

cols. 6 and 7, a second sample of the size given in col. 4 shall be taken and examined for the requirements. The lot shall be considered to have satisfied these requirements. The lot shall be considered to have satisfied these requirements if the cumulative sample is less than or equal to the corresponding acceptance number given in col. 6, otherwise not.

F-1.5 Reversion Test

F-1.5.1 The lot, having satisfied visual and dimensional requirements, shall be tested for reversion as given in 18.9.4.4.

F-1.5.2 For this purpose, the number of pipes given for the first sample in col. 4 of Table F-2 shall be taken from the lot. The sample pipe failing the reversion test shall be considered as defective. The lot shall be deemed to have met the requirements given in this specification for the reversion test, if the number of defectives found in the first sample is less than or equal to the corresponding acceptance number given in col. 6. This lot shall be deemed not to have met these requirements, if the number of defectives found in the first sample is greater than or equal to the corresponding rejection number given in col. 7 if, however, the number of defectives in the first sample lies between the corresponding acceptance and rejection numbers given in col. 6 and col. 7, a second sample of size given in col. 4 shall be taken and examined for the requirements. The lot shall be considered to have satisfied the requirements, if the number of defectives found in the cumulative sample is less than or equal to the corresponding acceptance number given in col. 6, otherwise not.

TABLE F-2
Scale of Sampling for Reversion, Vicat Softening Temperature and Density Test
(Clause F-1.5.2, F-1.6.2 and F-1.7.2)

<i>Sl. No.</i>	<i>Number of pipes in the lot</i>	<i>Sample number</i>	<i>Sample size</i>	<i>Cumulative sample size</i>	<i>Acceptance number</i>	<i>Rejection number</i>
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(i)	Up to 1000	First	5	5	0	2
		Second	5	10	1	2
(ii)	1001 to 3000	First	8	8	0	2
		Second	8	16	1	2
(iii)	3001 to 10000	First	13	13	0	2
		Second	13	26	1	2
(iv)	10001 & above	First	20	20	0	3
		Second	20	40	3	4

F-1.6 Vicat Softening Test

F-1.6.1 The lot, having satisfied visual and dimensional requirements shall be tested for Vicat softening temperature as given in 18.9.4.5.

F-1.6.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be the same as that for reversion under F-1.5.2 using Table F-2.

F-1.7 Density

F-1.7.1 The lot, having satisfied the visual and dimensional requirements, shall be tested for density as given in 18.9.4.6.

F-1.7.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be the same as that for reversion under F-1.5.2 using Table F-2.

F-1.8 Resistance to External Blow at 0°C

F-1.8.1 The lot, having been found satisfactory according to F-1.4, F-1.5, F-1.6 and F-1.7 shall be tested for resistance to external blow at 0°C as given in 18.9.5.3.

F-1.8.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be as specified in Table 18.18 and Table F-3.

TABLE F-3
Scale of Sampling for Resistance to External Blow at 0°C

<i>Sl. No.</i>	<i>Number of pipes in the lot</i>	<i>Sample number</i>	<i>Sample size</i>	<i>Cumulative sample size</i>	<i>Acceptance number</i>	<i>Rejection number</i>
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(i)	Up to 3000	First	3	3	0	2
		Second	3	6	1	2
(ii)	3001 to 10000	First	3	5	0	2
		Second	5	10	1	2
(iii)	10000 & above	First	8	8	0	2
		Second	8	10	1	2

F-1.9 Internal Hydrostatic Pressure Test (Acceptance Test)

F-1.9.1 The lot having been found satisfactory according to F-1.4, F-1.5, F-1.6, F-1.7 and F-1.8 shall be subjected to the requirements of the acceptance test for internal hydrostatic pressure as given in 18.9.5.1 and Table 18.17 Sl. No. (i). The number of pipes to be taken from the lot shall depend on the size of the lot and shall be according to Table F-4.

TABLE F-4
Scale of Sampling for Internal Hydrostatic Test
(Clause F-1.9.1 and F-1.9.3)

<i>Sl. No.</i>	<i>Number of pipes in the lot</i>	<i>Sample size</i>	<i>Acceptance number</i>
(1)	(2)	(3)	(4)
(i)	Up to 3000	2	0
(ii)	3001 to 10000	3	0
(iii)	10000 & above	5	0

F-1.9.2 The pipes shall be taken at random from the lot. In order to ensure the randomness of selection, procedures given in IS 4905 may be followed.

F-1.9.3 Number of Tests and Criteria for Conformity

The number of test samples shall be as given in Table F-4. The lot shall be considered to have satisfied the requirements for this test, if the number of test samples failing in this requirement is equal to the corresponding acceptance number given in column 4 of Table F-4.

F-2 TYPE TESTS

F-2.1 Type tests are intended to prove the suitability and performance of a new composition or a new size of pipe. Such tests, therefore, need to be applied only when a change is made in polymer composition or when a new size of pipe is to be introduced. Type test for compliance with 18.9.4.2, 18.9.4.3, 18.9.5.1 (Type test only) and 18.9.5.4 shall be carried out.

F-2.1.1 Verification of Malfunction Temperature T_{mal}

For this test, the manufacturer to the testing authority one assembly, selected preferably from a regular production lot.

F-2.1.2 Opacity

For this test, the manufacturer or the supplier shall furnish to the testing authority one sample of the pipe of the thinnest wall section, selected preferably from a regular production lot.

F-2.1.2.1 The sample so selected shall be tested for compliance with requirements for opacity as given in 18.9.4.2.

F-2.1.2.2 If the sample passes the requirements of the opacity test, the type of the pipe under consideration shall be considered to be eligible for approval, which shall be valid for a period of one year.

F-2.1.2.3 In case the sample fails in the test, the testing authority, at its discretion, may call for a fresh sample and subject the same to the opacity test. If the sample passes the repeat test, the type of pipe under consideration shall be considered eligible for approval. If the sample fails in the repeat test, the type of pipe shall not be approved. The manufacturer or the supplier may be asked to improve the design and re-submit the product for type approval.

F-2.1.2.4 At the end of the validity period (normally one year) or earlier, if necessary, the testing authority may call for a fresh sample for opacity test for the purpose of type approval.

F-2.1.3 *Test for Effect on Water*

For this type test, the manufacturer or the supplier shall furnish to the testing authority three samples of the smallest size of pipe taken from each machine (selected preferably from a regular production lot).

F-2.1.3.1 Three samples so selected shall be tested for compliance with the requirements for effect on water as given in 18.9.4.3.

F-2.1.3.2 If all three samples pass the requirements for effect on water, the type test of the pipe under consideration shall be considered to be eligible for approval, which shall be normally valid for a period of one year.

F-2.1.3.3 In case any of the samples fails in this test, the testing authority, at its discretion, may call for fresh samples not exceeding the original number, and subject them to the test for effect on water. If, in the repeat test, no single failure occurs, the type of pipe under consideration shall be considered eligible for type approval. If any of the samples fails in the repeat test, the type of pipe shall not be approved. The manufacturer or the supplier may be asked to improve the design and resubmit the product for type approval.

F-2.1.3.4 At the end of the validity period (normally one year) or earlier, if necessary, the testing authority may call for fresh samples for effect on water test for the purpose of type approval.

F-2.1.4 *Internal Hydrostatic Pressure Test (Type Test) and thermal Stability*

For this type test, the manufacturer or the supplier shall furnish to the testing authority, three samples of pipes of different diameters and different classes (selected preferably from a regular production lot).

F-2.1.4.1 Three samples so selected shall be tested for compliance with the requirements of type test given in Table 18.9.4.3.

F-2.1.4.2 If all the three samples pass the requirements of the quality test, the type of pipe under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of one year.

F-2.1.4.3 In case any of the samples fail in this test, the testing authority, at its discretion, may call for fresh samples not exceeding the original number and subject them to the type test. If, in the repeat test, no single failure occurs, the type of pipe shall be considered for type approval. If any of the samples fails in the repeat tests, the type of pipe shall not be approved. The manufacturer or the supplier may be asked to improve the design and resubmit the product for type approval.

F-2.1.4.4 At the end of the validity period (normally one year) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

F-2.1.5 Tensile Strength Test (Type Test)

For this type test, the manufacturer or the supplier shall furnish to the testing authority, five samples of pipe of different diameters and different class (selected preferably from a regular production lot).

F-2.1.5.1 Five samples so selected shall be tested for compliance with the requirements of type test given in 18.9.5.4.

