Inspection and testing of welds shall be as per IS: 822.

17.4.2.6 Assembly: Before welding is commenced, the members to be welded shall first be brought together and firmly clamped or tack welded to be held in position. This temporary connection has to be strong enough to hold the parts accurately in place without any disturbance. Tack welds located in places where final welds will be made later shall conform to the final weld in quality and shall be cleaned off slag before final weld is made.

17.4.2.7 Erection: The specifications shall be as described in 10.3.3. except that while erecting a welded structure adequate means shall be employed for temporary fastening the members together and bracing the framework until the joints are welded. Such means shall consist of erection bolts, tack welding or other positive devices imparting sufficient strength and stiffness to resist all temporary loads and lateral forces including wind. Owing to the small number of bolts ordinarily employed for joints which are to be welded, the temporary support of heavy girders carrying columns shall be specially attended. Different members which shall be fillet welded, shall be brought into as close contact as possible. The gap due to faulty workmanship or incorrect fit if any shall not exceed 1.5 mm. or more occurs locally the size of fillet weld shall be increased at such position by an amount equal to the width of the gap.

17.4.2.8 Painting: Before the member of the steel structures are placed in position or taken out of the workshop these shall be painted as specified in para 10.2.2.

17.4.3 Measurements

The mode of measurements shall be the same as specified in 10.2.4 except that weight of welding material shall not be added in the weight of members for payment and nothing extra shall be paid for making and filling holes for temporary fastening of members during erection before welding.

17.4.4 Rate

The rate shall include the cost of all labour and materials involved in all the operation described above.

RELEVANT EXTRACTS FROM BIS CODES

Relevant Extracts from IS: 818-1968 – Code of Practice for Safety & Health Requirements in electric Gas Welding and Cutting.

18. PREVENTIONS IN WELDING OPERATIONS

18. Fire prevention and Protection

18.1 Basic Precautions

18.1.1 Where practicable, the object to be welded shall be moved to a safe location designated for welding.

18.1.2 if the object is such that it is not possible to move it readily, all movable fire hazards in the vicinity shall be taken to a safe place.

18.1.3 If it is neither possible to move the object nor it is possible to move all the fire hazards to a safe place, then guards shall be used to confine the heat, sparks and slag, and to protect the immovable fire hazards.

18.1.4 if it is not possible to follow the requirements stated under 6.1.1,6.1.2 and 6.1.3, no welding or cutting shall be performed.

18.2 Special Precautions

18.2.1 When the nature of work to be performed falls under the conditions given under 6.13, certain additional precautions shall be taken.

18.2.2 After combustible floors have been swept clean, they shall be protected by thoroughly wetting with water, covering with damp sand, sheet metal, asbestos, etc., or such other equivalent material. Provisions shall be made to protect welders from the hazard of shock when floors are wet.

18.2.3 Suitable, incombustible tables, jigs or work-places shall be provided for support of small or moderate size work during welding and cutting operations. Such operations should not be undertaken on work resting directly on concrete floors.

18.2.4 Wherever there are floor openings or cracks which are not possible to close, it is advisable to make certain that there are no highly combustible materials on the floor below to ensure that there is no fire hazard due to spark which might drip through to the floor. This precaution shall also be observe with regard to cracks or holes in walls, open door-ways and open or broken windows.

18.2.5 Suitable fire-extinguishing equipment, such as pails of water, buckets of sand, hose lines or portable extinguishers shall be kept in readiness for instantaneous use. Care shall be taken to maintain them in good working condition at all times.

18.2.6 Additional personnel may be stationed as fire watchers, if required, not only while the actual welding or cutting operations are being performed but also for a sufficient period of time after completion of the work to ensure that no fire exists. This period may vary from 30 minutes to several hours, depending on the site conditions.

18.2.7 Where unusual fire hazard conditions prevail, the site shall be inspected by a qualified person and welding and cutting coming within the scope of 6.1.2 and 6.1.3 authorized before any work is started.

18.3. Welding or Cutting Containers

18.3.1 Welding or cutting operations on containers filled with explosive or inflammable substances shall be prohibited except in certain particular for :

(a) the repair by the electric welding process of water-sealed gas-holders contain town gas, coal gas, furnace gas or similar inflammable gases other than acetylene at more than the atmospheric pressure;

(b) Urgent repairs in the open air of gas mains, where such gas mains contain town gas, coal gas, furnace gas or similar inflammable gases, other than acetylene at more than the atmospheric pressure; and

(c) such repair of pipes in oil refinery as is essential for safety.

18.3.2 If parts of installations subjected to great stresses, such as steam boilers and other pressure vessels, are to be repaired by welding, then such repairs shall be carried out by welders authorized for such work by a competent authority; and only such methods, equipment and filler metal as have been declared permissible for such purposes by the competent authority shall be used.

18.3.3 If an inert gas is used for purging, after the vessel has been filled, the gas should be allowed to flow slowly into it throughout the welding or cutting operation.

18.3.4 All hollow spaces, cavities or containers shall be vented to permit the escape of air or gases before preheating, cutting or welding. Purging with inert gas is recommended.

18.3.5 Welding of oil drums, motor car petrol tanks or any other containers which might at any time have contained a liquid giving off and inflammable gas shall not normally be permitted. However, in case welding of such containers is absolutely necessary, the following precautions shall be taken before welding them:

(a) They shall be thoroughly degreased using an alkaline or any other type of degreasing solution;

(b) They shall then be thoroughly rinsed with hot water and allowed to dry for a few days;

(c) After drying and before welding, they shall be purged thoroughly for a period of at least five minutes with an inert gas; and

(d) The inert gas shall be allowed to flow through the container under a positive pressure while welding is taking place.

18.3.6 **Sprinkler Protection**- Where sprinkler protection exists, it shall be maintained without interruption while welding or cutting work is being performed. If welding or cutting is to be done quite close to automatic sprinkler heads, sheet asbestos or damp cloth guards shall be used to shield the individual heads temporarily.

For more details regarding fire precautions reference may be made to IS : 3016-1965 'Code of Practice for fire precautions in welding and cutting operations'.

19. Protection of personnel

19.1 General

19.1.1 In every factory all floors, steps, stairs, passages and gangways shall be of sound construction and properly maintained. These shall be provided with suitable hand-rails wherever necessary.

19.1.2 Safe means of access shall be provided to every place at which any person is at any time required to work as far as practicable.

19.1.3 A welder or helper working on platform, scaffolds or runways shall be protected against falling. This may be accomplished by the use of railings, safety belts, life lines, or such other equally effective safeguards. Life belts and similar devices shall be of a type that will permit quick escape of the workman.

19.1.4 Automatic and semi-automatic resistance welding machines shall, where practicable, be equipped with gate guards or two-handed tipping devices so designed as to prevent the hands of the operator from reaching the danger zone after the pressure control has been actuated.

19.1.5 All portable welding equipment, such as gas cylinders, hoses, electric cables, etc., shall be so installed at the working place as to prevent all risks of the equipment, falling or tipping and of persons stumbling or tipping.

19.1.6 it shall be strictly prohibited to use any compressed gas or compressed air to clean dust, dirt, etc., of worker's clothes when these are being worn.

20.Protective Equipment

20.2.1 The object of protective equipment is to protect the eyes and face from heat and the injurious effects of the rays (infra red, visible light and ultra violet) given off from the electric arc. They should, therefore, be constructed of heat-resisting, non-ignitable material which is also impervious to the harmful rays. They shall be light for convenience in use, and strong to withstand rough service. The minimum amount of metal shall be used in their construction, particularly on the outside of the shield, for example, there should be no metal frame for the glass either on the outside or on the inside; metal rivets should not be used unless one end is covered by an insulating material, as these may be the means of causing electric shock.

20.2.2 Head shields shall be fitted with an adjustable band to fit the wearer's head. This device shall be made as far as practicable from an insulating materials. Any metal work forming part of it shall be thoroughly insulated from the wearer's head and the insulation shall be non-absorbent. The sides of the shiled shall be sufficiently large so as to give protection to the neck and side of the head. This is especially important where welders work near each other.

20.2.2.1 The handles of head shields shall be of a material which is a bad conductor of both electricity and heat .it shall be fixed either inside the shield to protect the head from the heat and rays of the arc ,or fixed outside and provided with a good guard .

20.2.2.2. The widow through which the operator views the arc shall be of the required grade .The frame shall be such as to take protective glass with a piece of plain glass fixed in front facing the arc so that spatter from the arc is intercepted by the plain glass which may be renewed by time to time .The protecting glass shall be fixed such that the arc is not visible through cracks and chinks rounds the edges. Helmets shall be pe\referred to head shields.

20.2.3 Goggles

20.2.3.1 Goggles shall be used:

(a) to protect the eyes of persons, other than the rays of and electric arc; and

(b) to protect the eyes of persons from small flying pieces of slag while chipping it from the weld.

20.2.3.2 Goggles to protect the eyes from the injurious rays shall always be fitted whit opaque side shields. The glasses of the goggles shall be of a suitable grade. Alternately, the goggles shall be fitted whit Crookes spectacle glass. However, goggles fitted with this glass are suitable only for protection when the arc is not the immediate neighbourhood. Glasses of greenish neutral colour are considered to afford the maximum protection for the eyes.

20.2.3.3 Goggles to protect the eyes from small flying pieces or slag shall be fitted with clean non-splinter able glass if there is no need to protect the wearer from rays from the arc. Side screens should, however, be fitted but they may be transparent it preferred. If goggles to protect the eyes from slag are also required to give protection from arc rays, they shall comply with the requirements specified under 7.2.2.1 and the optical glass should be protected from mechanical damage by a superimposed and easily replaceable piece of clear glass.

Note- It should be noted that goggles do not provide adequate protection for a welder, as it is necessary for his face to be protected in addition to his eyes and he should, therefore, use a helmet or head shield.

20.2.4 Screens-All electric welding operations shall be screened to prevent the rays of the arc from affecting other persons working in the neighbourhood. Where the work is done at fixed benches or in welding ships, permanent screens shall be erected, as far as practicable. Where this is not possible, temporary screens shall be used to limit the radiation. All screens shall be opaque, of sturdy construction to withstand rough usage, and of material which shall not readily catch fire by sparks or hot metal. They shall not, however, be so heavy or cumbersome as to discourage their use.

20.3 Protection of Fellow Workers from Arc-Welding Rays

20.3.1 Where arc welding is regularly carried on in a building, the walls of the welding bay shall be painted with a non-reflecting colour to prevent flickering reflections.

20.3.2 When the work permits, the welder shall be enclosed in an individual booth painted with a non-reflecting paint, such as zinc oxide or lamp black. Alternately, an enclosure of non-combustible screens similarly painted shall be provided. Booths and screens shall permit circulation of air at floor level. Workers or other persons adjacent to the welding areas shall be protected from the rays by non-combustible or flame-proof screens or shields or shall be required to wear appropriate goggles.

20.4 Protective Clothing- Protective clothing required for any welding operations varies with the size, nature and location of the work to be performed. However, they should not be of such type or weight as to restrict the comfort of the operator unduly, thus discouraging its use.

20.4.1 The following protective means may be employed:

(a) Leather or asbestos gloves, except when engaged in light work;

(b) Flame-proof aprons made of leather, asbestos, or other suitable material for protection against radiated heat and sparks; and

(c) Woollen clothing in preference to cotton clothing, the clothing being reasonably free from oil or grease.

20.4.2 Sleeves and collars shall be kept buttoned and pockets eliminated from the front of overalls and aprons. Trousers or overalls shall not be turned up on the outside.

20.4.3 For very heavy work, fire-resistant leggings, high boots or other equivalent means shall be used.

7.4.4 Lower-cut shoes with unprotected tops shall not be used.

7.4.5 In production work a sheet metal screen in front of the worker’s legs any be employed to provide further protection against sparks and molten metal in cutting operations.

7.4.6 Caps or shoulder covers made of leather or other suitable material shall be worn during overhead welding or cutting operations. Leather skull caps may be worn under helmets to prevent head burns.

7.4.7 For overhead welding, or welding in extremely confined spaces, ear protection is also desirable. This may be accomplished by placing wool or rubber plugs in the ears or by covering them with wire screen protectors.

7.4.8 Where there is exposure to sharp or heavy falling objects, hard hats or head protectors should be used.

7.5 Work in Confined Spaces

7.5.1 Adequate ventilation shall be provided in confined spaces in accordance with the requirements laid down under 8.

7.5.2 When welding or cutting is being performed in any confined space, the gas cylinders and welding machines shall be left on the outside. Before operations are started, heavy portable equipment mounted on wheels shall be securely blocked to prevent accidental movement.

7.5.3 Where a welder has to enter a confined space through a manhole or other small opening, means shall be provided for quickly removing him in case of emergency. When safety belts and life lines are used for this purpose they shall be so attached to the welder's body that he is not jammed in a small exit opening.

7.5.4 When arc-welding is to be suspended for any substantial period of time, such as during lunch hours or overnight, all electrodes shall be removed from the hoders and the holders carefully located so that there is no possibility of accidental contact. The machine shall also be disconnecte from the power source. The welders should use fully insulated electrode holder.

7.5.5 When gas welding or cutting, the torch valves shall be closed and the gas supply to the torch positively shut-off at some overnight. Where practicable, the torch and hose shall also be removed from the confined space.

7.5.6 After welding operations are completed, the welder shall mark the hot metal or provide some other means of warning other workers.

7.6 First-Aid Provisions- All injuries shall be reported as soon as possible for medical attention. Provision shall b made for rendering first-aid in accordance with the requirements specified under the Factories Act, 1948.

7. Ventilation and Health Protection

8.1 General

8.1.1 The requirements for ventilation and health protection have been established on the basis of the following three factors in gas-and arc-welding which govern the amount of contamination to which welders may be exposed:

(a) Dimensions of space in which welding is to be done (with special regard to height of ceiling);

(b) Number of welders employed on the work; and

(c) Possible evolution of hazardous fumes, gases or dusts depending upon the metal being welded.

8.1.2 In individual instances, additional factors than those specified under 8.1.1 may also be involved, in which case ventilation or respiratory protective devices shall be provided to meet individual requirements. Such factors include:

(a) atmospheric conditions,

(b) heat generated, and

(c) presence of volatile solvents.

8.1.3 In addition to the hazards from burns, electricity and radiation, means for the control of which have already been standardized, under certain conditions there may be health hazards due to gases, fumes or dusts containing lead, zinc, cadmium, fluorine, mercury or compounds thereof or to the possible formation of oxides of nitrogen or due to extreme heat. These potential hazards are not serious except in spaces not properly ventilated. Helalth hazards from welding operations may be controlled by local exhaust or general ventilation, depending upon the nature of the hazard. When such a hazard is present, sufficient ventilation or individual respiratory protection shall be provided in accordance with the requirements of this section.

8.1.4 When it becomes necessary to perform welding in a space entirely screened on all sides, the screens shall be so arranged that no serious restriction of ventilation exists. It is desirable to have the screens so mounted that they are about 60 cm above the floor unless the work is performed at so low a level that the screen should be extended nearer to the floor to protect nearby workers from the glare of welding.

8.1.5 Local or general ventilating systems shall be provided and arranged sufficient to keep the amount of toxic fumes or dust below the maximum allowable concentration as specified in Table 1. where, because of the intermittent nature of the work or for other goods reasons, it is impracticable to control gases, fumes or dusts by such means, welders shall be required to used respiratory protective equipment.

TABLE 1: MAXIMUM ALLOWABLE CONCENTRATION OF TOXIC DUSTS AND GASES FOR EXPOSURE NOT EXCEEDING EIGHT HOURS DAILY

(Clause 8u.1.5)

Dust or Gas	Volume per 1000 000 Parts of Air at 25º C and 760 mm Pressure	Weight per liter at 25ºC and 760 mm Pressure
(1)	(2)	(3)
	Parts	Mg
Xylene	200	0.868
Lead and certain of its inorganic compounds, the carbonate, sulphate, oxides, nitrate and chloride	--	0.000015
Toluene (toluole)	200	0.752
Oxides of nitrogen (calculated as NO_2	5	--
Styrene monomer	200	1.7
Methanol (methyl alcohol)	200	0.26
Formaldehyde	5	0.012
Methyl chloride	100	0.2
Trichloroethylene	200	--
Metallic arsenic and arsenic trioxide	--	0.0005
Mercury	--	0.0001

Dust or Gas	Volume per 1000 000 Parts of Air at 25º C and 760 mm Pressure	Weight per liter at 25ºC and 760 mm Pressure
Chromium (as chromate, dichromate dust or as chromic acid mist)	--	0.0001
Manganese dust and fumes	--	0.006
Carbon monoxide	100	0.11
	(with atmospheric oxygen not below 19 percent by vol.), and	
	400	0.46
	(for exposures not exceeding a total of one hour daily)	
Hydrogen sulphide	20	0.028
Benzene (benzol)	35	0.32
Cadmium or its compounds	--	0.0001
Carbon disulphide	20	0.062

8.1.5 In confined spaces or other location where the amount of toxic substances is likely to exceed the maximum allowed concentrations, supplied-air respirators, such as air-line respirators or hose masks with or without blowers shall be provides . This applies not only to the welder but also to helpers and other personnel working in the immediate vicinity. Air supply for steel equipment shall be clean and of equable temperature. Since welding operations are liable to alter the compositions of atmosphere, blowing in fresh air may help to remove the polluted atmosphere in tanks and enclosed spaces.

8.1.6 Where welding operations are incidental to general operation, local exhaust ventilation shall be provided to prevent contamination of the general work.

8.1.7 Individual respiratory equipment shall be well maintained. It shall not be transferred from one employee to another with being sterilized.

8.1.8 Manufacturers' instructions pertaining to fluxes and electrode coverings shall be carefully observed.

8.1.9 No Welding or cutting shall take place in the room where a vapour degreasing plant is also situated.

8.2 Lead Cadmium and mercury- All welders engaged in welding or cutting metal containing (or coated with) lead, cadmium or mercury-bearing substances, shall be provided with an approved type air-line respirator or hose mask except where exhaust ventilation, sufficient to control the fumes generated as specified under 8.5 is provided and used . Exhaust ventilate shall not be substituted for respiratory protection required in welding or cutting operations inside confined spaces.

8.3 Fluoride-Bearing Fluxes and Zinc – Welding or cutting metals coated with zinc-containing substances and welding involving the use of fluoride-bearing flux shall be done indoors only when local exhaust ventilation as proscribed under 8.5 is provided. Where the work is to he done in a confined space, air-supplied respirators shall be provided.

8.4 All Other Welding and Cutting- When welding or cutting is done on metals under conditions not covered under 8.2 & 8.3, mechanical ventilation shall be resorted to only under one or more of the following conditions.

(a) The working space is less than 280 m^3 per welder;

(b) The room in which welding has to be done has a ceiling height of less than 5.00 m; and

(c) The available space is confined or contains partitions, balconies or other structural barriers to the extent that they significantly obstruct cross ventilation.

8.4.1.1 The mechanical ventilation shall be at the minimum rate of 56 m3 minute per welder or four air changes per hour, whichever is greater, except where local exhaust hoods and booths have been provided as specified in 8.5 or air-line respirators are provided. Natural ventilation is considered sufficient for welding or cutting operations where the restrictions listed under 8.4 are not present.

8.5 Local Exhaust Hoods and Booths- Mechanical local exhaust ventilation shall be provided by the following methods;

(a) By means of freely movable hoods intended to be placed by the welder as near as practicable to the work being welded and provided with a rate of air flow sufficient to maintain a velocity in the direction of the hood of 30.0 linear meters per minute at the point of welding when the hood is at its most remote distance from the point of welding. The rates of ventilation required to accomplish this control velocity using a 7 –cm wide flanged suction opening are given in Table 2; and

(b) By means of a fixed enclosure with a top and not less than two sides which surround the welding or cutting operations and with a rate of air flow sufficient to maintain a velocity away form the welder of not less than 15 linear meters per minute.

TABLE 2 : RATE OF VENTILATION REQUIRRED

Welding Zone From Arc or Torch	Minimum Air Flow	Duct Dia
(1)	(2)	(3)
cm	m^3	cm
10 to 15	4.5	7
15 to 20	8.0	9

20 to 25	12.0	11
25 to 30	17.0	13

Note 1 – Wherever possible, all exhaust from operation shall be discharged to the outdoors.

Note 2 – For hoods not provided with flanges, minimum air flow shall be increased by 60 m^3 per minute.

- Nearest 1 cm duct dia based on 1200 m per minute velocity in pipe.

8.6 Work in Confine spaces – The following additional requirements shall be met where welding is done in confined spaces:

(a) All welding and cutting operations carried on in confined spaces shall be adequately ventilated to prevent the accumulation of toxic gases or possible oxygen deficiency.

(b) All air, replacing that withdrawn shall be clean and repairable. In such circumstances where it is impossible to provide such ventilation, air-supplied respirators or hose masks shall be used.

(c) Where welding operations are carried on in confined spaces & welders & helpers are provided with approved air-supplied respirators or hose marks, a workman shall be stationed on outside of such confined space to service the power & ventilation lines to ensure the safety of those working within.

(d) Oxygen from cylinder or torch shall never be used for ventilation.

8.7 Medical Control:

8.7.1 All workers and workmen engaged in welding operations shall be thoroughly examined periodically.

8.7.2 Employment of persons under 18 years of age shall be prohibited in gas or arc welding & oxygen cutting tanks or in confined spaces, on scaffolding or per heated assemblies.

EXPLANATORY NOTES AND COMMENTS

WELDING

Oxyacetylene Welding

Tow kinds of torches are available to a welder: (1) a two line torch used for welding and (2) a three line torch used for cutting. Except for the welding of non-ferrous metals such as aluminium the use of the flame in welding is rare. Both the hand fed and the automatically fed equivalent in use today for welding aluminium are oxyacetylene torches. However, the welding torch has many other uses in a shop, including: straightening small areas of warp inaccessible to straightening machines, surface hardening of certain metals to make them wear resistant or abrasion resistant , descalling of badly rusted pieces prior to painting, and preheating prior to cutting or welding.

Welding torch. Using a welding torch, the welder “cracks” the tanks (see exbt:10.6) then shuts them tightly again and cleans out the hose by allowing some gas to flow through, carefully avoiding any sparks or fires. After checking the pressure gauges, he starts the flame with a spark from a spark lighter. After the yellowish flame is burning, oxygen is turned on the produce a bright blue flame at the tip and a larger light blue flame surrounding the tip.

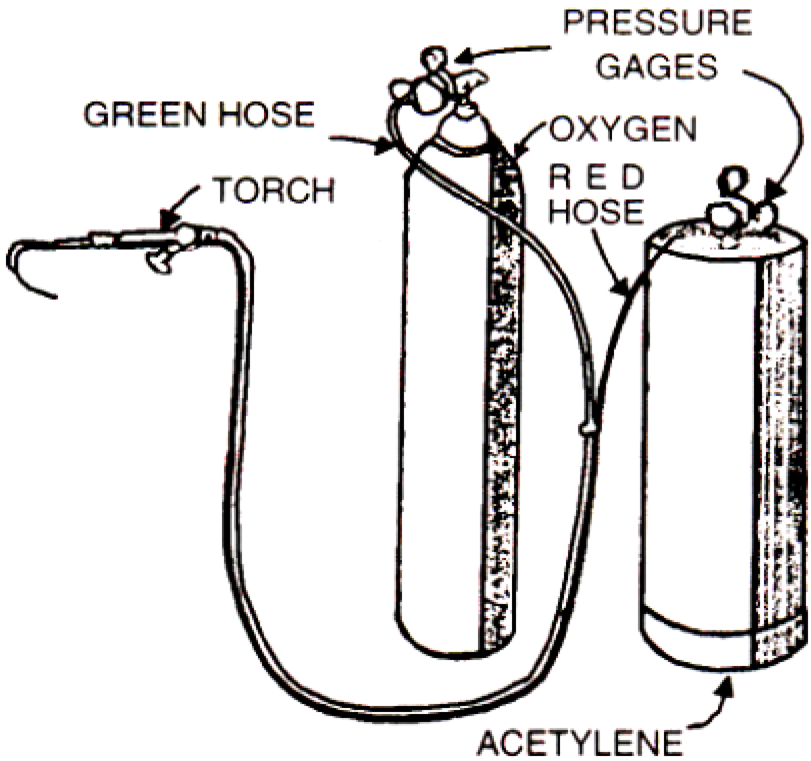


Exhibit 10.6 : Equipment and Arrangement for Oxyacetylene Welding

The type of flame produced depends on the amount of oxygen used in relation to the amount of acetylene. Although it takes a 2-1/2 to 1 ration of oxygen to completely consume the acetylene, approximately a 1 to 1 ration comes from the tank, the rest coming from the air. Oxygen from the tank breaks acetylene completely into carbon monoxide and hydrogen. These gases then combine with the oxygen present in the air to produce, finally, carbon dioxide and water, and the combustion is complete.

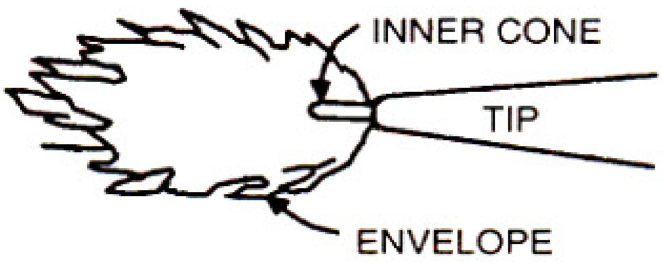


Exhibit 10.7: Envelope Flame from Welding Torch

When the ratio of tank oxygen to acetylene is between 1.04 and 1.14, the flame produced is called neutral, and is used for welding and preheating during cutting. The envelope flame (see Exhibit 10.7) is slightly luminous light blue, while the inner cone is luminous bluish-white. When the ratio of tank oxygen to acetylene is increased between 1.15 to 1.7, the flame is of the same characteristics, but it is much shorter and hotter, and is used for fusion welding of brass and bronze, and in bronze welding of steel and cast iron. When the ratio of tank oxygen to acetylene is reduced between .85 to .95, the flame is slightly cooler and contains an intermediate cone within the envelope but outside the inner cone. It is called a reducing or carbonizing flame, and is used for welding high-carbon steel and such not-ferrous alloys as monel metal. It is also used in silver soldering operations.

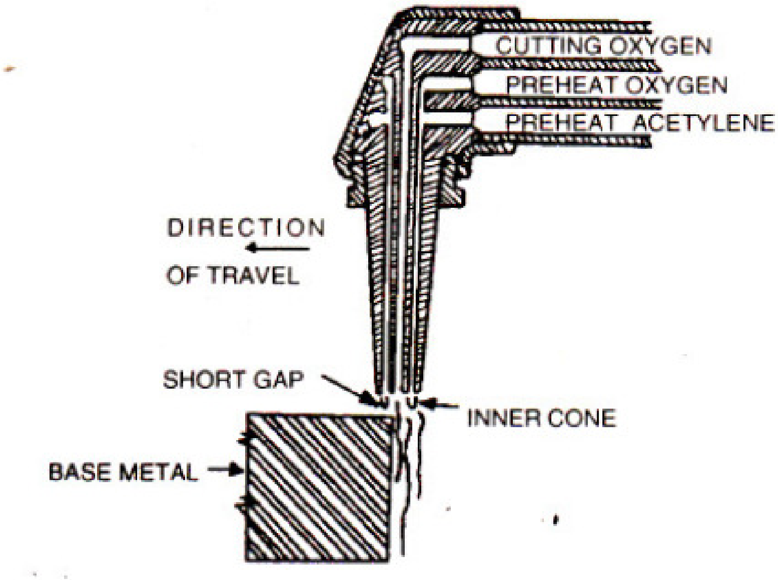


Exhibit 10.8 : Notice the added passage for the flow of oxygen Cutting Torch – Hand -

Cutting torch. As shown in exhibit 10.8 the cutting torch has, instead of the tip of the welding torch, a head containing a third tube for the passage of oxygen. This second source of oxygen actually does the cutting by combining with the hot iron and forming, in effect, a gaseous rust which separates from the parent metal. Actually, if the metal ware absolutely clean and free of impurities, after the cut were started, it would be entirely sustained by this high pressure oxygen line operating alone. The oxyacetylene preheat is required, however, to maintain a smooth cut in the usual job.

Clause 10.4.4

The head shown in Exhibit 10.8 is a 90^0 head although 75^0 and straight heads are available. Various size tips are used, depending upon the thickness of the metal to be cut. Annexure 10.1 shows tip size numbers for various plate thickness together with the proper acetylene and oxygen pressure in kgs per square centimeter.

Regardless of the tip or type of head used, the base metal is preheated with a neutral flame to a bright cherry red before the cutting operation starts. The cutter should proceed at a slow smooth rate of travel, just fast enough to produce a steady stream of sparks from the far side of the material.

The theoretical oxygen requirement for cutting is 0.285 cum of oxygen per kg of iron removed from the slot formed by cutting. Actually, since some of the metal removed is unoxidized, as little as 0.22 cum of oxygen is consumed per kg of iron removed.

ANNEXURE 10.1

TIP SIZE NUMBERS FOR OXYACETYLENE WELDER

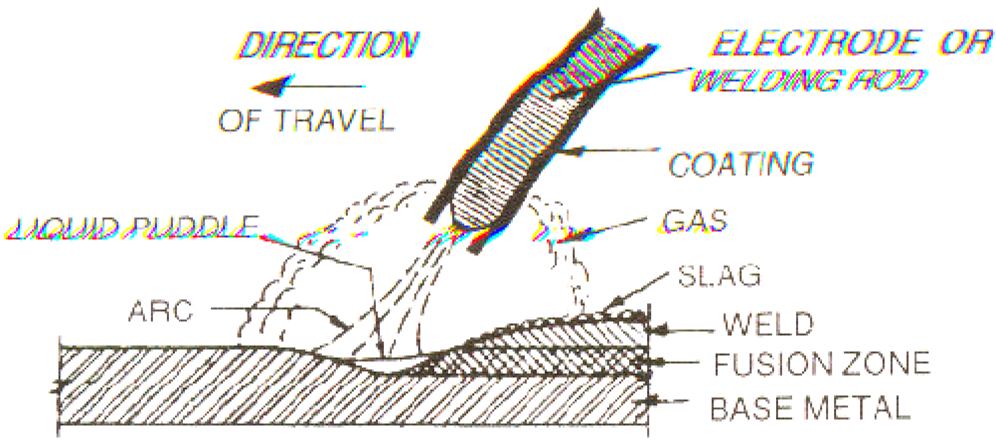
Plate Thickness mm	Tip Size No	Acetylene Pressure kgs/cm^3	Oxygen Pressure kgs/cm^3
6mm	0	0.21	1.75 to 2.10
9.5 to 12 mm	1	0.21	2.10 to 2.8
20 to 25 mm	2	0.21	2.8 to 3.5
38 mm	3	0.21	3.15 to 3.5
50 mm	4	0.21	3.5 to 3.85
75 to 100 mm	5	0.21	3.5 to 4.6
125 to 150 mm	6	0.28	3.85 to 4.21
200 to 250 mm	7	0.35	4.21 to 5.00
300 mm	8	0.42	5.00 to 5.60

WELDED CONNECTIONS

Although there are many kinds of welding employed with various metals, the two most commonly used in conjunction with structural work are arc welding and gas welding. The latter, employing an oxyacetylene torch, is used extensively for cutting and shaping. Sometimes the torch is held by a machine for extensive burning work of excellent quality. However, for blocking and coping, a skilled operator is indispensable. Even for a straight cut, a highly trained technician can produce a finished product almost at par with that accomplished by a saw.

As per CPWD specification gas welding shall only be resorted to using oxyacetylene flame with specific approval of the Engineer-incharge. Also gas welding shall not be permitted for structural steel work.

Electrical welding is used almost exclusively for bonding together structural members. The necessary equipment consists of a generator of source of high voltage, a clamp attaching a lead wire to the base metal (or parent metal) and a holder with a hand grip. The holder contains an electrode, which is simply coated welding rod. When the switch on the holder is “ON” and the rod is sufficiently close to the base metal, the current will bridge the gap with a spark, creating enough heat (about 2,450 C) to melt the parent metal and burn off the end of the rod. The rod and the parent metal will fuse together so strongly that the weld is often stronger than the parent metal.



Exihibit 10.9 : Welding Rod in Operation

The rod coating which extends below the rod, burns more slowly than the rod itself (see Exhibit 10.9), thus directing and shielding the upper part of the arc. As it burns however the coating becomes a gas which keeps air away from the weld.

The greater part of the coating becomes slag which floats on top of the weld, protecting it from the atmosphere during cooling, thus preventing it from becoming brittle. The slag is easily knocked off the weld after the work is completed. Uncoated rods are used with welding machine in the shop, while field work is done with coated rods.

TYPES OF WELDS

Classification by Method of Application

Welds can be classified on the basis of their shape and method of application. Regardless of shape or function, the largest single factor of cost is the method by which the weld is applied. When the two pieces to be joined at 90^0 angle are positioned in the shop so that they each form a 45^0 angle with the floor and the weld is inserted from above, we have a flat weald as shown in Exhibit 10.10 This is the cheapest weld and should be used whenever possible. Progressively more expensive welds are the horizontal, vertical, and over head, since they take more time to produce. Over head welds should be avoided if possible. Even a horizontal weld takes 10 to 50 per cent more time to produce than a flat weld, that is why field welding, where positioning of welding is impossible, costs more than shop welding.. Incidentally, field welding is not considered as strong as welding done in the shop.

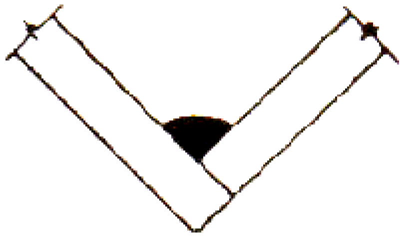


Exhibit 10.10 : Flat Weld

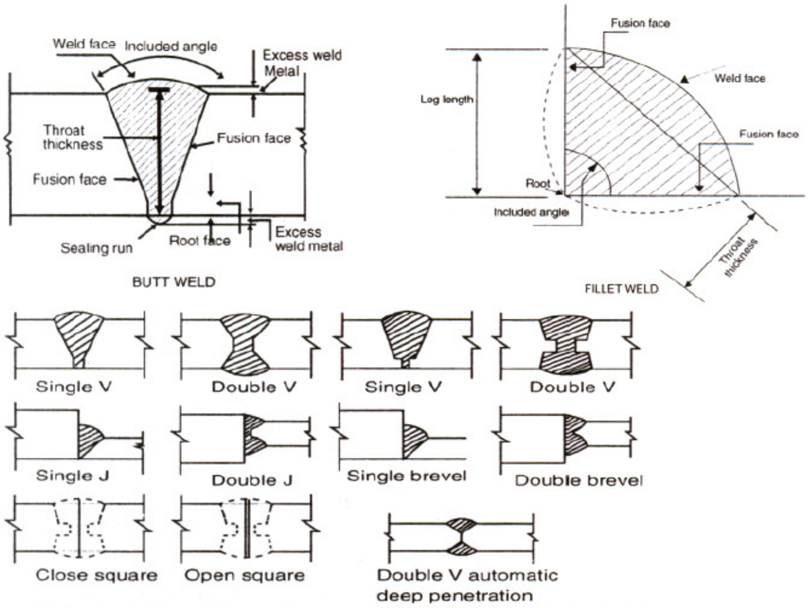


Exhibit 10.11A : Different types of Butt Welds and Fillet Weld

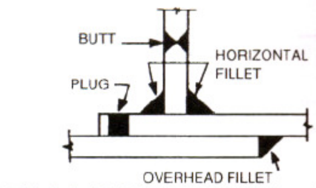


Exhibit 10.11B : Horizontal and over Head Fillet Welds and Square Butt Weld

Exhibit 10.12 : Warp in a Welded Connection

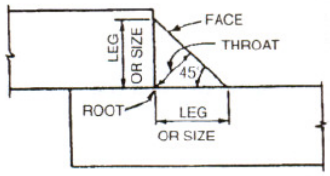


Exhibit 10.13 : Fillet Weld Nomenclautre

Classification by Shape

Basically, there are two shapes of welds, called fillet and butt as shown in Exhibit 10.11 A and 10.11B. The plug and slot welds are first cousins of the fillet; although the weld metal is placed in the prepared holes, it still joins two pieces which form a 90^0 inter section. The butt weld is used for tension or compression joints and may assume many shapes, depending upon how the base metal has been prepared with a torch. In addition there are square butt joints and may assume many shapes, depending upon how the base metal has been prepare d with a torch. In addition there are square butt joints welded on one or both sides as shown in Exhibit 10.11B Although a single vee is cheaper to prepare and apply, a double vee gives better quality construction since a single vee results in a warp due to uneven surface heating and cooling as shown in Exhibit 10.12, whereas the surface will remain flat with a double “V” or double “U”. U joints cost more than vee joints and are not common. All these joints may be chipped, chipped and ground, or even polished to get a flat smooth, surface. These procedures cost money however, and the added aesthetic quality is rarely worth the added cost.

Fillet welds resist applied forces through shear action, although they may be subjected to tension, compression, bending, or torsion. While in rare cases unequal legs may be called for, such fillet welds are special, and the normal practice is that both legs of the weld are of equal length as shown in Exhibit 10.13.

A 12 mm fillet weld means that both legs are 12 mm long. A 6 mm X 12 mm fillet means one leg is 6 mm long & other 12 mm long.

Determination of Weld Size

Since fillet welds are the most common types of welds they are being considered in detail. The size and depth of weld selected for any job depends on several factors. Paramount among these is economy. A longer weld of smaller size is to be preferred to a shorter weld of larger size, specially if it is possible to use a 8 mm or smaller weld. Any weald larger than 8 mm requires two or more passes with the rod to build up to the required size, which greatly increases the labour cost. Furthermore, although it's strength is directly proportional to the weld size, the amount of weld metal deposited varies with the area. Thus a 12 mm weld is twice as strong as 6 mm weld, but requires four times as much material.

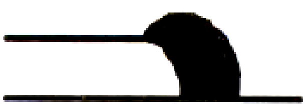
ANNEXURE 10.2

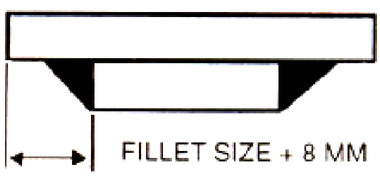
Minimum weld sizes

Weld size in mm	4.75	6	8	9.5	12	16
Max thickness of part in mm	12	20	30	50	120	Over 150

The second factor in weld size selection is the physical dimensions of the materials being joined. The minimum size of welds mandatory required for certain size of the materials being joined, are given in Annexure 10.2 Maximum effective size of fillet are also given late under "model specifications for welding jobs".

If a fillet weld is applied to the square edge of a plate as deep as the plates thickness, it would melt down the upper edge of the part. Therefore the maximum size of fillet weld that is applied to the square edge of a plate is limited to 1.5 mm less than the thickness of the plate. At a curved edge, such as at the toe of an angle or the flange of an I-beam it would be difficult indeed to get full thickness without causing stress concentrations where the weld meet the top surface of the part as shown in Exhibit 10.14 due to the sharp angle that would be formed there. In such cases, the fillet weld size cannot exceed ¾ of the thickness of the legs or flange. In both cases full thickness is permitted it the weld is specially built up, but this is expensive and should be avoided.