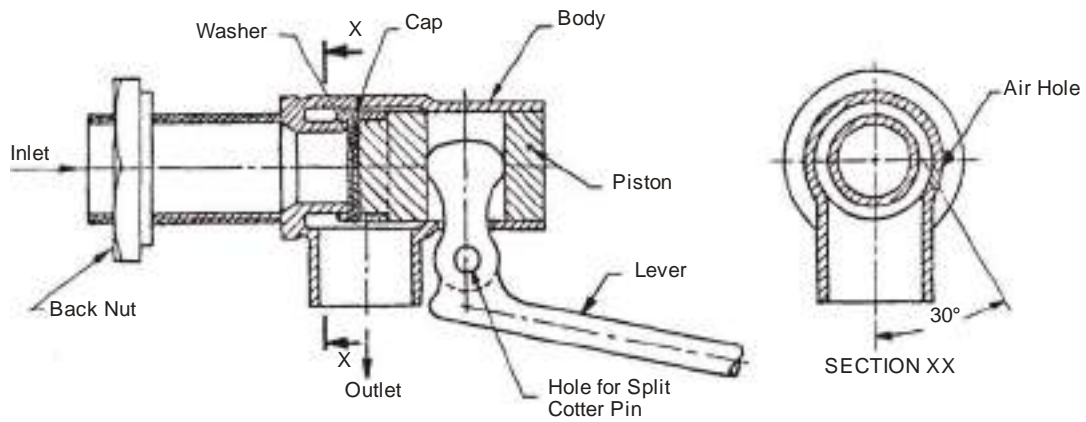
F-2.1.5.2 If all the five samples pass the requirement of the quality test, the type test of pipe under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of one year.

F-2.1.5.3 In case any of the samples fails in this test, the testing authority, at its discretion, may call for fresh samples not exceeding the original numbers and subject them to the type test. If, in the repeat test no single failure occurs, the type of pipe shall be considered for type approval. If any of the samples fail in the repeat tests, the type of pipe shall not be approved. The manufacturer or the supplier may be asked to improve the design and resubmit the product for type approval.

F-2.1.5.4 At the end of the validity period (normally one year) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

BALL VALVE (ASSEMBLY)

Sub Head : Water Supply
Clause : 18.3.1

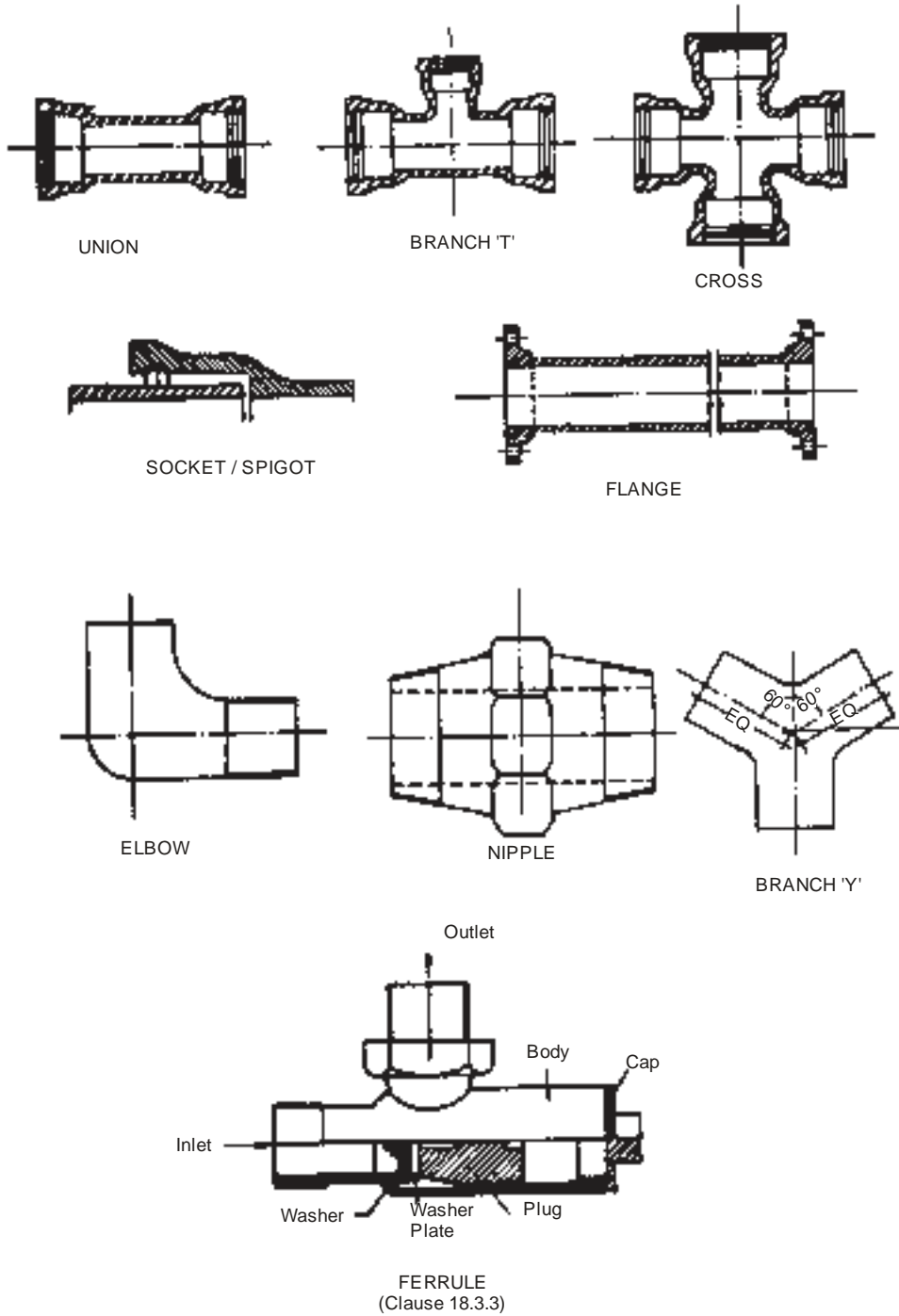


Note : The shapes of the component parts are only illustrative but the dimensions and minimum requirements, where specified, are binding.

Fig. 18.1 : Ball Valve (Assembly)