Exihibit 10.14 Incorrect Fillet Weld Size **Exhibit 10.15 : Fillet Weld Clearance**

Just as there must be room provided to manipulate a torque wrench or a riveting gun, so too clearance must be provided for the holder and electrode. It is better to envision the job, ensuring that the root of the weld is always visible to the operator and that the electrode forms a 30^0 angle with the vertical side of the fillet being laid down. Of course better accommodations are always welcome.

One must also allow for human error, and construction tolerances. Adequate space must be provided upon which the fillet weld is to be placed. A general practice adopted by many work shops is to allow 8 mm distance beyond the weld size as shown in Exhibit 10.15 Thus a 6 mm fillet requires 14 mm clearance.

The available length may also determine weld size. The given force must be resisted by total weld strength which is computed as product of length and size. In other words, a shorter length would require a larger weld for the same strength as a longer length with smaller weld would give.

Operation of equipment. – The welder starts the arc with either a tapping or a slight brushing motion for the electrode on the base metal. In the striking or brushing method the end of the electrode is brought down to the work in a continuous motion along the circumference of a circle. As soon as the electrode touches the surface, the welding current is short-circuited, causing both the end of the electrode and a small spot on the plate beneath the electrode to melt instantly. Immediately the electrode is raised to establish the arc. The proper arc length, or gap between electrode and work, is approximately equal to the electrode diameter. In the tapping method the electrode is held perpendicularly to the plate, then tapped or bounced against the plate then slowly raised to a short distance.

When striking the arc, if the electrode is withdrawn too slowly, it will stick or freeze to the base metal, and must be snapped off. If the electrode is brought up too quickly, the arc length will become too long and will go out. It is very important to keep the proper arc length, since this factor is vital to the quality of the weld. With the correct arc length the molten base metal will be protected by the flame. The globule melted from the rod will be in contact with both the rod and the molten work for an instant and then will be deposited uniformly and neatly.

The speed with which the welder moves the rod (makes a pass) and the pattern with which he waves the rod on multiple pass welds (those to be over 8 mm in size) are also vital to the quality of the weld . the sound of the arc is probably the best indication of proper arc length and speed. On the first pass the rod should be held steady, not wobbled, and moved only along the direction of weld. On all subsequent passes, the welder weaves the rod across the face of the previous pass in such a pattern as to get good fusion at the corners without undercutting, which requires a slight pausing or lapping motion, at the same time building up a fairly smooth, uniform layer. The welder develops the most comfortable and natural weave motion.

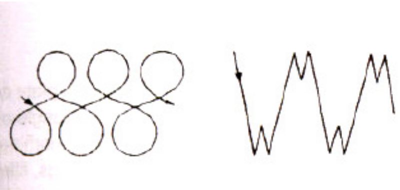


Exhibit 10.16 : Two of the Weave Motions used in Butt Welding

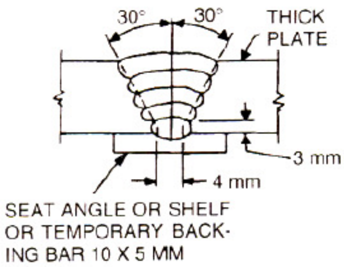


Exhibit 10.17 : V-cut Butt Weld

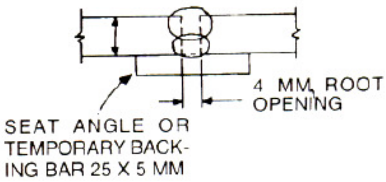


Exhibit 10.18 : Plates with 4 mm Root Opening

Butt. Vertical overhead welds: In butt welding the weld is built up from the points closest to contact. Exhibit 10.16 shows two of the weave motions used in butt welding. Thicker plates which have had their edges prepared with a V-cut for instance are spaced a trifle over 3 mm apart if possible (Exhibit 10.17). Plates up to 6mm in thickness do not require edge treatment, but are spaced at the same 4 mm (Exhibit 10.18).

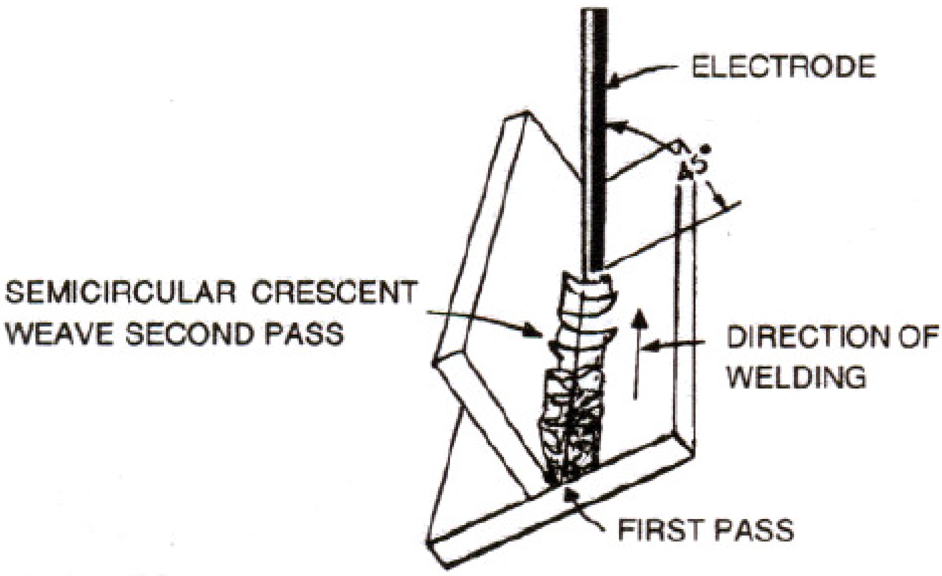


Exhibit 10.19 : Slow Crescent Weave for a Multiple Pass Vertical Weld

Vertical welds are started from the bottom of the weld and worked in an upward direction. In this way the solidified weld which has been formed first catches and holds the molten metal above if. On fillet and butt welds, the rod is moved in a triangular motion sideways as it is traveling upward, for singe pass welds. The weave on multiple passes is a slow crescent (See Exhibit 10.19). Vertical bead welds are put on with a whipping up motion, although some welders weld down when putting on vertical bead weld. In all vertical welds the current settings are lower than on the corresponding flat welds so as to melt the rod more slowly in order to gain better control on the weld. Since vertical welds are slower they cost more.

Overhead welds are extremely difficult and tedious. The welding rods used are smaller and the passes more numerous for the same size weld. A 12 mm butt weld may require as many as nine passes. Even a single pass fillet weld may be put on with a motion of drawing the arc out and slightly away from the crater to allow the puddle to solidify if the molten metal becomes too fluid and tend to sag. Of course, the electrode is then returned immediately to the crater and the welding continued. All this, however, takes a great deal of time and is relatively costly.

Regardless of the kind or position of the weld, the surface to be welded must be clean and free of grease, dirt and impurities. On multiple passes, the previous weld should have the slag chipped off or wire brushed before the new bead is applied.

Arc welding is used at times for cutting. The welder holds a bare electrode in the spot to be burned for a longer time than for welding, and proceeds at a slower rate.

Model specification On Welding

(a) **Types of Weld** : But, fillet, plug or slot welds or a combination of these types may be used in making joints and joining components.

(b) **Qualification of Weld Details**: The details of all joints (including for but welds, the groove form, root facing etc.) to be employed shall comply with all of the requirements of joints as accepted under the relevant Indian standards published by B.I.S.

(c) **Minimum Size of Fillet Welds**:

Size of Fillet mm	Max. Thickness of per in mm
4.75	12
6	20
8	30
10	50
12	150
16	over 150

(d) Maximum Effective Size of Fillet Welds : The maximum size fillet weld applied to a nominally square edge of plate shape shall be 1.5 mm less than the nominal thickness of the edge, and the size of fillet weld used along the toe of an angle the rounded edge of a flange shall not exceed three-fourths the nominal thickness of the angle leg or three-fourths and nominal edge thickness of the flange; except that when required by the design condition and specially designated on the drawings, fillet welds equal in size to the edge of a plate or rolled section may be used, provided that the weld is built out in such a manner as to insure full throat thickness, full throat thickness, full fusion area, and no injury to the base metal that will reduce its thickness adjacent to the weld.

(e) Length of Fillet Welds: The minimum effective length of a strength fillet weld shall be not less than four times the nominal size, or else the size of the weld shall be considered not to exceed one-fourth of its effective length.

The effective length of any segment of intermittent fillet welding shall be not less than four times the weld size with minimum of 40 mm.

If longitudinal fillet welds are used alone in end connections, the length of each fillet weld shall be not less than perpendicular distance between them.

(f) End Returns of fillet Welds: Side or end fillet welds terminating at ends or sides, respectively, of parts or members shall, wherever practicable, be returned continuously around the corners for a distance not less than twice the nominal size of the weld. This provision shall apply to side and top fillet welds connecting brackets beam seats and similar connections, at the tension side of such connections, on the plane about which bending moments are computed. End returns shall be indicated on the design and detail drawings.

(g) Plug and Slot Welds: Plug or slot welds, or fillet welds in holes or slots, may be used in plates not more than 25 mm thick, where subjected principally to shearing stresses or where needed to prevent buckling of lapped parts.

The diameter of the holes for plug welds and the width of slot welds shall be not less than the thickness of the part containing the hole or slot, plus 8mm rounded to the next greater mm. The diameter of plug welds and the width of slot welds shall not be greater than 3 times the thickness of the weld metal.

The maximum length of slot welds shall not exceed 10 times the thickness of the part containing the slot.

ERECTION

Field Practice

In many jobs the construction site is large enough to accommodate a storage yard where the steel can be placed until required. In highly congested areas, where the building occupies the entire land area, such an arrangement is impossible and a nearby storage site must be obtained.

Preliminary Erection Information

In any event, the individual pieces delivered to the place of storage by truck are placed on the ground with their identifying marks of numbered sides visible so that each piece can be found when wanted. The steel should never be placed in piles over two rows high, since it is difficult to find any member in a pile when the number is hidden. Beams can often be recognized by the nature of their end connections and then verified by mark. Due of this, it is wise to have a complete set of shop drawings on the jobs.

Allocation of Work

The actual erection process starts when the anchor bolts are placed by the general contractor (see Note below). The erection of the steel framework is usually the function of a specialist contractor. On larger jobs the fabricators and erectors are the same concern. The general tender conditions specify certain obligation on the general contractor of the work and cooperation expected of him under a standard contract, such as the settling of anchor bolts and all loose intels, establishing of grade lines and benchmarks, and the setting of light, loose base plates, to mention a few items.

Note: Though the item, providing an fixing Anchor bolt is so important is structural steel works, surprisingly the departmental specifications including the CPWD specification, on the subject, is not at all clear and even in the Delhi schedule of Rates there is not specific item for providing and fixing Anchor bolts with ancillary works.

The CPWD specification under clause No. 10.3.3.4 and 10.3.3.5 though pertains to anchor bolts, the details given are not a t all specific and explanatory, and mainly stress on the point that the job of providing and fixing anchor bolts should be done as per drawings.

The result generally noted is that some size of bolts are simply inserted in the concrete in a haphazard manner and later when the base plate is fixed, in a number of cases all the bolts would not tally the holes and only correct bolts are tightened and the non suitable bolts are cut off to a certain length, and the whole matter is covered by increasing the thickness of grout or additional concrete. This type of fixing Anchor bolts for foundations on which the superstructure vests, has caused a number of fatal accidents, even on small jobs.

Exhibit 10.20 and Annexure 10.3 will be suitable guideline to a Site Engineer for enabling him to maintain the correct fixing position of Anchor bolts including selecting correct length of bolts as per diameter, etc. The Site Engineer/contractor can follow the above procedure of fixing the bolts by selecting the correct length of bolt and execute a quality job.

ANCHOR BOLTS EMBEDEMENT DETAILS (FOR FULL TENSION CAPACITY)

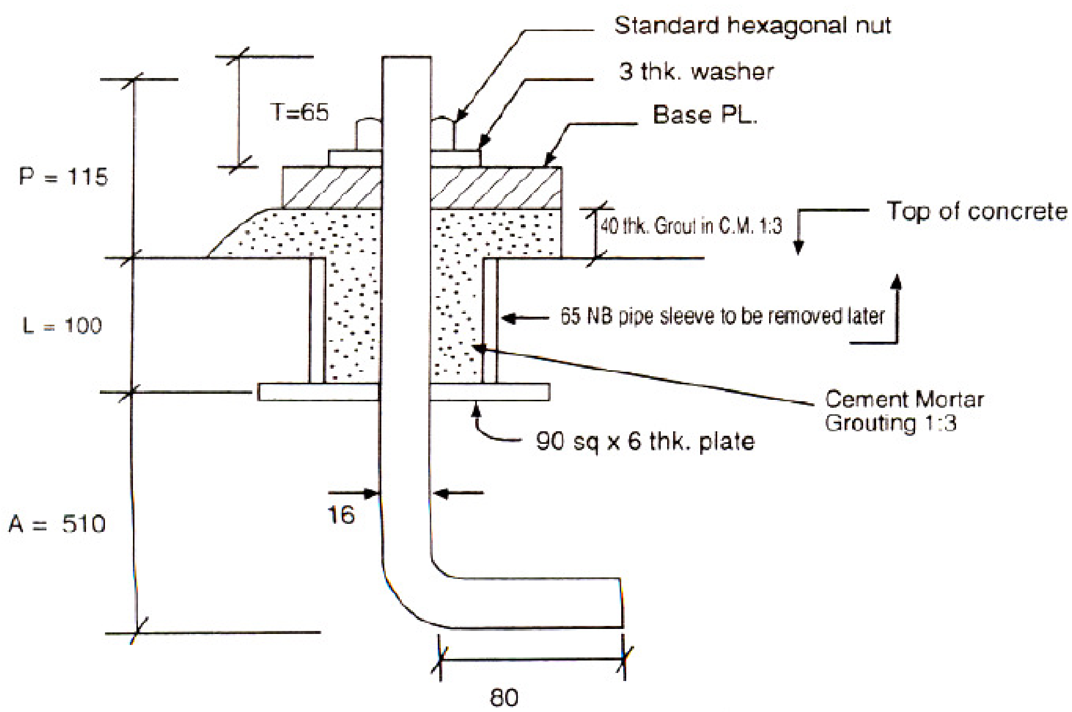


Exhibit 10.20 : Typical Detail for 16 Ø Anchor Bolt

16.DRAINAGE

21. 4 Construction Manholes (Fig 3 to8)

21.4.0 At every change of alignment g diameter of a dram there shall be a manhole of inspection chamber Bends and junctions in the drains shall be grouped together in manhole as far as possible The maximum distance between manholes shall be 30 m.

Manholes of different types and sizes as specified shall be constructed in the sewer line at such place and to such levels and dimensions between brick faces of the manholes.

Where the diameter of the drain is increased the crown of the pipes shall be fixed at the same level and necessary slope given in the invert of the manhole chamber In exceptional cases and where unavailable the crown of the branch sewer may be fixed at lower level but in such cases the peak flow level of the two sewers shall be kept the same.

Sewers of unequal sectional area shall not be jointed at the same invert in a manhole The invert of the smaller sewer at its junction with main shall be at least 2/3 the diameter of the main above the invert of the main The branch sewers shall deliver sewage in the manhole in the direction of main flow and the junction must be made with care so that flow in main is not impeded.

No drain from house fittings e g gully trap or soil pipe etc to manhole shall normally exceed a length of 6 m unless it is unavoidable.

Manholes 90*80 cm are generally constructed within compound for house drainage only and near the buildings for house drainage Manhole 1.2 m *90 cm are generally for main drainage work for depths less than 1.5 m.

Manhole 1.4 m *90 cm are of the arched type and are generally constructed for main drainage works where depth is 1.50 m or more The width of manhole shall be increased more than 90 cm on bends or junctions or pipes with diameter greater than 450 mm and that the benching width on either side of the channels is minimum 20 cm.

Manholes 1.4 m internal diameter are generally constructed for main drainage works where depth is 2.45 m or more as an alternative to manholes of arch type The diameter shall be increased suitably for pipes with diameter greater than 450 mm in the same manner as in the case of rectangular manholes.

Before deciding size of manholes local municipal bye laws shall be consulted As a general guide some typical type designs of manholes followed in Delhi have been shown in fig 4 to 7 When manholes are constructed in foot path these shall be provided with cover and medium duty casting and when built within the width of the road under vehicular traffic these shall be provided with cover of heavy duty casting.

21.4.1 Excavation

The excavation for manhole shall be true to dimensions had levels shown on the plans or as directed by the Engineer-in-charge.

21.4.2 Bed Concrete

The manhole shall be built on a bed of cement concrete 1 4 8 (1 cement 4 coarse sand 8 graded stone aggregate 4 mm nominal size) unless required by the local authorities the thickness of the bed concrete shall be 20 c m for manhole up to 4.25 m depth and 30 cm for depth beyond 4.25 m unless otherwise specified or directed by the Engineer-in-charge In bed ground special foundations as suitable shall be provided.

21.4.3 Brick work

The brick work shall be with class 75 bricks in cement mortar 1 4 (1 cement 4 coarse sand)The external joints of the brick masonry shall be finished smooth and the joints of the pipes with the masonry shall be made perfectly leak proof For arched type and circular manholes brick masonry in arches and arching over the pipes shall be in cement mortar 1 3 (1 cement 3 fine sand)In the case of manhole of circular type the excess shaft shall be corbelled inwardly on three sides at the top to reduce its size to the cover frame to the fitted.

The walls shall be built of one brick thickness for depths up to 4.25 m in ordinary subsoil the wall thickness shall be increased to one and half brick and at 9.75 m below grown two brick walls shall be built.

21.4.4 Plaster and pointing

The walls of the manholes shall be plastered inside with 12 mm thick cement plaster 1 3 (1 cement 3 coarse sand) finished smooth In the case of arched type manhole the walls of the manholes shall be plastered inside all around only up to the crown level and flush pointed for the shaft with cement mortar 1 2 (1 cement 2 fine sand)where the saturated soil is met with also the external surface of the walls of the manhole shall be plastered with 12 mm thick cement plaster 1 3 (1 cement 3 coarse sand) finished smooth up to 30 cm above the highest sub-soil water level with the approval of the Engineer-in-charge The plaster shall further be water proofed with addition of approved water proofing compound in a quantity as per manufacturers specifications In case local authorities bye laws specifies richer specifications the same shall be adopted.

For earth work excavation bed concrete brick work plaster and pointing R.C.C. work and refilling of earth respective specifications shall be followed:

21.4.5 Benching

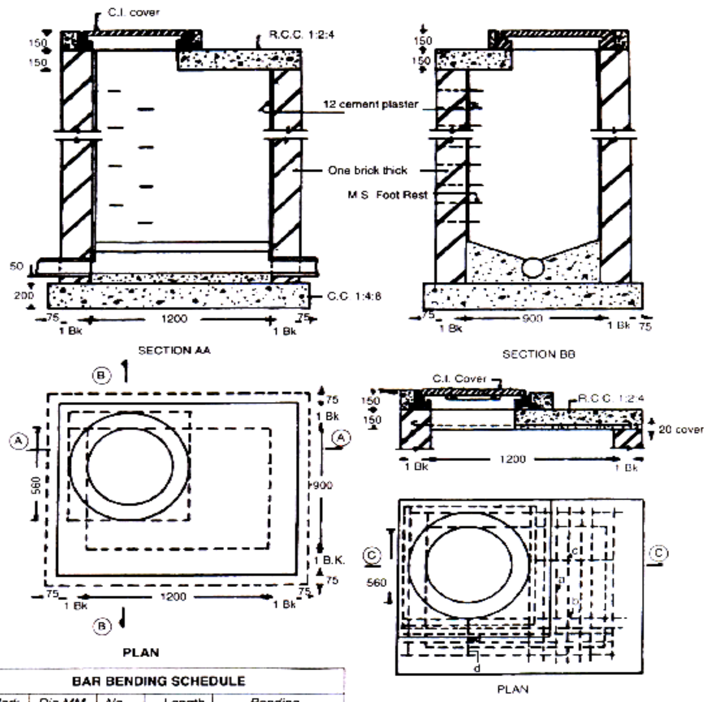
The channels and benching shall be done in cement concrete 1 2 4 (1 cement 2 coarse sand 4 graded stone aggregate 20 mm nominal size) and rendered smooth with neat cement The depth of channels and benching shall be as given in table 21.8.

21.4.6 Foot Rests (Fig 8)

All manholes deeper than 0.8 m shall be provided with M S foot rests These shall be embedded 20 cm deep in 20 * 20 *10 cm blocks of cement 1 3 6 (1 cement 3 coarse sand 6 graded stone aggregate 20 mm nominal size)The concrete blocks with M S foot rests placed in its centre shall be cast in situ along with the masonry and surface finished with 12 mm thick cement plaster 1 3 (1 cement 3 coarse sand)finished smooth.

TABLE-21 8

Size of drain mm	Top of channel at the center above bed concrete cm	Depth of benching at side walls above bed concrete cm
100	15	20
150	20	30
200	25	35
250	30	40
300	35	45
352	40	50
400	15	55
450	50	60

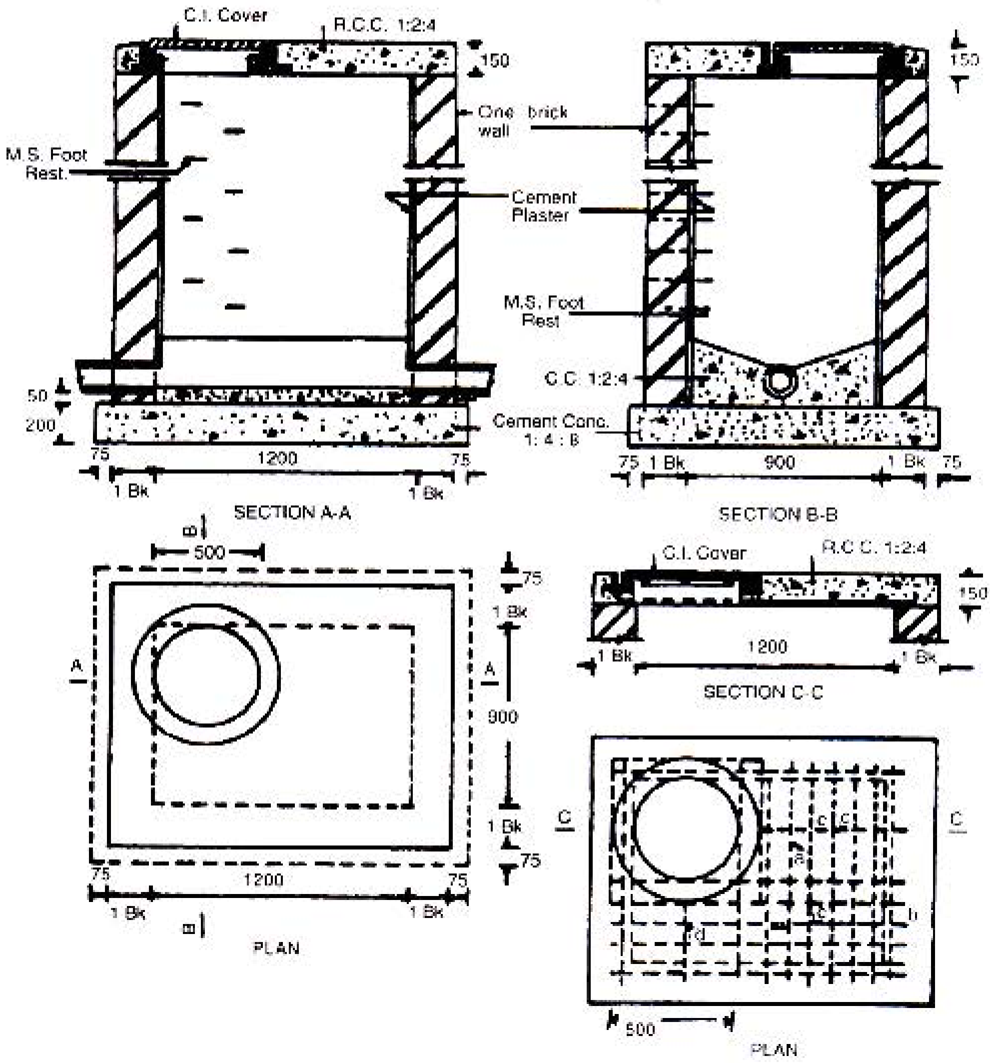


BAR BENDING SCHEDULE

Mark	Dia MM	No.	Length	Bending
a	12	4	1200	100 1000 100
b	12	4	1300	100 1100 100
c	12	1	580	100 300 100
d	12	1	625	100 425 100

DRAWINGS NOT TO SCALE
ALL DIMENSIONS ARE IN MM

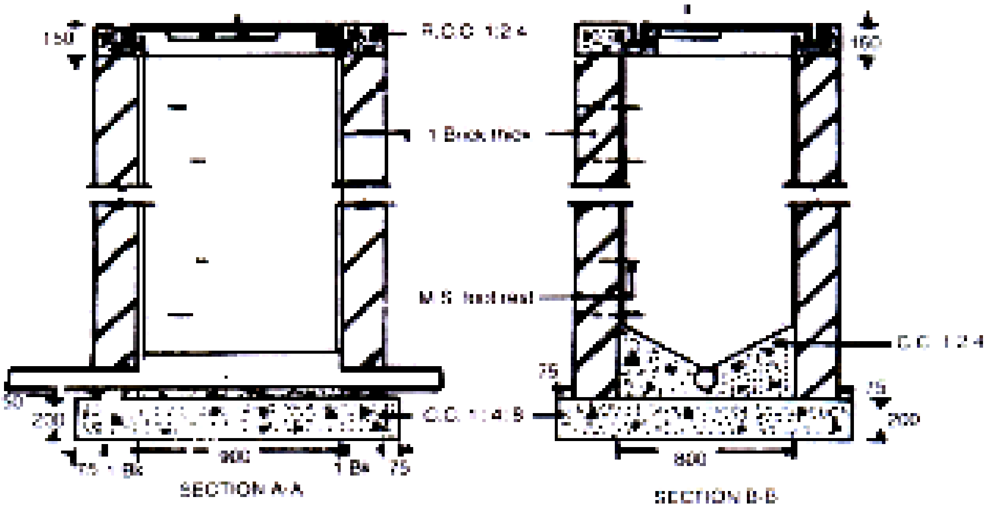
Fig. 3 : Manhole
Size 1200 x 900 Heavy Duty Cover
(Clause 21.4)

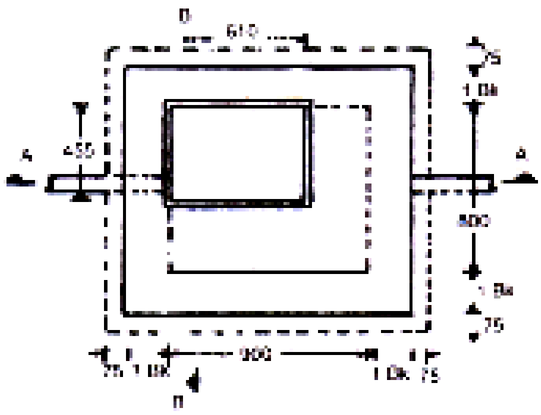


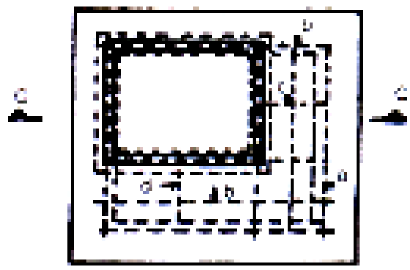
BAR BENDING SCHEDULE				
Mark	Dia MM	No.	Length	Bending
a	12	6	1300	100 ______ 100 1100
b	12	6	1600	100 ______ 100 1400
c	12	1	980	100 ______ 100 780
d	12	1	680	100 ______ 100 480

DRAWINGS NOT TO SCALE
ALL DIMENSIONS ARE IN MM

Fig. 4 : Manhole (Contd.)
Size 1200 x 900 with Medium Duty Cover
(Clause 21.4)





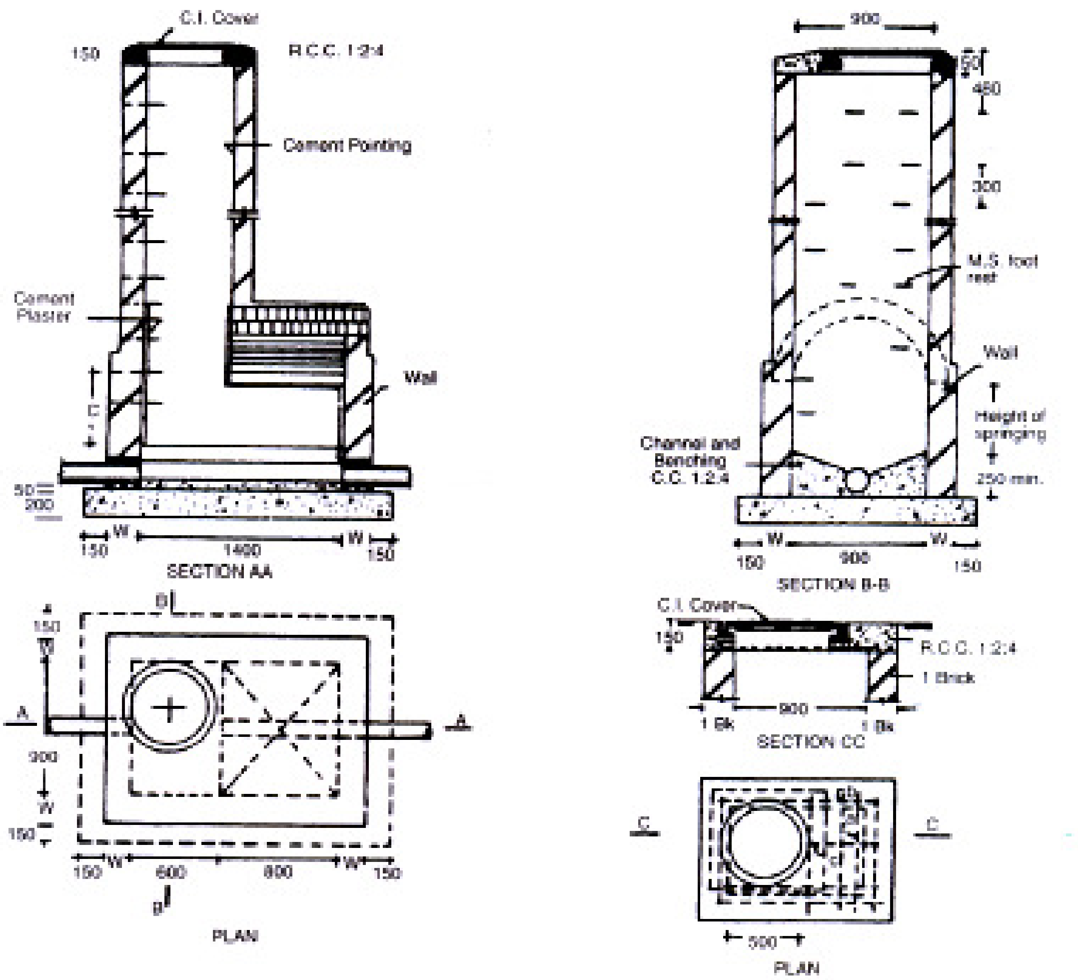


BAR BENDING SCHEDULE

Mark	Dia MM	No.	Length	Bending
a	12	4	1200	100 ___ 100 1000
b	12	4	1300	100 ___ 100 1100
c	12	4	580	100 ___ 100 380
d	12	4	625	100 ___ 100 425

DRAWINGS NOT TO SCALE
ALL DIMENSIONS ARE IN MM

Fig. 5 : Manhole (Contd.)
Size 900 x 800 with Light Duty Cover
(Clause 21.4)



Depth of Manhole from Top of C.I. cover	From Top 4250 (W)	From 4250 to 9750 from Top (W)	Beyond 9750 from Top (W)	H	T
2450 to 4250	1 Bk	—	—	900	200
More than 4250 upto 9750	1 Bk	1½ Bk	—	1800	300
More than 9750	1 Bk	1½ Bk	2 Bk	1800	300

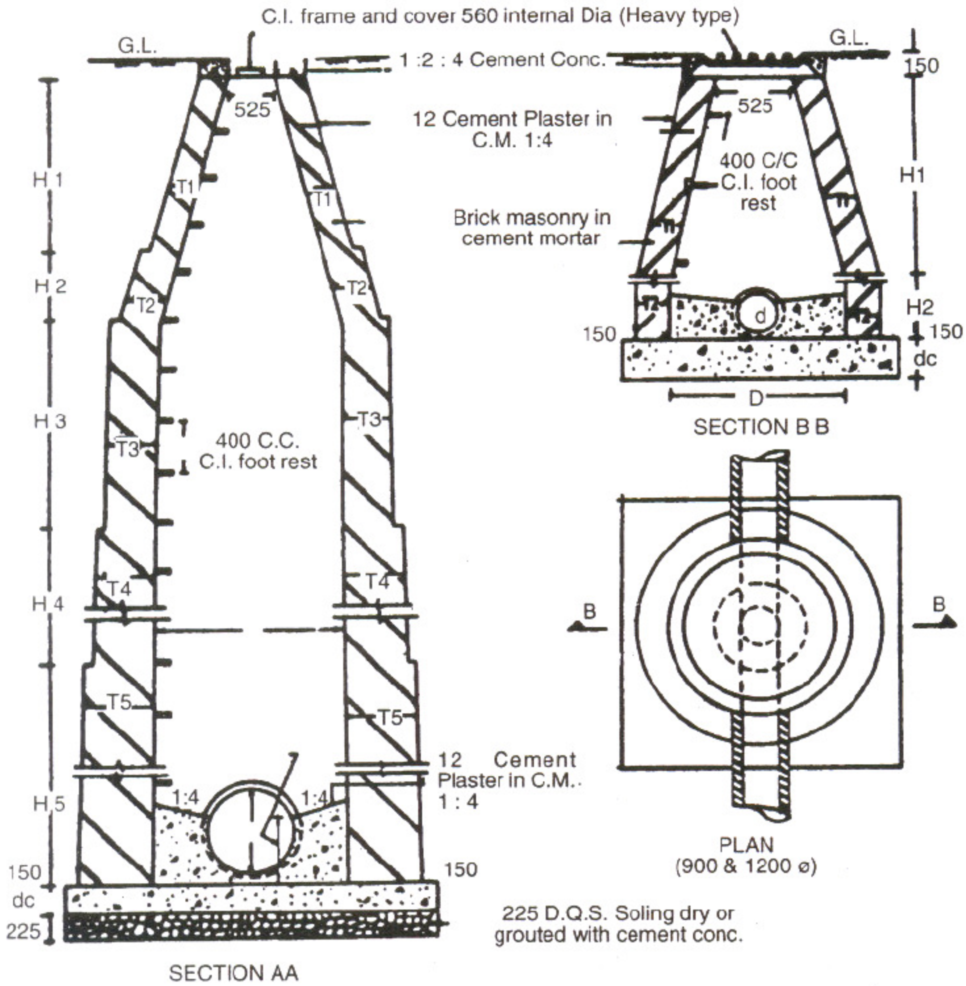
W — Width of Wall
H — Height of spring of arch above the benching level
T = Thickness of foundation concrete

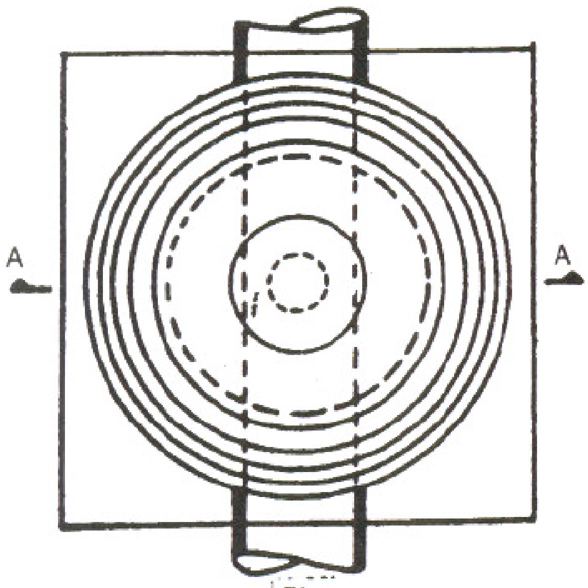
DRAWINGS NOT TO SCALE
ALL DIMENSIONS ARE IN MM

BAR BENDING SCHEDULE

	Mark	Dia	No.	Length	Bending
For Medium Duty	a	12	5	1000	100 800 100
	b	12	3	1300	100 1100 100
	c	12	1	680	100 480 100
For Heavy Duty	a	12	5	1000	100 800 100
	b	12	2	1300	100 1100 100
	c	12	1	620	100 420 100

Fig. 6 : Manhole (Contd.)
Arched Type 1400 x 900
(Clause 21.4)





Plan
(1500 & 1800 ø)

Dia Man-hole	H1	H2	H3	H4	H5	T1	T2	T3	T4	T5	Bed Conc. de	Remarks
900	750	DEPTH Variable Up to 750	–	–	–	1 Bk	1 Bk	–	–	–	226	The soling will be provided where the site engineer will feel necessary
1200	1350	–do–	–	–	–	1 Bk	1 Bk	–	–	–	300	
1500	1950	750	2100	4050	DEPTH Variable Up to 4000	1 Bk	$1\frac{1}{2}$ Bk	2 Bk	$2\frac{1}{2}$ Bk	3Bk	300	
1800	1950	750	2250	4050	–do–	1 Bk	$1\frac{1}{2}$ Bk	2 Bk	$2\frac{1}{2}$ Bk	3 Bk	300	

H – Height of wall

T – Thickness of Wall

D – Dia of Manhole

d – Dia of Pipe

dc – Depth of Bed conc. M.C.D. Drg. No. DE 404

Fig.7: Manhole (Contd.) Municipal Corporation Delhi Design

(Clause 21.4)

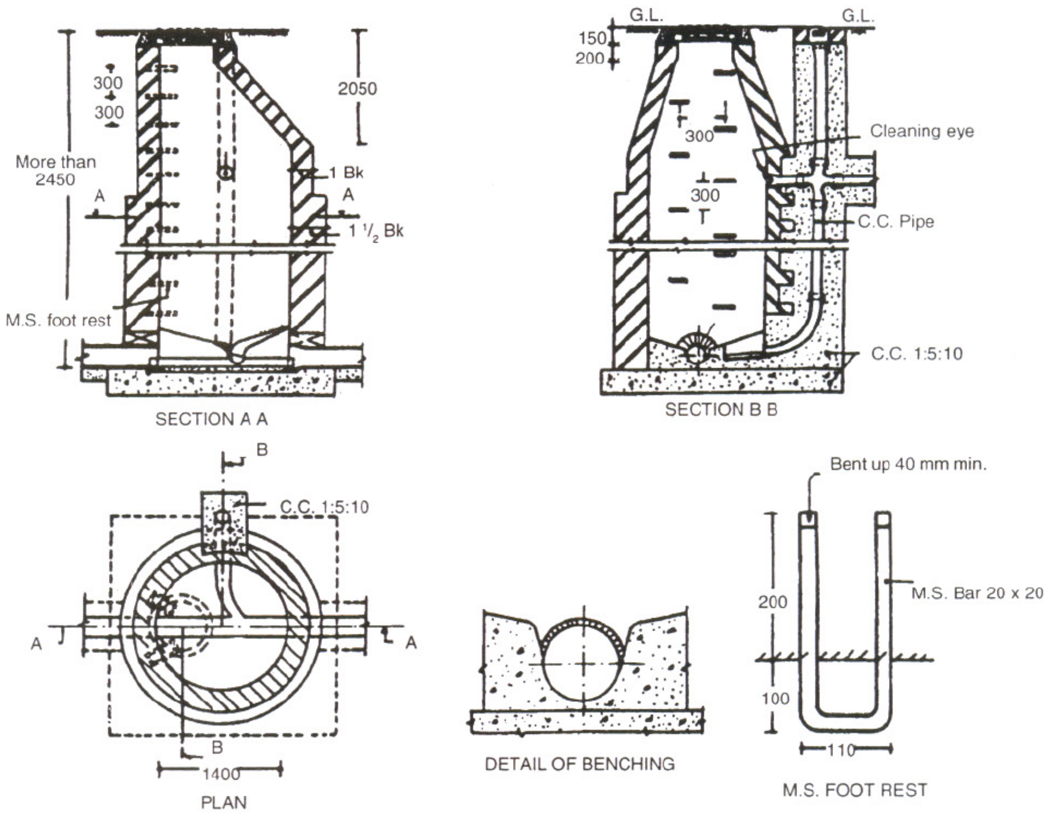


Fig.8: Manhole (With Drop Connections) (Clause 21.4.6 & 21.5)

Foot rests which shall be of 20*20 sq M S bars as shown in fig 8 shall be fixed 40 cm apart vertically and staggered laterally and shall project 10 cm beyond the surface of the wallThe top foot rests shall be 45 cm below the manhole cover.