FITTINGS & SPECIALS

Sub Head : Water Supply
Clause : 18.3.9

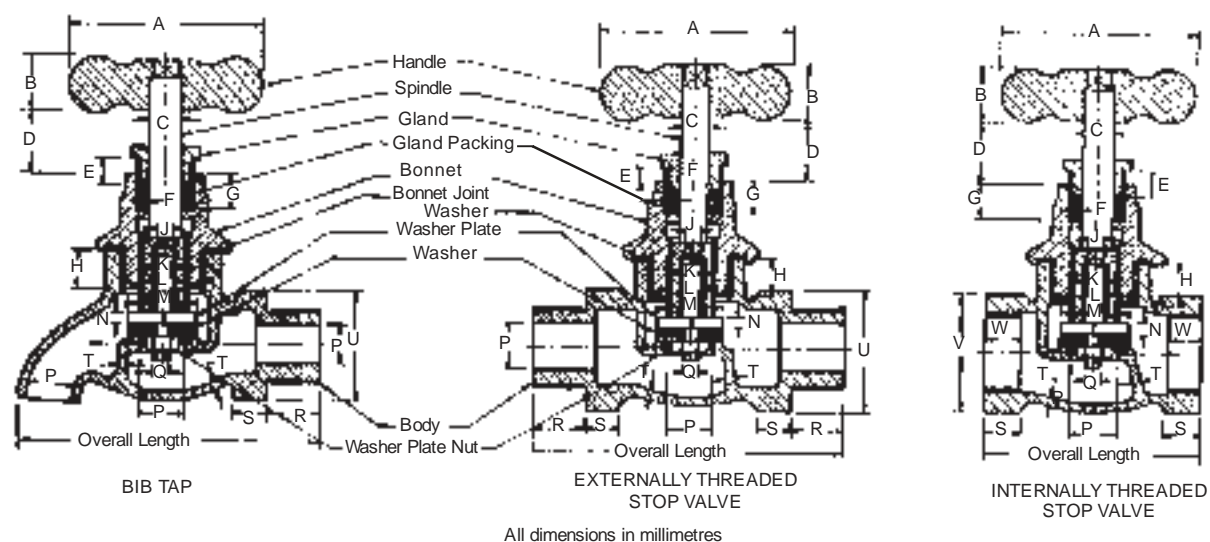


Drawing not to Scale

Fig. 18.2 : Fittings & Specials

BIP TAP & STOP VALVE

Sub Head : Water Supply
Clause : 18.3.2



Dimensions →	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V	W	Lift of Washer Plate (with Washer in Position, Min.)
Nominal Sizes ↓														+ 0.0 - 0.5								
	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
8	47.8	13.3	7.8	16.5	6.3	2.0	7.9	7.0	3.8	10.0	M 20x 1.5	14.3	2.8	6.5	2.4	11.0	4.7	1.6	15.2	19.5	7	3.5
10	54.0	14.0	9.4	18.7	7.5	2.0	9.5	9.5	4.7	11.5	M 20 x 1.5	15.9	3.2	9.0	3.2	11.4	7.9	2.0	20.8	23.3	7	4
15	54.0	14.0	9.4	19.0	7.5	2.0	9.5	11.0	5.6	11.5	M 24 x 1.5	19.0	3.2	13.0	4.1	15.0	9.5	2.0	25.6	28.3	9	4.5
20	60.4	15.7	10.9	20.1	8.9	2.5	11.1	12.5	6.4	13.5	M 30 x 1.5	25.4	4.0	18.0	4.9	16.3	10.3	2.0	30.5	33.0	10.5	6
25	66.8	18.0	12.5	23.0	10.1	2.5	12.7	13.0	7.1	17.0	M 39 x 1.5	33.3	4.0	23.0	4.9	19.1	11.0	2.8	37.6	42.4	11.5	7
32	74.6	20.5	14.1	30.9	11.4	2.5	14.3	16.0	7.8	19.0	M 48 x 1.5	40.1	4.3	30	5.9	21.4	12.7	3.2	47.2	52.1	13.5	9.5
40	82.5	22.0	15.7	33.3	12.7	2.5	15.9	17.5	8.6	20.5	M 56 x 1.5	47.7	5.5	36	6.6	21.4	14.3	3.2	56.4	58.5	13.5	11
50	95.0	25.3	17.3	35.9	14.0	2.5	17.4	17.5	12.5	26.0	M 72 x 1.5	63.5	6.3	46	8.3	25.1	15.9	4.0	70.1	71.5	16.5	14.5

Note 1 : Length of thread R includes cut back under hexagon, if any.

Note 2 : The values of K are for core diameter.

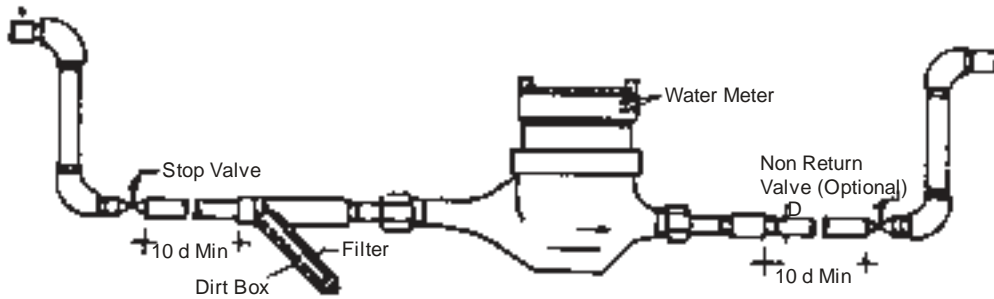
Note 3 : The diameter of U and V are for face to face.

Note 4 : The dimension F is packing space.

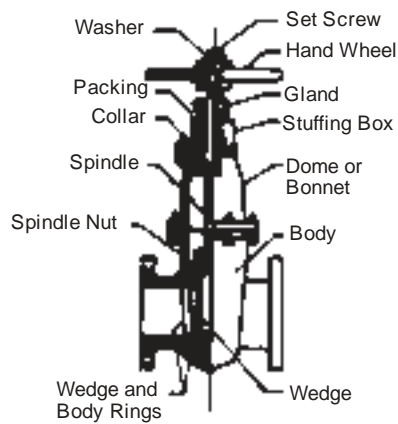
Fig. 18.3 : Bib Tap & Stop Valve

COCKS VALVES & METER

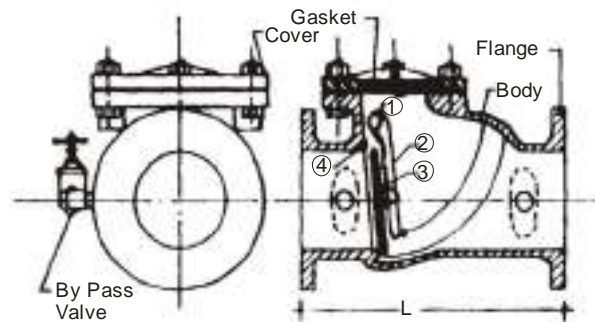
Sub Head : Water Supply
Clause : 18.3.15



WATER METER ASSEMBLY



SLUICE VALVE
(Clause 18.3.13)



NON-RETURN VALVE
(Clause 18.3.8)

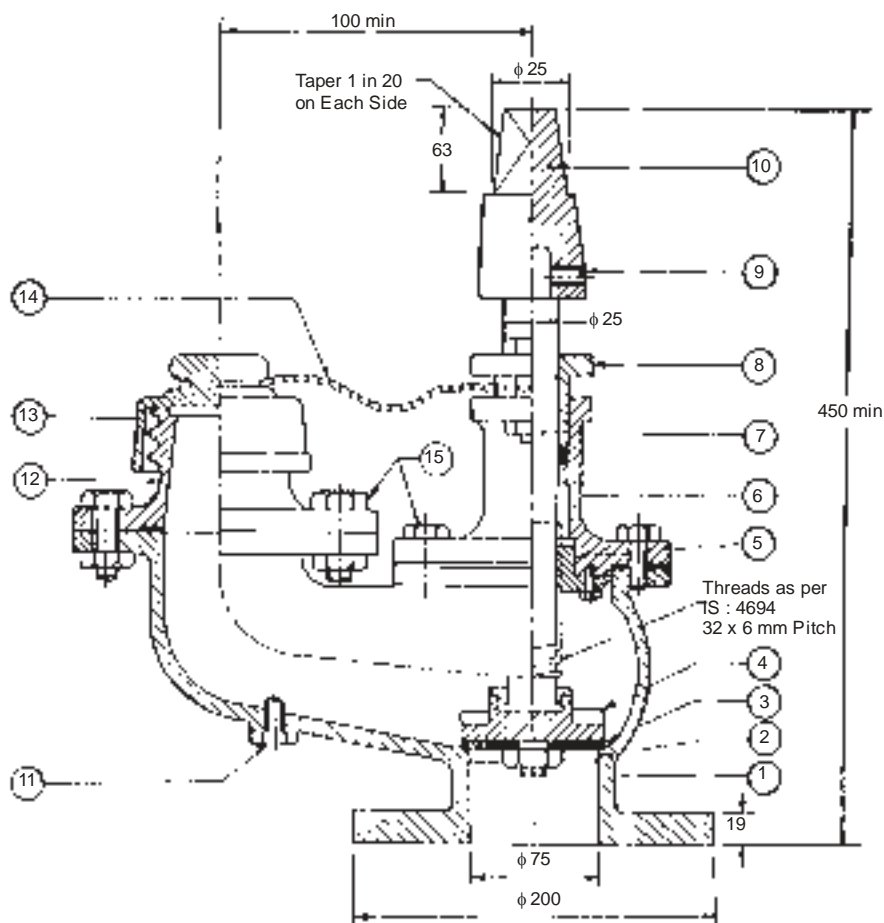
- ① Hinge Pin
- ② Hinge
- ③ Door
- ④ Body Ring

Drawing not to Scale
All Dimensions are in MM

Fig. 18.4 : Cocks Valves & Meter

UNDERGROUND FIRE HYDRANT, SLUICE-VALVE GATE

Sub Head : Water Supply
Clause : 18.3.4



No.	Description	Mat.	Mat. Specification
1	Body	C.I.	IS 210-1972 FG-200
2	Valve Seat	G.M.	IS 318-1981 LTB-2
3	Washer	Rubber	IS 937-1981
4	Valve	G.M.	IS 318-1981 LTB-2
5	Spindle Nut	G.M.	IS 318-1981 LBT-2
6	Bonnet	C.I.	IS 210-1978 FG-200
7	Spindle	Brass	IS 319-1989
8	Gland	C.I.	IS 210-1978 FG-200
9	Grush Screw (12 mm)	M.S.	IS 6094-1981
10	Spindle Cap	C.I.	IS 210-1978 FG-200
11	Drain Bolt	M.S.	-
12	Outlet	G.M.	IS 318-1981 LTB-2
13	Cap	C.I.	IS 210-1978 FG-200
14	Chain	Gal. MS	-
15	Nut and Bolt	M.S.	-

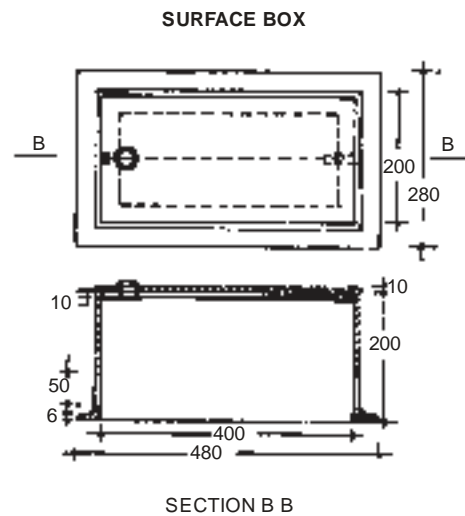
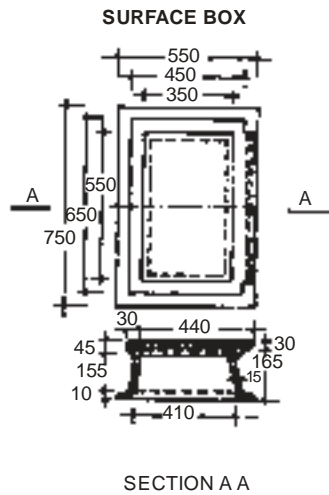
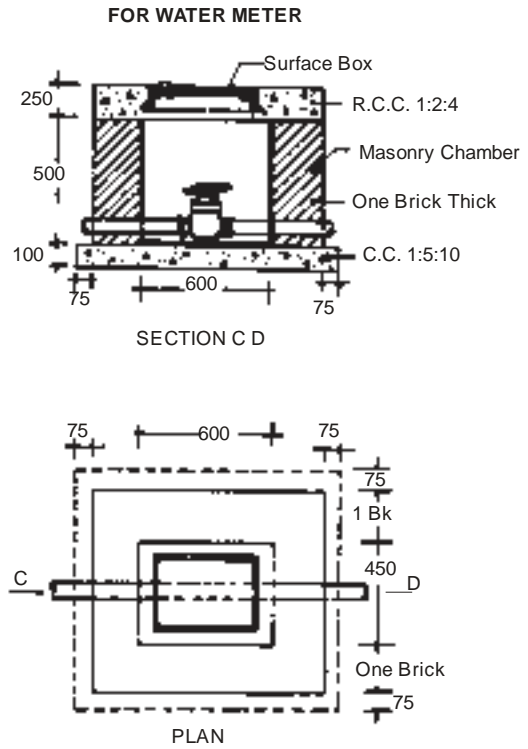
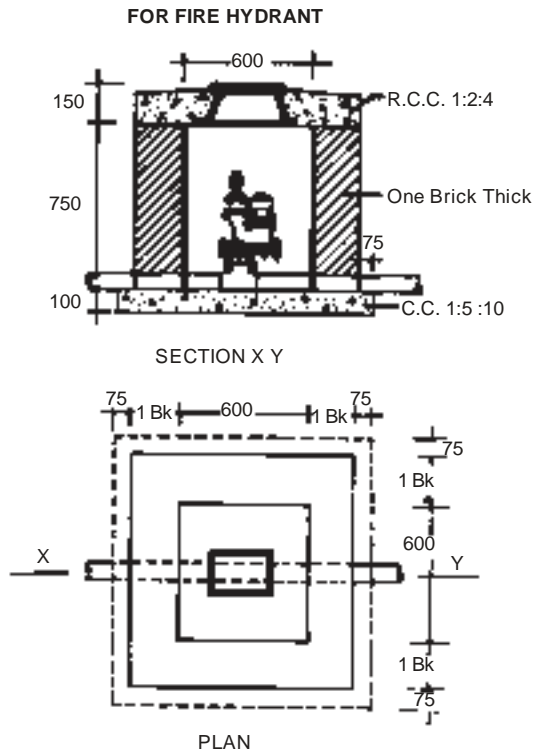
TOLERANCES AS PER IS 2102-1962

All Dimensions are in MM

Fig. 18.5 : Underground Fire Hydrant, Sluice-Valve Gate

MASONRY CHAMBERS & SURFACE BOXES

Sub Head : Water Supply
Clause : 18.3.14



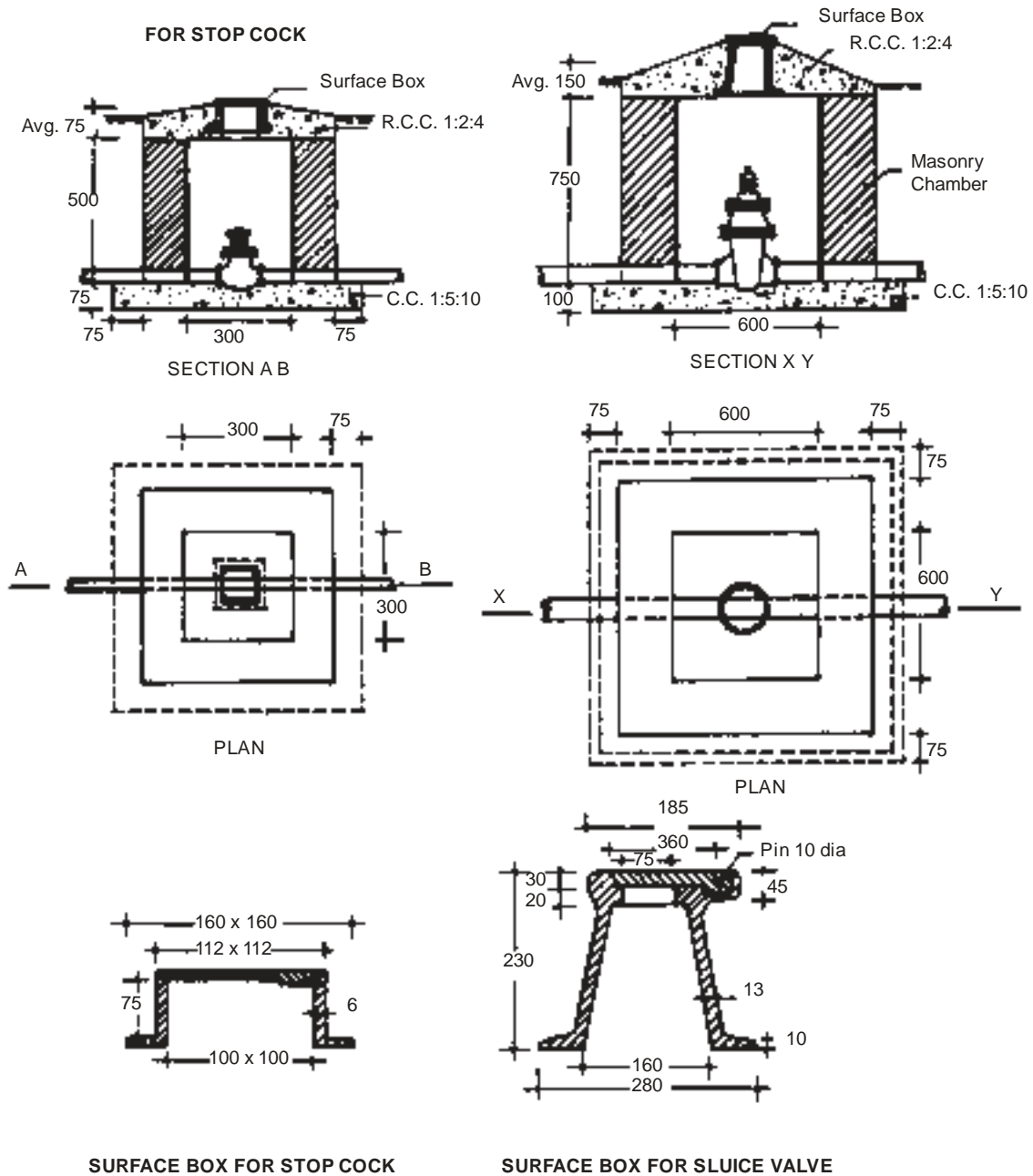
Drawing not to Scale
All Dimensions are in MM

Fig. 18.6 : Masonry Chambers & Surface Boxes

MASONRY CHAMBERS & SURFACE BOXES (Contd.)