Foot rests shall be painted with coal tar the portion embedded in the cement concrete block being painted with thick cement slurry before fixing.

21.4.7 Manhole Covers and Frames

The frame of manhole shall be firmly embedded to correct alignment and levels in R C C slab or plain concrete as the case may be on the top of the masonry After completion of the work manhole covers shall be sealed by means of thick grease.

21.4.8 Measurements

Manholes shall be enumerated under relevant items The depth of the manhole shall be reckoned from the top level of C I cover to the invert level of channel The depth shall be measured correct to cm The extra depth shall be measured and paid as extra over the specified depth.

21.4.9 Rate

The rate shall include the cost of materials and labour involved in all the operations described above but exclude the cost of (I)excavation (ii) M S foot rests and (iii) 12 mm thick cement plaster with water proofing material applied at the external surface of the manhole if required These items shall be paid for separately under relevant items of work.

21.5 Constructing Drop Connection (Fig-8)

21.5.0 In cases where branch pipe sewer enters the manhole of main pipe sewer at a higher level than the main sewer a drop connection shall be provided The work shall be carried out as per Fig 8 S C I pipes and special conforming to IS 1729 shall be of the same size as that of the branch pipes sewer.

For 150 and 250 mm main line if the difference in level between the water link (peak flow level) and the i9nvert level of the branch line is less than 60 cm the drop shall be provided externally.

The main lines up to 350 mm dia are designed for half depth of flow from 350 mm to 900 mm for 2/3 depth of flow and beyond 900 mm for ¾ depth of flow.

21.5.1 Excavation

The excavation shall be done for the drop connection at the place where the branch lines meets the manhole the excavation shall be carried up to the bed concrete of the manhole and to the full width the branch line.

21.5.2 Laying

At the end of branch sewer line S C I cross shall be fixed to the line which shall be extended through the wall of the manhole by a horizontal piece of S C I pipe to form an inspection or cleaning eye The open end shall be provided with chain and lid The S C I drop pipe shall be connected to the cross at the top and to the S C I bend at the bottom The bend shall be extended through the wall of the manhole by a piece of S C I pipe which shall discharge in to the channel Necessary channel shall be made with cement concrete 1 2 4 (1 cement 2 coarse sand 4 graded stone aggregate 20 mm nominal size) and finished smooth to connect the main channel The joint between S C I pipe and fittings shall be led caulked as described in 20 5 3 The joint between S C I cross and S W branch line shall be made with cement mortal 1 1 (1 cement 1 fine sand) The exposed portion of the drop connection shall be encased all around with minimum 15 cm thick concrete 1 5 10 (1 cement 5 fine sand 10 graded stone aggregate 40 mm nominal size) and cured For encasing the concrete around the drop connection the necessary centering and shuttering shall be provided The holes made in the walls of the manhole shall be made good with brick work in cement mortar 1 4 (1 cement 4 coarse sand) and plastered with cement mortar 1 3 (1 cement 3 coarse sand) on the inside of the manhole walls The excavated earth shall be back filled in the trench in level with the original ground level.

21.5.3 Measurements

Drop connection shall be enumerated. The depths beyond 60 cm shall be measured in running meters correct to a cm under relevant items.

21.5.4 Rate

The rate shall include the cost of labour and materials involved in all operations described above but excluding the cost of excavations and refilling.

17. SPECIFICATIONS FOR COMPACTED CLAYS & AMENDED SOIL

FOR LANDFILL LINERS

A competent barrier made of compacted soils – clays or amended soils – is normally expected to fulfil the following requirements :

a) hydraulic conductivity of 10^{-7} cm/sec or less;

b) thickness of 100 cm or more;

c) absence of shrinkage cracks due to desiccation;

d) absence of clods in the compacted clay layer;

e) adequate strength for stability of liner under compressive loads as well as along side slopes; and

f) minimal influence of leachate on hydraulic conductivity.

Clays of high plasticity with very low values of permeability (usually well below the prescribed limit), exhibit extensive shrinkage on drying, as well as tend to form large clods during compaction in the relatively dry state. Their permeability can also increase on ingress of certain organic leachates. Well compacted inorganic clays of medium plasticity, either natural or amended, appear to be most suitable for liner construction.

According to various investigators, soils with the following specifications would prove to be suitable for liner constructions: Percentage fines – between 40 and 50%; plasticity index – between 10 and 30%; liquid limit – between 25 and 30%; clay content – between 18 and 25%. It is necessary to perform detailed laboratory tests and some field trial tests prior to liner construction to establish that the requirements pertaining to permeability, strength, leachate compatibility and shrinkage are met.

1. Design Process

The design process for a compacted soil liner consists of the following steps:

I. Identification of borrow area or source of material – in-situ or nearby.

II. For in-situ soils, conducting field permeability tests to assess suitability of the natural soil in its in-situ condition.

III. Laboratory studies on liner material (from in-situ or nearby locations), comprising of soil classification tests, compaction tests, permeability tests, strength tests, shrinkage tests, compaction tests, permeability tests.

IV. Identification of source of additive, if natural soil does not satisfy liner requirements – natural clay from not too distant areas or commercially available clay such as bentonite.

V. Laboratory studies (as detailed in (iii) above) on soil – additive mixes using different proportions of additive to find minimum additive content necessary to archieve the specified requirements.

VI. Field trial on test pads, to finalise compaction parameters (layer thickness, nember of passes, speed of compactor), as well as to verify that field permeability of the compacted soil lies within pre-specified limits.

2. Laboratory Studies

For amended soils, the following tests should be conducted to arrive at the minimum additive content.

Additive Composition : Grains size distribution, plasticity tests and mineralogy tests, are performed to identify the clay content, activity and clay mineralogy of the additive.

Host Material Composition: Grain size distribution and plasticity tests are performed on the host material, to assess that the host material will mix readily with the additive. Clean , usually mix readily with clays and bentonites. Cohesive hosts are more difficult to mix due to balling effect yielding uneven mixing. The host material must be sufficiently dry for proper mixing. The host material must be sufficiently dry for proper mixing.

Soil-Additive Compaction Tests : Standard Proctor (or modified) tests are undertaken with variable quantities of additives mixed to the soil, usually in increments of 2 to 5 percent. The influence of the additive on dry density and optimum moisture content are evaluated[Fig. 17.27 (a)].

Soil-Additive Permeability Tests : Permeability tests are conducted on ascompacted-then-saturated samples of amended soil with different percentages of additive, each sample compacted to maximum density at optimum water content [Fig. 17.27(b)]. It is possible to identify a minimum additive content, from a series of tests, which may be required to achieve the desirable hydraulic conductivity.

Analysis of Laboratory Results : Field engineers usually require a compaction specification, which states the minimum acceptable dry density as well as the acceptable range of water content. It is usually possible to arrive at a narrow acceptable range of water content and dry density as shown in Fig. 17.28. A step-by-step process of elimination is to be adopted to identify this acceptable range of water content and dry density, which should then be communicated to the field engineer.

3. Field Trial Test Pads

The construction of a field trial test pad prior to undertakinh construction of the main liner has many advantages. One can experiment with compaction equipment, water content, number of passes of the equipment, lift thickness and compactor speed. Most importantly, one can conduct extensive testing, including quality control testing and hydraulic conductivity tests, on the test pad.The test pad should have a width which is significantly more than the widthof the construction vehicles (>10 m) and greater length. The pad should ideally be the same thickness as the full-sized liner, but may sometimes be thinner. The in-situ hydraulic conductivity may be determined by the sealed double ring infiltrometer method. In in-situ tests on test pads, the hydraulic conductivity is measured under zero over burden stress. Hydraulic conductivity measured on a test pad, should be corrected for the effects of overburden stress, based on results of laboratory conductivity tests performed over a range of compressive stresses.

4. Construction Aspects

Compacted Clays: The typical sequence of construction for compacted clay liners is as follows:

(a) Clearing of borrow area by removal of shrubs and other vegetative growth.

(b) Adjustment of water content in the borrow area – sprinkling or irrigating for increasing the water content and ripping and aerating for lowering the water content.

(c) Excavation of material.

(d) Transportation to site in haulers or through conveyor systems (short distance).

(e) Spreading and leveling of a thin layer (lift) of soil (of thickness about 25 cm).

(f) Spraying and mixing water for final water content adjustment.

(g) Compaction using rollers.

(h) Construction quality assurance testing.

(i) Placement of next lift and repetition of process till final thickness is achieved.

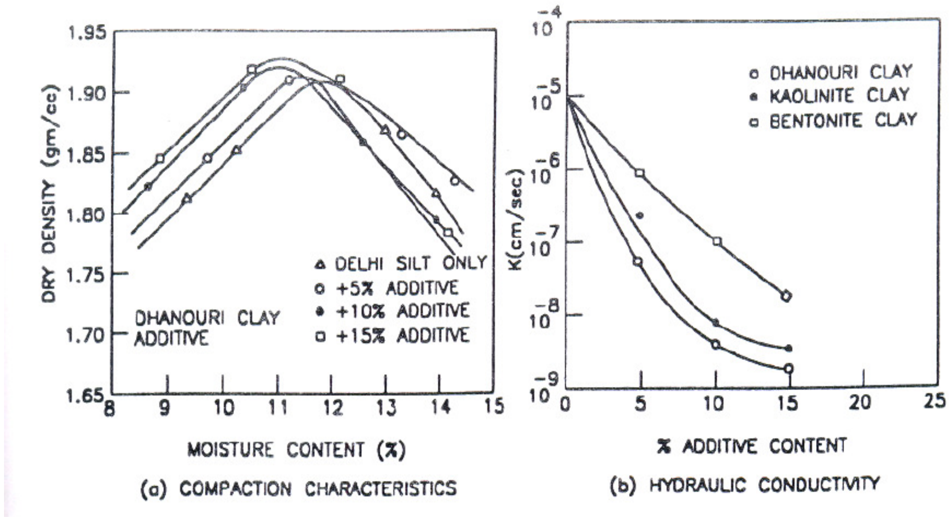


Fig. 17.17 (a) & (b): Influence of Additives on Compaction Characteristics and Hydraulic Conductivity of Sandy Silt

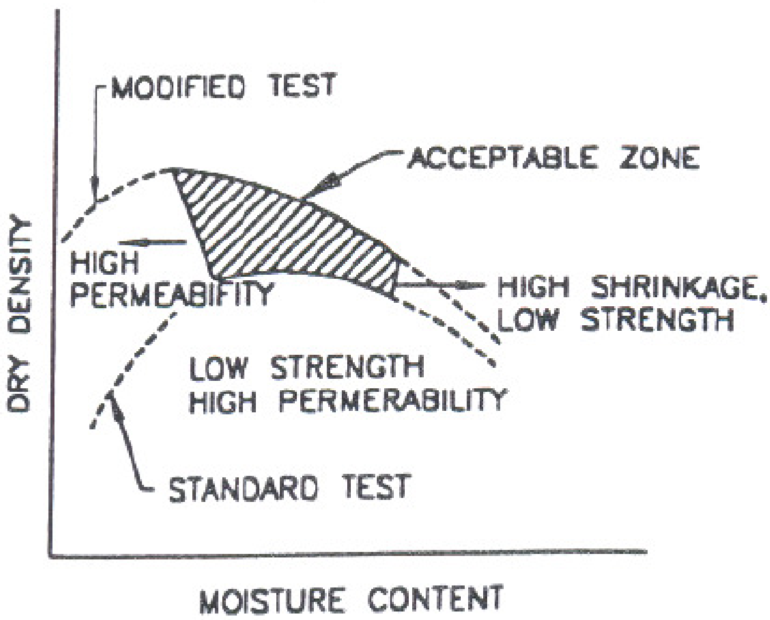


Fig. 17.28: Identification of Acceptable Zone for Liner Compaction

The two fold objectives of soil compaction are (a) to break and remould the clods into a homogenous mass, and (b) to densify the soil. If the compaction is performed such that the required density at the specified moisture content is obtained, the required permeability will be achieved in the field. Regulations generally require that a minimum 100 cm thick compacted clay liner be constructed. This thickness is considered necessary so that any local imperfections during construction will not cause hydraulic short-circuit of the entire layer. Compacted soil liners are constructed in a series of thin lifts. This allows proper compaction and homogeneous bonding between lifts. Generally, the lift thickness of clay liners is 25 to 30 cm before compaction and about 15 cm after compaction. It is important that each lift of clay liner be properly bonded to the underlying and overlying lifts. If this is not done, a distint lift interface will develop, which may provide hydraulic connection between lifts.

Sheep foot rollers are best suited for compacting clay liners. Rollers with fully penetrating feet have a shaft about 25 cm long. Unlike partially penetrating rollers (pad-footed rollers), the fully penetrating sheep foot roller (Fig. 17.29) can push through an entire soil lift and remold it. In addition to increasing bonding between lifts, one should maximize the compactive energy by considering factors such as roller weight, area of each foot, number of passes and the speed of the roller.

The lifts are typically placed in horizontal layers. However, when liners are constructed on the side slopes, the lifts can be placed either parallel to the slope (for slopes up to 2.5 Horizontal : 1 Vertical, due to limitations of compaction equipment) or in horizontal lifts (Fig. 17.30). Horizontal lifts require a width which is at least the width of one piece of construction equipment (usually 3 to 4 m).

Amended Soils : The process of construction of amended soil liners is similar to that for compacted clay liners with the modification that the additive is introduced in two ways by in-place mixing or by central plant method. In the latter technique, soil and additive are mixed in a pugmill or a central mixing plant. Water can also be added in the pugmill either concurrently with bentonite or in a separate processing step. The central mixing plant method (Fig. 17.31) is more effective than in-place mixing and should be adopted. The use of small truck mounted concrete batching plants for mixing bentonite can also be examined.

The quality of the mix must be checked to ensure uniformity and correctness of the additive. A minimum of five trial runs should be made to check the quality of the mix visually and using grain size analysis. The permeability should also be checked using the field mix, compacted in the laboratory.

5. Construction Control

During construction, quality control is exercised to ensure that the constructed facility meets the design specifications.

Borrow area material control and amended soil control involves the following tests : (a) grain size distribution; (b) moisture content; (c) Atterberg's limits; (d) laboratory compaction tests; and (e) laboratory permeability tests. The frequency of testing varies from one test per 1000 cu.m, to one test per 5000 cu.m.

Compacted soil liner control involves the following tests: (a) in-situ density measurements; (b) in-situ moisture content measurements; (c) laboratory permeability tests on undisturbed samples; (d) in situ permeability tests; (e) grain size distribution and Atterberg's limits of compacted samples. The frequency of the testing for in-situ density and moisture content may be as high as 10 tests/hectare/lift whereas the other tests may be conducted at a lower frequency of about 2 tests/hectare/lift [Sharma and Lewis (1994)].

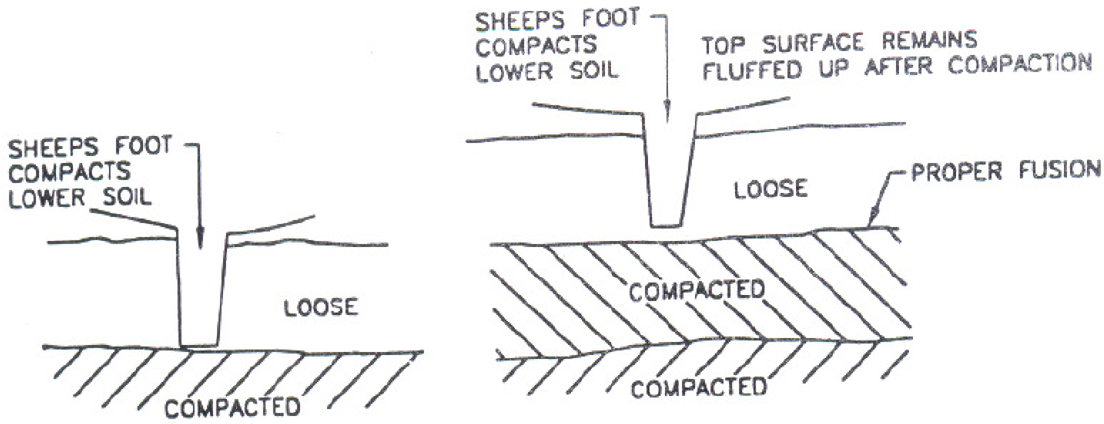


Fig. 17.29: Full Penetration During Kneading Compaction (Sheeps Foot Roller)

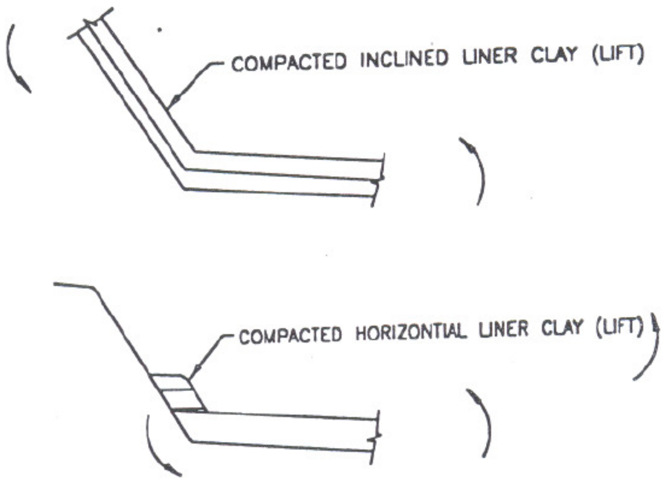


Fig. 17.30: Construction of Inclined and Horizontial Side Slope Liners

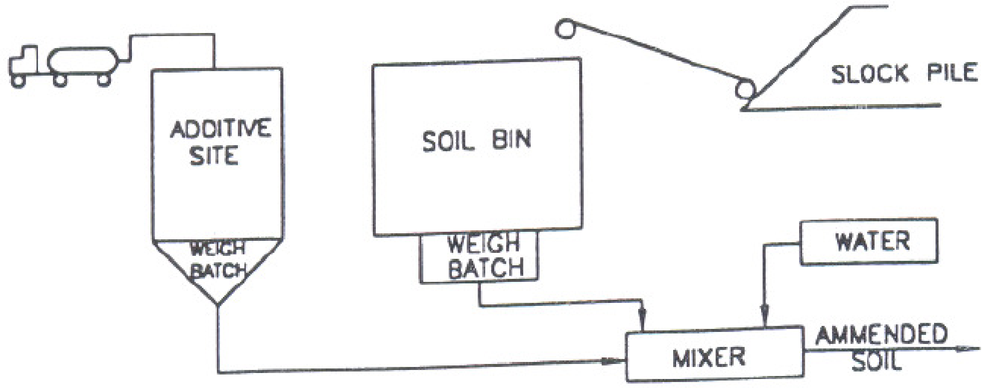


Fig. 17.31: Flow Diagram For Soil-Additive Mixing

GEOMEMBRANES

A High Density Poly ethylene (HDPE) geomembrane of minimum thickness of 1.5 mm is to be laid over the compacted clay/amended soil with no gaps along the surface of contact.

Specifications

The geomembrane is normally expected to meet the following requirements:

a) It should be impervious

b) It should have adequate strength to withstand subgrade deformations and construction loads

c) It should have adequate durability and longevity to withstand environmental loads

d) The joints/seams must perform as well as the original material.

Typical specification for geomembrane liners are given in Table 17.5. The specifications are only suggestive and need to be refined by a geosynthetics specialist for each landfill site.

TYPICAL VALUES FOR GEOMEMBRANES MEASURED IN PERFORMANCE TESTS

Sl.No.	Property	Typical Value
1.	Thickness Density	1.5 mm (60 mil) 0.94 gm/cc
2.	Roll Width x length Tensile Strength Tensile Strength at yield Tensile Strength at Break Elongation at Yield Elongation at Break Secant Modulus (1%)	6.5. m x 150 m 24 kN/m 42 kN/m 15% 700% 500 MPa
3.	Toughness Tear Resistance (initiation) Puncture Resistance Low Temperature Brittleness	 200N 480 N -94ºF

Sl.No.	Property	Typical Value
4.	Durability Carbon Black Carbon Black Dispersion Accelerated Heat Ageing	 2% A-1 Negligible strength changes after 1 month at 110ºC
5.	Chemical Resistance Resistance to Chemical Waste Mixture Resistance to Pure Chemical Reagents	 10% strength change over 120 days 10% strength change over 7 days
6.	Environmental Stress Crack Resistance	1500 hrs
7.	Dimensional Stability	±2%
8.	Seam Strength	80% or more (of tensile strength)

Design Aspects

The following components have to be designed/checked for in the case of geomembranes :

a) anchor trench

b) sliding along slopes

c) allowable weight of vehicle

d) uneven settlement

e) panel layout plan

Design details are provided by Bagchi (1994)

Construction/Installation of Geomembranes

Although the construction activities for geomembrane installation are not as time consuming as clay liner construction, the quality control tests are intensive. The surface of compacted clay/ amended soil must be properly prepared for installation of synthetic membrane. The surface must not contain any particles greater than 1.25 cm (0.5 in) size. Larger particles may cause protuberance in the liner. The panel layout plan should be made in advance so that travel of heavy equipment on the liner. Seaming of panels within1.0m of the leachate collection line location should be avoided if possible; this issue can be finalized during the layout plan. The subbase must be checked for footprints or similar depressions before laying the liner. The crew should be instructed to carry only the necessary tools and not to wear any heavy boots (teninis shoes are preferred). Laying of the synthetic membrane should be avoided during high winds [24 kmph or more]. Seaming should be done within the temperature range specified by the manufacturer.

Several types of seaming methods are available. The following are some of the commonly used seaming techniques: thermal-hot air, hot wedge fusion, extrusion welding (fillet or lap), and solvent adhesive. The manufacturer usually specifies the types of seaming to be used and in most cases provides the seaming machine. Manufacturer's specifications and guidelines for seaming must be followed. Seaming is more of an art even with the automatic machines. Only persons who are conversant with the machine and have some actual experience should be allowed to seam. For HDPE, hot wedge fusion and extrusion welding type seaming are commonly practiced.

Geomembranes must be covered with protective soil as soon as possible. Enough volume of soil should be stockpiled near the site so that it can be spread on the finished membrane as soon as the quality control test results are available and the final inspection is over. Synthetic membranes can be damaged by hoofed animals. Bare membrane should be guarded against such damage by fencing the area or by other appropriate methods.

At least 30cm of fine sand or silt or similar soil should be spread on the membrane as a protective layer. The soil should be screened to ensure that the maximum particle size is 1.25cm or less. The traffic routing plan must be carefully made so that the vehicle(s) does not travel on the membrane directly. Soil should be pushed gently by a light dozer to make a path. Dumping of soil on the membrane should be avoided as much as possible. One or two main routes with extra thickness of soil (60-90cm) should be created for use by heavier equipment for the proposes of soil moving .Even the utmost precaution and quality control during installation will be meaningless if proper care is not taken when covering the membrane. Slow and careful operations are the key to satisfactory soil spreading.

The geomembrane bid specification should include warranty coverage for transportation installation and quality control tests. The cost of a project may increase due to the warranty. The experience of the company (both in manufacturing and installation), quality control during manufacturing and installation , physical installation should be asked in the bid so proper comparisons among different bidders can be made.

Tests of several physical properties of the membrane must be performed before installation. Usually most of these tests are performed at time of manufacturing in the manufacturer's laboratory. The owner may arrange for an independent observer to oversee the tests, conduct the tests in an independent laboratory, or use a "split sampling" technique. This issue of responsibility for pre installation quality control tests must be clearly mentioned or resolved during the bidding process. The following are test used for quality control purposes: (a) sheet thickness, (b) melt index,(c) percentage carbon black,(d) puncture resistance,(e) tear resistance, (f) dimensional stability,(g) density,(h) low temperature brittleness, (i) peel adhesion, and (j) bonded seam strength.

The quality control tests that are performed during installation include the following:

(a) Inspection of surface of compacted clay/ amended soil layer.

(b) Verification of the proposed layout plan.

(c) Check roll overlap.

(d) Checking anchoring trench and sump.

(e) Testing of all factory and field seams using proper techniques over full length.

(f) Destructive seam strength test.

(g) Patch up repair.

1.156 Roads & Pavements

1.157 Water Bound Macadam Sub-Base

Scope

1.157.1.1 This work shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonding together with screening, binding material where necessary and water laid on a properly prepared sub grade/sub-base/base or existing pavement, as the case may be and finished in accordance with the requirements of these Specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the Engineer.

1.157.1.2 It is, however, not desirable to lay water bound macadam on an existing thin black topped surface without providing adequate drainage facility for water that would get accumulated at the interface of existing bituminous surface and water bound macadam.

1.157.2 Materials

1.157.2.1 Coarse aggregates

Coarse aggregates shall be either crushed or broken stone, crushed slag, over burnt (Jhama) brick aggregate or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Material other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel/shingle is used, not less then 90 per cent by weight of the gravel, shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table -1. The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water adsorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part 5).

1.157.2.2 Crushed or broken stone

The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

Table 1. Physical Requirements of Course Aggregates for Water Bound Macadam for Sub-Base/Base Courses

Sr.	Test	Test Method	Requirements
1.	* Los Angeles Abrasion Value Or ** Aggregate Impact value	IS:2386 (Part -4) IS:2386 (Part-4) or IS:5640**	40 per cent (Max.) 30 per cent (Max.)
2.	Combined Flakiness and Elongation Indices (total)***	IS:2386 (Part-1)	30 per cent (Max.)

* *Aggregate may satisfy requirements of either of the two tests.*

** *Aggregates like brick metal, kankar, laterite etc. which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS:5640*

*** *The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone and crushed slag*

1.157.2.3 Crushed slag

Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11.2 kN per m3 and the percentage of glossy material shall not be more than 20. It should also comply with the following requirements:

1. Chemical stability : To comply with requirements of appendix of BS:1047
2. Sulphur content : Maximum 2 per cent
3. Water absorption : Maximum 10 per cent

1.157.2.4 Over burnt (Jhama) brick aggregates

Jhama brick aggregates shall be made from over burnt bricks or brick bats and be free from dust and other objectionable and deleterious materials.

1.157.2.5 Grading requirement of coarse aggregates

The coarse aggregates shall conform to one of the Gradings given in Table 2 as specified, provided; however, the use of Grading No. 1 shall be restricted to sub-base courses only.

Table 2, Grading Requirements of Coarse Aggregates

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
1.	90 mm to 45 mm	125 mm 90 mm 63 mm 45 mm 22.4 mm	100 90-100 25-60 0-15 0-5
2.	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-5
3.	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95-100 65-90 0-10 0-5

Note: The compacted thickness for a layer with Grading 1 shall be 100 mm while for layer with other Gradings i.e., 2 & 3, it shall be 75 mm.

Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as murum or gravel (Other than rounded borne material) may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 per cent.

Screenings shall conform to the grading set forth in Table 3. The consolidated details of quantity of screenings required for various grades of stone aggregates are given in Table 4. The table also gives the quantities of materials (loose) required for 10 m2 for sub-base/base compacted thickness of 100/75 mm.

The use of screenings shall be omitted in the case of soft aggregates such as brick metal, kankar, laterites, etc, as they are likely to get crushed to a certain extent under rollers.

Table 3 Grading For Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by weight passing the IS Sieve
A	13.2 mm	13.2 mm 11.2 mm 5.6 mm 180 micron	100 95-100 15-35 0-10
B	11.2 mm	11.2 mm 5.6 mm 180 mm	100 90-100 15-35

Table 4 Approximate Quantities of Coarse Aggregates and Screenings Required For 100/75 mm Compacted Thickness of Water Bound Macadam (WBM) Sub-Base /Base Course for 10m² Area

				Screenings			
Classification	Size Range	Compacted thickness	Loose Qty.	Stone Screening		Crushable Type such as Murum or Gravel	
				Grading Classification & size	For. WBM Sub-base/base course (Loose quantity)	Grading Classification & size	Loose Qty.
Grading 1	90 mm to 45 mm	100 mm	1.21 to 1.43 m^3	Type A 13.2 mm	0.27 to 0.30 m^3	Not uniform	0.30 to 0.32 m^3
Grading 2	63 mm to	75 mm	0.91 to 1.07 m^3	Type A 13.2 mm	0.12 to 0.15 m^3	-do-	0.22 to 0.24 m^3

Classification	Size Range	Compacted thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable Type such as Murum or Gravel	
				Grading Classification & size	For. WBM Sub-base/base course (Loose quantity)	Grading Classification & size	Loose Qty.
	45 mm						
-do-	-do-	-do-	-do-	Type B 11.2 mm	0.20 to 0.22 m^3	-do-	-do-
Grading 3	53 mm to 22.4 mm	75 mm	-do-	-do-	0.18 to 0.21 m^3	-do-	-do-

1.157.2.6 Binding material

Binding material to be used for water bound macadam as a filler material meant for preventing ravelling, shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS:2720 (Part-5).

The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 m3/10m2 and 0.08-0.10m3/10m2 for 100 mm compacted thickness.

The above mentioned quantities should be taken as a guide only, for estimation of quantities of construction etc.

Application of binding materials may not be necessary when the screenings used are of crushable type such as murum or gravel.

Construction Operations

1.157.2.7 Preparation of base

The surface of the sub grade/sub-base/base to receive the water bound macadam course shall be prepared to the specified lines and cross fall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water. Any sub-base/base/surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (leveling course) to Specifications.

1.157.2.8 As far as possible, laying water bound macadam course over an existing thick bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous weaning course where water bound macadam is proposed to be laid over it. However, where the intensity of rain is low and the interface drainage facility is efficient, water bound macadam can be laid over the existing thin bituminous surface by cutting 50 mm x 50 mm furrows at an angle of 45 degrees to the centre line of the pavement at one m intervals in the existing road. The directions and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base course beneath the existing thin bituminous surface.

1.157.2.9 Inverted choke

It water bound macadam is to be laid directly over the sub grade, without any other intervening pavement course, a 25 mm course of screenings (Grading B) or coarse sand shall be spread on the prepared sub grade before application of the aggregates is taken up. In case of a fine sand or silty or clayey sub grade, it is advisable to lay 100 mm insulating layer of screening or coarse sand on top of fine grained soil, the gradation of which will depend upon whether it is intended to act as a drainage layer as well. As a preferred alternative to inverted choke, appropriate geo synthetics performing functions of separation and drainage may be used over the prepared sub grade as directed by the Engineer.

1.157.2.10 Spreading coarse aggregates

The coarse aggregates shall be spread uniformly and evenly upon the prepared sub grade/sub-base/base to proper profile by using templates places across the road about 6m apart, in such quantities that the thickness of each compacted layer is not more than 100 mm for Grading 1 and 75 mm for Grading 2 and 3, as specified. Wherever possible, approved mechanical devices such as aggregate spreader shall be used to spread the aggregates uniformly so as to minimise the need for manual rectification afterwards. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one of more layers by any approved means so as to achieve the specified results.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved Drawings.

The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operations.

1.157.2.11 Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, where screenings are not to be applied, as in the case of crushed aggregates like brick metal, laterite and kankar, compaction shall be continued until the aggregates are thoroughly keyed. During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or subbase course.

The rolled surface shall be checked transversely and longitudinally, with templates and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired crossfall (camber) and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which gets crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates.

It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses as per specifications.

1.157.2.12 Application of screenings

After the coarse aggregate has been rolled to specifications,screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screening are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

1.157.2.13 Sprinkling of water and grouting

After the screenings have been applied, the surface be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or sub grade does not get damaged due to the addition of excessive quantities of water during construction.

In case of lime treated soil sub-base, construction of water bound macadam on top of it can cause excessive water to flow down to the lime treated sub-base before it has picked up enough strength (is still "green") and thus cause damage to the sub-base layer. The laying of water bound macadam layer in such cases shall be done after the sub-base attains adequate strength, as directed by the Engineer.

1.157.2.14 Application of binding material

After the application of screenings in the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

1.157.2.15 Setting and drying

After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.

Surface Finish and Quality Control of work

1.157.2.16 The surface finish of construction shall conform to the requirements of **Section 902 of MORTH Specifications for Road and Bridge Works (III Revision).**

1.157.2.17 Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900 of MORTH Specifications for Road and Bridge Works (III Revision).**

1.157.2.18 The water bound macadam work shall not be carried out when the atmospheric temperature is less than 0 degree centigrade in the shade.

1.157.2.19 Reconstruction of defective macadam

The finished surface of water bound macadam shall conform to the tolerance of surface regularity as prescribed in **Section 902 of MORTH Specifications for Road and Bridge Works (III Revision).** However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to subgrade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and re compacted. In no case shall depressions be filled up with screenings or binding material.

Arrangement for Traffic

1.157.2.20 During the period of construction, the arrangement of traffic shall be done as per **Clause 1.9.2.**

1.158 Measurements for payment

1.158.1.1 Water bound macadam shall be measured as finished work in position in cubic metres.

Rate

1.158.1.2 The Contract unit rate for water bound macadam sub-base/base course shall be payable in full for carrying out the required operations including full compensation for all components including arrangement of water used in the work as approved by the Engineer.

1.159 Tack Coat

Scope

1.159.1.1 This work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction over it.

Materials

1.159.1.2 Binder

The binder used for tack coat shall be a bituminous emulsion or cutback as specified in the Contract.

Construction Operation

1.159.1.3 Preparation of base

The surface on which the tack coat is to be applied shall be cleaned of dust and any extraneous material before the application of the binder, by using a mechanical broom or any other approved equipment/method as specified by the Engineer.

1.159.1.4 Application of binder

Binder may be heated to the temperature appropriate to the grade of cutback used and approved by the Engineer and sprayed on the base at the rate specified in Table 5. The normal range of spraying temperature for a bituminous emulsion shall be 20 degree centigrade-60 degree centigrade for a cutback 50 degree centigrade - 80 degree centigrade. If IRC-70/ MC-70 grade is used. It shall be the responsibility of the Contractor to carefully handle the inflammable bituminous cutback material so as to safeguard against any fire mishap. The binder shall be applied uniformly with the aid of either self-propelled or towed bitumen pressure sprayer with self-heating arrangement and spraying bar with nozzles having constant volume or pressure system, capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. Work should be planned so that no more than the necessary tack coat for the day's operation is placed on the surface. After application and prior to succeeding construction allow the tack coat to cure, without being disturbed, until the water/cutter has completely evaporated as determined by the Engineer.

Table 5 Rate of Application of Tack Coat

Sr.	Type Surface	Quantity Of Liquid Bituminous Material In kg Per 10 sqm area
1.	Normal bituminous surfaces	2.0 to 2.5
2.	Dry and hungry bituminous surfaces	2.5 to 3.0
3.	Granular surfaces treated with primer	2.5 to 3.0
4.	Non bituminous surfaces	
(i)	Granular base (not primed)	3.5 to 4.0
(ii)	Cement concrete pavement	3.0 to 3.5

Note: There is no need to apply a tack coat on a freshly laid bituminous course if the subsequent bituminous course is overlaid the same day without opening it to traffic.

Quality control of Work

1.159.1.5 Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900 of MORTH Specifications for Road and Bridge Works (III Revision).**

Arrangements for Traffic

1.159.1.6 During the period of construction, the arrangement of traffic shall be done to **Clause below;**

1.159.1.7 Traffic Safety and Control

1. The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required by the Engineer for the information and protection of traffic approaching or passing through the section of the highway under improvement. Before taking up any construction, an agreed phased programme for the diversion of traffic on the highway shall be drawn up in consultation with the Engineer.

2. The barricades erected on either side of the carriageway/portion of the carriageway closed to traffic, shall be of strong design to resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise.

3. At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriage way) the channel for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar devices as per the directions of the Engineer. At night, the passage shall be delineated with lanterns or other suitable light source.

4. One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for two-lane traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

5. On both sides, suitable regulatory/warning signs as approved by the Engineer shall be installed for the guidance of road users. On each approach, at least two signs shall be put up, one close to the point where transition of carriageway begins and the other 120 m away. The signs shall be of approved design and of reflectory type, if so directed by the Engineer.

1.159.1.8 Maintenance of Diversions and Traffic Control Devices

Signs, lights, barriers and other traffic control devices, as well as the riding surface of diversions shall be maintained in a satisfactory condition till such time they are required as directed by Engineer. The temporary travel way shall be kept free of dust by frequent application of water, as directed by the Engineer.

Measurement for Payment

1.159.1.9 Tack coat shall be measured in terms of surface area of application in square metres.

Rate

1.159.1.10 The contract unit rate for tack coat shall be payment in full for carrying out the required operations including full compensation for all components applicable to the work specified in these Specifications

1.160 Cement Concrete Pavement

Scope

1.160.1.1 The work shall consist of construction of unreinforced, dowel jointed, plain cement concrete pavement in accordance with requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the Drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connecting with the work, as approved by the Engineer.

1.160.1.2 The design parameters, viz., thickness of pavement slab, grade of concrete, joint details etc., shall be stipulated in the Drawings.

Materials

1.160.1.3 Source of materials

The Contractor shall indicate to the Engineer the source of all materials to be used in the concrete work with relevant test data sufficiently in advance, and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the Contractor later proposes to obtain materials from aggregate different source, he shall notify the Engineer for his approval, at lest 45 days before such materials are to be used with relevant test data.

1.160.1.4 Cement

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but the preference should be to use at least the 43 Grade or higher.

1. Ordinary Portland Cement, 33 Grade, IS : 269.
2. Ordinary Portland Cement, 43 Grade, IS : 8112.
3. Ordinary Portland Cement, 53 Grades, IS : 12269.

If the soil around has soluble salts like Sulphates in excess of 0.5 percent, the cement used shall be Sulphate resistant and shall conform to IS : 12330.

Guidance may be taken from IS:SP:23, Handbook for concrete mixes for ascertaining the minimum 7 days strength of cement required to match with design concrete strength. Cement to be used may preferably be obtained in bulk form if cement in paper bags are proposed to be use, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them of suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in accordance with IS specs. The cement shall be subjected to acceptance test just prior to its use.

1.160.1.5 Admixtures

Admixtures conforming to IS:6925 and IS:9103 shall be permitted to improve workability of the concrete or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used, must be furnished to the Engineer in advance to obtain his approval before used. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in trial paving works. If air entraining admixture is used, the total quantity of air in air-entrained concrete as aggregate percentage of the column of the mix shall be 5 ± 1.5 percent for 25 mm nominal size aggregate.

1.160.1.6 Aggregate

Aggregates for pavement concrete shall be natural material complying with IS:383 but with aggregate Los Angles Abrasion Test result not more than 35 percent. The limits of deleterious materials shall not exceed the requirements set out in IS:383. The aggregate shall be free from chert, flint, chalcedony or other silica in aggregate form that can react with the alkalis in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 per cent by weight and the total Sulphate content expressed as sulphuric anhydride (SO_3) shall not exceed 0.25 per cent by weight.

Coarse aggregate

1. Coarse aggregate shall consist of clean, hard, strong, dens, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 25 mm for pavement concrete. Continuously graded or gap graded aggregate may be used, depending on the grading of the fine aggregate. No aggregate which has water absorption more than 2 per cent shall be used in the concrete mix. The aggregates shall be tested for soundness in accordance with IS:2386 (Part-5). After 5 cycles of testing the loss shall not be more than 12 per cent if sodium Sulphate solution is used or 18 per cent in magnesium Sulphate solution is used.
2. Dumping and stacking of aggregates shall be done in an approved manner. In case the Engineer considers that the aggregate are not free from dirt, the same may be washed and drained for at least 72 hours before batching as directed by the Engineer.

Fine aggregate

1. The fine aggregate shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS:383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregate shall not contain deleterious substances more than the following :

• Clay lumps	4.0 per cent
• Coal and lignite	1.0 per cent
• Material passing IS Sieve No. 75 micron	4.0 per cent

1.160.1.7 Water

Water used for mixing and curing of concrete shall be clean and free from injurious amount of soil, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS:456.

1.160.1.8 Mild Steel bars for Dowels and Tie Bars

These shall conform to the requirements of IS:432, IS:1139 and IS:1786 as relevant. The Dowel bars shall conform to Grade S 240 and tie bars to Grade S 415 of IS.

1.160.1.9 Pre moulded Joint filler

Joint filler board for expansion joints which are proposed for used only at some abutting structures like bridges and culverts shall be of 20-25 mm thickness within a tolerance of ± 1.5 mm and of firm compressible material and complying with requirements of IS:1838, or BS Specifications **Clause** No. 2630 or Specification for Highway Works, Vol. I **Clause** 1015. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ± 3 mm and provided to the full width between the side forms. It shall be in suitable lengths which shall not less than one lane width. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

1.160.1.10 Joint sealing compound

The joint sealing compound shall be of hot poured, elastomeric type or cold poly sulphide type having flexibility, resistance to age hardening and durability. If the sealant is of hot poured type it shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

1.160.1.11 Storage of materials

All materials shall be stored in accordance with the provisions of relevant IS Specifications and other relevant IS Specifications. All efforts must be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The platform where aggregates are stock piled shall be leveled with 15 cm of watered, mixed and compacted granular sub-base material. The area shall have slope and drain to drain off rain water. The storage space must also permit easy inspection, removal and storage of the materials. Aggregates of different sizes shall be stored in partitioned stack-yards. All such materials even though stored in approved godowns must be subjected to acceptance test as per **Section 903 of MORTH Specifications for Road and Bridge Works (III Revision)** immediately prior to their use.

Proportioning of Concrete

1.160.1.12 After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighted proportions of all ingredients for the approval of the Engineer. The mix design shall be submitted at least 39 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IS:10262 (recommended Guidelines for Mix Design) or on the basis of any other rational method agreed to by the Engineer. Guidance in this regard can also be obtained from IS:SP:23 Handbook on Concrete Mixes. The target mean strength for the design mix shall be determined as indicated in **Section 903.5.2 of MORTH Specifications for Road and Bridge Works (III Revision)**. The mix design shall be based on the flexural strength of concrete.

1.160.1.13 Cement content

The cement content shall not be less than 350 kg per cum. of concrete. If this minimum cement content is not sufficient to produce in the field, concrete of the strength specified in the Drawings/design, it shall be increased as necessary without additional compensation under the Contract. The cement content shall, however, not exceed 425 kg per cum. of concrete.

1.160.1.14 Concrete strength

While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty testy on samples. However, quality control in the field shall be exercised on the basis of flexural strength. It may, however, be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or other means approved by the Engineer and the maximum free water cement ratio shall be 0.50.

The ratio between the 7 and 28 day strengths shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at lest six batches of trial mix. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio 'R' shall be determined. The ratio 'R' shall be expressed to three decimal places.

If during the construction of the real length or during normal working, the average value of any four consecutive 7 days test results falls below the required 7 day strength as derived from the value of 'R', then the cement content of the concrete shall, without extra payment, be increased by 5 per cent by weight or by an amount greed by the Engineer. The increased cement content shall be maintained at lest until the four corresponding 28 day strengths have been assessed for its conformity with the requirements as per specs. whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

1.160.1.15 Workability

The workability of the concrete at the point of placing shall be adequate for the concrete to be fully compacted and finished without undue flow. The optimum workability for the mix to suit the paving plant being used shall be determined by the Contractor and approved by the Engineer. The control of workability in the field shall be exercised by the slump test as per IS:1199.

The workability requirement at the Batching Plant and paving site shall be established by slump tests carried during trial paving. These requirements shall be established from season to season and also when the lead from Batching plant site to the paving site changes. The workability shall be established for the type of paving equipment available. A slump value in the range of 30 ± 15 mm is reasonable for paving works but this may be modified depending upon the site requirement and got approved by the Engineer. These tests shall be carried out on every truck / dumper at Plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate trucks or as per the instructions of the Engineer.

1.160.1.16 Design mix

The Contractor shall carry out laboratory trials of design mixes with the materials from the approved sources to be used. Trial mixes shall be made in present of the Engineer or his representative and the design mix shall be subject to the approved of the Engineer. They shall be repeated if necessary until the proportions that will produce a concrete which complies in all respects with this Specification, and conforms to the requirement of the design/Drawings have been determined.

The proportions determined as a result of the laboratory trial mixes may be adjusted if necessary during the construction of the trial length. Thereafter, neither the materials nor the mix proportions shall be varied in any way except with the written approval of the Engineer.

Any change in the source of materials or mix proportions opposed by the Contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial length unless approval is given by the Engineer for minor adjustments like compensation for moisture content in aggregates or minor fluctuations in the grading of aggregate.

Sub-base

1.160.1.17 The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant Drawings and Specifications contained in **Section 601 of MORTH Specifications for Road and Bridge Works (III Revision)**. If the sub-base is found damaged at some places of it has cracks wider than 10 mm., it shall be repaired with fine cement concrete or bituminous concrete before laying separation layer. Prior to laying of concrete it shall be ensured that the separation membrane as per specifications is placed in position and the same is clean of dirt or other extraneous materials and free from any damage.

Separation Membrane

1.160.1.18 A separation membrane shall be used between the concrete slab and the sub base. Separation membrane shall be impermeable plastic sheeting 125 microns thick laid flat without creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheeting shall be replaced at the Contractor’s expense. The separation membrane may be nailed to the lower layer with concrete nails.

Joints

1.160.1.19 The location and type of joints shall be as shown in the Drawings. Joints shall be constructed depending upon their functional requirement as detailed in the following paragraphs. The location of the joints shall be transferred accurately at the site and mechanical saw cutting of joints done s per stipulated dimensions. It should be ensured that the full required depth of cut is made from edge to edge of the pavement. Transverse and longitudinal joints in the pavement and sub base shall be staggered so that they are not coincident vertically and are at least 1 m and 0.3 m apart respectively. Sawing of joints shall be carried out with diamond studded blades soon after the concrete has hardened to take the load of the sawing machine and personnel without damaging the texture of the pavement. Sawing operation could start as early as 6-8 hours depending upon the season.

1.160.1.20 Transverse joints

Transverse joints shall be contraction and expansion joints constructed at the spacing described in the Drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints which is the straight line transverse to the longitudinal axis of the carriageway at the position proposed by the Contractor and agreed to by the Engineer, except at road junctions or roundabouts where the position shall be as described in the Drawings :

1. Deviations of the filler board in the case of expansion joints from the intended line of the joint shall not be greater than ± mm.
2. The best fit straight line through the joint grooves as constructed shall be not more than 25 mm from the intended line of the joint.
3. Deviations of the joint groove form the best fit straight line of the joint shall not be greater than 10 mm.
4. Transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Transverse joints shall have a sealing groove which shall be sealed .

Contraction joints

1. Contraction joints shall consist of 2 mechanical sawn joint groove, 3 to 5 mm wide and 1/4 and 1/3 depth of the slab ± 5 mm or as stipulated in the Drawings and dowel bars as detailed in the Drawings.
2. The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damages to the slab.

Expansion joints

The expansion joints shall consist of a joint filler board and dowel bars complying as detailed in the Drawings. The filler board shall be positioned vertically with the prefabricated joint assemblies along the line of the joint within the tolerances and at such depth below the surface as will not impede the passage of the finishing straight edges or oscillating beams of the paving machines. The adjacent slabs shall be completely separated from each other by providing joint filler board. Space around to dowel bars, between the sub-base and the filler board shall be packed with a suitable compressible material to block the flow of cement slurry.

1.160.1.21 Transverse construction joint

Transverse construction joints shall be placed whenever concreting is completed after a day’s work or is suspended for fore than 30 minutes. These joints shall be provided at the regular location of contraction joints using dowel bars. The joint shall be made butt type. At all construction joints, steel bulk heads shall be used to retain the concrete while the surface is finished. The surface of the concrete laid subsequently shall conform to the grade and cross sections of the previously laid pavement. When positioning of bulk head/stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out to enable the movement of joint cutting machine so that joint grooves may be formed and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened.

1.160.1.22 Longitudinal joint

The longitudinal joints shall be saw cut as per details of the joints shown in the Drawing. The groove may be cut after the final set of the concrete. Joints should be sawn to at least 1/3 the depth of the slab ± 5 mm as indicated in the Drawing.

Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the Drawing

1.160.1.23 Dowel bars

Dowel bars shall be mild steel rounds in accordance with details / dimensions as indicated in the Drawing and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placement of the bars besides full re-compaction of the concrete around the dowel bars.

Unless shown otherwise on the Drawings, dowels bars shall be positioned at mid depth of the slab within a tolerance of ± 25 mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of carriageway and to each other within tolerances given there under, the compliance of which shall be checked as

For bars supported on cradles prior to the laying of the slab :

I. All bars in a joint shall be within ± 3 mm per 300 mm length of bar

II. 2/3rd of the bars shall be within ± 2 mm per 300 mm length of bar

III. No bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm length of bar in either the horizontal or vertical plane

IV. Cradles supporting dowel bar shall not extend across the line of joint i.e. no steel bar of the cradle assembly shall be continuous across the joint.

2. For all bars inserted after laying of the slab :

I. Twice the tolerance for alignment as indicated in (I) above.

Dowel bars, supported on cradles in assemblies, when subject to a load of 110 Contractor applied at either end and in either the vertical or horizontal direction (upwards and downwards and both directions horizontally) shall conform to be within the following limits:

1. Two thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar.
2. The remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints, shall have the following degree of rigidity when fixed in position:

1. For expansion joint, the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600 mm by means of a bar or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length of filler board, if a continuous fixing is used. The residual deflection after removal of the load shall be not more than 3 mm.
2. The joint assembly fixing to sub-base shall not fail under the 1.3 kN load applied for testing the rigidity of the assembly but shall fail before the load reaches 2.6 kN.

3. The fixings for contraction joint shall not fail under the 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.
4. Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3 mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar of timber packing.

Dowel bars shall be covered by a thin plastic sheath for at least two thirds of the length from one end for dowel bars in contraction joints or half the length plus 50 mm for expansion joints. The sheath shall be tough, durable and of an average thickness not greater than 1.25 mm. The sheathed bar shall comply with the following pull out tests.

1. Four bars shall be taken at random from stock and without any special preparations shall be covered by sheaths as required in this Clause. The ends of the dowel bars which have been sheathed shall be cast centrally into concrete specimens 150 x 150 x 600 mm, made of the same mix proportions to be used in the pavement, but with a maximum nominal aggregate size of 20 mm and cured in accordance with IS:516. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall not be greater than 0.14 MPa.

For expansion joint, a closely fitting cap 100 mm long consisting of waterproofed cardboard or on approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry between dowel and cap it may be taped.

1.160.1.24 Tie bars

Tie bars in longitudinal joints shall be deformed steel bars of strength 415 MPa complying with IS:1786 and in accordance with the requirements given below. The bars shall be free from oil, dirt, loose rust and scale.

Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm on each side of the joint by a protective coating of bituminous paint with the approval of the Engineer. The coating shall be dry when the tie bars are used.

Tie bars in longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placement of the bars and recompaction of the concrete around the tie bars.

Tie bars shall be positioned to remain within the middle third of the slab depth as indicated in the Drawings and approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bat on the intended line of the joints within a tolerance of ± 50 mm, and with a minimum cover of 30 mm below the joint groove.

Weather and Seasonal limitations

1.160.1.25 Concreting during monsoon months

When concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other water proof cloth shall be provided along the line of the work. Any time when it rains, all freshly laid concrete which had not been covered for curing purposes shall adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be retextured in accordance with the directives of the Engineer.

1.160.1.26 Concreting in hot weather

No concreting shall be done when the concrete temperature is above 30 degree Centigrade. Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., if so desired by the Engineer, tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer. The temperature of the concrete mix on reaching the paving site shall not be more than 30^{o}C. To bring down the temperature, if necessary, chilled water or ice flakes should be made use of.

No concreting shall be done when the concrete temperature is below 5 degree Centigrade and the temperature is descending.

Side Forms, Rails and Guide wires

1.160.1.27 Side forms and rails

All side forms shall be of mild steel of depth equal to the thickness of pavement or slightly less to accommodate the surface regularity of the sub-base. The forms can be placed on series of steel packing plates or shims to take care of irregularity of sub-base. They shall be sufficiently robust and rigid to support the weight and pressure caused by a paving equipment. Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rails shall be firmly secured in position by not less than 3 stakes/pins per each 3 m length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3 m and when in place shall not settle in excess of 1.5 mm in 3 m while paving is being done. Forms shall be cleaned and oiled immediately before each use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the Drawings within tolerances ± 10 mm and ± 3 mm respectively. The bedding shall not extend under the slab and there shall be not vertical step between adjacent forms of more than 3 mm. The forms shall be got inspected from the Engineer for his approval before 12 hours on the day before the construction of the slab and shall not be removed until at least 12 hours afterwards.

1.160.1.28 At all times sufficient forms shall be used and set to the required alignment for at least 200 m length of pavement immediately in advance of the paving operations, or the anticipated length of pavement to be laid within the next 24 hrs whichever is more.

1.160.1.29 Use of guide wires

Where slip form paving is proposed, a guide wire shall be provided along both sides of the slab. As described in the contract/Drawing within a vertical tolerance of ± 3 mm. additionally, one of the wires shall be kept at a constant horizontal distance from the required edge of the pavement as indicated in the contract/Drawing within a lateral tolerance of ± 10 mm.

The guide wires shall be supported on stakes not more than 8 m apart by connectors capable of fine horizontal and vertical adjustment. The guide wire shall be tensioned on the stakes so that a 500 gram weight shall produce a deflection of not more than 20 mm when suspended at the mid point between any pair of stakes. The ends of the guide wires shall be anchored to fixing point or winch and not on the stakes.

The stakes shall be positioned and the connectors maintained at their correct height and alignment from 12 hours on the day before concreting takes place until 12 hours after finishing of the concrete. The guide wire shall be erected an tensioned on the connectors at any section for at least 2 hours before concreting that section.

The Contractor shall submit to the Engineer for his approval of line and level, the stakes and connectors which are ready for used in the lengths of road to be constructed by 12 hours on the working day before the day of construction of slab. Any deficiencies noted by the Engineer shall be rectified by the Contractor who shall then re-apply for approval of the affected stakes. Work shall not proceed until the Engineer has given his approval. It shall be ensured that the stakes and guide wires are not affected by the construction equipment when concreting is in progress.

Construction

1.160.1.30 General

A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying but the work, detailing all the activities including indication of time-cycle, equipment, personnel etc., shall be got approved from the Engineer before the commencement of the work. The above shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving rate of at least 300 mm in one day.

1.160.1.31 Batching and mixing

Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place which takes into account sufficient space for stockpiling of cement, aggregates and stationary water tanks. This shall be, however, situated at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the Contractor.

1.160.1.32 Equipment for proportioning of materials and paving

Proportioning of materials shall be done in the batching plant by weight, each type of material being weighted separately. The cement from the bulk stock may be weighed separately from the aggregates and water shall be measured by volume wherever properly graded aggregate of uniform quality cannot be maintained as envisaged in the mix design, the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity of the laying/paving equipment.

Batching plant and equipment

1. General

The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety device shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned.

2. Bins and Hoppers

Bins with minimum number of four adequate separate compartments shall be provided in the batching plant.

3. Automatic weighing devices

Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells.

4. Mixers

- Mixers shall be pan type, reversible type or any other mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specific mixing period, and of discharging the mixture, without segregation. Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed 90 seconds or as per the manufacturer's recommendation. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of batches mixed.
- The mixers shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20 mm or more. The Contractor shall (1) have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in references to original height and depth, or (2) provide permanent marks on blade to show points of 20 mm wear from new conditions. Drilled holes of 5 mm diameter near each end and at midpoint of each blade are recommended. Batching Plant shall be calibrated in the beginning and thereafter at suitable interval not exceeding 1 month.

5. Control cabin

An air-conditioned centralised control cabin shall be provided for automatic operation of the equipment.

Paving equipment

1. The concrete shall be placed with an approved fixed form or slip paver with independent unit designed to (i) spread, (ii) consolidate, screed and float-finish, (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand pavement in conformity with the plans and Specifications. The paver shall be equipped with electronic controls to control/sensor line and grade from either or both sides of the machine.
2. Vibrators shall operate at a frequency of 8300 to 9600 impulses per minute under load at a maximum spacing of 60 cm. The variable vibration setting shall be provided in the machine.

Concrete saw

The Contractor shall provide adequate number of concrete saws with sufficient number of diamond-edge saw blades. The saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition. The concreting work shall not commence if the saws are not in working conditions.

1.160.1.33 Hauling and placing of concrete

Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of trucks/tippers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete. Covers shall be used for protection of concrete against the weather. The trucks/tippers shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver is to be regulated in such a way that the paving is done in an uninterrupted manner with a uniform speed throughout the days work.

Placing of concrete

Concrete mixed in central mixing plant shall be transported to the site without delay and the concrete which, in the opinion of the Engineer, has been mixed too long before laying will be rejected and shall be removing from the site. The total time taken from the addition of the water to the mix, until the completion of the surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25°C and 90 minutes when the concrete temperature is between 25°C to 30°C. Trucks/tippers delivering concrete shall not run on plastic sheeting nor shall they run on completed slabs until after 28 days of placing the concrete. The Paver shall be capable of paving the carriageway as shown in the Drawings, in a single pass and lift.

Where fixed from pavers are to be used, forms shall fixed in advance as per the Specifications. Before any paving is done, the site shall be shown to the Engineer, in order to verify the arrangement for paving besides placing of dowels, tie-bars etc., as per the relevant Clauses of this Specification. The mixing and placing of concrete shall progress only at such a rate to permit proper finishing, protecting and curing of the pavement.

In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The addition of water to the surface of the concrete to facilitate the finishing operations will not be permitted except with the approval of the Engineer when it shall be applied as a mist by means of approved equipment.

If considered necessary by the Engineer, the paving machines shall be provided with approved covers to protect the surface of the slab under construction from direct sunlight and rain or hot wind.

While the concrete is still plastic, its surface shall be brush textured and the surface and edges of the slap cured by the application of a sprayed liquid curing membrane.. After the surface texturing, but before the curing compound is applied, the concrete slab shall be marked with the chainage at every 100 m interval.

As soon as side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by the using fine concrete composed wherever irregularities have occurred by using fine concrete composed of one part of cement to 3 parts of fine chips and fine aggregate under the supervision of the Engineer.

If the requirement of **Section 902.4 of MORTH Specifications for Road and Bridge Works (III Revision)**. for surface regularity fails to be achieved on two consecutive working days, then normal working shall cease until the cause of the excessive irregularity has been identified and remedied.

Construction by fixed form paver

The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition onto the sub base. The spreader shall be operated to strike off concrete up to a level requiring a small amount of cutting down by the distributor of the spreader. The distributor of spreader shall strike off the concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer. If necessary, poker vibrators shall be adjacent to the side forms and edges of the previously constructed slab. The vibratory compactor shall be set to strike off the surface slightly high so that it is cut down to the required level by the oscillating beam. The machine shall be capable of being rapidly adjusted for changes in average and differential surcharge necessitated by changes in slab thickness or cross fall. The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by over working.

1.161 Prime Coat over Granular Base

Scope

1.161.1.1 This work shall consist of application of single coat of low viscosity liquid bituminous material to an absorbent granular surface preparatory to any superimposed bituminous treatment or construction.

Materials

1.161.1.2 The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. These are:

1. Surfaces of low porosity; such as wet mix macadam and water bound macadam,
2. Surfaces of medium porosity; such as cement stabilized soil base,
3. Surfaces of high porosity; such as a gravel base.

1.161.1.3 The different ranges of viscosity requirements for the primers to be used for the different types of surfaces to be primed.

1.162 Bituminous Macadam

Scope

1.162.1.1 The work shall consist of construction, in a single course, of compacted crushed aggregates premixed with a bituminous binder, to serve as base/binder course, laid immediately after mixing, on a base prepared previously in accordance with the requirement of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawing or as directed by the Engineer.

Materials

1.162.1.2 Bitumen

The bitumen shall be paving bitumen of suitable penetration grade (30/40 to 80/100) as per IS:73. The actual grade of bitumen to be used shall be decided by the Engineer appropriate to the region, traffic, rainfall and other environmental conditions. Guidelines on selection of the grade of bitumen are given in **Appendix 4 of MORTH Specifications for Road and Bridge Works (III Revision)**.

1.162.1.3 Aggregates

The aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. If crushed shingle/gravel is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall preferably be hydrophobic and of low porosity. It hydrophilic aggregates are to be used, the bitumen shall preferably be treated with anti-stripping agents of approved quality in suitable dose as per **Appendix-5 of MORTH Specifications for Road and Bridge Works (III Revision)**. The aggregates shall satisfy the physical requirements set forth in Table 6.

Table 6 Physical Requirements of Aggregates for Bituminous Macadam

Sr.	TEST	TEST METHOD	REQUIREMENT
1	Los Angeles Abrasion Value*	IS:2386 (Part - 4)	40 per cent Maximum
2	Aggregate Impact Value*	-do-	30 per cent Maximum
3	Flakiness and Elongation Indices (Total)	IS:2386 (Part - 1)	30 per cent Maximum
4	Coating and Stripping of Bitumen Aggregate Mixtures	AASHTO T 182	Minimum retained coating 95 per cent
5	Soundness: I. Loss with Sodium Sulphate 5 cycles II. Loss with Magnesium Sulphate 5 cycles	IS:2386 (Part - 5)	 12 per cent Maximum 18 per cent Maximum
6	Water absorption	IS:2386 (Part - 3)	2 per cent Maximum

** Aggregates may satisfy requirements for either of the two tests.*

Note: If crushed slag is used, Clause 13.2.2.3 shall apply

The aggregate for bituminous macadam shall conform to one of the two gradings in Table 7, depending on the compacted thickness; the actual grading shall be as specified in the Contract.

1.162.1.4 Proportioning of materials

The bitumen content for premixing shall be 3 to 3.5 per cent by weight of the total mix except when otherwise directed by the Engineer.

Table 7 Aggregate Grading for Bituminous Macadam

IS Sieve Designation	Per cent by weight passing the sieve	
	Grading 1	Grading 2
45.0 mm	100	-
26.5 mm	75-100	100
22.4 mm	60-95	75-100
11.2 mm	30-55	50-85
5.6 mm	15-35	20-40
2.8 mm	5-20	5-20
90.0 micron	0-5	0-5

The maximum compacted thickness of a layer shall be 100 mm.

The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

1.162.1.5 Variation in proportioning of material

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content ± 0.3 per cent by weight of total mix shall, however, be permissible for individual specimens taken for quality control tests vide **Section 900 of MORTH Specifications for Road and Bridge Works (III Revision)**.

Construction Operations

1.163 Prime Coat over Granular Base

1.163.1 Scope

1.163.1.1 This work shall consist of application of single coat of low viscosity liquid bituminous material to an absorbent granular surface preparatory to any superimposed bituminous treatment or construction.

1.163.1.2 Materials

1.163.1.3 The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. These are:

4. Surfaces of low porosity; such as wet mix macadam and water bound macadam,
5. Surfaces of medium porosity; such as cement stabilized soil base,
6. Surfaces of high porosity; such as a gravel base.

The different ranges of viscosity requirements for the primers to be used for the different types of surfaces to be primed

1.163.1.4 Weather and seasonal limitations

The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10o C or less.

1.163.1.5 Preparation of the base

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross-sections and a priming coat where needed shall be applied in accordance as directed by the Engineer.

1.163.1.6 Tack coat

A tack coat as per **Clause above** shall be applied over the base.

1.163.1.7 Preparation and transport of mix shall be as per MORTH specifications

1.163.1.8 Compaction

After the spreading of mix, rolling shall be done by 80 to 100 KN rollers or other approved equipment. Rolling shall start as soon as possible after the material has been spread deploying a set of rollers as the rolling is to be completed in limited time frame. The roller shall move at a speed not more than 5 km/h. Rolling shall be done with care to avoid unduly roughening of the pavement surface.

Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except that on super elevated and uni-directional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or break-down rolling shall be done with 80-100 kN static weight smooth wheel roller (3 wheels or tandem), as soon as it is possible to roll the mix without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the break-down rolling with vibratory roller of 80 to 100 kN static weight or pneumatic tyred roller of 150 to 250 kN weight, with minimum 7 wheels and minimum tyre pressure of 0.7 MPa as closely as possible to the paver and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while material is still workable enough for removal of roller marks, with 60-80 kN tandem roller. During the final rolling, vibratory system shall be switched off. The joints and edges shall be rolled with a 80 to 100 kN static roller.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding mix material. The rolling shall then be continued till the entire surface has been rolled to 95 per cent of the average laboratory density (obtained from Marshall specimens compacted as defined & there is no crushing of aggregates and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. The roller wheel shall be kept damp if necessary to avoid bituminous material from sticking to the wheels and being picked up. In no case shall fuel, lubricating oil be used for this purpose, nor excessive water poured on the wheels.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 100^o C.

Roller(s) shall not stand on newly laid material while there is a risk that surface will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

Surface Finish and Quality Control of Work

1.163.1.9 The surface finish of construction shall conform to the requirements of **Section 902 of MORTH Specifications for Road and Bridge Works (III Revision)**. Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900 of MORTH Specifications for Road and Bridge Works (III Revision)**.

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, without any delay. If these is to be any delay, the course shall be covered by a seal coat to the requirement of **Section 513 of MORTH Specifications for Road and Bridge Works (III Revision)** before allowing any traffic over it. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

Arrangements of Traffic

1.163.1.10 During the period of construction, arrangement of traffic shall be done.

Measurements for Payment

1.163.1.11 The work shall be measured as finished work in cubic metres or by weight in metric tonnes as provided in the Contract.

Rate

1.163.1.12 The contract unit rate for the work shall be payment in full for carrying out the required operations including full compensation for:

1. Making arrangements for traffic to except for initial treatment to verge, shoulders and construction of diversion;
2. Preparation of base except for laying of profile corrective course but including filling of potholes;
3. Providing all materials to be incorporated in the work including arrangement for stock yards, all royalties, fees, rents where necessary and all leads and lifts;
4. All labour, tools, equipment's, plant including installation of hot mix plant, power supply units and all machineries, incidental to complete the work to the Specifications;
5. Carrying out the work in part widths of the road where directed;
6. Carrying out all tests for control of quality; and

7. The rate shall cover the provision of bitumen at 3.25 per cent of weight of total mix, with the provision that the variation of quantity of bitumen will be assessed and the payment adjusted as per the rate of bitumen quoted.

1.164 Mix Seal Surfacing

Scope

1.164.1.1 This work shall consist of laying and compacting mix seal surfacing in a single course composed of suitable aggregates premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of these Specifications, to serve as a wearing course.

1.164.1.2 Mix seal surfacing shall be of Type A or Type B as specified.

Materials

1.164.1.3 Binder

Section 509.1.2.1 of MORTH Specifications for Road and Bridge Works (III Revision) shall apply.

1.164.1.4 Course aggregates

Section 509.1.2.2 of MORTH Specifications for Road and Bridge Works (III Revision) shall apply.

1.164.1.5 Fine aggregates

The fine aggregates shall consist of crusher run screening, natural gravel/sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic or deleterious substances.

1.164.1.6 Aggregates gradation

The coarse and fine aggregates shall be so graded or combined as to conform to the grading set forth in Table -8.

Table 8 Aggregates Gradation for Mix Seal Surfacing

IS Sieve Designation	Per cent by weight passing the sieve	
	For Type A Mix Seal Surfacing	For Type B Mix Seal Surfacing
13.2 mm	-	100
11.2 mm	100	88-100
5.6 mm	52-88	31-52
2.8 mm	14-38	5-25
90 micron	0-5	0-5

1.164.1.7 Proportioning of materials

The total quantity of aggregates used for Type A or B mix seal surfacing shall be 0.27 cubic metre per 10 sqm area. The quantity of binder used for premixing in terms of straight-run bitumen shall be 22.0 kg and 19.0 kg per 10 square metres area for Type A and Type B surfacing respectively.

Construction Operations

1.164.1.8 **Section 509.1.3.1 through 509.1.3.5.of MORTH Specifications for Road and Bridge Works (III Revision)** shall apply.

Opening to Traffic

1.164.1.9 Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature.

Surface Finish and Quality Control of Work

1.164.1.10 The surface finish of construction shall conform to the requirements of Section 902 of MORTH Specifications for Road and Bridge Works (III Revision).

1.164.1.11 Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MORTH Specifications for Road and Bridge Works (III Revision).

Arrangements for Traffic

1.164.1.12 During the period of construction, arrangement of traffic shall be done

Measurements for Payment

1.164.1.13 Mix seal surfacing, Type A or B shall be measured as finished work in sqm.

Rate

1.164.1.14 The contract unit rate for mix seal surfacing, Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed.

1.165 Electrical

1.166 General

Following clauses specify General Electrical requirements and standard of workmanship for the equipment and installations. General Specification classes shall apply where appropriate except where particularly redefined in the Special Specification Clauses.

1.167 Standards

Equipment offered shall comply with the relevant Indian Standards. Equipment conforming to approved International Standards, which is equivalent or superior shall be acceptable. However, the Contractor shall substantiate such equivalence or superiority.

1.168 Requirement Of Statutory Authorities

The electrical equipment / installations shall comply with the requirements of Rules / Regulations as amended up-to-date, required by Statutory Acts or Authorities.

- The Indian Electricity Rules, 1956
- The Indian Electricity Act
- The Indian Electricity (Supply) Act, 1948
- The requirements of Chief Electrical Inspector to the Government.
- The requirement of State Electricity Board
- Fire advisory Committee Insurance Act

The Contractor shall get the drawings, layouts of HT sub station etc. approved from Electricity authority and Chief Electrical Inspector to the government, wherever necessary. The contractor also shall arrange to get the installation inspected by CEIG and carryout modifications/rectification as required by CEIG, prior to commissioning of sub station/electrical equipment.

1.169 Voltage Regulation

During starting of heavy equipment the voltage may drop by a maximum of 31% for period of 45-60 seconds depending upon the duty of the driving equipment. All the electrical equipment shall, therefore, be suitable for trouble free and uninterrupted operation even during such voltage variation at the time of starting of heavy equipment.

1.170 Ambient Temperature

Where the equipment is installed outside and exposed to direct sunrays, these shall be suitable for operation at higher ambient temperature and rigorous weather conditions under which they are required to operate. Equipment offered shall be suitable for continuous operation under high ambient temperature 45°C. Motors used in areas where inflammable gases or liquids exist and associated wiring shall be explosion proof. Motors for outdoor installation shall be weatherproof. Switchboards shall not be exposed to moisture or corrosive gases. Contractor shall submit layout drawings, clearly indicating the location of switchboard and other equipment proposed to be installed, for the approval of CEIG, Electricity authority.

1.171 Power Factor

Suitable rating capacitors shall be provided to each individual motor above 1.5 KW rating along with discharge device of appropriate rating to improve the power factor upto 0.95.

1.172 Approval By Fire Insurance Authority

Equipment supplied along with accessories shall be those approved for use in electrical installations by the Fire Sectional Committee, Central Regional Council of Insurance Association of India.

1.173 H-Frame Steel Structure

General

H-frame galvanized steel self supporting shall have the following equipment

- Lightning Arrestors
- Gang Operated A.B. switch
- DO Fuses
- String Insulators
- Pin Insulators
- ACSR conductors of appropriated sizes to connect all the equipment.

Lightning Arrester

Lightning arrestor shall be provided on each 11 KV line before the termination on the 11 KV isolator in the switchyard. Lightning arresters shall be suitably mounted on the H pole structure or 4 pole structures provided for receiving 11 KV supply per IS 3070 part I. The lightning arresters shall be station class as per I.S., Heavy duty design fitted with anti-contamination feature and pressure relief devices with current limiting gaps generally conforming to IS: 3070 Part I. Alternatively the gap-less type arrester may also be offered of 200 A capacity and short time current of 31 KA (rms) having a peak current of 38 KA, for 1 second duration. Switches shall be complete with base frames comprising hot dip galvanized channels from base, copper contacts, Cu or Cu clad horns, etc. as per IS: 1818.

Gang Operated Air Break Switch

Switches shall be provided with horizontal connecting bar for gang operation, G.I pipe as down rod lever coupling and operating handle with padlock and other components necessary for complete assembly.

11 KV Drop- Out Fuses

The 11 KV drop –out lift off fuses shall offer protection against short circuit and suitable for use in conjunction with 11 KV system having fault level of 500 MVA. The fuses shall be designed for vertical mounting. The fuse carrier shall comprise of insulating material tubes open at both ends. The fuse carrier shall drop down in the event of fuse blow out in order to enable clear indication from long distance. Rewiring of blown fuse shall be possible from ground level. All other current carrying parts shall be of aluminum bronze. The glazed porcelain insulators shall conform to IS: 731 and IS : 2544. The complete fuse shall meet impulse voltage in accordance with BS: 2692 or IS: 3106. Each fuse shall be assembled separately and mounted on channel base. Rated current of the fuse shall be decided as per the requirement. The complete fuse unit shall withstand power frequency wet withstanding voltage in accordance with IS: 1818. A suitable insulated operating rod shall be provided with each fuse assembly. Two pairs of rubber hand gloves for working on 11 KV shall be provided.

Insulators

The disc, pin and post type insulators used shall be of high quality glazed porcelain. The electrical and mechanical characteristics shall conform to IS: 731 and IS: 2544. Insulators shall have following character tics suitable for use in an effectively earthed system.

- System voltage : 11 KV
- Dry / Wet one minute power frequency to withstand voltage : 35 KV
- 1.2/50 micro second impulse withstand voltage : 75 KV
- Power frequency puncture withstand test voltage on units: 1.3 times of the dry flashover voltage on the unit.
- Visible discharge voltage : 9 KV
- Total minimum creep distance for post and disc insulator
- : 320-mm for post insulation
- : 320 mm for disc insulation.

Current and Potential Transformers

The current and potential transformers for metering and protection shall be fitted with the standard accessories and will in general conform to IS: 2705 and IS: 3316 respectively.

Bus Bars and Jumpers

The Bus Bars shall be aluminum Tubes / flats of adequate size to carry continuous current and 13.1 KA short circuit current for one second duration. The current density of Bus Bars, jumpers and inter connection shall be designed such that, the temperature shall not exceed 70°C and hot spot temperature shall exceed 75°C over an ambient temperature of 45°C. the terminations shall be through locked type clamps. The clamps and connection shall be suitable of withstanding the stress due to cyclic temperature variation as a result of variation in the low current. The bus bars are Tee shall conform IS: 5561.

1.174 H.T Panel Board

Scope

Manufacturing, testing, supplying and commissioning of integrated cubicle type, floor mounted, free standing extensible, sheet steel enclosed, front operated. Indoor type switchboard, operated by vacuum circuit breaker as per specifications.

System

The switchboard shall be suitable for the following system:-

Rated voltage 11kv, 3phase, 50Hz earthed system as specified in the design.

Standard

Unless otherwise stated below, HT switchboard shall conform to the following relevant India Standards and Indian Electricity and Regulations.

IS	:	3427
IS	:	2147
IS	:	375
IS	:	2705
IS	:	3316
IS	:	722 (Part I & II)
IS	:	3231
IS	:	1248

1.175 Construction Features

The board shall be made from MS sheet steel minimum 2 mm thick and shall be folded and braced as necessary o provide a rigid support for all components, joints of all kind in sheet metal shall be seam welded, and sledding slag grouted off and welding ports wiped smooth with plumber metal. All panels and covers shall be properly fitted and square with the frames, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate of metal or provided with hank nuts. Self-threading screws shall not be used in the construction of switchboards. The boards be totally of enclosed design, completely dust and vermin proof. Gaskets between all adjacent units and beneath all over shall be used to render the joints effectively dust proof. The gaskets shall be chemically treated Neoprene.

The switch board shall be extensible at site on either side. Soft compressible gaskets shall be used between all metal joints, doors and covers to prevent ingress of dust.

The switch gear shall be with louvers for ventilation and shall provide a degree of protection IP44. All louvers shall have screens and filters. Vent opening shall be covered with grills so arranged that hot gasses or other material cannot be discharged through tem in a manner that can injure the operating personnel. The screens and grills shall be made of either brass or G1 wire mesh.

1.175.1 Metal enclosed unit shall comprise rigid welded structural frame enclosed completely by metal sheet of 2.5 mm thick (hot rolled) or 2.00 mm (cold rolled) smooth finished, leveled and free from flaws.