Sub Head : Water Supply
Clause : 18.3.14

FOR SLUICE VALVE

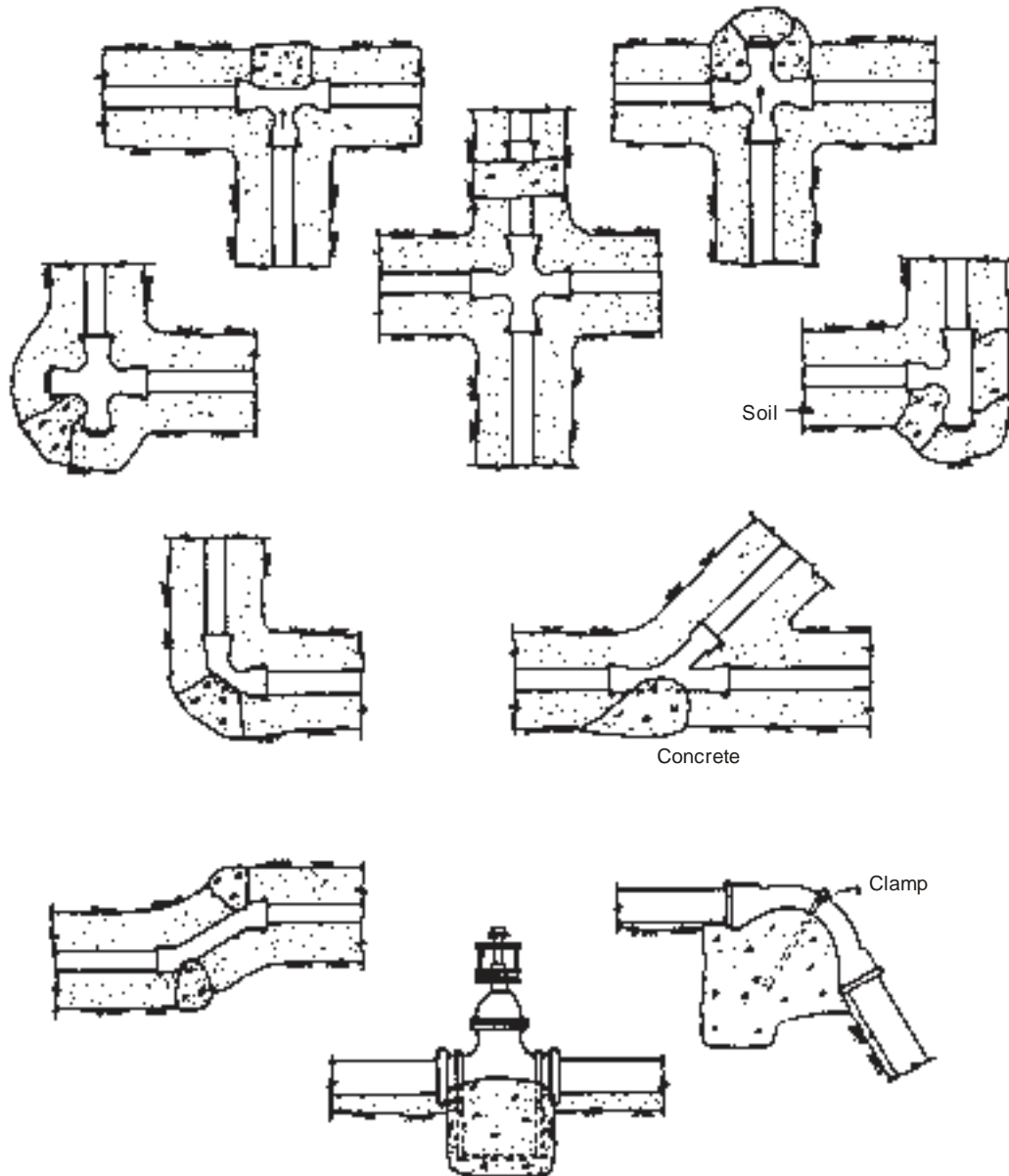


Drawing not to Scale
All Dimensions are in MM

Fig. 18.7 : Masonry Chambers & Surface Boxes (Contd.)

THRUST BLOCKS

Sub Head : Water Supply
Clause : 18.4.6

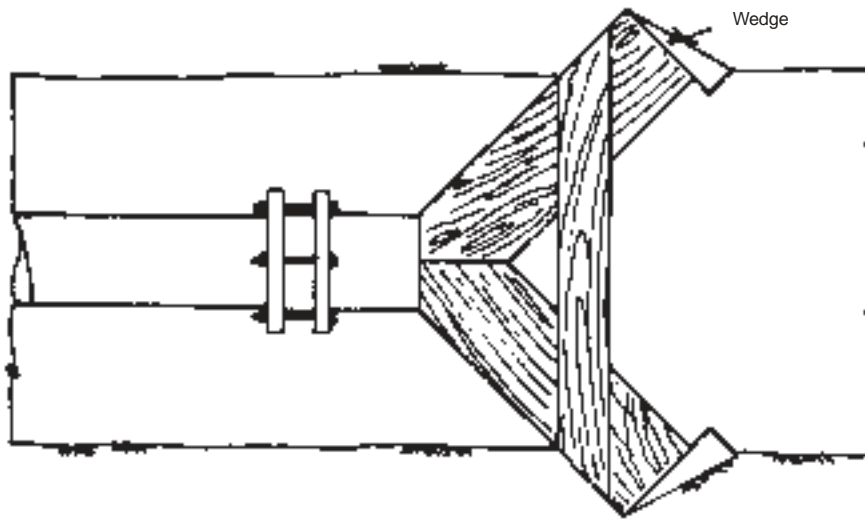


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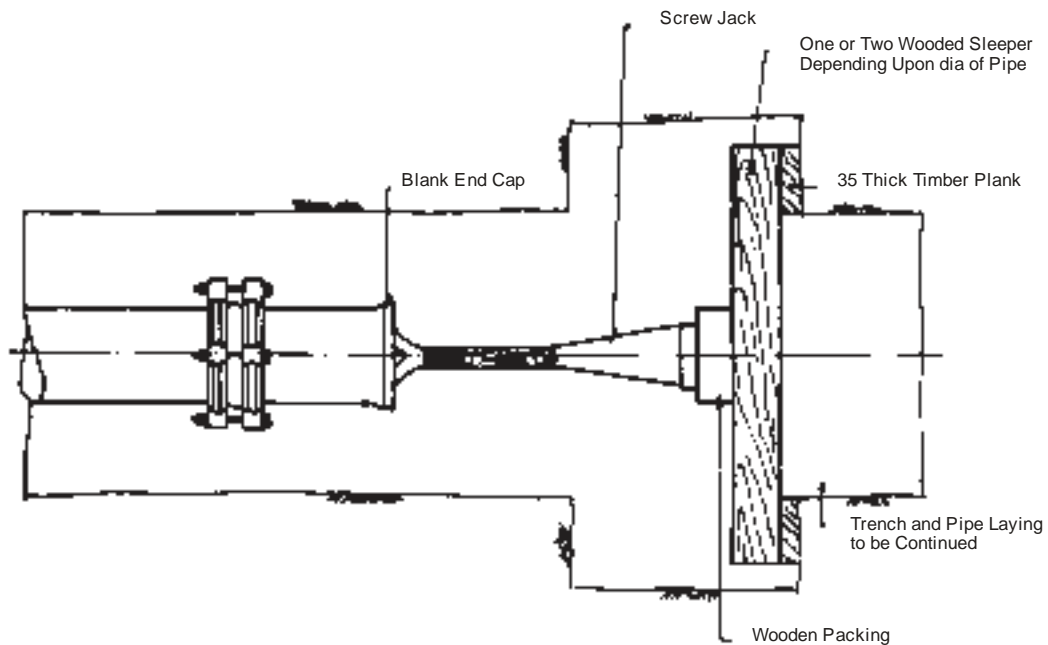
Fig. 18.8 : Thrust Blocks

HYDROSTATIC TESTS (END CLOSURE FOR PIPES)

Sub Head : Water Supply
Clause : 18.4.8



FOR PIPES UPTO 125 NOMINAL DIA



FOR PIPES OF NOMINAL DIA OVER 125

Drawing Not to Scale
All Dimensions are in mm

Fig. 18.9 : Hydrostatic Test (End Closure for Pipes)

SUB HEAD : 19.0

DRAINAGE

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LIST OF BUREAU OF INDIAN STANDARDS (BIS) CODES

<i>S. No.</i>	<i>IS No.</i>	<i>Subject</i>
1.	IS 458	Pre-cast Concrete Pipes (with and without reinforcement).
2.	IS 651	Specification for Salt Glazed Stoneware Pipes and Fittings.
3.	IS 783	Code of Practice for Laying Concrete Pipes
4.	IS 1726	Specification for Cast Iron Manhole Covers and Frames
5.	IS 1729	Cast Iron /Ductile Iron Drainage Pipes and Pipe Fittings Socket and Spigot Series for Over-ground Non-pressure Pipe Line.
6.	IS 4127	Code of Practice for Laying of Glazed Stone Ware Pipes
7.	IS 4885	Specifications for Sewer Bricks
8.	IS 12592	Pre-cast Concrete Manhole Covers and Frames – Specifications

19.0 DRAINAGE

19.0 TERMINOLOGY

Benching (Fig. 19.8): The sloped floor of a manhole or an inspection chamber on both sides and above the top of the channel.

Channel: The open waterway through which sewage, storm water or other liquid waste flow at the invert of a manhole or an inspection chamber.

Cleaning Eye (Fig. 19.8): An access opening having a removable cover to enable obstructions to be cleared by means of a drain rod.

Connections: The junction of a foul water drain, surface water drains with public sewer, cesspool soak-way or other water courses.

Flushing Tank (Fig. 19.1) : Tank used to flush the sewer lime/manholes.

Curb, Kerb: The stone margin of a side walk.

Dispersion Trench: A trench in which open jointed pipes surrounded by coarse aggregate media and overlaid by fine aggregate, are laid. The effluent from septic tank gets dispersed through the open joints and is absorbed in the surrounding soil.

Depth of Manhole: The vertical distance from the top of the manhole to the outgoing invert of the main drain channel.

Drain: A line of pipes including all fittings and equipment, such as manholes traps, gullies and floor traps used for the drainage of a building, or a number of buildings or yards appurtenant to the buildings, within the same cartilage. Drain shall also include open channels used for conveying surface water.

Drainage: The removal of any liquid by a system constructed for the purpose.

Drop Connection (Fig. 19.8): A branch drain of which the last length of piping of the incoming drain, before connection to the sewer, is vertical.

Drop Manhole (Fig. 19.8): A manhole incorporating a vertical drop for the purpose of connecting a sewer or drain at high level to one at lower level.

Effluents

(a) **Tank Effluent:** The supernatant liquid discharge from a septic tank.

(b) **Filter Effluent:** The liquid discharged from a biological filter.

Gully Chamber (Fig. 19.2): The chamber built of masonry around a gully trap, for housing the same.

Gully Trap (Fig. 19.2): A trap water seal provided in a drainage system in a suitable position to collect waste water from the scullery, kitchen sink, wash basins, baths and rain water pipes.

Haunching (Fig. 19.11): Concrete bedding with additional concrete at the sides of the pipe.

Junction Pipe: A pipe incorporating one or more branches.

Invert: The lowest point of the interior of a sewer or drain at any cross action.

Inspection Chamber: A water tight chamber constructed in any house drainage system which takes wastes from gully traps and disposes off to manhole with access for inspection and maintenance.

Interceptor Manhole (Interceptor Chamber): A manhole incorporating an intercepting trap, and providing means of access thereto and equipped with a fresh air inlet on the upstream side of the trap.

Manhole (Manhole Chamber): Any chamber constructed on a drain or sewer so as to provide access thereto for inspection testing or the clearance of obstruction.

Rest Bend (Duck Foot Bend): A bend supported in a vertical position by a foot formed at its base.

Saddle: A purpose made fitting, so shaped as to fit over a hole cut in a sewer or drain, and used to form connections.

Soffit: The highest portion of the interior of a sewer or drain at any cross-section.

Soil Waste: The discharge from water closets, urinals, slope sinks, stable or cowshed gullies and similar appliances.

Soil Pipe: Which receives the discharges from soil fitments, such as water closets urinals, and slope sinks.

Sullage Waste Water: Spent water from baths, wash basins kitchen sinks, and similar appliances which does not contain human or animal excreta.

Sewer: A closed drain carrying night soil and other water borne waste.

Surface Water Drain: A drain conveying surface water including storm water.

Surface Water: The run off from precipitation, other water that flows over surface of the ground.

Sub Soil Water: Water occurring naturally below the surface of the ground.

Sludge: The settled solid matter in semi solid condition.

Soak Pit (Seepage Pit Soak Way) (Fig. 19.17) : A pit through which effluent is allowed to seep or leach into the surrounding soil.

Septic Tank (Fig. 19.15 & 19.16) : A water tight single storied tank in which sewage is retained sufficiently long to permit sedimentation of suspended solids and partial digestion of settled sludge by anaerobic bacteria.

Scum: The greasy and other substances floating on the surface of sewage.

Vent Pipe: A pipe line installed to provide flow of air to or from a drainage system or to provide circulation of air within such system to protect trap seals from siphonage and back flow.

Waste Water: The discharge from wash basins, sinks and similar appliance, which does not contain human excreta.

19.1 GENERAL REQUIREMENTS

19.1.1 In designing a drainage system for building(s), the aim shall be to provide a self cleansing conduit for the conveyance of soil, waste, surface or sub-surface waters and for the removal of such wastes speedily and efficiently to a sewer or other outlet, without risk of nuisance and hazard to health.

19.1.2 The discharge of water through a domestic drain is intermittent and limited in quantity and therefore, small accumulations of solid matter are liable to form in the drains between the building and the public sewer. There is usually a gradual shifting of these deposits as discharges take place. Gradients shall be sufficient to prevent these temporary accumulations building up and blocking the drains.

19.1.3 Normally, the sewer shall be designed for discharging three times the dry weather flow flowing half-full with a minimum self cleansing velocity of 0.75 metre per second. The approximate gradients which give this velocity for the sizes of pipes likely to be used in building drainage and the corresponding discharges when flowing half-full are given in Table 19.1. The sizes and slopes shall conform to Local Municipal Bye-laws.

19.1.4 In cases, where it is practically not possible to conform to the minimum gradients, a flatter gradient may be used but the minimum velocity in such cases shall on no account be less than 0.61 metres per second.

19.1.5 On the other hand, it is undesirable to employ gradients giving velocity of flow greater than 2.4 metres per second. Where it is unavoidable, cast iron pipes shall be used. The approximate gradients which give a velocity of 2.4 metres per second for the various sizes of pipes and the corresponding discharge when flowing half-full are given in Table 19.1.

TABLE 19.1
Gradients for Sewers

<i>Diameter mm</i>	<i>Minimum Gradient</i>		<i>Maximum Gradient</i>	
	<i>Gradients</i>	<i>Discharge cum/Min.</i>	<i>Gradients</i>	<i>Discharge cum/Min.</i>
100	1 in 57	0.18	1 in 5.6	0.59
150	1 in 100	0.42	1 in 9.7	1.32
200	1 in 145	0.73	1 in 14	2.4
230	1 in 175	0.93	1 in 17	2.98
250	1 in 195	1.10	1 in 19	3.60
300	1 in 250	1.70	1 in 24.5	5.30

19.2 PIPES AND SPECIALS

19.2.1 Glazed Stone Ware Pipes and Fittings

All pipes with spigot and socket ends and fittings shall conform to class SP1 of IS 651. These shall be sound, free from visible defects such as fire cracks or hair cracks. The glaze of the pipes shall be free from crazing. The pipes shall give a sharp clear tone when struck with a light hammer. There shall be no broken blisters. The thickness of pipes shall be as given in the Table 19.2.

TABLE 19.2
Stoneware Pipes

<i>Internal Diameter (mm)</i>	<i>Mean Thickness of the Barrel and Socket (mm)</i>
100	12
150	15
200	16
230	19
250	20
300	25
350	30
400	35
450	37

The length of pipes shall be 60, 75, 90 cm exclusive of the internal depth of the socket. The pipes shall be handled with sufficient care to avoid damage to them.

19.2.1.1 S.W. Gully Trap (Fig. 19.2): Gully traps shall conform to IS 651. These shall be sound, free from visible defects such as fire cracks, or hair cracks. The glaze of the traps shall be free from crazing. They shall give a sharp clear tone when struck with light hammer. There shall be no broken blisters.

Each gully trap shall have one C.I. grating of square size corresponding to the dimensions of inlet of gully trap. It will also have a water tight C.I. cover with frame inside dimensions 300 x 300 mm the cover weighing not less than 4.50 Kg and the frame not less than 2.70 Kg. The grating, cover and frame shall be of sound and good casting and shall have truly square machined seating faces.

19.2.1.2 Laying and Jointing Stone Ware Pipes : For all sewers and drains, glazed stoneware pipes shall be used as far as possible in preference to other types of pipes. These are suitable, particularly where acid effluents or acid sub-soil conditions are likely to be encountered.

- (i) *Trenches:* Specifications described in 19.2.2.1 shall apply, as far as possible.

The trench shall be so dug that the pipe can be laid to the required alignment and at the required depth. When the pipe line is under a roadway, a minimum cover of 90 cm is recommended for adoption, but it may be modified to suit local conditions. The trench shall be excavated only so far in advance of pipe laying as specified by the Engineer-in-Charge. The trench shall be so shored and drained that the workmen may work therein safely and efficiently. The discharge of the trench dewatering pumps shall be conveyed either to drainage channels or to natural drains.

The excavation shall be carried out with manual labour or with suitable mechanical equipment as approved by the Engineer-in-Charge.

Unless otherwise specified by the Engineer-in-Charge, the width at bottom of trenches for different diameters of pipes laid at different depths shall be as given below:—

- (a) For all diameters, up to an average depth of 120 cm, width of trench in cm = diameter of pipe + 30 cm.
- (b) For all diameters for depths above 120 cm, width of trench in cm = diameter of pipe + 40 cm.
- (c) Notwithstanding (a) and (b) the total width of trench shall not be less than 75 cm for depths exceeding 90 cm.

The width of trench in the upper reaches shall be increased as described in sub-head 'Earthwork'.