1.175.2 Circuit breaker carriage shall be fitted with positive guide so as to ensure proper alignment.

1.175.3 Switch gear cubicle shall be provided with top sheet metal plates 2mm thick (minimum). Cubicles with bottom entry shall be fitted and removable plates for fixing XLPE cable terminating kits and glands.

1.175.4 Metals sills in the form of metal channels properly drilled shall be supplied along with anchor bolts for mounting the switchgear cubicles.

Switchgear shall be provided with painted legend, indicating Switch Gear Designation, rating and Duty. Early relay, instrument, Switch, fuse and other devices shall be provided with separate legend. The main name plate shall be PVC/Acrylic engraved.

Safety, Interlocks and Features

a) Switch gear shall be provided with the following interlocks.

b) Operation on circuit breaker shall not be possible unless it is fully on to working position withdrawn to service position (isolated from power supply.), or fully drawn out.

c) The breaker carriage shall be earthed before the Main circuit Breaker Controls are plugged in the stationary contacts. Positive earthing of circuit breaker frames truck shall be maintained in the connected position.

d) Caution name plat: “Caution live terminals” shall be provided at all points where terminals are likely to remain live and isolation should be possible only at remote end.

Bus bar

a) Bus bar shall be made from rectangular section of high wrought copper and the current density shall not exceed 1.2A/ sq.mm.

b) Bus bar shall not be accessible after opening bus bar channel door. A separate wire mesh cover shall be provided between bus bar and channel door.

c) Bus bar shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current specified. Bus bar support on insulators, to with stand dynamic stresses conforming to IS 2544.

d) Bus bar shall be suitably colour coded for phase indication.

1.175.5 Vacuum Circuit Breaker

a. The closing release shall operate correctly at all voltage between 86% and 110% of rated voltage. A shunt trip shall operate correctly under all operating conditions of the breaker voltage between 85% and 110%.

b. Working parts of mechanism shall be of Corrosion Resistive Materials. Bearings which require grease shall be equipped with pressure type grease fitting: bearing pins, bolts, nuts and other parts shall be adequately pinned and locked to prevent loosening or changing adjustment with repeated operations of breaker.

13.1kA at 11 KV vacuum circuit breaker comprise of the following

1. Assembly of 3 vacuum interrupters complete with epoxy supports insulators and self aligning finger type isolating contacts.
2. Truck having integral racking in device for insertion and withdrawal of VCB complete with necessary inter locks.
3. Manually charged spring closing / tripping mechanism.
4. Mechanical operation counter.

Load Break Switch

Air break, manually operated type load break switch for 3 phases, 3 wire 50 hz system with earth switch interlocked with main switch, manual ON/OFF indicators and comprising.

a. Emergency Tripping push button
b. 3 Nos. 11KV.H.T.H.R.C fuses of suitable rating.
c. 2'NO' +2'NC' Auxiliary Contacts.
d. 30V.D.C Shunt trip coil.
e. 3 nos. of resin cast CTs of suitable ratio, 31VA, class 0.5 for metering.
f. Relay chamber fitted with 1no TPN IDMT & E.F Relay
1. Separate instrument chamber sealable type fixed with T.O.D meter having class 0.5 accuracy and suitable for applicable tariff.
g. 1No. 3 phase, 3L, 11Kv/110V CI-1 fitted with L.T & H.T Fuses.
2. 1 rear cable box to connect incoming cable & 1 side cable box to connect out going cable.

Relay panels

a. All relays shall be draw out type with built – in test facilities. Test plug shall also be provided.
b. Push button shall be of adequate rating with two "NO" and "NC contact points.
c. Indicating lamps shall be panel mounting type with series resistor. Preferably built in the lamp assembly. The lamps shall have translucent lamp covers to diffuse lights in red, green, blue etc. colour as specified.

Fuses

H.R.C cartridge type fuses of adequate rating shall be used for all control circuits. Fuses shall have operating indicators for indicating blown out condition. Fuse carrier base shall be imprinted with fuse voltage rating.

Terminal Blocks for Control wiring

Terminal blocks shall be 650 V grade, suitable rating, and one piece moulded, complete with insulated barriers, terminal pressure clamp type, washer's nuts and identification strips. CT and PT secondary lead terminal blocks shall have test links and isolating facilities. Also CT secondary leads shall be provided with short–circuiting and earthing facilities.

1.175.6

Heaters and plug point

Space heater shall be provided complete with switch fuse unit (240 V, 1ph, 50Hz) Plug point of 240 V, 1Ph, 50 Hz shall be provided for hand lamps.

Cable boxes and cable entries

1.175.7 Cable boxes and glands shall be provided Double compression GI cable glands shall be provided for power and control cables.

Test Reports

a. Test certificates of circuit breakers, CTs, PTs, Relays, etc. shall be provided before the panels and dispatched to the site.

b. Operating, maintenance, installation and testing manuals. Technical specifications of relays and circuit breakers shall also be furnished before dispatch of panel.

Drawing and Data

Complete assembly drains of switch gear showing plan, elevation, typical sectional views, location of cable boxes, bus bar chambers design, metering and relay compartments and terminal blocks for external wiring connections, shall be submitted for approval before installation.

Auxiliary DC power supply

1.175.7.1 Battery Charger

Quantity	:	1 set
Type of cell	:	Tabular Stationary battery
No. of cells	:	Fifteen (31)
Rating	:	30V 120 AH
Duty	:	Substation duty
Input	:	230V

Automatic / Manual selection of boost and trickle charger digital voltmeter and ammeter with adequate protection using MCB's /MCCB's

1.175.7.2 Battery charger and DC distribution board:-

The battery charger shall be designed for charging the battery in float as well as boost modes or simultaneously supply the load as may be required by the plant. The charges shall consist of input switchgear, transformer, rectifier, regulator output switchgear, metering, protective devices and indication.

The charger transformer shall have taps as follows:-

Primary	:	(0-200-220-240)V
Secondary	:	(0-32-34-36-38-40)V

The charging transformer shall be double would copper winding with CRGO core, continuously rated to work in an ambient of 55 deg. C and insulated with appropriate class of windings. The continuous current rating of the transformer shall be the rating sufficient to cater to boost current of 1.5 times rated current of the battery bank with 20% safety design margin. The rectifier bridge shall consist of separately mounted silicon diodes on heat sinks and shall be rated with factor of safety of 1.5, even when supplying worst boost charging current as above. PIV of the diodes shall be 1000 V and full wave bridge shall be provided with surge suppressor network. Output voltage of bridge for float charging shall be 33 V DC max and for boost charging shall be 40V DC max. The charger shall be provided with manual – change over circuitry from float to boost mode and vice versa. The float circuit shall be designed for the required continuous load and the boost circuit shall be suitable for delivering a charging current suitable or 24 V, 12 AH battery, not exceeding the rated current of the battery.

A D.C distribution board shall be supplied with the charger with the following

One (1) – 63 A, 2 Pole MCB (DC) for incomer

One (1) - 20A, 2 pole MCB (DC) for outgoing

The DC distribution board shall be complete with automatic change over switch for supply of emergency lighting power failure, DC UV relay, AC UV relay, contactor, etc.

1.176 High Tension Cabling

General

This specification provides for the design, Engineering, manufacture, testing before dispatch at manufacturer's works, supply and delivery of 11 KV three core and single core 500 sq.mm and three core 300 sq.mm cross linked polyethylene insulated PVC sheathed underground cable (11 KV XLPE UG CABLE) as specified here in after in this specification for the use in the sub project.

Standards

The 11 KVXLPE UG Cables offered shall comply in all respects with the Indian Standards Specification IS 7.98 (Part 2) – 1985 with latest amendments of any other authoritative standard IEC Publication No. 501 (1983) which ensures equal or higher quality material. Offers confirming to the standard other than IS 7098 shall be accompanied by the English version of the relevant standards in support of the guaranteed particulars.

Storing

On receipt of HT cable at site, cable shall be inspected to detect any damage. If any defect/damage is found, it shall be reported to the Site Engineer or his Representative, for action. The ends of cables shall be in sealed condition after inspection and shall be stored in a proper place. The cable drum shall not be stored flat to the ground with flanges horizontal.

Materials

1.177 Conductor

1.178 Aluminum

The conductor shall be composed of plain aluminum wires complying with IS: 8139/1984.

1.179 Form of conductor

The conductor shall the circular shaped and stranded. It shall be clean, uniform in size and shape, smooth and free from harmful defects.

1.180 Joints in conductor

Joints shall be permitted in the individual wires of which the conductor is formed, but no joint shall be within 300mm of any other joint within the same layer. The joints shall be made by resistance but welding, fusion welding, gas welding, brazing or silver soldering.

1.181 No joints shall be made in the conductor after it has been standard.

Insulation

1.182 The insulation shall be of cross linked polyethylene confirming to Standard specification.

Screening

1.183 The screening shall consist of the following as specified elsewhere.

(a) Non-metallic semi conducting tape.

(b) Non-metalic semi conducting compound and

(c) Non-Magnetic metallic tape wire, strip or sheath.

The semi conducting tape and semi conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

1.184 Fillers and Inner Sheath

The fillers and inner sheath shall be of the following:

a. Vulcanized or un vulcanized rubber or

b. Thermoplastic materials.

Vulcanized of unvulcanized rubber or thermoplastic material used for inner sheath shall not be harder that ZLPE and PVC used for insulation and outer sheath respectively. Fillers and inner sheath materials shall be chosen to be compatible with the temperature ratings of the cable and shall have no deleterious effect on any other components of the cable.

1.185 Armoring

1.186 Armouring shall be of the following:

(a) 4mm diameter Galvanized round steel wire or

(b) 1.4mm galvanized steel strip

1.187 The galvanized steel wires/strips shall comply with the requirements of IS:3975-1979.

1.188 Outer Sheath

1.188.1. The outer sheath shall be of polyvinyl chloride (PVC) compound conforming to the requirements of Type ST2 i.e., heat resisting sheath intended for use in cables operating at a maximum rated conductor temperature 90°C. of IS: 5831-1984.

1.188.2. The insulation and sheath shall satisfy the test requirement as per section r and the identification, packing and marking shall be as per Section 5 of the IS: 7098 (Part 2) 1985.

1.189 Construction

1.190 Conductor

The conductor shall be stranded construction complying with Clause 2 of IS: 8130-1984.

1.191 Conductor Screening

The cable shall be provided with conductor screening by applying non metallic semi conducting tape or by extrusion of semi conducting compound or a combination of the two.

1.192 Insulation

1.192.1. The conductor shall be provided with cross linked polyethylene insulation applied by extrusion.

1.192.2. The average thickness of insulation shall be not less than 3.6mm.

1.192.3. The smallest of measured values of insulation shall not fall below the value specified by more than 0.46mm. The thickness of any separator or semi conducting screening on the conductor or over the insulation shall not be included in the thickness of insulation.

1.192.4. The insulation shall be so applied that it fits closely on the conductor and it shall be possible to remove it without damaging the conductors.

1.192.5. Insulation Screening

1.192.6. The insulation screening shall consist of two parts, namely metallic and non metallic.

1.192.7. Non metallic part shall be applied directly over the insulation of each core and shall consist of either a semi conducting tape or extruded semi conducting compound or a combination of the two or either material with a semi Conducting coating.

1.192.8. Metallic part shall consist of either tape, or braid, or concentric serving of wires or a sheath, shall be non magnetic and shall be applied over the non metallic part as per Clause 12-4 of IS 7098 (Part 2) – 1985.

1.192.9. Core Identification

Core identification for three core cable shall be by using coloured strips applied on the cores. Red, Yellow and Blue colours, shall be used to identify phase conductors.

1.192.10. Laying Up of Cores

The cores shall be laid together with a suitable right hand lay. Where necessary, the interstices shall be filled with non hygroscopic material.

1.192.11. Inner Sheath

1.192.12. The laid up cores shall be provided with inner sheath applied either by extrusion or by wrapping. It shall be ensured that the shape is as circular as possible.

1.192.13. The inner sheath shall be so applied that it fits closely on the laid up cores and it shall be possible to remove is without damage to the insulation.

1.192.14. The thickness of inner sheath shall be 0.7mm.

1.192.15. The materials used for inner coverings and fillers shall be suitable for the operating temperature of the cable and comparable with the insulating material.

1.192.16. When one or more layers or binder tapes are applied over the laid up cores, the thickness of such shall not be construed as a part of the inner sheath.

1.192.17. Armouring

1.192.18. Armouring shall be applied over inner sheath. The armour wires/ strips shall be applied as closely as practicable.

1.192.19. The direction of lay of the armour shall be left hand. For double layer armoured cables, this requirement shall apply to the inner layer. The outer layer shall be applied in the reverse direction to the inner layer and there shall be a separator of suitable non hygroscopic material between the inner and outer layers of armour wires/strips.

1.192.20. The armour shall consist of either galvanized round steel wire or galvanized steel strips.

1.192.21. The nominal diameter of the galvanized steel strip if used shall be 4.0 mm and nominal thickness of the galvanized steel strip if used shall be 1.4 mm.

1.192.22. The joints in armour wires/strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 30mm from the nearest joint I n any other armour wire/strip in the completed cable.

1.192.23. Outer Sheath

1.192.24. The outer sheath shall be applied by extrusion over the armouring.

1.192.25. The colour of the outer sheath shall be black.

1.192.26. The letters "K.S.E.B" shall be embossed on the out sheet at intervals of 1m throughout the length of the cable.

1.192.27. The thickness of the PVC outer sheet shall not fall below the nominal value of 4.0mn by more than 1.0mn.

1.192.28. Lengths

Unless otherwise agreed to between the employer and the contractor the cables shall be supplied in the manufacturer's usual production lengths and with the permitted variation of ± 5% in the length of any one cable length.

Quality and Tests

1.192.29. Quality Tests and Test Certificates

1.192.30. The cables shall confirm to type and shall be subjected to all tests as stipulated in IS 7098 (Part 2) – 1985 or any authoritative standard to which the cable conforms.

1.192.31. The tests shall be subjected as specified in Indian standards or any authoritative standard in the presence of Employer's representative if so desired by the Employer. All test reports should be submitted and should be got approved by the Employer before dispatch.

1.192.32. Copies of the Type Test reports for the 11KV CLPE cable shall be submitted along with the Bid for the purpose of preliminary study.

1.192.33. The power system parameter are as under:-

1.	Rated Voltage	-	11 KV
2.	Rated frequency	-	50 Hz
3.	Neutral Earthing	-	Effectively earthed
4.	Installation -		Underground
5.	Short Circuit level	-	500 MVA

Identification, Packing and Marking

1.192.34. Manufacturer's Identification

1.192.35. The manufacturers shall be identified throughout the length of cable by manufacturer's name or trade mark, the voltage grade and year of manufacture indented. Printed or embossed or by means of a tape bearing this information. The identification, printing or embossing shall be done only on the outer sheath.

Cable code: The following code shall be used for designating the cable.

Sl. No.	Constituent	Code Letter
1.	Aluminium Conductor	A
2.	XLPE Insulation	2X
3.	Steel round wire armour	W
4.	Non magnetic round wire armour	Wa
5.	Steel strip armour	F
6.	Non magnetic strip armour	Fa
7.	Double steel round wire armour	WW
8.	Double steel strip armour	FF
9.	PVC Outer sheath	Y

1.192.36. The cable shall be wound on a drum and packed. The ends of the cable shall be sealed by means of non hygroscopic sealing material.

1.192.37. The cable shall carry the following information stenciled on the drum.

a) Reference standard
b) Manufacturer's name or trade mark
c) Type of cable and voltage grade
d) Number of cores
e) Nominal cross sectional are of conductor
f) Cable code
g) Length of cable on the drum
h) Number of lengths on the drum
i) Direction of rotation of drum
j) Gross weight
k) Country of manufacturer
l) Year of manufacture
m) Contract No.
n) Name of consignee
o) Lot number

1100 VOLTS GRADE ARMOURED LT POWER AND CONTROL CABLES

1.192.38. Technical Specification for Control and Special Cables

1.192.39. General

The LT power, control and special cables to be supplied are required for the LT power distribution, control and protection connections in the Substations of the Sub-projects. These shall be 1100 volts grade, heavy duty multicore, annealed stranded high conductivity aluminium conductor for power cables and tinned copper conductor for control and special cables, H.R. PVC insulated armoured, overall sheathed by extruded PVC. Standards:-

1.192.40. These shall conform to the latest revision of I.S., IEC or any other acceptable International Standards. Some of the Indian Standards / IEC considered relevant to the cables are given below –

1. IS 3314 – P.V.C. Insulated (Heavy duty) electric cables for working voltages upto and including 11oo volts.
2. IS 5831 – P.V.C. Insulted and sheath of electric cables.
3. IS 8130 – Conductors for insulated electric cables and Flexible cords.
4. IS 3975 – Mild steel wires, strips and tapes for armouring cables.
5. IEC – Test methods for insulation and sheaths of electric cable and cords.
6. IEC. 502 – Extruded solid dielectric insulated power cables for rated voltages from 1 K.V to 30 K.V.
7. IEC. 754-1 Test method for acid gas generation.

1.193 Conductor

1.193.1. The cable conductor shall be made from stranded aluminium for power cables and stranded annealed copper for control cables and special cable to form compact conductor having a resistance with in the limits specified in IS:8130. The minimum number of strands for conductor shall be 7 (seven). The minimum conductor size for LT power cable shall be 1-sqmm aluminium. However, 2.5 sq.mm copper conductors may be used for small power distribution. For LT power cables, following sizes of aluminium conductor shall be used:-4 core, 10 sq.mm; 4 core 25 sq.mm; 3.5 core 50 sq.mm; 3.5 core 95 sq.mm and 3.5 core 300 sq.mm.Control cables of 2.5 sq.mm copper conductor with the following number of cores shall be used. 3 core, 5 core, 7 core, 10 core and 12 core.

1.194 Insulation

1.194.1. The cable insulation shall be of best quality H.R.PVC compound suitable for 85o C operation as per IS: 5831 (1931). The insulation shall be designed and manufactured for the specified voltage grade. The insulation shall fit closely in the conductor and shall be free from voids, foreign particles and burnt material etc., to ensure good insulation properties throughout the cable length.

1.195 Sheath

The laid up cores in cable shall be inner sheathed by extruded PVC covering, which shall be suitable to withstand the site conditions and the desired temperature. The sheath shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects.

1.196 Armour/Shield

The control cables shall be armoured with galvanized round steel wire as per clause 13.0 of IS 3314 (Part I)

1.197 Serbing / Outer Sheath

Extruded PVC serving as per IS 5831 shall be applied over the armouring with suitable additives to prevent attack by rodent and termites. All serving must be give anti-termite treatment.

1.198 Fillers

Fillers shall not be used. However, if they are absolutely essential, they shall be chemically inert, rot proof, non-absorbent and non-absorbent. They shall be suitable for the operating temperature of the cable and compatible with the insulting material.

1.199 Identification

1.199.1. The cores in the control cables shall be identified by a colour scheme as per IS 3314 (Part 1). Over and above this, the cores shall further be identified by he indelible printing of serial number on the cores at neither distance nor more than 75 mm.

1.199.2. All cables shall carry the manufacture's data in a permanent legible manner at an interval of at least three meter run. The manufacturer's data shall include the name, the cable size, and voltage rating together with any other information which the manufacturer considers appropriate.

Drum Length and Cable Drums

1.199.3. The cables covered by this specification shall be supplied in drum length (continuous length) of 1000/500 m +5%)

1.199.4. The cables shall be supplied in non-returnable wooden drums of robust construction. The wood used for construction of the drum shall be properly seasoned, sound and free from defects and wood preservative shall be applied to the entire drum.

1.200 Packing

1.200.1. All cables shall be wound on substantial logged wooded non-returnable drums. A layer of water-proofed paper shall be applied to the surface of the drums and over the outer cable layer. A clear space of at least 40m shall be left between the cable and the logging.

1.200.2. Each drum shall carry the manufacturer's name the Employer's name, address and order number, item number and type, size and length of cable, net and gross weight stenciled on the drum.

1.201 Cable Runs and Operation

1.201.1. The control cables are proposed to be laid on racks in covered trenches, cable tunnels and along ceiling and walls in substation. The control cables will run on separate racks from the power cables.

1.201.2. The cables shall have heat and moisture resistant properties for satisfactory operation under tropical humid conditions.

1.202 Tests

1.201.3. During the manufacture of cables manufacturer's standard tests shall be performed and copies of test certificates shall be furnished to the Employer for approval.

1.201.4. After completion of manufacture of cables, type, routine and acceptance tests shall be performed strictly as per applicable standards and copies of test certificates shall be furnished to the Employer for approval.

1.201.5. The test report on all cables shall be got approved form the Employer before dispatch of the cables.

1.201.6. The test on the cables that will be conducted by the Bidder shall be mentioned in the schedule of tests for each type of cables separately in the form of a tabular chart. Also the testing facilities available at the manufacturer's work shall be clearly indicated in the schedule.

1.201.7. The Employer reserves the right to witness all type and routine tests and the Bidder shall provide all facilities in this regard and shall inform the Employer sufficiently in advance to enable him to depute his representative to witness the same.

1.201.8. Type test: Type test in each type and size of the cable shall be conducted as per applicable standards. The following shall be performed as type tests:-

1. Annealing test (IS: 8130)
2. Conductor resistance test (IS 8130)
3. Test for armour wires/ strips (IS 3945)
4. Persulphate test (IS 8130)
5. Test for thickness of insulation and sheath (IS 3304 part-1/ IEC – 502)
6. Tensile strength and elongation test for insulation and sheath (IS 5831)
7. Ageing tests for insulation and sheath (IS 5831)
8. Loss of mass test for PVC insulation and sheath (IEC –540 & IEC 502)
9. Shrinkage test (IS 5831)
10. Hot deformation test (IS 5831)
11. Cold bend test (IS 5831)
12. Cold impact test (IS 5831)
13. Heat shock test (IEC – 540, IEC – 502)
14. Thermal stability (IEC – 540, 540A)
15. Test for bleeding and blooming of pigments for PVC (IS 5831)
16. Fire resistance test (IS 5831)
17. Measurement of insulation resistance (IS 5831)
18. High voltage test (IS 3314 part I).

1.201.9. Test for rodent and termite repulsion property of sheath are to be preformed by the manufacturer. The details of tests to be given by the manufacturer.

1.201.10. Routine tests and acceptance tests:- The following tests shall constitute routine tests and acceptance tests.

1. Annealing test
2. Conductor resistance test
3. Insulation resistance test
4. Test for thickness of insulation and sheath.

High Voltage test

The test methods, condition of test and test requirement shall comply with those given the type tests. The high voltage test shall, however, be performed as per the methods specified under relevant clause for routine test in IS 3314 (part I). Apart from these conductor examination, check of dimensions etc., shall be carried out as routine tests.

1.203 Installation, Testing and Commissioning

1.203.1. General

1.203.2. The scope shall cover the complete installation of all equipment and accessories covered under this contract.

1.203.3. Installation work pertaining to equipment, cabling, lighting, earthings, lightning protection etc. shall comply with the applicable Standards, Safety Codes etc.

1.203.4. Installation shall be carried out strictly in accordance with the approved drawings. Modifications, if any, required suiting the site conditions shall be carried out only with the prior approval of the Employer. All such changes shall be incorporated in he “As built” drawings to be furnished by the Contractor.

1.203.5. It shall be the responsibility of the Contractor to move/transport from stores/storage yard/shed etc. relevant items and accessories to the place of installation and where necessary assemble all parts of equipment.

25.1 Laying Of High Tension Cables

25.1.1 Cables shall be laid in outdoor trenches wherever called for. The depth of the trenches shall not be less than 1200 mm, below the final ground level. The width of the trenches shall not be less than 450 mm. However, where more than one cable is laid, a coaxial distance of not less than 300 mm shall be maintained between the cables. The trenches shall be cut square with vertical side walls and with uniform depth. Suitable shoring and propping may be done to avoid caving - in of trench walls. The floor of the trench shall be rammed level. Sand cushions of not les than 80 mm shall be provided above and below the cable with a protective concrete slab on the top of the sand layer. The cable trench shall be back filled and compacted.

25.1.2 The cable drums shall be laid unrolled in the direction of the arrow for unrolling. Wherever cables are bent, the minimum bending radius shall not be less than 12 times the diameter of the cable. Cable shall be laid in concrete or hume pipes at all road crossing. After the cable has been properly laid, it shall be covered with 80 mm thick layer of sand, lifted and placed over sand cushion. Again, the cable shall be covered with a sand layer of 80 mm thick. Over this sand a layer of brick shall be placed. Then the Trenches shall be back filled with earth and consolidated to suitable grade and direction of run of the cables shall be installed at every 25 meters intervals and marking must be done in all bends.

25.1.3Cable Joints

Cable jointing shall be done as per the instruction of the cable manufactures. Cable jointing shall be carried out only by competent cables jointers. Cable shall be jointed using standard cable joint boxes with lead sleeve and with protection boxes. The box shall be of split type with compound filling hole and plug. The lead shall be free from moisture, impurities etc. Cable shall be jointed as per colour coding or numbering of the cores.

25.1.4The cables seal not be removed until all preparation for jointing are completed. Jointing the gland and armoured clamp shall establish good electrical contact between cable armour, lead sheath and body of the switch gear. The cable box gland shall be bonded to the main earth bus with suitable size conductors.

1.204 Power Transformer

1.205 Scope

The scope of work include supply of power transformer manufactured to IS specification, delivery to site and installation, testing and commissioning as per specifications given below and / or as recommended by the Engineer.

1.206 Codes and Standards

The design, materials, construction, manufacture, inspection and performance of power transformer shall comply with all currently applicable standards, regulations and safety codes in the locality where the equipment shall be installed. The equipment shall also conform to the latest applicable standards and codes and practices. The transformer shall generally conform to IS: 2026 latest edition and duty cycle as per IS: 11171.

1.207 Genral Features

1.207.1. All the materials used shall be of the best quality and suitable for working under the condition specified to withstand the variation of temperature and atmosphere condition without distortion, deterioration or setting up of undue stresses in any part.

1.207.2. Pipes and pipe fitting, screws, studs, nuts and bolts used for external connection shall be as per the relevant standards. The steel bolts and nuts exposed to atmosphere shall be either galvanized or zinc passivated.

1.207.3. Diagram and rating plate shall be of stainless and shall indicate the details of transformer connection diagram, vector group, tap changing diagram etc. all label plates shall be of non corrosive materials.

1.207.4. Transformer shall be capable of delivering the rated current at a voltage equal to 110% of the rated voltage without exceeding the limited temperature rise.

1.207.5. All rated quantities such as ratio, impedance, regulations, load losses, temperature rise and no load losses, shall be within the tolerance limits given in applicable standards.

1.207.6. If two transformers are installed in one place, they should be identical in the following aspects for parallel operations.

1.207.7. KVA ratings

1.207.8. Primary and Secondary Voltage

1.207.9. Vector Groups

1.207.10. One Number thermometer pocket with plug on tope cover is essential.

1.207.11. The bolted shell shall be made up of MS plate and shall be of welded construction.

1.207.12. Inspection covers with bolted arrangement shall be provided in the top or sides of transformers for easy access to the lower ends of bushing, tap changes and to permit replacement of auxiliaries without removing tank covers.

1.207.13. The transformers shall be provided with 4 bi-directional rollers fitted on cross channel to facilitate the movement of transformer in both directions.

1.207.14. The transformer shall be having winding temperature indicator with two independent mercury contacts one for alarm and another for trip.

1.207.15. The magnetic circuit shall be connected to the clamping structure at one point only and this be brought out of the top cover of the transformer tank to facilitate disconnection from the ground for IR measurement purpose.

1.207.16. Ending shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.

1.207.17. All threaded connections shall be locked. Leads from the winding to the terminal block and bushing shall be rigidly supported to prevent injury from vibration.

1.207.18. Terminals of all windings shall be through bushing for external connection

1.207.19. The noise level shall be 60db +/ - 5 at distance of 2M.

1.208 Protection

1.207.20. All protection for the primary and secondary of the transformer as envisaged by Electrical Inspectorate shall be provided.

1.209 Earthing

1.210 Internal Earthing

Internal metal parts of the transformer, with the exception of the individual animation, core bolts and their individual clamping plates shall be earthed.

1.211 External Earthing

The size of earth flats/ wires shall be chosen from the tabulation shown in earthing system clause No. 6-18-4.

1.211.1. The metallic parts of the transformer viz. cable glands shall be earthed by two separate and distinct connection with earth of suitable size of earth wire as per table shown in earthing system chapter.

1.211.2. The top clamping structure shall be connected to the tank by copper strip. The bottom clamping structure shall be earthed by one or more of the following methods.

a. By connecting through vertical tie – rods to the top structure

b. By direct metal to metal contact with the tank base.

c. By a connection to the core as the main earth connection to the tank

1.211.3. Neutral Earth

a. The neutral of the transformer shall be earthed by not less than two separate and distinct connections with earth pits.

b. The neutral earth lead should be kept away from the body of the transformer tank.

1.211.4. Drawings and Leaflets

The copies of manuals of complete instruction for installations, operations, maintenance and repairs, circuit diagram, foundation and trenching details shall be provided with the transformer.

1.211.5. Installation

Transformers shall be fitted with cable for HT cable termination on HT side and LT Cable termination on LT side. HT and LT shall be terminated with suitable cable socket / lug and cable terminal lugs contact surface pressure is maintained permanently by suitable bolts and nuts.

1.211.6. A suitable protection device to protect the transformer from over voltage, under voltage, and earth fault shall be provided.

1.211.7. Minimum 3 feet clearance shall be given to the transformer from all sides.

1.212 Electrical And Performance Requirements

1.212.1. Shall be operated at rated kVA at any voltage within + /- 10% of the rated voltage of that particular tap position in case of off – load tap changing transformer.

1.212.2. Shall be designed for 110% continuous over fluxing to withstanding capacity.

1.212.3. The neutral terminals of the winding with connection shall be designed for the highest current that can flow through the winding.

1.213 Connections and Vectors Group

Delta on HT side and star connection on LT side with neutral terminal shall be brought out for solid earthing.

1.214 System of Supply

3 phases, 50 cycle, 11kV supply as specified in the technical data sheet

1.215 Rating

Suitable for continuous rating.

1.216 Terminals

Shall be suitable for 3 core XLPE double steak to be armoured aluminium conductor cable on HT side L.T side shall be suitable for 3.5 core AYFY Aluminum conductor cable.

1.217 Testing Certificates

a. No load loss test
b. Load loss test
c. Insulation resistance test
d. Polarity test
e. Load test from 25% to 125% of its full load in steps of 25%
f. Turns ratio test on all tap positions on all the three phases.
g. Winding resistance measurement test.

1.218 Motor Control Center

1.218.1 Description

This specification covers the technical requirements of design, fabrication, supply of motor control centre required for receipt, control and distribution of power to various motors. The motor control panel shall have the following equipment installed as specified below:

- Main switch fuse or MCB, MCCB with required capacity in case of 431V motor pump sets.
- ACB or suitable circuit breaker to suit the motor capacity and voltage in case of HT motor pump sets.
- Motor starter - Auto transformer / Star Delta.
- Contactors
- Single phase preventor
- Ammeter with selector switch
- Voltmeter
- Pilot lamps for indication

- Trip Alarm
- Stop push button
- Start Push Button
- Addition equipment if any

1.218.2 Standards

The equipment covered by this specification shall, unless otherwise stated, be designed, constructed and tested in accordance with the latest revisions of relevant Indian standards and shall conform to the regulations of local statutory authorities.

IS: 375	-	Making and arrangement for switchgear busbar main connections and auxiliary wiring
IS: 2147	-	Degree of protection provided by enclosure for low voltage switchgear and control gear.
IS: 3914	-	Selection of AC induction motor starter.
IS: 4237	-	General arrangement of switchgear and control gear for voltages not exceeding 1000V.
IS: 722	-	AC electricity meters.
IS: 1822	-	Motor starters, AC voltages not exceeding 1000V
IS: 2208	-	HRC cartridge fuse links upto 650V.
IS: 4064	-	Air break switches for voltages not exceeding 1000V
IS: 2959	-	Contactors for voltages not exceeding 1000V AC
IS: 6875	-	Control switches for voltages not exceeding 1000V AC
IS: 1248	-	Direct acting electrical indicating instrument.
IS: 2516	-	Circuit breakers.
IS: 8623	-	Specifications for factory built assemblies for voltage upto 1000V AC & 1200V DC

1.218.3 Low Tension Switchboard

The Switchboards (SB's) shall be floor mounted free standing multi tier compartment cubicle type fabricated out of 2 mm (14G) CRCA sheet steel. The load bearing members of SB's shall be fabricated out of 3.31 mm thick sheet steel or 40 X 40 X 6 mm MS. Angle

The Switchboard (SB's) shall be single front, fixed design, having individual compartments to house each of the circuit and shall be extensible on either side.

The Switchboard (SB's) shall be provided with a fabricated base frame of 75 mm height at the bottom. The base frame shall have adequate provision for grouting the Switchboards (SB's) on the foundation.

The Switchboard (SB's) shall have a degree of protection of not less than 1P 54 as specified in IS: 2147. The rear cover of Switchboards (SB's) shall be welded to the frame work, while dished type side doors shall be bolted to the frame work.

All doors shall be provided with fixed neoprene gaskets. The door shall be provided with quick opening type Bakelite molded knobs with circlips. All hardware to be used shall be zinc passivated.

The Switchboard (SB's) shall have horizontal busbars at the top. A vertical busbar chamber shall be provided to connect individual feeders.

The busbar chamber shall be totally segregated from the rest of the compartment and shall be inaccessible under normal operating conditions. No equipment shall mounted on the busbar chamber.

The busbar shall be of electrolytic aluminum alloy and shall have a continuous rating as indicated in the drawings. The neutral busbar shall be half the size of the phase busbar.

The busbar shall be covered with heat shrinkable PVC sleeves in the colours red, yellow, blue for the phase busbars and black for the neutral busbar.

The busbar shall be supported with high quality non-hygroscopic resin bonded DMC insulators designed for the specified short circuit level.

The busbar design shall have test certificate to guarantee the fault with standing capacity of 25MVA at 431 Volts.

Tapping from the busbar to the feeder switch shall be by means of insulated or sleeved busbar depending on the rating and terminal capacity of the switch.

A copper earth strip of size 25 × 3 mm shall be provided at the bottom throughout the length of the board.

Vertical cable alley common to vertical section shall be provided for running cables. Cable clamping arrangement shall be provided in the alley. All cable entries shall be from the bottom. Each compartment door shall be interlocked with the switch hand such that the door cannot be opened with the switch in the ON position.

Each compartment shall be connected to the earth strip at the bottom of the board with a PVC insulated multi-stranded aluminum wire of size 10 mm2

The size and layout of the each compartment shall be as such as to enable easy maintenance of the equipment mounted therein.

The height of the Switchboards (SB's) shall be restricted to 2,300 mm including the busbar compartment at the top and the base frame at the bottom.

The minimum operating height shall not be less than 200 mm for switches with a rating of less than 100A and 400 mm for Switches with a rating of 100A and above. The maximum operating height shall not exceed 1800 mm.

The current transformer shall be of the epoxy molded window type suitable for busbar mounting metering current transformer shall be of class-1 type. The ratio and rated burden of the current transformers shall be as specified in the drawings.

The meters shall be flush mounting type. The voltmeter and ammeter on the incoming feeders shall be of size 144 x 144 mm and on the outgoing feeders of size 96 x 96 mm. All switches and Fuse-switch / switch fuse unit shall confirm to duty category AC23 as specified in IS: 4064

All contactors shall confirm to the utilisation category AC3 as specified in IS: 2959. The insulator for the Switch fuse unit shall be on the busbar side and the fuses on the lead site. Shrouds shall be provided to the screen the live parts. The fuses shall be of the HRC link type capable of clearing the fault level specified.

All energy meters, Ammeter, Voltmeter shall be mounted in a separate meter compartment and shall be located at a convenient reading height.

The panel shall have provision for incoming feeder with interlocking arrangement. The following color code shall be adopted for the wiring of the switchboard:

Phase: Red, Yellow and Blue

Neutral: Black

Earth: Green

All equipment shall be fixed in the compartment in such a way that they are removable and replaceable from the front only.

The SB's shall be painted as specified elsewhere to the specification and shall undergo suitable pre-treatment prior to painting. Plastic engraved identification labels shall be provided for each circuit and for the board itself. Details of the feeders of the switchboard shall be as shown in the pertinent drawings. The Contractor shall submit for approval four (4) sets general arrangement and wiring drawings of the switchboard before commencing manufacture. The board shall be supplied and installed as per electricity authority / CEIG standards.

1.218.4 Fuse Distribution Boards – HRC

The board shall be dust and vermin proof conforming to IP 42 and fabricated out of 16 SWG sheet steel and powder coated panel finish. The Distribution Boards shall be surface mounting type and shall be provided with electrolytic copper Bus bars of suitable size. They shall have phase barriers and earth terminals. They shall be provided with removable type end covers at top and bottom and shall have hinged covers with locking arrangement. The frame work for mounting the HRC DB and incomer shall be fabricated out 40 x 40 x 5 mm and 40 x 5 mm flat iron frame work with necessary hold fast supports shall be welded to the frame. An earth bar shall be provided for termination of protective earth conductors (Incoming as well as outgoing) and it shall be complete with necessary studs (for each conductor) and washers. The HRC Distribution Boards shall be provided with reverse entry or side entry adopter box at the top made of 16 SWG sheet steel. The adopter box shall be 75 mm height and shall have same depth as the distribution board. The length shall be sufficient to accommodate all the outgoing cables easily. The incoming isolator shall be provided with suitable cable end box at the bottom complete with removable gland plate of suitable size.The board shall be installed by suitably grouting the frame work on wall. Where required these boards shall be recessed in the wall. All metal works shall be painted prior to erection with one coat of anti rust primer. After erection they shall be painted with two coats of appropriate enamel paint on all sides wherever accessible.Shop drawing showing the detailed dimensions, design including disposition of various mountings shall be submitted for approval of consultant before fabrication.Fuses shall be non deteriorating HRC Cartridge link type. Diazed fuses are not acceptable.The fuses shall be provided with operation indicator, which shall be visible without removal of fuses from service.Fuses shall be pressure fitted type and shall preferably have ribs on the contact blades to ensure good line contact.It shall be possible to handle fuses during off load conditions with full voltage available on the terminals. Wherever required fuse pullers shall be provided. The fuse bases shall be so located in the modules to permit insertion of fuse pullers and removal of fuse links without any problems.

1.218.5 Timer

Knob type electro-pneumatic timers with a delay relay range 0 to 60 seconds shall be used conforming to IEC.337-1-1970 or IS-31834 Part I 1973. Timers shall be convertible from ON delay to OFF delay or vice versa, suitable for 110 VAC 50 Hz rating, 1.5 Amps, terminal capacity for 2.5 mm2 copper control wire, with 1 No + 1 NC.

1.218.6 Isolating Switches

Isolating switches shall be on load double break type and shall have suitable current and voltage ratings. The "ON" and "OFF" position shall be clearly marked.

Isolators used for motor control circuits shall be of motor cut type, capable of carrying the starting current of the motor. The isolators shall conform to IS: 4046 and IS: 4237.