- (ii) *Laying (Fig. 19.11) :* Where the pipes are laid on soft soil with maximum water table lying at invert level of the pipe, the pipes shall be bedded in cement concrete with thickness and mix as specified, projecting on each side of the pipe to the specified width of the trench (Fig. 19.11(i)). The pipes with their crown level at 1.20 m depth and less from ground shall be covered with 15 cm thick. Concrete above the crown of the pipe and sloped off to meet the outer edges of the concrete, to give a minimum thickness of 15 cm all-around the pipe (Fig. 19.11 (iii)). Pipes laid at a depth greater than 1.20 m at crown and maximum water table level rising above the invert level of pipe, shall be concreted at the sides up to the level of the centre of the pipe and sloped off from the edges to meet the pipe tangentially (Fig. 19.11(ii)).

The pipe shall be carefully laid to the alignments, levels and gradients shown on the plans and sections. Great care shall be taken to prevent sand etc. from entering the pipes. The pipes between two manholes shall be laid truly in a straight line without vertical or horizontal

undulation. The pipes shall be laid with socket ends facing upstream. The body of the pipe shall for its entire length rest on an even bed of concrete and places shall be excavated in the concrete to receive the socket of the pipe.

Where pipes are not bedded on concrete, the trench floor shall be left slightly high and carefully bottomed up as pipe laying proceeds, so that the pipe barrels rest on firm and undisturbed ground. If the excavation has been carried too low, the desired levels shall be made up with concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size) for which no extra payment shall be made.

If the floor of the trench consists of rock or very hard ground that cannot easily be excavated to smooth surface the pipe shall be laid on a levelling course of concrete as desired.

When S.W. pipes are used for storm water drainage, no concreting will normally be necessary. The cement mortar for jointing will be 1:3 (1 cement: 3 fine sand). Testing of joints will also not be done.

- (iii) *Jointing* : Tarred gasket or hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be slipped home well into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly home so as to fill not more than 1/4th of the total depth of the socket.

The remainder of the socket shall be filled with stiff mixture of cement mortar in the proportion of 1:1 (1 cement: 1 fine sand). When the socket is filled, a fillet shall be formed round the joint with a trowel forming an angle of 45 degree with the barrel of the pipe.

After a day's work any extraneous material shall be removed from the inside of the pipe. The newly made joints shall be cured for at least seven days.

- (iv) *Testing of Joints* : Stoneware pipes used for sewers shall be subjected to a test pressure of 2.5 m head of water at the highest point of the section under test. Before commencing test, the pipeline shall be filled with water and maintained full for 24 hours under head of 0.6 m of water. The test shall be carried out by suitably plugging the lower end of the drain and the ends of the connection if any and filling the system with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head, or the top may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitable for observation. The tolerance of two liters per centimeter of diameter per kilometer may be allowed during a period of 10 minutes.

If any leakage is visible, the defective part of the work shall be cut out and made good. A slight amount of sweating which is uniform may be overlooked, but excessive sweating from a particular pipe or joint shall be watched for and taken as indicating a defect to be made good.

Any joint found leaking or sweating, shall be rectified or embedded into 15 cm layer of cement concrete (1:2:4) 30 cm in length and the section retested.

- (v) *Refilling* : In cases where pipes are not bedded on concrete special care shall be taken in refilling trenches to prevent the displacement and subsequent settlement at the surface resulting in uneven street surfaces and dangers to foundations etc. The backfilling materials shall be packed by hand under and around the pipe, and rammed with a shovel and light tamper. This method of filling will be continued up to the top of pipe. The refilling shall rise evenly on both sides of the pipe continued up to 60 cm above the top of pipe so as not to disturb the pipe. No tamping should be done within 15 cm of the top of pipe.

- (vi) *Measurements* : The lengths of pipes shall be measured in running metres nearest to a cm as laid or fixed, from inside of one manhole to the inside of the other manhole. The length shall be taken along the centre line of the pipes over all fittings such as bends, junctions, etc. which shall not be measured separately.

Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

- (vii) *Rate* : The rate shall include the cost of materials and labour involved in all the operations described above excluding the cost of concrete which shall be paid for separately.

19.2.1.3 Fixing S.W. Gully Trap (Fig. 19.2)

- (i) *Excavation* : The excavation for gully traps shall be done true to dimensions and levels as indicated on plans or as directed by the Engineer-in-Charge.
- (ii) *Fixing* : The gully traps shall be fixed on cement concrete foundation 65 cm square and not less than 10 cm thick. The mix for the concrete will be 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size). The jointing of gully outlet to the branch drain shall be done similar to jointing of S.W. pipes described above.
- (iii) *Brick Masonry Chamber* : After fixing and testing gully and branch drain, a brick masonry chamber 300 x 300 mm (inside) in brick work of specified class in cement mortar 1:4 (1 cement: 4 fine sand) shall be built with a half brick thick brick work round the gully trap from the top of the bed concrete up to ground level. The space between the chamber walls and the trap shall be filled in with cement concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size). The upper portion of the chamber i.e. above the top level of the trap shall be plastered inside with cement mortar 1:3 (1 cement: 3 coarse sand), finished with a floating coat of neat cement. The corners and bottom of the chamber shall be rounded off so as to slope towards the grating.

C.I. cover with frame 300 x 300 mm (inside) shall then be fixed on the top of the brick masonry with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) and rendered smooth. The finished top of cover shall be left about 4 cm above the adjoining ground level so as to exclude the surface water from entering the gully trap.

- (iv) *Measurements* : The work shall be enumerated. Excavation shall be measured separately under relevant item of earth work.
- (v) *Rate* : The rate shall include the cost of materials and labour involved in all the operations described above, except earth work which shall be paid for separately.

19.2.2 Cement Concrete Pipes (with and without Reinforcement) (Light Duty, Non-Pressure)

The pipes shall be with or without reinforcement as required and shall be of class not lesser than NP2. These shall conform to IS 458 and shall be capable of withstanding a test pressure of 0.07 MPa (7 m head). The reinforced cement concrete pipes shall be manufactured by centrifugal (or spun) process while un-reinforced cement concrete pipes by spun or pressure process. All pipes shall be true to shape, straight, perfectly sound and free from cracks and flaws. The external and internal surface of the pipes shall be smooth and hard. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

Concrete used for the manufacture of un-reinforced and reinforced concrete pipes and collars shall not be leaner than 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate). The maximum size of

aggregate should not exceed one third of the thickness of the pipe or 20 mm whichever is smaller for pipes above 250 mm internal diameter. But for pipes of internal diameter 80 to 250 mm, the maximum size of aggregate should be 10mm. The reinforcement in the reinforced concrete pipes shall extend throughout the length of the pipe. The circumferential and longitudinal reinforcements shall be adequate to withstand the specified hydrostatic pressure and further bending stresses due to the weight of water when running full across a span equal to the length of pipe plus three times its own weight.

The dimensional requirements of concrete pipes are given in Appendix I.

The minimum clear cover for reinforcement in pipes and collars shall be as given in Table 19.3.

TABLE 19.3

<i>Sl. No.</i>	<i>Precast concrete pipe/collar</i>	<i>Minimum clear cover, mm</i>
(i)	Barrel wall thickness	
(a)	Upto and including 75 mm	8
(b)	Over 75 mm	15
(ii)	At spigot steps	5
(iii)	At end of longitudinal	5

Note : An effective means shall be provided for maintaining the reinforcement in position and for ensuring correct cover during manufacture of the unit. Spacers for this purpose shall be of rust proof material or of steel protected against corrosion.

19.2.2.1 Laying and Jointing Cement Concrete Pipes and Specials

- (i) **Trenches:** Trenches shall be as described in 18.4.4. Where the pipes are to be bedded directly on soil, the bed shall be suitably rounded to fit the lower part of the pipe, the cost for this operation being included in the rate for laying the pipe itself.
- (ii) Loading, transporting and unloading of concrete pipes shall be done with care. Handling shall be such as to avoid impact. Gradual unloading by inclined plane or by chain pulley block is recommended. All pipe sections and connections shall be inspected carefully before being laid. Broken or defective pipes or connections shall not be used. Pipes shall be lowered into the trenches carefully. Mechanical appliances may be used. Pipes shall be laid true to line and grade as specified. Laying of pipes shall proceed upgrade of a slope.
- (iii) If the pipes have spigot and socket joints, the socket ends shall face upstream. In the case of pipes with joints to be made with loose collars, the collars shall be slipped on before the next pipe is laid. Adequate and proper expansion joints shall be provided where directed.
- (iv) In case where foundation conditions are unusual such as in the proximity of trees or holes, under existing or proposed tracks manholes etc. the pipe shall be encased all-around in 15 cm thick cement concrete 1:5:10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) or compacted sand or gravel.
- (v) In cases where the natural foundation is inadequate the pipes shall be laid either in concrete cradle supported on proper foundations or on any other suitably designed structure. If a concrete cradle bedding is used the depth of concrete below the bottom of the pipe shall be at least 1/4th of the internal dia of the pipe subject to the min. of 10 cm and a maximum of 30 cm. The concrete shall extend up the sides of the pipe at least to a distance of 1/4th of the outside diameter of pipes 300 mm and over in dia. The pipe shall be laid in this concrete bedding before the concrete has set. Pipes laid in trenches in earth shall be bedded evenly and firmly and as far up the

haunches of the pipe as to safely transmit the load expected from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under around the curve of the pipe to form an even bed. Necessary provision shall be made for joints wherever required.