1.218.7 Fuses and Fuse Carrier

All fuses shall be HRC cartridge type conforming to IS: 2208, mounted on plug-in type fuse bases. All accessible line connections to fuse base shall be adequately shrouded.

The fuses shall have operation indicators for indicating blown fuse condition. The fuse and fuse carrier shall be suitably selected for rated and fault currents. The fuse for motor control circuits shall be so selected that the same shall not operate during motor starting. For switch ratings above 200 Amps, fuse switch shall also be acceptable.

1.218.8 Contactors

The three pole contactors with minimum of 2 No. + 2 NC working contacts and one number of 1 No + 1 NC spare contact shall be used. The contact made of anti-weld silver cadmium shall be designed to give minimum bounce to ensure long contact life. The rating of the contactor shall suit the motor and capacitor circuit duty. The contactor shall be suitable for AC 3 duty in respect of making and breaking operations at specified power factors. The contactors shall conform to IS: 2959.

1.218.9 Single Phase Preventor

The single phasing preventor shall be provided for all 431 V, motors above 5 kW rating. The single phasing preventor shall be current operated type using minimum current detection / negative phase principle. Necessary current transformers shall be provided to suit the requirement of the single phasing preventor. The single phasing preventor shall be stable during the starting of the motor. The maximum operating time to the single phasing preventor shall not exceed 2/3 second even in the starting condition of motor.

1.218.10 Equipment Wiring

All the Switchboards, panels, annunciator panel and mimic panel shall be neatly wired using 1100/660 volt grade PVC insulated stranded copper conductor cable of minimum 2.5 mm to suit the requirement. The wiring shall be bunched in groups by non-metallic clips or bands. Each group shall be adequately supported along its run to prevent sagging and strain on the terminals.

Sharp and tight bends shall be avoided. Each wire shall be identified at both ends by ferrules indicating the designation of the wire in accordance with the Schematic / wiring diagrams. The wire shall be terminated on the terminals of the relays, switches, instrument, contactors, lamps etc., or on the terminal blocks as the case may be. No joints shall be provided in between. Terminal blocks shall have screw type terminals, which can take at least two wires per terminal on each side. At least 20% spare terminals shall be provided on each terminal block.

1.218.11 Interlocking Arrangement

The control panels containing the contactors, relays, etc. shall be enclosed in free standing steel sheet enclosure with front cover so interlocked with the isolator that the door cannot be opened with isolator at ‘ON’ position. These panels shall be front wired, front connected and provided with closing handles with ON and STOP mechanical indication having in-built locking system so that back access would not be required for inspection and maintenance. The enclosure shall be dust and vermin proof type built using 2 mm. thick steel sheet while doors and partitions may be fabricated from 1.6 mm thick sheet. Since the entry of cables of the panel is generally from the bottom, the cable gland supporting plate shall be mounted not less than 600 mm above the floor level.

1.218.12 Inspection of Circuits

Facility for inspection of the circuits, to ascertain if all the Contactors, relays, fuses, etc. are in proper working order/condition or otherwise shall be provided by means of a push button or selected switch.

1.218.13 Labeling

Labels of switchgears shall indicate reference number of the switch, the specified current rating and part of distribution controlled. Labels on circuit breaker boards shall indicate the reference number of controlling switch. Lettering of all labels shall not be less than 5 mm, high. Schedule and details of labels shall be submitted to Engineer for approval.

1.218.14 Cable Entry

The cable entry shall preferably be from the bottom, which shall be dust and vermin proof. The cable entry on each equipment shall be through a compression type cable gland. The cable gland plate shall be sufficiently strong to take the load of the cables and shall be mounted not less than 300 mm. above the floor level. The cables shall be suitably clamped before the cable gland to avoid any strain on it.

1.218.15 Painting

The panels shall undergo chemical derusting sand blasting degreasing, pickling in acid bath and phosphatised as per IS: 6005 and primed. The panels shall be thoroughly rinsed with clean water after phosphating, followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed by the application of two coats of ready mixed, stoving type zinc chromate primer.
Two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The final finished thickness of the paint film on steel shall not be less than 100 microns and shall not be more than 310 microns. The colour for the finishing paint shall be bright battleship grey as per IS: 5 (Shade No. 631). The finished painted appearance of panels shall present aesthetically pleasing appearance free from dust and uneven surface.The paint shall withstand humid tropical climate, rain, etc. The paint shall not scale of or crinkle or removed by abrasion during normal handling. Sufficient quantity for touch-up paint shall be furnished for application at site.

1.218.16 Testing

MCC shall be completely assembled, wired, adjusted and tested for operation under simulated conditions to ensure accuracy of wiring, correctness of control schemes and proper functioning of all equipment.

1.218.17 Type Tests

The contractor shall furnish two (2) sets of type test certificates for all the tests indicated below, along with bid.

- Short-time current test.
- Temperature rise test.
- One minute power frequency voltage withstand test.

1.218.18 Routine Tests

- Mechanical operation tests
- Dielectric tests.

1.218.19 Drawing & Manuals

The following drawings and manuals shall be furnished:

a) General arrangement drawing of motor control centre showing:

- Overall dimensions.
- Terminal location & dimensional data
- Total weight
- Bill of materials
- Foundation details
- Sectional views

b) Single line diagram

c) Technical details for starters, contactors, switch fuses, lamps, meters etc.

d) Manufacturing schedule and test schedule

1.218.20 Particular Specification for Supply of Motor Control Centre

The MCC shall be supplied as per the specification and as per data sheet. Incoming feeder shall include following

a) Suitable rated, TP & N manually operated load break fuse switch unit with door interlocking

b) Voltmeter with 3 position selector switch and protective fuses

c) Suitably rated ammeter with 3-position selector switch with CTs

d) Indicating lamp for ‘POWER ON’

Each outgoing motor feeder shall include the following:

a) Suitably rated TP&N fuse switch with door interlock

b) Suitably rated TP contactor

c) Suitably rated thermal overload relay

d) Indicating lamps

e) Motor start / stop PDS

f) Control circuit fuse

g) Outgoing terminal for connection to remote start & start PB

h) Outgoing terminals for main power connections.

1.218.21 Recommended Makes of Equipment

1.	MCCB	-	L&T/GE/CG/LEGREND/ SIEMENS/ABB
2.	Fuse switch	-	L&T/GE/STANDARD/SIEMENS / CONTROLS & SWITCHGEAR
3.	Instruments	-	AE / IMP
4.	Selector switch	-	KAY CEE/BCH/CONTROLS

		& SWITCHGEAR	
5	Contactor	-	L&T/TELEMECHANIQUE/ SIEMENS
6.	Push buttons	-	SIEMENS / BCH

1.218.22 Motors For Submersible Pumps

1.218.23 Supply Voltage and Characteristics for Motors

All MV motors shall be squirrel cage induction type and suitable for the following.

- Supply voltage: 431 Volts, 3 Phase, 50 Hz AC supply
- Voltage variation : ± 10%
- Frequency variation: ± 5%
- Combined variation of Voltage & Frequency: 10%

All motors shall be foot / flange mounted squirrel cage induction type and shall be capable of developing at least 10% more power than demanded by the pump or driven equipment over its entire range of safe operation.

Motors shall be continuous maximum rated as per IS: 325 and IS: 4722 (latest edition) and preferably be designed for low starting current and smooth acceleration except for cases where the driven equipment characteristic demand otherwise. Motors shall be of 4/6/8 pole design fitted with ball roller bearings and provided with one or more terminal boxes large enough to accommodate armored PVC insulated aluminum conductor of appropriate ratings.

1.218.24 Motor Winding

Motor winding shall be insulated with Class F insulation with temperature rise limited to Class B rating as per IS: 325 and IS: 4722 over an ambient temperature of 45^0C. The pull out torque of the motors at rated voltage and frequency shall preferably be 200% of FLT in each motor above 5.5 KW rating. Motors shall be suitable for star-delta / or DOL starting.

1.218.25 Starting Current for Heavy Motors

However, when LT motors are switched on with full voltage applied onto their terminals, the starting current shall be limited to 550% of full load, current for squirrel cage induction motors. All LT motors shall be squirrel; cage type.

1.218.26 Motor Protection

All motor shall be provided with protection to IP 55. For hazardous location flame and explosion proof enclosures shall be provided.Appropriate water proof enclosures shall be provided to outdoor electric panels and starters, to provide sufficient protection from rains, dust, vermin etc.Degrees of protection provided by enclosures for rotating electrical machinery shall conform to the requirements of IS: 4691. Flame proof motors shall comply with relevant specification of mine safety requirements and other applicable specifications for this type motors including IS: 5571.

1.218.27 Motor Testing

Testing of motors shall comply with the requirements of IS: 4029. Dimensions of foot mounted motors shall comply with the requirements of IS: 1231. Generated values of efficiency and power factor at full load and 3/4 load shall be furnished by the tenderer.

1.218.28 Motor Starting Arrangements

Individual Motor starters / panels for 431 volt 3 Phase 50 Hz Motors shall be as below:-
For Squirrel cage motors up to 3.7 KW : Direct-on-line
Squirrel cage motors above 3.7 to 38 kW : Start-delta starters
Motors exceeding 38 KW: Auto transformer or any other soft starters acceptable to TNEB. Each control panel / starter shall incorporate isolator, HRC fuse contactors, timing relays, overload relays, single-phase preventor, Hour meter (for pump running hours) etc. appropriate for the scheme of control. Contactors shall be of Ac 3 duty (minimum). Contactor rating for each motor shall be at least 25% higher than the full load current of the motor and contactor shall comply with the requirements of IS: 2959, IS: 4237 and IS: 10118. Reversible starters shall be provided wherever necessary. Motor starter rated 30 kW and above shall be provided with auxiliary relay for motor space heater.

1.218.29 Cables and Cable Laying

The following type of cables shall be used:

	Power Supply		e X LPE, 11kV, Armored Aluminum cable.
	Power Supply		e, 4C, 3 core or 2 core 1100 / 600 v PVC insulated PVC sheathed armored cables.
	ntrol cables		ore Cu cable minimum 2.5 mm^2 with PVC insulation, armored and PVC sheathed.

The minimum size of control cable shall not be less than 2.5 mm2. All cables shall be suitably de-rated for grouping and higher ambient temperature. For selecting cable sizes, 450C ambient temperature shall be taken as base. The cables shall conform for LT to IS: 3314-Part I and for HT to IS: 3314 - Part - II.

1.218.30 Cable Accessories

All accessories like cable glands, lugs and terminal markings etc. shall be used conforming to relevant standards / as specified. End termination for HT cables shall be heat shrinkable type. For 1100V grade cables, Siemens type gland and crimping type lugs or approved equivalent shall be used.

1.218.31 Cable Laying

Cable laying and termination shall be such that chances of cable damage are remote.

LT cable shall be laid in cable tunnel on racks, trays or buried underground with appropriate protection. Black shall indicate the neutral, while red, yellow and blue for three different phases. All LT cables when laid on the cable racks shall be properly dressed and clamped as required without crisscrossing and unnecessary overlapping. Cables shall be properly dressed and clamped.

Laying of HT and LT Underground cables

The laying UG cables on ground by excavating a trench of 1.2 meter depth for HT cable and 0.75m depth for LT cable, and cables laid. The cables shall be protected by good quality bricks on the sides and top of the cables and fill up top layer with sand.

In routing, necessary barriers and spacing shall be maintained for cables of different voltages in case they lie side by side. Telephone cables shall cross the power cables only at about right angles and these two shall not run in close proximity.LT cables shall be bent in radius not less than 12 times their individual overall diameters, while HT cable shall have bends not less than 31 times their individual overall diameter. Routes of these cables shall be arrived at on the basis of the relevant drawings and after consulting the Engineer.

1.218.32 Drawings and Schedules

Sizes of cables shall be given in single line power diagrams. A cable schedule shall be prepared on the basis of relevant drawings. All cable and wires shall be adequately sized to carry continuously the normal currents expected on the relative circuits. All trenches for electrical cables shall be separate from water pipeline trenches.

1.218.33 Splicing and Termination

Straight through joints shall be avoided. In case, these are absolutely necessary they shall be made at convenient locations suitably protected as approved and sanctioned by the Engineer but in no case within the conduit pipes or ducts. Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and circular junction boxes. They shall be made only with approved porcelain connectors. Compression type cable and glands shall be used for cable connections. Double compression cable end glands shall be used for flame proof switch gears. Cable glands shall be of brass with cadmium or nickel plating. Tinned copper lugs shall be used for cable termination.

1.218.34 Testing

Cables shall be tested in accordance with IS: 3314 / 7098

1.218.35 Control Switches

Control and instrument switches shall be of rotary type flush mounting having enclosed contacts which are accessible by the removal of cover and shall be provided with properly designated escutcheon on plates clearly marked to show the operating positions. Control switches shall have momentary contacts, spring return to center with pistol grip handle. Instrument and selector switches shall have oval knob.

1.218.36 Push Buttons

Push Buttons shall be momentary contact type with rear terminal connections. The colour of the push buttons shall be “Green” for start and “Red” for stop. Whether required, the push button shall be suitably shrouded to prevent inadvertent operations. They shall be provided with integral inscription plates engraved with their functions. The contact element shall have at least 1 No. and 1 NC contacts. The contacts shall be able to make and carry at least 6A. at 431 AC.

1.218.37 Indicating Lamps

Indicating lamps shall be panel-mounting type with rear connection. The lamps shall be provided with the built-in series resistors on the lamp holder. The lamp shall have translucent lamp cover, of suitable color. The cover shall be oil and dust proof polycarbonate lenses. The bulb and lenses shall be interchangeable and replaceable from front of the panel.

1.218.38 Safety Equipment To Be Provided

The Contractor shall provide the following safety equipment as per IE rules, on the HV panels, Generator panels, control panels and main MV panel-rooms.

- Rubber mat conforming to IS 5424 in-front of all the HT and MV panel for their entire length - 1m wide
- Sufficient pairs of electrically tested rubber gloves. These are to be kept in a suitable wooden box.
- A shock treatment instruction chart in Local language and English duly framed as detailed in IS 1355. The nearest medical facility available with phone number shall also be kept
- First aid box containing full compliments of medicines for treatment of electrical burns in the main switch-room
- Adequate number of portable fire extinguishers of dry powder (store type) as per IS 935 to suit the individual substation, pumping station requirement.
- Adequate number of caution notices in Tamil and English shall be fixed permanently on the equipment to comply the requirement of IE rules
- Safety posters for vigilance against electrical accidents as detailed in IS 1255
- Adequate number of fire buckets with MS angles stand
- 4 Nos. round bottom fire buckets marked “Fire” shall be provided

1.218.39 Lighting & Small Power

1.218.40 Definitions and Conventional Symbols

The definition of terms shall be in accordance with IS: 372 Code of Practice for Electrical Working Installation except for the definition of a “Point”. The wiring and the equipment shall comply in all respects with the requirement of rule 50 and 51 of IE rules / 56 as amended from time to time. The wiring and other electrical equipment shall be suitable for trouble free operation at variation of voltage and frequency prescribed in IE rules.

1.218.41 Point Wiring

Point wiring shall include all work necessary to complete wiring from switch circuit of any length from the tapping point on the distribution circuit Switchboard to the following.

- Ceiling rose for fans, lighting etc.
- Socket outlet (in the case of socket outlet points).
- Lamp holder (in the case of wall brackets, batten points, bulk head and similar fittings).
- Call bell buzzer (in the case of the works “via the ceiling rose / socket outlet or bell push where no ceiling rose / socket outlet is provided”).

1.218.42 Circuit Wiring

Circuit wiring shall mean the length of wiring from the distribution board up to the tapping point of the nearest first points of that circuit, viz., up to the nearest first switchboard measured along the run of wiring. Such wiring shall be measured on linear basis.

1.218.43 System of Wiring

The wiring shall be carried out on such a system as may be specified in the tender schedule or otherwise specified in the Special Specification (“Power” and “Heating” wiring shall be kept separate and distinct from

“Lighting” and “Fan” wiring). Recessed conduit wiring shall be done on distribution system main and branch distribution boards at convenient physical and electrical centers and without fuses at isolated places. All conductors shall run, as far as possible, along the walls and ceiling so as to be easily accessible and capable of being thoroughly inspected. In no case, the open wiring shall be run above the false ceiling without the approval of the Engineer. In all type of wiring due consideration shall be given for neatness, good appearance and safety.

1.218.44 Balancing of Circuits

The balancing of circuits in three phase installations shall be arranged before hand to the satisfaction of the Engineer.

1.218.45 Drawings

All wiring diagrams shall indicate clearly in plan, the main Switchboard, the distribution fuse board, the run of various mains and sub-mains and the position of all points with their classification

1.218.46 Cables

1.218.47 Scope

This specification covers the design, manufacture, testing at work, inspection and delivery at site of PVC insulated cables.

1.218.48 Standards

IS: 694 - PVC insulated cables for working voltage upto and including 1100V.

IS: 1554 - PVC insulated cables for working voltage upto and including 1100V (Part-I)

IS: 3961 - Recommended current rating for cables, PVC insulating and PVC sheathed (Part-II) heavy duty cables.

IS: 3975 - Mild steel wires, strips and tapes for armoring of cables.

IS: 8130 - Conductors for insulated electric cables and flexible cords.

IS: 5831 - PVC insulation and sheath of electric cables.

1.218.49 Conductors

The conductors shall be of copper Aluminum. The conductors shall be smooth, uniform in quality and free from scale, inequalities, splits and other defects. The stranded conductor shall be clean and reasonably uniform in size and shape and its conductor shall conform to the specification given in the relevant standards. The conductors shall be either circular or shaped.

1.218.50 Insulation

The cable for power distribution shall be insulated for 1100V and suitable for 431V, solidly earthed system. The insulation shall consist of the following:

- Compounded polyviny1 chloride.
- Suitable co-polymers, of which the major constituent shall be viny1 chloride.
- Mixture of polyviny1 chloride and suitable co-polymers which have been suitably compounded and processed so as to comply with the requirements of the relevant standards

1.218.51 Inner Sheath

For all cables having two or more cores, the individual cores shall be laid up and then be surrounded by common covering applied either by extrusion of wrapping or filling material containing a thermoplastic material. A proofed or plastic tape may be applied over the common covering employed. It must be ensured that the circularity of the cable is maintained.

1.191.1 ARMORING

Armoring shall be arranged over the inner sheath. The armor of cable shall be of galvanised steel wires or galvanised steel strips.

1.218.52 Outer Sheath

A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armoring to offer a high degree of mechanical protection against abrasion.

1.218.53 Manufacturer's Identification

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark, voltage grade and year of manufacture of the cable indented; embossing shall be done only on the outer sheath.

1.218.54 Packing and Marking

The cable shall be wound on a drum of suitable size, packed and marked. The marking done on the drum shall have the following information:

- Trade name, if any
- Name of the manufacturer
- Number of cores and nominal area of the conductor
- Type of the cable and voltage for which it is suitable
- Length of the cable on the drum
- Direction of rotation of drum (an arrow)
- Drum No.

The outer ends of the cables shall be sealed by means of non-hygroscopic sealing materials.

1.218.55 Testing

Factory Tests

Complete tests shall be made at the manufacturer's works to determine the performance and operating characteristics of the cables, to determine whether or not the guarantees have been met. The successful bidder shall give a complete description of the proposed test method.

Type Tests

The successful bidder shall submit two (2) sets copies of the following type test reports conducted on similar equipment for the approval of owner/consultant.

- Annealing test
- Conductor resistance test
- Test for armor wires
- Test for thickness of insulation and sheath
- Physical tests for insulation

- Physical tests for PVC sheath
- Fire resistance
- Cold-impsact
- Bleeding and blooming
- Partial discharge test
- Bending test
- Dielectric power factor tests
- Heating cycle test
- Impulse withstand test
- High voltage tests.

All the following routine/acceptance tests specified in relevant standards shall be witnessed by the owner.

Acceptance Tests

- Conductor resistance test
- Test for thickness of insulation and sheath
- Partial discharge test (for screened cables only)
- High voltage tests
- Routine Tests
- Conductor resistance test
- Partial discharge test (for screened cables only)
- High voltage tests

1.191.2 RECOMMENDED MAKES

Cables shall be manufactured by Unistar / Incab / CCI or approved equal

1.218.56 Rating Of Lamp, Fans

Socket Outlet Points and Exhaust Fans Incandescent lamps installed in pump house & other means shall be rated at 60 watts and 100 watts respectively. Table fans and ceiling fans shall be rated at 60 watts. Exhaust fans shall be rated according to their capacity. 5 A socket outlet points and 31 amp. socket outlet points shall be rated at 100 and 1,000 watts respectively, unless the actual values of load are known or specified.

1.218.57 Joint At Point Of Entry Supply

Unless other wise specified the wiring shall be done in the "Looping System". Phase of live conductors shall be looped at the switch box and neutral conductor can be looped from the light, fan or socket outlet. In non-residential buildings, neutral conductor and earth conductor and earth continuity wire shall be brought to each switchboard situated in room and halls. These shall be terminated inside the switchboards with suitable connectors and the switchboard shall be of adequate size to accommodate one number 5A socket outlet and control switch in future.

1.218.58 Control At Point Of Entry Supply

There shall be a linked main switch gear with fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of a linked switch gear. The neutral shall also be distinctively marked. In this connection rule 33(2) of the Indian electricity Rules, 1956 shall also be referred.

1.218.59 Main Switch Gear & Switchboards

The main switch gear shall be installed as near as practicable to the termination of service line and shall be easily accessible without the use of any external aid.

1.218.60 Indication Identifying Earthed Neutral Conductors

On the main switch gear, where the conductors include an earthed conductor of a two wire system or a conductor which is to be connected thereto, an indication of a permanent nature conductor. In this connection Rules 32(1) of the Indian Electricity Rules, 1956 shall be refereed.

1.218.61 Main Switchboard

All main switch gear shall be of metal clad and shall be fixed at close proximity to the point of entry of supply.

Open type Switchboards shall be fixed only in dry area and in well ventilated rooms and they shall not be placed in the vicinity of storage batteries and exposed to chemical fumes, Toilets, above gas stores etc. Switchboards Exposed to Weather shall have weather proof covering and the wiring shall be weather proof.

1.218.62 Bottom of Switchboard

A Switchboard shall not be installed so that its bottom is within 1.25 m above the floor unless the front of the Switchboard is completely enclosed by a door, or the Switchboards, is located in a position to which only authorized person have access.

1.218.63 Switchboard Recessed in Wall

Switchboard shall be recessed in the wall if so specified in the schedule of work or in the special specifications.

Equipment which is on the front of Switchboards shall be so arranged that inadvertent personnel contact with live parts is unlikely during the manipulation of switch gears, changing of fuses or like operations.

1.218.64 Screening of Live Parts

The various live parts unless they are effectively screened by substantial barriers of non-hydroscopic, non-flammable, insulating material shall be so placed that an arc cannot be maintained between such parts and earth.

1.218.65 Danger Notice Plate

All Switchboards connected to medium voltage and above shall be provided with “Danger Notice Plate, conforming to relevant Indian Standards.

1.218.66 Type of Switchboards

Metal clad switchgear shall preferably be mounted on any of the types of boards mentioned above.

1.218.67 Hinged Type Metal Boards

Such boards shall be suitable for mounting of metal clad switch gear consisting of not more than one switch gear and ICBD 4 way or 6 way. Metal Box shall consists of a box made of sheet not less than 3 mm thick and shall be provided with a hinged cover enable the boards to be swung open for the examinations of the wiring at the back. The joints shall be subsequently welded. Metal boards may be made of suitable size angle iron of maximum size of 25 mm x 35 mm x 6 mm or channel iron of minimum size of 25 mm x 25 mm x 6 mm frame work suitably mounted on front with a 3 mm thick M.S plate and on back with 1.5mm M.S. sheet. The front sheet shall be provided with suitable hinges to enable the board to be swung open for examination of the wiring. The joints shall be substantially welded.The boards shall be securely fixed to the wall by means of rag bolts and shall be provided with a locking arrangement and earthling stud. All wires passing through the metal boards shall be bushed. There shall be a clear distance of 30 mm between the front and back sheets. More space shall be allowed wherever necessary.A wooden board to thickness not less than 6 mm. may be provided at the back, if so required in the special specification in any particular. No apparatus shall project beyond any edge of panel. No fuse body shall be mounted within 25 mm of any edge of the panel.

1.218.68 Fixed Type Metal Board

Such boards shall be suitable for large Switchboards for mounting large numbers of switch gears and/or higher capacity metal clad switch gear. These shall consist of an angle of channel iron frame fixed on the wall at the top. There shall be a clear distance of 1 m. in front of the Switchboard. The connections between the switch gear mounting and the concerning cable upto the wall shall be enclosed in a protection pipe. The detailed dimensions and design of metal boards and angle from frame work for switch gears including the disposition of the various mountings which shall be symmetrically and neatly arranged for arriving at the over all dimensions shall be prepared and submitted before hand and have the prior approval of the Engineer.

1.218.69 Marking of Apparatus

When a board is connected to voltage higher than 250 volts all the terminals or leads on the apparatus mounted on it shall be marked in the following colours to indicate the different poles of phases to which the apparatus or its different terminals may have been connected.

AC Three Phase	:	Red, Blue and Yellow
Neutral	:	Black

When four wire three phase wiring is done, the neutral shall preferably be in one colour and the other wires in another colour.

Where a board has more than one switch gear each such switch gear shall be marked to indicate which section of the installation it controls. The main switch gear shall be marked as such. Where there is more than one main Switchboard in the building, each Switchboard shall be marked to indicate which section of the installation and building it controls.

All markings required under this rule shall be clear and permanent. All distribution boards shall be marked ‘Lighting’ or ‘Power’ as the case may be and also marked with the pressure and number of phases of the supply. Each shall be provided with a circuit, diagram and the current rating of the circuit and size of the fuse element.

1.218.70 Main and Branch Distribution Boards & Locations

Unless otherwise specified in the Special Specification main and distribution fuse boards shall be the metal clad type.

Main distribution Boards shall be controlled by a linked fuse unit and a circuit breakers. Each outgoing circuit shall be provided, of MCB with SP / TP as per requirement

Branch Distribution boards shall be controlled by a MCCB / MCB. Each outgoing circuit shall be provided with a fuse or ELCB / MCB. The earthened neutral conductor shall have provision for disconnecting individually for testing purpose. At least one spare circuit breaker of the same capacity shall be provided on each branch distribution board.

1.218.71 Capacity Of Circuits

Lights and fans may be wired on a common circuits, such circuit shall not have more than a total of ten points of light, fan and socket outlet or a load or 800 watts whichever is less.Power circuits on buildings shall be designed with a maximum of two outlets per circuit, based on the loading. Where, not specified the load shall be taken as 1 kW per outlet. Wherever the load to be fed is more than 1 kW it shall be controlled by an isolator switch or miniature circuit breaker.

1.218.72 Wall Penetrations

When conductors pass through walls, any one of the following methods shall be employed. Care shall be taken to see that wires pass very freely through protective pipe or box and that wire pass through in a straight line without any twist or cross in wires, on either end of such holes.A conductor shall be carried in an approved heavy gauge solid drawn or lap welded conduit or in a porcelain tube of such a size that it permits easy drawings in. The ends of conduit shall be neatly bushed with porcelain, wood or other approved material.Where a wall tube passes outside a building so as to be exposed to weather, the outer end shall be well mounted and turned downwards and properly bushed on the open end.

1.218.73 Fixing To Walls And Ceiling

Plug for ordinary walls or ceiling shall be of well seasoned teak or other approved hard wood not less than 5 cm. long by 25 cm. sq. on the inner and 2 cm. sq. on the outer end. They shall be cemented into walls within 6.5 mm of the surface the remainder being finished according to the nature of the surface with plaster. Where owing to irregular coarsing or other reasons the plugging of the walls or ceiling with wood plugs present difficulties, the wood casing, wood batten or metal conduit shall be attached to the wall or ceiling in an approved manner. In the case of white washing. Plugging of walls or ceiling can be done in a better way where neatness is the first consideration. In all such case approver type of asbestos or fibre fixing plug (Rawl or Phil plug) with correct size of tees shall be used and done in a workman like manner.Where this cannot be done, wooden plugs as described can be used with special permission of the Engineer.

1.218.74 Fittings

Lights, fans and sockets outlets shall be so located as to provide maximum comfort to the occupant and to enable him to utilise the electricity in the most economical manner.Where conductors are required to be drawn through tube or channel leading to the fitting, the tube or channel must be free from sharp angles or projecting edges.

Non-flammable shade form a part of a light fitting against all risks or fire, celluloid shade or light fitting shall not be used under any circumstances. Vitreous enameled iron shade shall be or size 250 mm x 90 mm (nominal) size with a tolerance to 5 mm). Plastic shade shall not be generally used in the fittings suitable for incandescent lamp. Enclosed type fittings shall be provided with a removable glass receptacles, arranged to enclose the lamp completely and of such size of construction as to prevent undue heating of the lamp, or if the position of fittings be such that the glass shall be protected by a suitable wire guard. The loads of pre-wired fixture shall be terminated on ceiling rose of connector. External light fittings and lamps shall have weather proof fittings of approved design so as to effectively prevent the admission of moisture. An insulating distance piece of moisture proof material shall be inserted between the lamp holder nipple and the fittings. In verandahs and similar exposed situations, where pendants are used they shall be of fixed rod type. Bulk head type fittings shall be of cast iron/cast aluminum body suitably painted white inside and gray outside complete with heat resistance glass cover, P.C. holder and wire guard suitable for 100 watts incandescent lamp. Where specified gasket for cover and shock proof B.C. holder shall be provided. Fluorescent tube light fittings of 40W / 80W fixed type shall be provided in general for conservation of energy and less maintenance.

1.218.75 Accessories

All switches shall be paced in the live conductor of the circuit and no single pole switch or fuse shall be inserted in the earth or earthed neutral conductors of the circuit.

1.218.76 Socket Outlets

A socket outlet shall not embody terminal as integral part of it. But the fuse may be embodies in plug in which case plug shall be non-reversible and shall be so arranged and connected that the fuse is connected to phase, live conductor or the non-earthened conductor of the circuit. Every socket outlet shall be controlled by a switch. The switch controlling the socket outlet shall be on the 'Live' side of the line. 5 Amps and 31 Amps socket outlet shall normally be fixed at any convenient space 23 cm above the floor level or near such levels in special cases as desired by the Engineer. 31 Amps switch and socket should be an integral provisions of an indicator diode. The switch for 5 Amps socket outlet shall be kept along with socket outlet. However, in special case, if desired by the Engineer the 5 Amps. socket outlet shall be kept at normal switch level and that for 31 Amp along with the socket outlet. however, in special case, if desired by the Engineer the 5 Amp socket outlet shall be placed at the normal switch level. 31A sockets shall have MCB/fuse with neon lamp indicator.Where socket outlet are placed at lower levels, they shall be enclosed in a suitable metallic box, as the case may be to harmonize with the system or wiring adopted. In an earthed system of supply a socket outlet and plug shall be of the three pin type. The third terminal shall be connected to earth.Conductors connecting electrical appliance with a socket outlet shall be of flexible twin cord with an earthing cored which shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance.

1.218.77 Attachment Of Fittings And Accessories

In case of conduit wiring, all accessories like switches sockets, outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes. Accessories like ceiling roses, brackets, battens, stiff pendants, etc. shall be fixed on metal outlet boxes.Aluminum alloy or cadmium platted iron screws shall be used to fix the accessories to their bases. The blocks/board shall normally be mounted with their bottom 1.25 m from floor level. The Boards shall have a sunmica finish.

1.218.78 Fans, Regulators And Clamps

Ceiling fans including their suspension shall conform to relevant Indian Standards. All ceiling fans shall be wired to ceiling roses or to a special connector boxes and suspended from hooks or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension rod.For concrete roofs, ceiling fan hooks shall be buried in the concrete during construction. M.S. flat of size 40 mm x 6 mm bent in the form of an inverted 'U' supported on two cross rods or cross flats. 60 mm long which are bound together to the top reinforcement of the roof shall be used. The distance between the vertical legs shall not be less than 31 cm. and the legs shall project at least 13 cm below the ceiling and oval holes shall be made in them for carrying a 31 cm dia rod hook.Alternatively a 31 mm dia, MS rod in the shape of ‘U’ with their vertical legs bent horizontally at the top at least 19 cm. on either side and bound to the top reinforcement of thereof shall be used.In building with concrete roofs having a low ceiling height where the fan clamp mentioned under clause (c) can not be used or whatever specified recessed type fan clamp inside a cast iron box, shall be used.Canopies on top of suspension rod shall effectively hide the suspension. Unless otherwise specified all ceiling fan shall be hung 2.75 M above the floor. In the case of measurement of extra down rod for ceiling fan including wiring the same shall be measured in units of 10 cms. Any lengths less than 5 cm. shall be ignored.

1.218.79 Exhaust Fans

Exhaust fans shall conform to the relevant Indian Standards.

Exhaust fans shall be fixed at the places indicated by the Engineer. For fixing an exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame, which shall be fixed by means of rag bolts embedded to the wall. The hole shall be neatly plastered to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.Exhaust fans for insulating in corrosive atmosphere the exhaust fan shall be painted with a special PVC paint or chlorinated rubber paint (Chloro rubber paint). Installation of exhaust fans at locations requires careful consideration. Regulators of ceiling/exhaust fans shall be connected to earth by loop earthling.

1.218.80 Indoor Decorative Luminaires

Luminaire shall be suitable for use with twin T.L. 40 watt 1200 mm (4’). 240V fluorescent lamps, comprising of CRCA sheet steel channel stove enameled grey which incorporates all electrical accessories like quick fit lamp holder, starter holder, polyester filled ballast, power factor correction capacitor and duly prewired upto the terminal block, with earthling arrangement facility, cover made for channel from CRCA sheet steel stove white enameled covering the channel fixed by twin screw, suitable for ceiling or pendent mounting suitable for 19 mm dia conduit, reflector plate for acrylic diffuser and end covers, complete in all respects ready for use. The luminaire shall conform to IS: 1913.

1.218.81 Industrial Luminaire

Luminaire shall be suitable for use with twin T.L 40 watts 1200 mm (4’), 240 V fluorescent lamps comprising of Rail made of CRCA sheet steel stove enameled white, incorporates all electrical accessories like quick fit lamp holders, starter holder, polyester filled ballast and power factor correction capacitor and duly provided upto the terminal block with earthing arraignment facility suitable for ceiling or pendant mounting suitable for 19 mm conduit with stove enameled reflector grey outside and white inside which can be installed without aid of any; tools, complete in all respects and ready for use. The luminaire shall conform to IS: 10322.

Emergency Light

Emergency light unit working on 230 volts. A.C. supply shall be self containing unit with 20 watts 600 mm long florescent lamp type ‘SWITCH ON MAIN FAILURE’. It shall be electronic automatic fluorescent type, which incorporates a unit trickle charge circuit, which shall prevent overcharging of battery. The battery shall be maintenance free. The unit shall provide 4 hours illumination following power failure. The units shall generally conform to IS: 9583.

Gate Lights

The gate lights shall be of post top lantern type, weather proof, and suitable for H.P.S.V. / metal halide lamp 70/310 watts and shall conform to IS: 2149. G.I. Pipes of suitable dia. shall be provided at gate concrete pillar as conduit for wiring and fixing post top lantern luminaire. The post top lantern shall be suitable for use with one number 70 watt H.P.S.V. / metal halide lamp. The luminaire shall comprise of a single self contained dia cast aluminum housing M.B.V. treated, incorporating the ballast, power factor improvement capacitor and ignitor, non-hygroscopic lamp holder all pre-wired upto terminal block. The housing shall be suitable for 60 mm O.D. mounted on post-top.Opel white one piece double conical dome made of vandal proof high density polyethylene resistant to ultra violet radiation and heat shall be provided. The degree of protection shall be 43. The housing shall be die cast aluminum MEV treated. The pressure ring shall be die cast aluminum M.B.V. treated.

1.219 Wiring

1.219.1. Surface Conduit Wiring System

PVC conduits pipes of approved gauge thickness shall be used. The maximum number of VIR/PVC insulated 250 volts grade aluminum conductor cable that can be drawn in one conduit of various sizes and the number of cables per conduit shall not be exceeded. The minimum PVC conduit dia. shall not be less than 25 mm. In long distance straight run of conduit, inspection type junction box at reasonable intervals shall be provided.

1.219.2. Fixing Of Conduit

Conduit pipes shall be fixed by heavy gauge clamps, secured to suitable wood plugs or other approved plugs with screws in an approved manner at an interval of not more than one metre but on either side of the couplers bends, or similar fittings, saddles shall be fixed at a distance of 30 cm from the centre of such fittings. the saddle should not be less than 24 gauge for conduits upto 25 mm dia and not less than 20 gauge for larger diameter.Where conduit pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or girder lips as required by the Engineer. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girders clips and clamps shall not be less than as stated below:

1.219.3. Switch Box

Switch box shall be made of metal on all sides, except on the front. In the case of cast boxes, wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, upto a size of 20 cm x 30 cm and above this M.S. boxes shall be used. Except where otherwise stated 3 mm thick phenolic laminated sheets like sunmica shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern. All fittings shall be flush pattern. Only a portion of the above box shall be sunk in the wall, the other portion being projected out for suitable entry of conduit pipes into the box.

1.219.4. Recessed Conduit Wiring System

Recessed PVC conduit wiring system shall comply with all the requirements of surface conduit wiring system specified in clauses above and in addition to the requirements specified in the following clauses.The chase in the wall shall be neatly made and out ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, fixed work, specials care shall be taken to fix the conduit and accessories in position along within the building work, to avoid damage to the finished wall etc.All outlets such as switches, wall sockets etc. shall be flush type. The outlet box shall be same as above and shall be mounted flush with the wall. The metal box shall be efficiently earthed with conduit by an approved means of earth attachment. To facilitate drawings of wire in the conduit. G.I mesh wire of 10 SWG shall be provided while laying of recessed conduit.

1.220 Street Lighting

1.221 General

1. Street lighting needs to offer good illumination. The materials used in street lighting should have good resistance to atmospheric condition and at the same time shall be appealing enough to add to the beauty of roads.
2. In tune with growing consciousness of society about energy conservation, street lights need to be energy efficient also.
3. Lighting system has to adequately take care of the Security concerns of pedestrians and motorists at night.
4. The basic purpose of illumination are as follows:
    a) Clear Visibility
    b) Divers Comfort
    c) Traffic Safety
    d) Ease of traffic flow
5. Besides the conventional High Pressure Sodium Vapour (HPSV) and High Pressure Mercury Vapour (HPMV) Luminaries Metal halide. (HM) Street light Luminaries may also be used.
6. CFL and FLT Luminaries shall be preferred for access and minor roads.
7. The light sources used generally are high-pressure sodium vapour lamp. The exact choice of light source is governed by functional, economic and aesthetic considerations.
8. The spacing between the luminaries should be uniform. Light sources may be mounted on one side or on both sides in parallel or staggered arrangement or on the median depending upon the width of the road and required recommended intensity of the lighting.
9. Special attention should be paid to the lighting of road junctions and crossings so that the kerbs and obstructions are clearly visible.
10. The pole, bracket and luminaries shall be of good integrated design and it should appear to have been designed as one unit.

1.222 Scope of Work

The supply and installation of lighting equipment for lighting schemes shall include all of the following: -

a) Lighting units of required height and type as specified elsewhere in the Contract/shown in the drawings, with lanterns, lamps, control gear, fuse links, cable service units, earthing, wiring, and sundries to complete the unit.
b) Lighting cabinets.
c) Service cable (Copper/XLPE/SWA/PVC) of size stated in the Contract including terminations.
d) Earthing of electrical equipment including supply of earthing material.
e) Termination work.

f) Excavation and backfilling of trenches, laying of cable access ducts, sealing of ducts, laying of protective tiles over cable etc.
g) Civil works associated with equipment erection and installation.
h) All labour, plant and materials for the complete erection, adjustment, testing, painting and commissioning of all equipment supplied and the system installed.
i) All material which is not expressly specified but which is necessary for the successful installation and commissioning of the street lighting system.
j) Providing computerised lighting calculations, luminance and illuminants charts / diagrams for selected areas required by the Engineer.
k) Maintaining the system during the defect liability period as stipulated in the contract.

1.223 Design requirements

a) All the electrical installations shall be designed to provide safety to personnel, reliability, provision for possible future requirements, a graded system of protective devices, equipment and material and adequate interrupting capacity, continuous current carrying capacity and insulation levels, all as required by systems voltages, capacities and short circuit levels.

b) Where lighting columns are to be in the vicinity of overhead power lines the Contractor shall ensure that the Engineer is informed and satisfied with the clearances provided and that warning notices are permanently fixed to the columns affected, prior to erection.

c) The Contractor shall investigate and ascertain the presence of existing or new services at the intended locations of new lighting units, cabinets, cables etc. and shall make minor adjustment, as required with the approval of the Engineer, to the location of the new equipment, in order to avoid the existing utilities.

d) Codes, Standards, Regulations and Recommendations:

Except where otherwise indicated, all the electric and electronic material, apparatus, machinery, equipment and installation must comply with the latest edition of the Indian Standards, CPWD codes, and local regulations. Relevant standards are referred to in subsequent Clauses of this Specification.

1.224 Local Regulations

Any general or particular regulation issued by local authorities, such as Fire Brigade, Safety Inspectorate, Municipality, Public Telephone Company etc.

1.225 Power Supply

The Contractor shall obtain power supply from the local Electricity Authority, for lighting cabinets at locations approved by the Engineer. The Contractor will arrange to install and connect lighting cabinets at the agreed locations and co-ordinate this item of work with the Authority. Power supply will be at 400/230 volts 3-phase, 4-wire, 50 Hz. The Contractor shall be responsible for the supply, installation and for terminations of the power supply cables as required by the Engineer.

57.4**1100 Volts Grade Armoured LT Power and Control Cables**

1.225.1. Power Cables

The cables shall comply the following: -

650/1100V grade with standard aluminium conductors over 6 mm2 and stranded copper conductor’s upto 6 mm2.

- Colour coded PVC insulation applied over conductor by extrusion.

- PVC inner and outer sheathed applied by extrusion.
- Steel armouring between inner and outer sheathed.
- Size of cables to suit duty and load sections. While selecting PVC insulated armoured cables for street lights not only the current carrying capacity of the cable but also the voltage drop shall be taken into account, which depends on number of lights and resistance of cable.
- Manufacturer's identifications (Name of trade mark) and voltage grade shall be embossed as the outer sheath.

1.225.2. Cable wound drum shall have the following information.

- Name of the manufacturer.
- Direction of rotation
- Type of cable, voltage grade, size and number of cores.
- Length of cable.

The Supplier shall ensure the following;

- Cable ends shall be sealed by means of non hydroscopic sealing materials.
- Necessary test certificates as approved in BIS shall be delivered along with cable drum.

1.225.3. Standards

This shall conform to the latest revision of I.S., IEC The Indian Standards/IEC considered relevant to the cables are given below:

1. IS. 3314 – P.V.C. Insulated (Heavy duty) electric cables for working voltages upto and including 1100 volts.
2. IS. 583 1 – P.V.C. Insulation and earth of electric cables.
3. IS. 8130 – Conductors for insulated electric cables and Flexible cords.
4. IS. 3975 – Mild Steel wires, strips and steps for armouring cables.
5. IEC. 540 – Test methods for insulation and sheaths of electric cable and cords.
6. Extruded solid dielectric insulated power cables for rated voltages from I K.V. to 30 K.V.
7. IEC. 754-1 Test method for acid gas generation.

1.225.4. Conductor

The cable conductor shall be made from stranded aluminium for power cables and stranded annealed copper for control cables and special cables to form compact conductor having a resistance within the limits specified in IS:8130. The minimum number of strands for conductor shall be 7 (seven).The minimum conductor size for LT power cable shall be 10 sq.mm aluminium. However, 2.5 sq.mm copper conductors may be used for small power distribution. For LT power cables, following sizes of aluminium conductor shall be used: 4 core, 10 sq.mm; 4 core 25 sq-mm; 3.5 core 50 sq.mm; 3.5 core 95 sq.mm and 3.5 core

300 sq.mm.Control cables of 2.5 sq.mm copper conductor with following number of cores shall be used. 3 core, 5 core, 7 core, 10 core and 12 core.

1.225.5. Insulation

The cable insulation shall be of best quality H.R. PVC compound suitable for 85℃ operation as per IS:5831 (1984). The insulation shall be designed and manufactured for the specified voltage grade. The insulation shall fit closely in the conductor and shall be free from voids, foreign particles and burnt material etc. to ensure good insulating properties throughout the cable length.

1.225.6. Sheath

The laid up cores in cable shall be inner sheathed by extruded PVC covering, which shall be suitable to withstand the site conditions and the desired temperature. The sheath shall, be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects.

1.225.7. Armour/Shield

The control cables shall be armoured with galvanized round steel wire as per clause 13.0 of IS: 31 54 (part – I).

1.225.8. Serving/Outer Sheath

Extruded PVC serving as per IS: 5831 shall be applied over the armouring with suitable additives to prevent attack by rodent sand termites. All serving must be given anti-termite treatment.

1.225.9. Fillers

1. Fillers shall not be sued. However, if they are absolutely essential, they shall be chemically inert, rot proof, and non-adsorbent. They shall be suitable for the operating temperature of the cable and compatible with the insulting material.

1.225.10. Identification

1. The cores in the control cables shall be identified by a colour scheme as per IS: 3314 (part – I). Over and above this, the cores shall further be identified by the indelible printing of serial numbers on the cores at distances not more than 75mm.
2. All cables shall carry the manufacture's data in a permanent legible manner at an interval of at least three metre run. The manufacturer's data shall include the name, the cable size, voltage rating, together with any other information which the manufacturer considers appropriate.

1.225.11. Drum Length and Cable Drums

The cables covered by this specification shall be supplied in drum length (continuous length) of 1000/500 metres+5%.

The cables shall be supplied in non-returnable wooden drums of robust construction. The wood used for construction of the drum shall be property seasoned, sound and free from defects and wood preservative shall be applied to the entire drum.

1.225.12. Packing

1. All cables shall be wound on substantial logged wooden nonreturnable drums. A layer of water-proofed paper shall be applied to the surface of the drums and over the outer cable layer. A clear space of at least 40mm shall be left between the cable and the logging.
2. Each drum shall carry the manufacturer's name, the Employer's name, address and order number, item number and type, size and length of cable, net and gross weight stenciled on the drum.

1.225.13. Cable Runs and Operation

1. The control cables are proposed to be laid on racks in covered trenches, cable tunnels an along ceiling and walls in substation. The control cables will sun on separate racks from the power cables.
2. The cables shall have heat and moisture resistant properties for satisfactory operation under tropical humid conditions.

1.225.14. Tests

1. The test on the cables that will be conducted by the Bidder shall be mentioned in the schedule of tests for each type of cables separately in the form of a tabular chart. Also the testing facilities available at the manufacturer's works shall be clearly indicated in the schedule.
2. The Employer reserves the right to witness all type and routine tests and the Bidder shall provide all facilities in this regard and shall inform the Employer sufficiently in advance to enable him to depute his representative to witness the same.
3. After completion of manufacture of cables, type, routine and acceptance tests shall be performed strictly as per applicable standards and copies of test certificates shall be furnished to the Employer for approval.
4. The test report on all cables shall be got approved from the Employer before despatch of the cables.

5. TYPE TESTS

Type test in each type and size of cable shall be conducted as per applicable standards. The following shall be performed as type tests:

1. Annealing test (IS:8130)
2. Conductor resistance test (IS:8130)
3. Test for armour wires/strips (IS: 3975)
4. Persulphate test IS: 8130)
5. Test for thickness of insulation and sheath (IS: 3314.part-1 / IEC – 502)
6. Tensile strength and elongation test for insulation and sheath (IS: 583 1)
7. Ageing test for insulation and sheath (IS: 583 1)
8. Loss of mass test PVC insulation and sheath (IEC-540 & IEC-502)
9. Shrinkage test (IS-583 1)
10. Hot deformation test (IS: 5 8 3 1)
11. Cold bend test (IS: 583 1)
12. Cold impact test QS5 83 1)
13. Heat shock test (IEC-540, IEC-502)
14. Thermal stability test (IEC-540, 540A)
15. Test for bleeding and blooming of pigments for PVC (IS,:583 l)
16. Fire resistance test (IS:583 1)
17. Measurement of insulation resistance (IS: 5 83 1)

18. High voltage test (IS'- 3314 part – 1)

6. Test for rodent and terminate repulsion property of sheath are to be performed by the manufacturer. The details of the tests to be given by the manufacturer.

7. Routine test and acceptance:

The following tests shall constitute routine tests and acceptance tests which shall be performed on samples collected from materials ready for dispatch.

1) Annealing test

2) Conductor resistance test

3) Insulation resistance test

4) Test for thickness of insulation and sheath

5) High voltage test.

Apart from these conductor examination, check of dimensions etc. shall be carried out as routine tests.

The test methods, condition of test and test requirement shall be as per the Indian Standards identified for the Type Tests. The high voltage tests shall, however, be performed as per the methods specified under relevant clause for routine test in IS: 3314 (part-I).

1.225.15. Laying of PVC Insulated Armoured Cable

1. The cable shall be laid in ground in one length without any jointing after cutting trench 0.6m wide and 0.76m.deep, leveling the bottom of the trench properly, making the trench free of stone and other hard materials to avoid damage of cables, giving brick (full size – 2nd class) protection to the cable by placing brick longitudinally on two sides and at the top at the rate of 12 nos. brick per m, filling of the space between the brick protection layer and the surface of the ground level with excavated soil and ramming by excavated soil to make the surface level with the adjoining area. The ground surface of the whole trench route shall be cleared

2. The width of the trench should be increased by 0.23m, for each of the additional cable in the same trench. The depth and other condition will remain same as stated in the paragraph above.

3. For lighting along bridges, the cable shall be laid through 310mm PVC pipe inserted in the bridge structure during construction. The pipe shall connect the spaces kept for housing loop box near each light pole on the bridge.

4. While selecting PVC insulated armoured cables for street lights not only the current carrying capacity of the cable, number of lights to be connected and the total power requirement shall be considered, but also the voltage drop shall be taken into account.

5. The voltage drop depends upon current consumed by the light and the resistance of the cable shall be terminated through heavy duty single compression cable glands of corrected size. Crimping type sockets shall be used for all cable termination.

6. Entry and out going cables to loop box shall be protected by metallic pipes.

1.225.16. Wiring and General Fixing

1. The wiring between the lantern and auxiliary gear to the cut-out in the column bases shall be carried out and tested by a qualified electrician and be in accordance with the C.P.W.D. General Specifications for electrical work Part II External 1994, to the entire satisfaction of the Engineer. All wires

shall be PVC insulated. The whole of the wiring shall be fully bonded for earthing. Size and make of wires shall be approved by the Engineer.

2. Unless otherwise described in the Contract wiring between the terminal block in the luminaire and components in the base of the light unit shall be PVC insulated and sheathed single, multi-core or composite cable to IS: 3314 Part I of 300/500 volt grade. Single phase 3 core copper conductors shall be not less than 2.5 sq.mm in cross section area except that where the vertical unsupported length does not exceed 6 metres their cross sectional area can be reduced to 1.5 sq.mm.

Where electronic ignitors are used with remote control gear single core cable shall be used.

The final connection between the lamp and equipment mounted in the base compartment shall be made using PVC insulated and sheathed 2 core and earth and minimum rated at 85oC.

3. All cables shall be correctly colour coded and labelled.

4. Unsupported lengths of cable shall be kept to a minimum and shall not be allowed to come in contact with components by their freedom of movement. Where there is more than one cable they shall be secured together at one metre intervals through out the unsupported length.

5. Wiring shall wherever possible be housed inside columns, wall brackets and posts or stiffening members. Where it is external it shall be as described in the Contract. Connections between conduit and sign housings, switch boxes and other components shall be waterproof and be smooth internally.

1.225.17. Cut-Outs

1. Cut-outs shall be dust and damp protected made of hot dip galvanised steel without rubber gasket, totally enclosed with MCB for Pole Circuit. The design of the cut-out shall permit withdrawal of the fuse carrier without exposing live connections. A separate fuse shall be provided for each and every lamp.

2. The cut-outs shall be provided with an earthing terminal and shall accept cables up to 25 sq.mm. The fuse carrier shall accept HRC fuses upto 20 Amp rating or C.B. All terminals shall be securely fixed within the cut-out enclosures. The cut-out shall be fitted with a suitable Brass Compression Cable Gland Type “CW” in accordance with BS 6121 and with Earth Tag and PVC Shroud. The cut-out shall be sized for looping in and out of the service cable.

3. Minimum thickness of body of the cut out box shall be 2.5mm and that of cover shall be 1.5mm.

4. Cut-outs should not have more than 2 incoming cable termination.

1.225.18. Control Gear

The control gear shall be designed to operate the lamp at the specified power rating indicated in the design criteria and shall be able to start the lamp and control it continuously for ambient temperatures ranging from + e deg C to + 50 deg C. The control gear shall be capable of accepting of supply voltage of 240V.

The following specifications shall be met by the control gear:-

a. Control gear shall be suitable for 50 Hz, 240V ± 10% operation.

b. For input voltage fluctuations of ± 10% from the nominal specified voltage, it shall regulate the lamp watts to ± 5%.

c. Control gear shall have an overall power factor of at least 0.9 when operated under rated lamp load.

d. Control gear shall operate the lamp without adversely affecting the lamp life and performance as specified herein.

e. Control gear shall withstand a 2500V dielectric test between core and windings for one minute.

f. The permissible voltage dip without causing the lamp to extinguish shall be 40 to 50%.

g. The ballast shall be impregnated, tropicalised with compact winding and insulation Class “H”. The maximum permissible winding temperature rise shall not exceed 130 deg C.

1.225.19. Auto Switch

1. For conservation of energy and on economical consideration auto switching is preferred in place of conventional manual switching.
2. Auto change over switch unit shall be complete with analogue / digital time switch with auto manual switching mode and following.
   - Suitable rated air break contractor.
   - Incoming cable terminal with MCB protection at point of entry.
   - On – Off indicating lamp.
   - Pollution free Lithium cell.
   - Internal wirings with stranded PVC insulated copper conductor cable.
3. The above unit shall be incorporated in MS box made of 5mm thick MS plate slightly rounded shape at corner and of solidly welded joints at the corners. It will have type double door to be opened in front. There shall be ventilation arrangement at top duly protected by canopy and close mess brass net. The top hood of the box shall be sufficiently projected on four sides to prevent of rain water inside the box.
   - Railway type locking and additional arrangement of pad locking is also to be made in front side.
   - Suitable base structure shall be provided with MS channel and angle with suitable G.I. Nut, bolt and washers. Bases shall be duly grouted with cement concrete in ground.
   - The bottom of the box shall be 750mm height above ground level and shall be complete with earth terminal and lifting hooks.
   - All components along with provision of housing KWH meter to be done on hylam sheet at the back side of the box.
   - The box is to be painted both inside and out side with two coats of red oxide primer after finishing the surface properly.
   - For convenience the switching unit is to be identified by marking in black Japan.
4. Over and above preset timers, photo electric controls may be used to turn light equipment on and off automatically at dusk and dawnif specifically required in the Contract. This will operate as soon as the ambient light level drops to a desired. This will switch on the system during cloudy weather.
5. The command of photo electric cell will supersede the timer setting.

   Analogue time switches shall conforms to

   IEC 60730-1

EN 60730-1

1.225.20. Lamp

1. The 250-Watt mercury vapour lamp shall comply with the following requirements:

(a) Power into lamp:250 watts (mercury vapour)

(b) Total luminous flux: 14,000 lumens

(c) Average life to burn out to exceed:24,000hrs

(d) At half life, the maintained luminous flux shall be a minimum of 80 percent of the initial luminous flux.

2. The 250 watt mercury vapour ballast shall be designed to operate the specified lamp of the power rating in these standard specifications and shall be able to start the lamp and control it continuously for ambient temperatures ranging from 0 degree to 55 degree C. The ballast shall be of high power factor for starting. The ballast shall be capable of accepting a supply voltage of 240 V. The following specifications shall be met by the ballast:

(a) Ballast shall be suitable for 50Hz, 240 V AC+10% operation.

(b) For input voltage fluctuations of + 10% from nominal specified voltage, it shall regulate the lamp watts to +5 percent.

(c) Ballast shall have an overall power factor of at least 0.9 when operated under rated lamp load.

(d) Ballast shall operate the lamp without adversely affecting the lamp life and performance as specified herein.

(e) Ballast shall withstand a 2000 V dielectric test between core and windings for one minute.

(f) The permissible voltage dip without causing the lamp to extinguish shall be minimum 40 percent when the lamp is new.

(g) Line starting amperes shall be not more than the operating amperes.

3. The 250 watt high-pressure sodium lamp shall comply with the following requirements:

(a) Power into lamp : 250 watts (high pressure sodium)

(b) Total luminous flux : 31,000 lumens

(c) Average life to burn out to exceed:24,000hrs

(d) At half life, the maintained luminous flux shall be a minimum of 90 percent of the initial luminous flux.

The contractor shall submit spectral distribution information for the Engineer's approval.

4. The 250 watt high pressure sodium ballast shall be designed to operate the specified lamp of the power rating in these standard specifications and shall be able to start the lamp and control it continuously for ambient temperatures ranging from 0 degree C to 55 degree C. The ballast shall be high of power factor for starting. The ballast shall be capable of accepting a supply voltage of 240 V. The following specifications shall be met by the ballast:

(i) Ballast shall be suitable for 50Hz, 240 V AC+10% operation.

(ii) For input voltage fluctuations of + 5% from nominal specified voltage, it shall regulate the lamp watts within lamp volt- watt trapezoid per ANSI Standard.

(iii) Ballast shall have an overall power factor of at least 0.9 when operated under rated lamp load.

(iv) Ballast shall operate the lamp without adversely affecting the lamp life and performance as specified herein.

(v) Ballast shall withstand a 2000 V dielectric test between core and windings for one minute.

(vi) The permissible voltage dip without causing the lamp to extinguish shall be minimum 25 percent when the lamp is new.

(vii) Line starting amperes shall be not more than the operating amperes.

1.225.21. Ballasts

1. Unless otherwise specified ballasts shall comply with IS 6616-1982 as appropriate and be for 240V operation.
2. The terminals shall be indelibly marked to indicate all wiring connections.

1.225.22. Ignitors for Discharge Lamps

1. Unless otherwise specified, ignitors shall not be incorporated in the lamps.
2. Compatibility between ignitor, lamp and ballast shall be established to the satisfaction of the Engineer.

1.225.23. Capacitors

1. Capacitors shall comply with IS 3169-1976 and be supplied complete with fixing clips, discharge resistors, and either sealed-in cable tails or shrouded terminals.
2. Capacitors shall correct the lamp circuit power factor to not less than 0.90 lagging unless otherwise agreed in writing by the Engineer.

1.225.24. Fuse Holders, Fuses and Miniature Circuit Breakers (MCBs)

1. Cut-outs, fuse holders and MCBs shall have moulded drip proof housings.
2. Terminals shall be sufficient for the conductors as specified. These shall be clearly labelled to differentiate circuits and phases.
3. When fuse holders are intended to be used as isolating devices, special tools or protective measures shall not be necessary to extract them.
4. Fuse links shall comply with the requirements of either IS 13703 Part 4 - 1993. They shall be of high breaking capacity type and be of a value specified to protect the circuit.
5. Miniature circuit breakers shall be in accordance with IS. 8828:1996 for use on 240V single phase supply or 431V three phase supply. Their short circuit current rating and type shall be described in the Contract. Thermal or magnetic excess current tripping devices shall be provided with a mechanism to ensure that the contact cannot be held closed against a fault.
6. Where MCBs are intended to be used as isolating devices, a ‘lock off’ facility should be provided.
7. All devices shall be rated for 50 deg C ambient temperature.

1.225.25. Specification of Road Light Fixtures

The street light luminaries will be supplied with IP-66 protection and conforming to IS: 10322 Part-5 section-3 with following technical specifications:-

a) Housing: High-pressure die-cast aluminium body/or with nyoril plastic, powder coated.

b) Reflector: Deep drawn high grade aluminium, electro chemically brightened and anodized.

c) Glass: toughened heat resistant glass sealed with silicon gasket.

d) Lamp holder: E-40 adjustable for various optics.

e) Control gear: Integral with electromagnetic copper wound ballast, ignitor & capacitor wired with heat resistant wire.

1.225.26. Street Light Luminaires

1. Street light luminaires housing and cover shall preferably be made in single piece die-cast LM6 aluminum.

2. The housing and cover shall be epoxy powder coated finish from outside.
3. Clear acrylic glass cover to be used

4. The lamp compartment to be fitted with an innovative electro chemically brightened and anodized aluminum reflector for better uniformity and high optical efficiency.

5. The glass covering to be held in position by stainless steel toggles.

6. Synthetic rubber gasket and toggles to be provided to make the luminaries dust and water proof.

7. Lamp replacement and accessories maintenance to be undertaken by opening the toggles.

8. The Luminaires shall be complete with following components
a) Copper wound Ballast
b) Power factor improvement capacitor
c) Electronic Igniter.
d) The mains connector to receive incoming power.
e) End mounting on pipe of suitable diameter.

9. Out door Industrial Luminaires for fluorescent lamp (corrosion proof) may be used for access and minor roads.

10. The Unit shall comprise of deep drawn CRCA M.S. sheet housing in epoxy powder coated finish as top canopy.

11. Reflector cum control gear tray will be fabricated from CRCA MS Sheet, finished in epoxy powder coated white.

12. The unit shall be prewired with vacuum pressure impregnated copper would ballasts, P.F. improvement capacitors, Lamp Holder and main connector to receive in coming power source.

13. An acrylic perplex and gasket will make the luminaries weather proof.

14. The perplex should be held in position by toggles.

15. Re lamping can be done easily by releasing toggles and opening the acrylic cover.

The contractor has to arrange inspection of pole and streetlight luminaries at manufacturer's premises to carry out necessary test contained in IS 2629 & IS: 10322 Part-5 section-3 respectively.

16. The wires shall be rated for 600 volt AC, XLPE insulated and shall be capable of withstanding high temperatures. The terminal block / connectors shall be high temperature grade porcelain or equivalent approved and be easily accessible and suitable for 2.5 sq.mm conductor. A suitable earthing terminal shall be provided in the lantern. Care is to be taken in positioning the terminal block such that whilst being readily accessible there is no possibility of accidental contact during maintenance.

17. All new lanterns and lamps shall be assembled fixed, focused, adjusted and wired in accordance with the manufacturer's instructions.

1.225.27. Feeder Pillar

The Contractor shall have to get the control panel fabricated form the list of approved vendors having type-test certificate form CPRI for 31 MVA short circuit rating up to 400 amp for cubical panels. The copy of the type test certificate shall have to be produced, failing which feeder pillar shall not be accepted.

1 The material/work shall conform to/shall be carried out as per CPWD specifications for electrical work (Part-I) 1994 internal (Part-II) external and (Part-IV) sub station work as amended up to date.

2 Provision IS. 8623/93 with up to date amendment shall be applicable for enclosure i.e., the conditional features routine test as recommended in the said IS shall be conducted type test however are not required.

3 All material used for the fabrication of feeder pillars shall be got approved form the Engineer-in-charge.

4 The feeder pillars shall have sloping canopy projecting out on all sides with suitable sloping channel on front for drainage of water.

5 Angle iron legs shall be suitably shaped at the bottom for anchoring in concrete base.

6 The feeder pillars shall be provided with ventilation window covered with wire net in double fold form inside. The window shall be provided on both the side panels of feeder pillars.

7 The feeder pillars shall be provided with a danger notice plate as per CPWD specifications for electrical work part-I internal 1994.

8 Interconnections of the various mountings on the feeder pillar shall be done using PVC insulated conductors, or solid strips with PVC taping/sleeving of appropriate sizes. Termination shall be made such that local heating is avoided.

9 All the metal work of feeder pillar shall be painted prior to erection with one coat of anti-rust primer. After erection, they shall be printed with two coats of appropriate enamel paint as required, on all sides wherever accessible.

10 Each feeder pillars must be provided with one 4P M.C.B. of sufficient capacity and time switch.

11 The bus bar must be of tined copper having the provision to connect the incomer cable.

12 Suitable M.C.Bs must be provided for taking the out lets.

1.225.28. Street Light Poles

1. The steel tubular poles shall be made of steel, swaged and welded type having ultimate tensile strength 42 kg. per sq mm. and conform to IS 2713 (Part – II, 1980). The steel tubular poles are of three sections with reduction in diameter for each section. The swaged and welded length at two points shall be over lapped with minimum of 200 mm length. The top portion of the steel tubular poles shall be bend in the shape of swan neck for fixing luminaire with the pole by getting a suitable length of E.R.W. pipe welded/ or separated fabricated brackets to be fixed on the pole top.

2. Plantation depth of steel tubular poles shall be as per length and local condition. The plantation depth of steel poles to be used on bridge is nil as it will be erected over the deck.

3. Cables shall be terminated through heavy duty single compression cable glands of corrected size. crimping type sockets shall be used for all cable terminations.

4. Entry and out going cables to loop box shall be protected by metallic pipes.

5. Poles shall be erected on the ground first after making foundation pit for atleast 310mm more than the planting depth, the placing the pole on a 600 mm x 600 mm x 310 mm thick cement concrete (4:2:1) and then making jhama metal concrete foundation (6:3:1) for 300 mm on all sides of the pole for the total planting depth and additional 300mm for muffing above ground level. The foundation pit beyond jhama concrete consolidation shall be filled with excavated earth as and where necessary and duly rammed. G.I. Earth bolt shall be provided after making drilled holes etc. on pile. The bottom portion of the poles before placing in the foundation pit shall be painted with two coats of black japan bitumen based paint. Extra cement concrete foundation (6:3:1) with dimension 600 mm x 600 mm x 750 mm above ground level with 3 mm thick neat cement finish shall be provided. There shall be opening for loop box.

6. Poles shall be painted with the two coats of paint having colour to the choice of Engineer–in-Charge over basic primer paint of two coats of red lead after cleansing the surface of the pole with sand paper/emery cloth.

7. Poles may be numbered in black letters and digits within a circle as required with the black Japan paint of approved make and brand. The size of the letter should be 45 mm and pole numbers shall be written with respect to pillar box as per direction of Engineer –in-Charge.

8. Following tolerance shall be measured in accordance to IS: -

Over all length (m)

Length of sections (m)

Outside dia. of sections (mm)

Thickness of sections (mm)

Weight of pole (kg)

Result shall be well within the limit.

9. Following tests to carry out at manufacturers works as per IS:

a. Deflection test (mm)

b. Permanent set test (mm)

c. Drop test

10. Following observations to be made before dispatch of poles from manufacturer's works

a. General workman ship

b. Straightness

c. Freedom from defects

d. Earthing arrangement

e. Protection against corrosion

11. Concrete poles are popular in certain region where cement and concrete aggregates are plentiful. The principal advantage of concrete pole is its comparatively low cost. The main consideration of concrete pole to replace steel tubular pole is its mechanical characteristic and configuration with respect to fixation of luminaries.

1.225.29. Loop in / Loop out Box

1.225.29.1. Loop boxes shall be fabricated from 2.03 mm (14 SWG) sheet steel. It shall be of weather proof construction and provided with rubber gasket, hinged and screwed cover with brass machine screws, earthing terminal with lug, railway type special mechanical locking arrangement.

1.225.29.2. The dimension of the box shall be 325 mm x 200 mm x 125 mm so that cable termination can be done with ease.

1.225.29.3. The loop box shall contain kitkat fuse units 3 or 1 aluminium bars (depending on requirements), neutral link housed on porcelain chair and having provision for taking out connection to the street light pole luminaries. It shall be painted with two coats of spray painting over two coats of primer.

1.225.29.4. The loop box shall be fixed with the steel pole but housed in the foundation with front door accessible from the front. For steel poles on the bridge, the loop box shall be fixed in the space provided near the pole on the foot path for pedestrian duly covered with RCC slab.

1.225.29.5. Lantern Construction

1.225.29.6. The housing shall be made of die-cast aluminum with refractor bowl of Methaceylate U.V stabilizer or glass and shall be capable of being easily dismantled for maintenance and repair purposes. The bowl shall be securely attached to the lantern body and in the open position shall be attached in such a way as not to be blown against column, bracket or other type of head assembly. Such lamp section shall accommodate one high intensity discharge lamp and shall include a reflector assembly with lamp stabiliser and clear tempered glassware, silicone sealed refractor. Lamp grip shall be porcelain Type E40 base.There shall be provision for horizontal or vertical adjustment. Frame hinging and latching mechanisms (except for release buttons) shall be completely concealed. The diffuser shall be U.V stabilized type. All hinges, toggles, catches, captive screws and nuts shall be made of stainless steel.

1.225.29.7. The frame to housing gasket shall be hollow section, memory-retention extruded rubber secured to the frame.

1.225.29.8. The hinged refractor and glassware assemblies shall be safely retained in the closed and open positions but shall be readily removable for cleaning without-lout use of tools.

1.225.29.9. Reflectors shall be fabricated of pure aluminum sheet. The reflective surface shall be mechanically polished to a mirror like finish, electrochemically brightened, anodised and sealed.

1.225.29.10. The lanterns shall be supplied with lamp holder fixed in a pre-designed position compatible with luminance study, on a die cast aluminum flange mounted in the housing in such a way that re-lamping or inadvertent mis-handling shall in no way change the pre-designed lamp position. Luminaires shall have rust proof collars located in the rear compartment for supporting the lantern on column arms upto 60mm dia.

1.225.29.11. Lanterns with integral gear shall have a fuse holder adjacent to the terminal block with a cartridge fuse protecting each set of control gear.

1.225.29.12. Lanterns shall be such as to comply with the performance criteria in the Luminaire Schedule.

1.225.29.13. At half life, the maintained luminous flux shall be a minimum of 90% of the initial luminous flux. Average life to burnout to exceed 20,000 hours.

1.225.30. Fluorescent Lamps

1.225.29.14. Starters for fluorescent lamps shall comply with BS 3772 and shall be incorporated in the electrical equipment where applicable.

1.225.29.15. Lamps for all similar applications shall be identical, of the same colour, temperature and from the same manufacturer.

1.225.31. Reference to Standards:

IS: 1944 (Part I & II) Lighting public through fares.

IS: 1944 (Part V) Lighting for grade separated junctions, bridges and elevated roads.

IS: 1944 (Part VI) Lighting for town and city centers and areas of civic importance.

IS: 1944 (Part VII) Lighting for Roads with special requirements.

IS: 2418: Tubular Fluorescent Lamp.

IS: 9974 (Part I & II) High Pressure Sodium Vapour Lamp.

IS: 9900 (Part I & IV) High Pressure mercury Vapour Lamp.

IS: 10322 (Part V / Sec 3) Particular requirements luminaries for Road and street lighting

IS: 6616: Ballast for HPMV Lamp

IS: 2231: Ballast for fluorescent lamp.

IS: 3314 - 1964: PVC insulated electric cables (heavy type)

IS: 1753 - 1967: Aluminium conductors for insulated cables.

IS: 3975 - M.S. wires strips and tapes for armouring of cable.

IS: 3961 - 1967 Recommended current ratings for cables.

IS: 5831 – PVC insulation and sheath of electric cables.

1.226 Earthing

1.216.1 Description

Earthing in general shall comply with C.P. (Code of Practice) 3043 of Indian Standards.Earth electrode either in the form of pipe electrode or plate electrode should be provided at all premises for providing earthing system. As far as possible, all earth connection shall be visible for inspection and shall be carefully made.Except for equipment provided with double installation all the non-circuit carrying metal parts of electrical installation are to be earthed properly. All metal conduit trunking cases, sheets, switch gears, distribution fuse boards, lighting fittings and all other parts made of metal shall be connected to an effective earth electrode.The main earth electrode should be G.I perforated pipes driven into the soil as per standard practice. Continuous looped earthing should be provided with adequate size G.I. wire / flat. Earthing work should conform to I.E Rules.The electrodes shall be situated at a distance not less than 3.0 m. from the building fencing structure and equipment foundations. The earth pit shall conform to IS : 3043 and GI earth electrodes of not less than 100 mm external dia shall be driven to a depth of atleast 3m in the ground below the ground level. The surrounding the electrodes, soil shall be treated up with salt, coke and charcoal.Earth electrode shall be installed near the main supply point and shall comprise a copper / GI earth of appropriate diameter and driven to depth of 3 metres below ground level, or to a greater depth, if so required to obtain a sufficiently low earth resistance value. Alternatively copper plate may be used as the main earth electrode conforming to IS: 3043. The electrodes shall be driven at least 3 m away from the building or any other earth station. Minimum requirement of earth pits as per I.E. rules are as under:

- Two numbers independent for transformer body
- Two numbers independent for transformer neutral
- Two numbers independent for four pole structure
- One number for lightning arrestors
- Two numbers for L.T. panel at sub-station and at pump house.
-

The main earth electrodes after being driven into the ground shall be protected at the top by constructing a concrete or block masonry chamber of size 300 mm x 300 mm x height 300 mm. and shall be provided with CI cover. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall not exceed 1.0 ohm. The remaining space in the bore hole shall be filled with bentonite. The bentonite will hold the earth rod in position. The neutral conductor shall be insulated throughout and shall not be connected at any point to the consumers earthing system.An earth continuity conductor shall run continuously from the farthest part of installation to the main earth electrode and shall be connected by branch conductor to all metal casing and sheathing housing electrical apparatus and/or wires and cables. all branches shall be connected to earthing. The earth continuity conductors shall have a cross-sectional area at least half to the size of the phase conductor and in no case less than 1.5 mm2 of Cu/GS.All earth wires and earth continuity conductor shall be galvanized MS flats of appropriate size. Interconnections of earth continuity main conductors and branch wires shall be brazed properly, ensuring reliable, permanent and good electrical connections. The earth lead run on structures must be securely bolted. Neutral earth leads shall be run on a separate supports without touching the body of the transformers. Earth wires shall be protected against mechanical damage and possibility of corrosion particularly at the junction points of earth electrodes and earth wire interconnections. Earth electrodes shall be connected to the earth conductors using proper clamps and bolt links. It shall not be allowed to use the armor of the incoming feeder's cable to the sub-distribution board as the only earthing system. Sheathed lugs of ample capacities and size shall be used for all underground conductors for sizes above 3 mm2 whenever they are to be fitted on equipment or flat copper conductor. The lugs shall be fitted on equipment body to be grounded or flat copper only after the portion on which it is to be fixed is scrubbed, cleaned of paint or any oily substance on a subsequently tinnedNo strands shall be allowed to be cut in case of stranded ground round conductors. G.I embedded conduits shall be made electrically continuous means of good continuity fixing and also be rounding copper wires and approved copper clamps.

1.216.2 Earthing Of Lighting Poles

All external poles are to be looped together with continuous 8 SWG GI earth wire clamped at dollies provided on every fuse box of poles and looped onwards to the other pole. Every fifth pole shall be connected to earth through an earth electrode.

1.216.3 Earthing For Lighting Installation

This shall be common grid system, the main grounding conductor laid and embedded in concrete being grounded at earth pits outside the buildings at approved locations or other places. The earthing of L.T panels shall be connected to two main grounding conductors each of which along with main cables shall run with cables to distribution boards in each floor. This shall run along with the cable and at the top floor be connected same section completing the grid.

1.216.4 Sizes Of Earthing Conductors

System	**Earthing conductor size and Material**	
	Buried in ground / concrete	**Above ground**
Main earthing grid	40 X 10 mm MS	----------
11 kV outdoor sub-station and 11 kV switchgear	40 X 10 mm MS	50 X 6 mm GS
431V switchgear, transformer, DG set, Capacitor Control panel	suitable to its ratings	Suitable to its rating.
Battery charger		25 X 3 mm GS
431V LT Motors		
- Valve motors		10 SWG GS wire
- 0 - 31 HP		8 SWG GS wire
- 31 - 40 HP		4 SWG GS wire
- 40 - 50 HP		25 X 3mm GS flat
- 50 HP and above		25 X 6 mm GS flat
Lighting distribution Board, 30V DC Tripping Unit.		25 X 3mm GS flat
Local push Button Stations, Junction Boxes.		14 SWG GS wire
Lighting and receptacle system		12 SWG GS wire
Earth Electrode		50 mm dia. 3000 mm long heavy duty GI pipe electrode
Street lighting poles		8 SWG GS wire

Notes	1	Conductors above ground shall be galvanised steel
	2	Conductors buried in ground or embedded in concrete shall be mild steel.

1.227 Power Capacitor

1.217.1 General

Power capacitor and capacitor control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at the top compartment. The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units.The assembly of the banks shall be such that it provides sufficient ventilation for each unit.Each capacitor case and the cubicle shall be earthed to a separate earth bus.Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.Film dielectric, Aluminum foil conductor, impregnated with Non PCB, Non Toxic biodegradable capacitor grade oil, under vacuum, two layers of bi-axially oriented propylene film shall be used.Each unit shall satisfactorily operate at 135% of rated KVAR including factors of over-voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage upto a maximum of 10% above the rated voltage, excluding transients.

1.217.2 Unit Protection

Each capacitor unit shall be individually protected by an MCCB / MCB fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The MCB breaking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

1.217.3 Capacitor Control Panel

The control equipment including capacitors shall be mounted in a panel made of 2 mm cold rolled sheet steel. The panel shall be of indoor type and shall consist of:

- Isolating switch / MCB or MCCB
- Contactor with overload element
- Relays responsive to current / voltage / kVAr / PF as specified for automatic switching
- Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in an out of circuit.
- Auto-manual selector switches
- Push button for opening and closing the power circuit.

- Red and Green lamps for capacitors ON/OFF indication.
- Protective relays to protect the healthy capacitor units when one unit fails in a series connection.
- Space heater and cubicle lighting as per the requirements is required.

1.217.4 Technical Particulars

The equipment shall conform to IS 2834

General

- Quantity : 2 banks for each pumping station
- Rated capacity As per single line diagrams
- Rated Voltage : 433 V
- Rated frequency, and phases : 50 Hz, 3 Phase
- Design Requirements
- Insulation level : 2.5 KV (rms)
- Capacitor bank connection : Delta
- Short circuit withstand for busbars :

Short time (1 sec) : 40 KA (rms)

Dynamic : 102 KA (peak)

Switches

- Type of Switching: Automatic switching shall be responsive to power factor through power factor sensing relay.
- Switching steps: As required
- For single motor operation, switching shall be with motor operation.
- Rating of contactor: To suit kVAr unit
- Incoming current rating: To suit-rated capacity of kVAr

1.228 Diesel Generator

1.218.1 General

Electrical power supply for each load point will be availed from nearby grid supply point. According to the load requirement HT at 11KV or LT at 431 V – 3 Phases will be availed from electricity grid.One Diesel driven alternator set of capacity in the Special Specification shall be provided to permit operation of the load in the event of failure of the grid electricity supply, complete with all equipment like Control gear, circuit breaker, cabling synchronizing equipment etc.The Contractor shall also make his own calculations with regard to the rating of the generating set(s), which shall each be large enough to start and run the pumping equipment but which shall not be less than that stated above, at a power factor of 0.8. The continuous rating of the motors shall be used to calculate the maximum demand. A 10 per cent margin of the capacity of the total load shall be allowed for contingencies and spare capacity.The engine alternator sets shall be designed such that the starting power peak shall not exceed 10 percent of the continuous engine rating and the voltage dip shall not exceed 31 per cent whilst starting the connected load under the worst conditions.The Contract Drawings show the building, floor and other details as they will be constructed and the space allocated for the generating plant, control gear and circuit breaker. If any deviations from the proposed layout are necessary, the Contractor shall show the modifications required on the drawings, and shall call the Engineer’s attention to these proposed alterations. Contractor’s attentions is specifically drawn to the operating conditions whereby generator sets could be running at little or no load due to the intermittent and differing load conditions. The diesel generator shall be capable of working varying load conditions.

1.218.2 Detailed Description of Generator Engine

Each engine shall be four stroke, naturally aspirated or pressure charged, water- cooled, vertical diesel type, of the airless injection principle with all cylinders and valve gear totally enclosed. Each engine shall run at a speed not exceeding 3100 rpm. And be suitable for remote operation provided with forced feed lubrication to all working parts including the camshaft, rocker gear, valve guides etc. A strainer shall be located in a satiable position in each system. The whole of the lubricating oil shall be cooled by means of an inter-cooler situated adjacent to the engine with circulating water dissipating the heat taken from the oil. The necessary circulating pumps shall be provided which shall be integral with the engine together with all the appropriate pipe work and appurtenance. Individual flow indicators shall be provided for the jacket and lubricating oil circuits. A sensitive Class A2 governor shall be incorporated and this shall be capable of maintaining a constant sped under all conditions of load in accordance with the requirements of BS. 5514. Motor operated speed regulating gear shall be provided to enable to speed of the engine to be varied by 5 percent up or down from normal speed while in operation. The remote control for this regulating gear is to be operated from the switchboard. Over –speed protection shall be provided so that in the event of the engine speed exceeding 10 per cent above the maximum operating speed an audible warning and indicator light shall be brought into operation, but should the speed still continue to rise to a figure of 31 per cent above normal speed the fuel supply shall be automatically cut off and the engine brought to rest. The audible warning hereafter, shall indicate on the monitoring panel in the alternator switchboard. A heavy type of flywheel shall be provided so that there will be a minimum of cyclic irregularity throughout the working range of the engine. Distortion or vibration and oscillation of the crankshaft shall be obviated under all normal working conditions. The crankshaft shall be of solid forged steel statically and dynamically balanced to very close limits. Hand operated barring gear shall be provided for each engine. Aspiration air filters shall be mounted directly on each engine and shall be of the heavy duty type, suitable for a sand laden atmosphere. Protected thermometers in suitable pockets shall be provided for measuring the temperature of the inlet and outlet cooling ion water and lubricating oil. Each engine shall be provided with a temperature indicator on each exhaust branch. Lubricating oil and circulating water pressure gauges shall be provided on the local panel. A positive driven tachometer and hours counter shall be provided and fixed in a convenient place on each engine and the tachometer shall be connected to an engine speed indicator mounted on a local panel to be mounted on each engine. In addition to the over-speed alarm, protection devices shall be provided in the lubricating oil circuits and cooling water circuits to operate alarms and indicators lights, in the event of abnormal running conditions prevailing. These lights shall indicate on the remote monitoring panel. The engine shall shut down under alarm conditions. The whole of the design, rating and testing of each engine shall be in accordance with BS: 5514 for solid injection liquid fuel engines. Each engine shall be designed to operate with an ambient air temperature of 450C and be capable of satisfactorily providing an output 10 per cent in excess of the BS rating at the same speed for one hour in any period of 12 hours consecutive running.

Each engine with flywheel and alternator shall be mounted and aligned on a common underbed. Anti-vibration mounting shall be provided between the underbed and the concrete foundation. Each cylinder shall have renewable wet liners, and be fitted with individual cylinder heads. Wet liners shall be treated on the water jacket side with a rust inhibitor. Immersion heater and thermosat control shall be incorporated in each engine oil sump and water jacket to ensure rapid warm up on starting. Each engine shall be provided with an oil drip tray complete with plugged outlet. The engine shall be painted in accordance with the Manufacturer's recommendations, colour finish a advised by the Engineer.

1.218.3 Engine Cooling Equipment

Each engine shall be cooled by a bed-plate mounted tropical rated radiator and cooling fan, adequately rated to maintained the normal working temperature, under continuous, full load operation, working in conjunction with a pressurized water system, thermostatically controlled with centrifugal water circulating pump, valves and pipe works.

1.218.4 Exhaust System

A complete engine exhaust system shall be provided for each engine and shall incorporate a highly efficient residential quality silencer, expansion box, tabular lengths or exhaust piping and all necessary flexible connections to lead the exhaust fumes outside the building.The exhaust piping shall be adequately lagged and clad within the station with polished aluminum sheeting. All the necessary supports shall be included. Closing plates to apertures in walls shall also be provided. Very special attention shall be paid to the preparation and protection of the exhaust system.

1.218.5 Bed-plates and Couplings

A rigidly constructed, fabricated steel combined bed-plate shall be provided for each generator set to withstand the weight and shall be suitably machined on top for the reception of the engine and alternator. The bed-plate design shall incorporate anti-vibration mounting to provide complete isolation of vibration from the concrete foundations. Each alternator shall be directly coupled to its associated engine by means of an adequately rated, flexible, multi- pi, balanced coupling in accordance with section 3 securely keyed to the shaft or close coupled to the engine. Each coupling, flywheel and any other moving part on the generator set shall be fitted with close mesh guards which shall show access to all greasing and lubrication points. Guards shall be readily removable for maintenance purposes.

1.218.6 Starting Equipment

Each of the generator sets shall be started by means of a heavy duty, acial, starter motor, fitted with automatic disengaging mechanism on engine start-up, operating in conjunction with a 24 volt battery panel, installed locally to each generator set. Batteries shall be of the heavy duty, 24 volt, nickel cadmium type, lead acid are not acceptable, and be complete with charger, housing cabinet and necessary interconnecting cable. The capacity of each battery allow for not less than 10 consecutive starts, each of 31 second duration. Each battery charger shall be connected to the main motor control center board in the control room.

1.218.7 Detailed Description of Alternators

The alternators shall be continuously rated for continuous operation and generate at 431 volts, 3 phase 50Hz., with the neutral point connected to a common earth bed. The alternator neutral contactor shall be closed when the alternator is running. The alternator enclosures shall be protected to IP 54 BS 4999 part 20. They shall be suitable in all respects for operating in the climate as detailed elsewhere. The alternator excitation equipment shall be of the quick response self-exciting, self regulating brush –less type, suitable for starting the motors. The insulation of the stator and rotor shall be in accordance with British Standard Class “F” but the alternator shall be designed for a Class “E” temperature rise. The efficiencies of the alternator shall be stated in the Schedule and shall be determined in conformity with the procedure laid down in BS 269 and shall be manufactured in accordance with BS 2613.

Each alternator shall be capable of satisfactorily providing an output 10 per cent in excess of the BS rating for one hour in any period of 12 hours consecutive running.Terminal boxes shall be provided and arranged with sealing chambers for the reception of the cables detailed in the relevant sections of the Specifications. Terminals shall be clearly marked to give phase identification. The alternator shall be painted in accordance with Manufacture’s recommendations, finished colour as instructed by the Engineer.

1.218.8 Fuel Oil System

A complete fuel oil system including bulk storage and daily service tanks and transfer pumps shall be provided. It shall comprise of one steel, domed end horizontal cylindrical storage tanks. Each tank shall be mounted on prepared foundations at each compound, all as indicated on the Drawings, and shall be complete with manholes, filling and draw-off connections, vent pipes and inspections holes and externally indicating contents gauges. The necessary access ladder and platforms over the tanks shall also be supplied. Each generator shall be provided with a free standing daily service tank of sufficient capacity to permit its associated generator to operate under full load conditions for a minimum period of 12 hours. There shall be no gravity feed bulk fuel to service tanks, and no possibility of promoting and maintaining siphoning through fuel transfer pumps. All necessary valves shall be included to ensure this. Service tank overflows shall be carried back to the bulk fuel storage to avoid any flooding of the engine room with fuel oil. Arrangement drawings shall be supplied to illustrate the complete fuel supply system showing the position of tanks, valves, pumps and all other related equipment. A single line scheme diagram of the system shall be submitted and of a form suitable for permanent display in the generator building. An accurate fuel oil meter shall be inserted in each feed from the daily service tanks to the engines. These meters shall be in such a position as to be readily readable. Two filters shall be provided in the main fuel oil supply line with by passes enabling one filter to be taken out and cleaned without interrupting the supply of oil through the other filter.

1.218.9 Bulk Fuel Tanks

One bulk fuel storage tank shall be provided and shall be manufactured and arranged with all ancillary apparatus to fit within the areas allocated on the Contract Drawings. The size of tank shall be such as to contain a sufficient quantity of fuel oil for a minimum of 31 days operation at full load continuously. Each tank shall be constructed of not less than 9.5 mm thick (nominal) plate which shall be free from imperfections and constructed as a rigid unit with internal partitions of bracing is necessary. The tank, or where it has more than one compartment, each compartment, shall be provided with a manhole and provision for ventilation to a single point shall be made. All seems shall be continuously welded from both sides. Provision shall be made to prevent damage to the tank bottom by impact from the dip –stick. For this purpose a welded stop collar shall be provided at the top of the dip-stick to rest on the manhole cover. The dip-stick shall be of non-ferrous material accurately calibrated and clearly marked so as to be readily identifiable with its respective tank and shall be supplied, calibrated in litres, by the tank manufactures. The dip-stick tube shall be incorporated in the manhole cover, no separate tank opening being provided for this purpose.Each tank shall be arranged for filling via a direct filling pipe which shall be positioned to give easy access for the delivery tanker. A minimum of 5 per cent by valume of the tanks contents shall be allowed as sullage. The filling pipe and dip-stick tube shall each have a liquid and vapour – proof screwed cap with captive chain and fitted with a lock with four keys. The filling pipe and dipping tube shall be carried down to within 50 mm of the tank bottom. The suction and return flow pipes shall terminate not less than 25mm above the bottom of the filling and dipping pipe so as to maintain a liquid seal. A vent pipe not less than 75 mm diameter shall be fitted to the highest point of the tank, and shall terminate with a wire cage for protective purposes (fine gauge shall not be used)

Each storage tank manhole shall be in an accessible position, and shall not be less than 600mm. Diameter clear opening. The manhole lid shall be securely fixed by bolts and have a liquid and vapour tight joint (close woven proofed asbestos graphite).The outlet pipe shall be so arranged as to leave a minimum of 75 mm dead space in bottom of the tank. Each tank shall have connections to receive the excess flow from the daily tank overflow. Each tank shall also be provided with an externally indicating contents gauge marked in Tamil and English to read “Full – ½ full – Empty”.All openings shall be closed with steel plugs and blanking off steel plates bolted to flanges for transit to site. The tank manufacture shall provide all details of his requirements for access holes, etc. required to the storage tanks to enable the Contractor to construct the tank installations generally shown on the Contract Drawings. Bulk storage tanks shall have the internal and external surfaces descaled by gtrit blasting pickling or other approved method. After descaling, external surface shall be given a phosphate coating followed by a cold water washdown. External surfaces shall be painted as specified. The interior shall immediately to oiled. Unless specifically stated in the Special Specification bulk storage may be resorted to in steel barrels. Hand operated fuel oil transfer pump may be used to transfer fuel oil barrels to day tank through flexible fuel hoses.

1.218.10 Daily Storage Tanks

Each engine shall be provided with a daily tank of sufficient capacity to allow 12 hours of continuous operation at full load. For permanent mounted sets each daily tank shall be provided with the following fittings:-

- Air vent of not less than 50mm. Diameter.
- Overflow piping of not less than 310 per cent diameter of the Fuel Delivery line.
- Cleaning hand hole and cover of not less than 300mm diameter
- Contents gauge in Tamil and English to read “Full – ½ - Empty”. The gauge shall be of the magnetically operated type and shall be of the magnetically operated type and shall be complete with low and high level control contacts.
- Outlet connection to engine not less than 50mm above tank base
- Fuel outlet isolating valve lockable in open position
- Drain plug
- Excess fuel return connection if necessary

- Inlet connection from bulk fuel supply system including pipework and connections.
- There shall be allowed a minimum of 5 percent of the volume of the tank contents as sullage. The top oil level of the tank shall not be less than 75 mm from top of the tank.
- Tanks prior to dispatch from manufacturer's works shall be tested hydraulically to pressure 0.5 bars.
- Daily tanks shall be complete with all supports and fixing bolts for mounting remote from engine. Base or skid mounted tanks will not be accepted.
- There shall be provided all necessary fuel oil pipe work, unions and valves between the day tank and the engine.
- Fuel connecting pipe work to engine shall e seamless steel and all pipes shall incorporate flexible section if not less than 250mm. Long (plastic pipes or fittings are not acceptable)

1.218.11 Fuel Transfer Pumps

Adjacent to each daily service tank there shall be provided an electrically driven fuel transfer pump operating in conjunction with the control switches fitted to the daily tank contents gauge. The pump shall be of the positive displacement type rated at a capacity to enable the associated daily tank to be completely filled from empty within 2hours. The pump motor shall be suitable for 431 volt 3 phase operation. Automatic control shall be provided for each pump, via the control contacts fitted to the associated fuel contents gauge, to maintain a minimum of 12 hours fuel storage in the daily tank. A semi – rotary, hand operated pump shall be installed and connected in parallel with each electric pump. Both pumps shall be complete with a minimum of 4m. of flexible hose and a two position hand valve to enable the pumps to extract from the Bulk Fuel Tank or, if necessary from a portable drum situated adjacent to the daily service tank.

1.218.12 Warning and Safety Notice

The following warning notice shall be supplied and fixed in a prominent position in the vicinity of each bulk fuel tank with 50mm. Plain block letters on a yellow background, printed in vernacular and English.

1.218.13 NO SMOKING

1.218.14 DIESEL FUEL – HIGHLY INFLAMMABLE

Additional notices shall be provided is required. The wording of the notices shall be subject to the Engineer's approval.

1.218.15 Pipe work and Valves

All fuel pipes and fittings shall be of seamless stainless steel, all valves shall be cast steel, and designed for the duty they are required to perform. Galvanized pipe work and fittings shall not be used for any lines handling fuel. All pipe work shall be fully supported and complete with all brackets and fixings.

Pipe work installations shall be carried out for the various items of plant equipment and shall include the following.

- All pipe work and valves from the bulk storage tanks to the daily storage tanks and filling point.

  For the storage tanks:

  1 No. easily cleaned filter

  2 No. shut off hand operated valves (one each side of filter)
- The main fuel line from the bulk storage tank installations shall be fitted with fail safe quick closing emergency valve with replaceable fusible link arrangement to shut fuel off in event of fire. The operating temperature of the heat sensitive element shall be 93° C.

- One complete set valves for each set of fuel transfer pumps comprising suction and delivery isolating valves, non-return valves and pressures relief valve with return pipe.
- Overflow pipe work and fittings from each daily tank to the bulk storage tanks.

1.218.16 Load Banks

The Contractor shall provide load banks of the non-inductively wound, resistance type units mounted in outdoor weather and waterproof oil filled containers. The resistance units shall be rated correctly for each pump and site and shall be clearly labeled in this respect. The units shall comply with Section for construction, materials, fittings as applicable for transformers and oil filled switch gear. External connections shall be by sealed cable boxes with glands, gaiters and segregated terminal connections. The first filling of oil shall be included, together with 2 No. sealed silica gel dehydrating breather replacement elements of each unit.

1.218.17 Performance Requirement

The diesel generator and accessories shall be so designed as to meet the following performance requirement.

- The unit shall be capable of starting from cold condition, reaching operating speed and taking up load within the shortest possible period.
- The unit shall be capable of delivering continuously at the generator terminals a net output specified. This net output shall be obtained after necessary derating of engine due to site conditions and unit auxiliary power requirements have been taken into consideration.
- The unit shall be capable of a peak output of 10% in excess of the rated output for a period of one hour out of a total of twelve consecutive hours of operation, without exceeding permissible temperature limits and with a fairly visible exhaust.
- The unit shall be continuously rated to supply power for the periods.

The following items of performance shall be guaranteed during site performance tests by the supplier in respect of the diesel generator and the auxiliary for the specified site conditions:-

- Net electrical output
- Fuel oil consumption at ½, ¾ and full load
- Jacket water temperature to and from engine
- Lubricating oil temperature to and from engine
- 10% overload for one hour out of a total of twelve consecutive hours of operation without overheating or showing signs of undue stress and within specified frequency variations.
- Freedom from vibration and noise.
- Governor response, over-speed trip ad speed gear capability
- Voltage regulator response
- Excitation at full load and under specified variation of voltage and speed.

Window type annunciators shall be supplied and mounted on generator control panel to give visual and audible indication for the following conditions.

- High jacket cooling water temperature
- High lubricating oil temperature
- Low lubricating oil pressure
- Low fuel oil tank level

- Engine over- speed and trip
- Over current
- Earth fault
- Contactor on & off indication
- Voltage out of limit
- Excitation failure
- Generator fault.

1.218.18 Drawing & Data

The contractor shall submit the following drawing /data to the Engineer for approval before placing any order with suppliers.

- Control panel dimensions and drawings showing plan, front view, foundation details inside view, terminal block location etc.
- Schematic diagrams of the electrical circuitry
- General arrangement of the complete DG Set.

1.218.19 Mode of Operations

Although it is intended to staff each site on a 24 hour basis, the starting, running up, loading and paralleling of units shall normally be carried out automatically. Facilities, must however, be incorporated for full manual control.

1.218.20 Diesel Engine

On occurrence of main power failure, the following sequence shall apply.

- The loss of power shall be detected by mains monitoring relays associated with the main incoming circuit breaker.
- The mains monitoring relays shall give a signal to the Generator Switchboard and sound an audible alarm, warning staff to standby for generator start up.
- After a time delay, to be determined, achieved by an adjustable time, 0-31 minutes, the station incomer shall open together with the 4 pole air break change over contactor. The delay is to allow for a possible restoration of supply via the incoming feeder.
- When the time delay has expired, the station incomer and changeover contactor have opened and a visual and audible warning has been given, the first or only duty engine shall start up.
- When the unit has achieved the correct voltage and frequency, it shall automatically switch “on busbars”, followed immediately by the closure of the appropriate generator circuit breaker and changeover contractor. The visual and audible alarms shall then be cancelled.

1.218.21 Electrical Operation

The circuit breaker and changeover contactors shall operate under the sequence detailed in this clause and shall be interlocked as follows: -

- Main supply and generator circuit breakers cannot be closed together.
- The changeover contactor can only connect one source of supply to the busbars and only close when that supply is available and the circuit breaker are closed.
- Interlocks shall be both permissive and prohibitive and all shall be present and operative before operation of the breaker or changeover can take place.

1.218.22 Testing & Commissioning

The supplier shall perform all the standard shop tests to ensure that the equipment conforms to the specifications and meets the performance guarantees.

The installations / commissioning of the Diesel Generator set shall be as per the applicable code of practice and the manufacturer's instructions.

1.218.23 Tests And Test Reports

All tests shall be conducted in accordance with the latest edition of IS – 2834 and as applicable for the controls. Type test certificates for similar capacitor units shall be furnished.

1.218.24 Drawings

The following drawings shall be submitted for the approval of Engineers

- Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.
- Complete schematic and wiring diagrams for capacitor control panel.

1.229 Solar Power Fencing

Solar Power fencing comprises pre-fabricated posts and fence wires connected to them. Pre-fabricated posts 5 feet high, suitable for carrying the fence wire, shall be erected on suitable foundation in cement concrete 1:2:4 of size 600 mm x 600 mm x 600 mm at a spacing of 3 meters. Alternative poles shall be 'T' angular dimensions with 12 no. holes of 5 mm. The hole shall be fitted with insulator through which fence wire is carried. The fence wire shall be of 2.5 mm dia H.T. G.I., with break strength of 740 kg.

1.230 Measurement:

Solar Power Fencing will be measured in running meters correct to one cm.

1.231 Rate:

Rate shall include labour, cost of all materials at site, erection etc. complete for the finished work. The pre-fabricated posts will be measured separately.

1.232 Solar C.S. 250 units or Equivalent

A rechargeable battery – preferably tubular or VRLA having sufficient A.H. capacity of 120 Hrs back up shall be supplied with Solar photovoltaic Module capable of charging the battery at medium sunlight. The module also must have provision for regulating the charging current. This module must generate the necessary high voltage pulses to feed the fencing.

1.233 Measurement:

The unit will be measured in number.

1.234 Rate:

Rate shall include labour, cost and conveyance of components, trial run etc. complete for the finished work.

1.235 Alarm facility

The alarm system should sense any tampering over the fencing and actuate the audio alarm circuit. The alarm system must also be provided with a switching module to deliver 12 V out put which can be used for triggering gadgets like, closed circuit TV, Flood lights and Computer peripherals.

1.236 Measurement:

The unit will be measured in number.

1.237 Rate:

Rate shall include labour, cost and conveyance of components, trial run etc. complete for the finished work.

1.238 Fence

Fencing shall be done using special pre-fabricated posts End post / Corner post, supported with hot-dipped G.I. pipes of 32 mm diameter. The support pipe must be clamped with the posts by using GI brackets. Alternate posts shall be 'T' shaped with 25 x 25 x 3 mm angles. These posts must be provided with 12 nos. of 5 mm holes fitted with reel insulators. 2.5mm H.T. G.I. wire of UTS. 140 kg/ mm carried through the holes of the post for the fencing.

1.239 Measurement:

The unit will be measured in number.

1.240 Rate:

Rate shall include labour, cost and conveyance of components, trial run etc. complete for the finished work.

1.241 Pre-fabricated Posts:

The posts shall be fabricated with pre-tensioning system approved by the Engineer. Steel form work shall be used. Concrete 1:2:4 with 20 mm graded material shall be used. Surfaces shall be smooth. Any pitting has to be finished smooth and flush with the surrounding using cement mortar 1:3. Post shall be cured for 21 days. Length of the post shall be 5 feet out of which 1 feet is grouted to the side of the compound wall. Posts used at end or corner shall consist of supporting pipes of 25 mm dia. The support shall be provided with G.I. clamps.

1.242 Measurement:

Pre-fabricated posts will be measured in numbers.

1.243 Rate:

Rate shall include labour, cost and conveyance of all materials, hire for form work, casting, wiring etc. complete for the finished work.

1.244 Intermediate Post

The intermediate 'T' post shall be made of 25 x 25 x 3 mm angles. 12 Nos. of 5 mm holes fitted with reel insulators to carry the fence wire shall be provided.

1.245 Measurement:

Intermediate posts will be measured in numbers.

1.246 Rate:

Rate shall include labour, cost and conveyance of all materials, hire of tools, fabrication etc. complete for the finished work.

1.247 Gate

The gate shall be provided with spring loaded barricades. Provision shall be made to electrify the gate and actuate the alarm system if the gate is opened forcibly.

1.248 Measurement:

Gate will be measured in number.

1.249 Rate:

Rate shall include labour, cost of all materials, fixing etc. complete for the finished work.

1.250 Schedule Of Makes (Electro – Mechanical Items)

A Schedule of popular makes of Electro-Mechanical items is furnished at ANNEXURE – 30.1. The list is not exhaustive and the contractor shall consider other equivalent products as well if not specified..

ANNEXURE – 30.1

SCHEDULE OF MAKES

Centrigugal Horizontal Split case Pumps	Kirloskar Jyoti M&P Worthington Fair Bank Morse
Motors	Kirloskar NGEF Jyoti BHEL Crompton Greaves
Valves (sluice valves and non return valves)	Kirloskar IVC Four ESS
HOT crane	W.H. Brady & Co. Hercules Hoists Ltd. (INDEF) Sharp Engineering Pvt. Ltd.
Exhaust fans / Ceiling Fans	Bajaj Electricals Crompton Greaves Jay Engineering Works (USHA)
Power Transformers	NGEF Bharat Bijlee Ltd. Kirloskar Crompton Greaves BHEL
11 KV / 6.6 KV switch gear	Jyoti Siemens Crompton Greaves Kirloskar MEI
431 V Switch Gear and Control Gear	L&T Siemens Control and Switchgear Bhartia Cuttler Hammer HH Elecon ELPAN English Electric Crompton Greaves
CablesCCables	CCI Incab

	Universal Tropodur
Lighting Fixtures	Philips Crompton Greaves Bajaj
Power Capacitors	Khatau Junker Usha Asian Shakti Crompton Greaves
Instruments and Controls	Automatic Electric Universal Electric MECO Instruments Pvt. Ltd. Industrial Motors (P) Ltd.
431 V ACBs	English Electric Larsen & Toubro Siemens Kirloskar Crompton Greaves
RelaysSControl and Relay Panels	English Electric Jyoti Universal Electricals Ltd. Easun Reyrolles Relays Hindustan Brown Bowery MEI
Battery Station type Battery	Standard Exide Chloride India Ltd. AMCO
Battery Charger	AFCO Automatic Electric Uptron
Pressure Gauges	Manometers India Ltd. H Guru Instruments Pvt. Ltd. A.N.Instruments General Instrument Pvt. Ltd.
Fire Extinguisher	Kooverji Devshi & Co. Pvt. Ltd. Vijay Fire Protection Systems Pvt. Ltd. Steelage Industries
Switch fuses and MCCBs	L&T English Electric

	Siemens Control and Switchgear Bharatia Cuttler & Hammer Crompton Greaves
Gear Reduces	Essen Pro Radicon Elecon
CTs & PTs	MEI Automatic Electric Pvt. Ltd. Kappa Electricals Hindustan Brown Boveri Nagpur Transformers

1.251 Typical Specification Of Bulldozer

1.252 Salient Features:

1. Required minimum rated bhp: 100HP @ 1750 rpm

2. Sturdy direct injection type diesel engine for sustained power and fuel economy

3. Main frame and steering case welded into a rigid monoblock construction

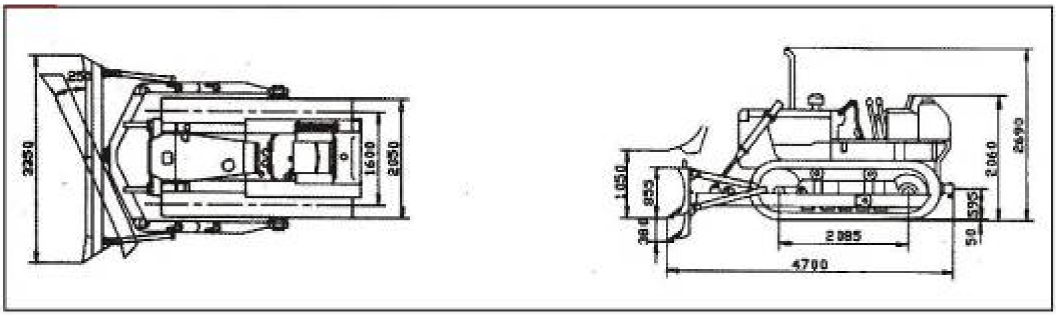
4. Wet type main clutch hydraulically boosted and foot controlled for light touch and smooth operation

5. Unit construction of engine, clutch and transmission assemblies for quicker and easier servicing and overhaul

6. Reduced maintenance time and costs as well as extended serviceability of undercarriage assured with floating seals in oil filled rollers, sprockets and idlers

7. Dust seals located between link bushing and pin entry of abrasive dirt or mud and ensure long track life

Typical Dimensions:



1.253 Typical Specification Of Backhoe Cum Front Loader

1.254 Salient Features:

1. Productivity:

Proven diesel engine of gross power 75hp @ 2200 rpm, torque converter with power shuttle synchromesh transmission giving four forward and four reverse speeds, fully oscillating steerable front axle

2. Reliability:

Attention-free wet multiple disc brakes on rear axle wheels. All structures shall be made of high tensile steel for longer life. The cutting edges, teeth, pins, bushings shall be highly reliable and durable.

3. Maneuverability:

Effortless power steering, optimum combination of travel speed, turning radius and wheel base.

4. Serviceability & Maintainability

Electronic display and monitoring system helps to prevent minor problems from becoming major ones. Special dust seals for all linkages joints for higher performance and less maintenance.

5. Comfort:

Spacious walk through, FRP top safety cab with two doors, two side windows & sliding rear window, ergonomically arranged controls& instruments and cushioned seat. Excellent visibility ensures easy operating of implements.

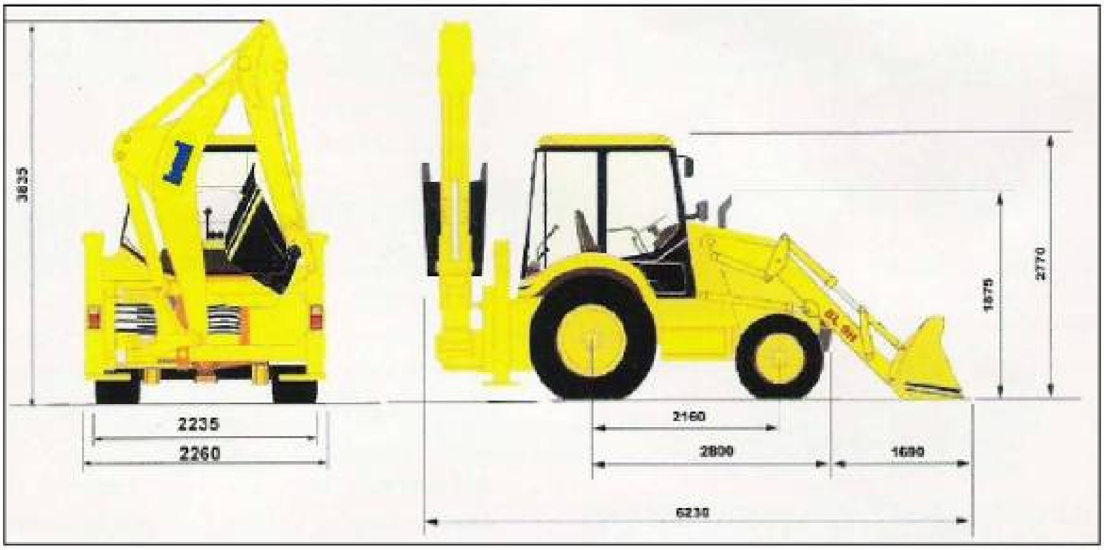
Minimum Specification

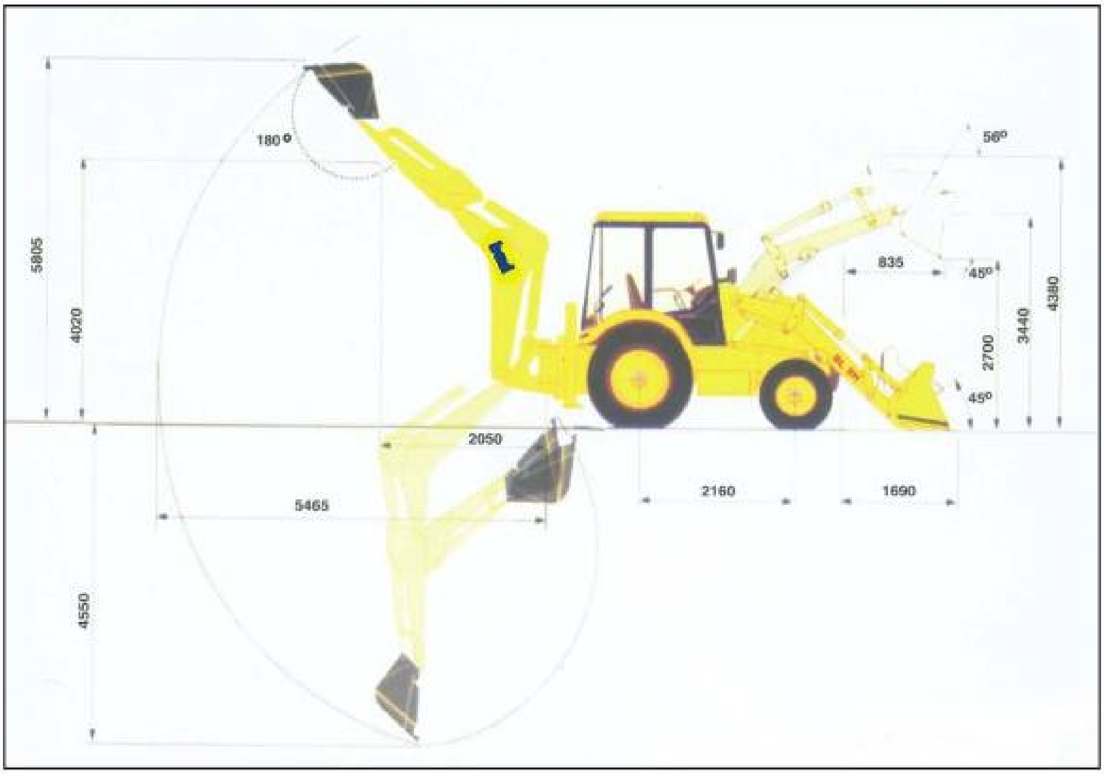
Loader Bucket Capacity : 1.0m3

Backhoe bucket capacity : 0.24 m3

Operating mass : 8000 kg

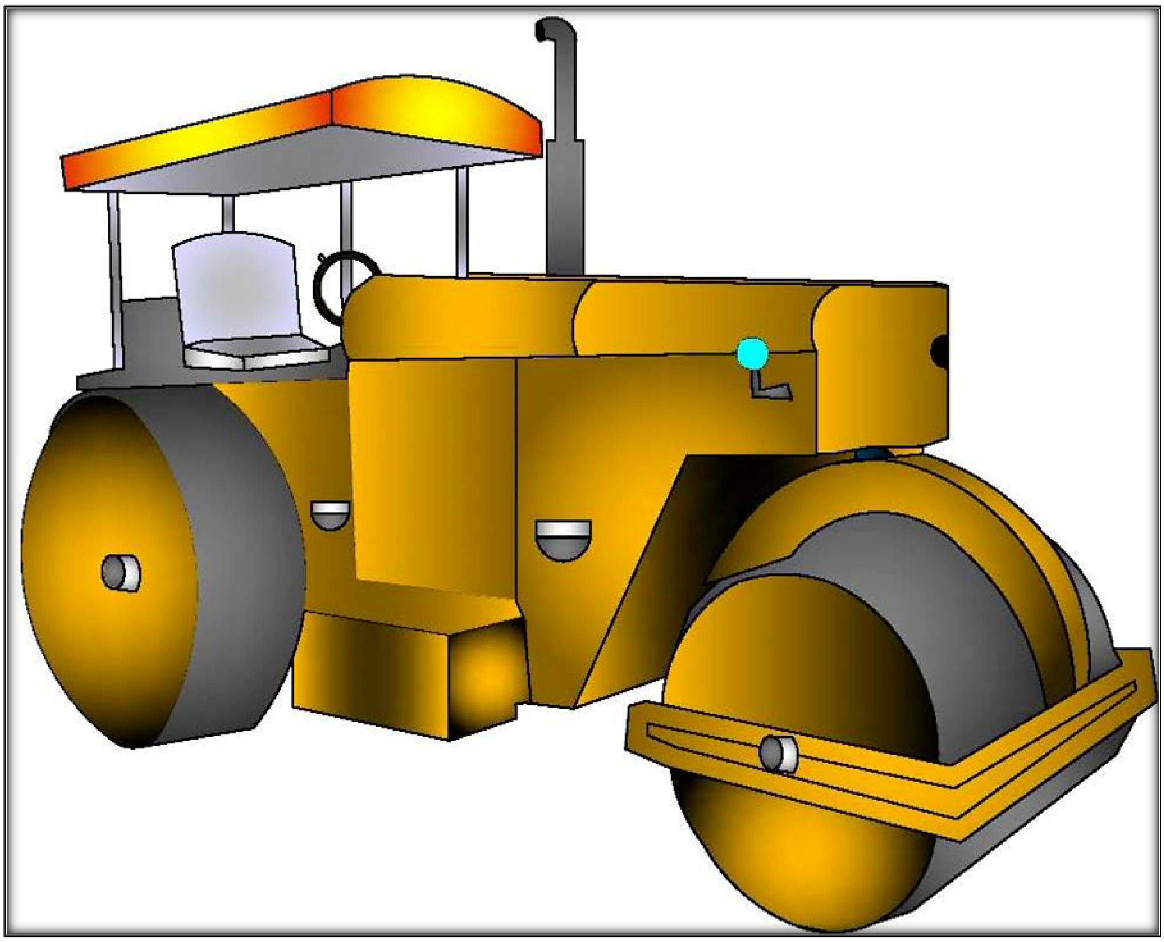
Typical Dimensions:


3835
2235
2260
2160
2800
1690
6230
1675
2770


180°
5805
4020
56°
835
45°
45°
2700
3440
4380
2050
5465
2160
1690
4550

Typical Specification Of Road Roller/Compactor

Typical Drawing for Road Roller (Diesel) :



1.255 Typical Technical specification

Overall Dimensions	MM
Rolling width	1830
Height of Roof	2620
Height without roof	1980
Wheel Base	3015
Overall length	5080
Diameter of front Roll	5080
Width of Front Roll	508
Diameter of Rear Roll	1450
Width of Rear Roll	508
Turning Radius (Inner)	3450
23. Turning Radius (outer)	5800
Weights	33.92 kg ± 5%
Standard Weight	8 Tonnes ± 5%
With water Ballast	9 Tonnes ± 5%
With Sand Ballast	10 Tonnes ± 5%
Ground Pressure per CM/Width	Front
Unballasted	29.30 kg ± 5%
Ballasted Water Sand	32.33 kg ± 5%
36. BHP (Continuous)	35 @ 1500 R.P.M
Rear	47.24 ± 5%
58.22 ± 5%	61.17 ± 5%

Excerpt from CPWD specifications, 1996 volume I & VI with up-to-date correction slip nos. 1 to 19 & revised CPWD specifications 2002, for mortar, cement concrete & RCC till these are amended/modified along with Nabhi's commentary on CPWD specifications - Volume I & II.
AND
Manual on municipal solid waste management published by ministry of urban development, government of India. May, 2000.