- (vi) When the pipe is laid in a trench in rock hard clay, shale or other hard material the space below the pipe shall be excavated and replaced with an equalising bed of concrete, sand or compacted earth. In no place shall pipe be laid directly on such hard material.
- (vii) The method of bedding and laying the pipes under different conditions are illustrated in Fig. 19.9.
- (viii) When the pipes are laid completely above the ground the foundations shall be made even and sufficiently compacted to support the pipe line without any material settlement. Alternatively the pipe line shall be supported on rigid foundations at intervals. Suitable arrangements shall be made to retain the pipe line in the proper alignment, such as by shaping the top of the supports to fit the lower part of the pipe. The distance between the supports shall in no case exceed the length of the pipe. The pipe shall be supported as far as possible close to the joints. In no case shall the joints come in the centre of the span. Care shall be taken to see that super imposed loads greater than the total load equivalent to the weight of the pipe when running full shall not be permitted.

Suitably designed anchor blocks at change of direction and grades for pressure lines shall be provided where required.

- (ix) **Jointing:** Joints are generally of rigid type. Where specified flexible type joints may also be provided.
 - (a) *Rigid Spigot and Socket Joint (Fig. 19.10):* The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar in the proportion of 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking tool. After a day's work any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.
 - (b) *Rigid Collar Joint (Fig. 19.10):* The two adjoining pipes shall be butted against each other and adjusted in correct position. The collar shall then be slipped over the joint, covering equally both the pipes. The annular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking tool. After a day's work any extraneous materials shall be removed from the inside of the pipe and the newly made joint shall be cured.
 - (c) *Semi Flexible Spigot and Socket Joint (Fig. 19.10):* The joint is composed of specially shaped spigot and socket ends on the concrete pipes. A rubber ring shall be placed on the spigot which shall be forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and the socket, stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) shall then be filled into the remaining annular space and rammed with a caulking tool. After day's work any extraneous materials shall be removed from the inside of the pipe and the newly made joint shall be cured.
 - (d) *Semi Flexible Collar Joint:* This is made up of a loose collar which covers two specially shaped pipe ends as shown in the Fig. 19.10. Each end shall be fitted with a rubber ring which when compressed between the spigot and the collar, seal the joint. Stiff mixture of

cement mortar 1:2 (1 cement: 2 fine sand), shall then be filled into the remaining annular space and rammed with a caulking tool. After day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

- (e) *Internal Flush Joint (Fig. 19.10)*: This joint is generally used for culvert pipe of 60 cm dia and over. The ends of the pipe are specially shaped to form a self centering joint with an internal jointing space 1.3 cm wide the finished joint is flush with both inside and outside with the pipe wall as shown in Fig. 19.10. The jointing space is filled with cement mortar 1:2 (1 cement: 2 fine sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. After day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.
 - (f) *External Flush Joint* : This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends as shown in Fig. 19.10. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar 1:2 (1 cement: 2 fine sand) sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.
 - (x) In all pressure pipe lines the recess at the end of the pipe line shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.
- The number of pipes that shall be jacked together at a time shall depend on the diameter of the pipes and the bearing capacity of the soil, for small pipes up to 25 cm diameter, six pipes can be jacked together at a time.
- The quantity of jute and bitumen in the ring shall be just sufficient to fill the recess in the pipe when pressed hard by jacking or by any other suitable method. Before and during jacking care shall be taken to see that there is no offset at the joint.
- (xi) *Testing*: For pressure pipes, the completed pipeline shall be tested for pressure (Known as site test pressure) which shall not be less than the maximum pipeline operating pressure plus the calculated surge pressure, but in no case shall it exceed the hydrostatic test pressure. For non-pressure pipes the joints shall be tested as per procedure laid down under Para 19.2.1.2 (iv).
 - (xii) *Refilling of Trenches*: The specification described in 19.2.1.2 (v) shall apply. In case where pipes are not bedded on concrete special care shall be taken in refilling, trenches to prevent the displacement and subsequent settlement at the surface resulting in uneven street surfaces and dangers to foundations etc. The backfilling materials shall be packed by hand under and around the pipe and rammed with a shovel and light tamper. This method of filling will be continued up to the top of pipe. The refilling shall rise evenly on both sides of the pipe and continued up to 60 cm above the top of pipe so as not to disturb the pipe. No tamping shall be done within 15 cm of the top of pipe. The tamping shall become progressively heavier as the depth of the backfill increases.
 - (xiii) *Measurements* : The lengths of pipes shall be measured in running metres nearest to a cm as laid or fixed, from inside of one manhole to the inside of the other manhole. The length shall be taken along the centre line of the pipes over all fittings such as bends, collars, junctions, etc. which shall not be measured separately.

Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

- (xiv) *Rate*: The rate shall include the cost of materials and labour involved in all the operations described above.

19.2.3 Cast Iron (Centrifugally Cast) Pipes and Specials

Cast iron (centrifugally cast) pipes and specials shall conform to the specifications described in 18.3.10.

19.2.4 Road Gully Grating (Fig. 19.13)

19.2.4.1 Horizontal Gully Grating: The casting of the grating and frames shall be the same as that of manhole covers described in 19.2.2.1. The gully grating cover shall be hinged to the frame to facilitate its opening for cleaning and repairs. A typical grating is shown in Fig. 19.13 & 19.14. The weight of grating shown in Figure shall be minimum 75 Kg. In case of R.C.C. horizontal gully grating it shall be in cement concrete 1:1:2 (1 cement: 1 coarse sand: 2 graded stone aggregate 20 mm nominal size) as shown in Fig. 19.13.

19.2.4.2 Vertical Gully Grating: The chamber shall be of brick masonry, 12 mm dia, round bar shall be fixed in cement concrete block at the bottom. The bars at the top shall be welded or riveted to M.S. flat 40x6 mm as shown in Fig. 19.14.

19.2.4.3 Horizontal and Vertical Gully Grating: The details of typical road gully chamber of brick masonry with horizontal and vertical grating shall be as given in Fig. 19.14.

19.3 MANHOLE COVERS & FRAMES

19.3.1 Manhole Covers

The covers and frames shall conform to IS 1726 for cast Iron and IS 12592 for pre-cast concrete covers and shall be of the following grades and types.

<i>Grades</i>	<i>Grade Designation</i>	<i>Type/shape of cover</i>
Light Duty	LD - 2.5	Rectangular, Square, Circular
Medium Duty	MD - 10	Rectangular, Circular and Square (for pre-cast concrete manhole covers)
Heavy Duty	HD - 20	Circular-Square, Rectangular, (Scrapper Manhole)
Extra Heavy Duty	EHD - 35	Circular, Square, Rectangular, (Scrapper Manhole)

19.3.1.1 Cast Iron Manhole Covers and Frames

- (i) Manhole covers and frame shall be manufactured from appropriate grade of grey cast iron not inferior than FG150 grade of IS 210.
- (ii) They shall be cleanly cast and shall be free from air and sand holes, cold shuts and warping.
- (iii) Covers shall have on its operative top a raised chequered design to provide for an adequate no-slip grip. The rise of chequers shall be not less than 4mm.
- (iv) Key holes, keys and lifting devices shall be provided in the manhole covered to facilitate their placement in the frames and their operative maintenance.

- (v) Manhole covers and frames shall be coated with materials having base with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to temperature of 63°C and shall not be so brittle as to chip off at temperature of 0°C.
- (vi) Size and shape and performance requirement of manhole covers and frames shall conform to IS 1726.
- (vii) Each manhole covers and frame shall have cast on them the following information:
 - (a) Manufacturer's name or trade-mark
 - (b) Grade designation
 - (c) Date of manufacturer
 - (d) The words SWD or 'Sewer' to denote 'storm water drain' or 'sewer' respectively
 - (e) Identification marks as required by Engineer-in-Charge.
- (viii) The cover shall be gas tight and water tight.
- (ix) The sizes of covers specified shall be taken as the clear internal dimensions of the frame.
- (x) The approximate weight of the various type of manhole covers and frames shall be as per IS 1726.
- (xi) The cover shall be capable of easy opening and closing and it shall be fitted in the frame in workmanship like manner.

19.3.2 Pre-Cast Concrete Manhole Covers & Frames

Pre-cast reinforced cement concrete manhole covers intended for use in sewerage and water works shall generally conform to IS 12592.

19.3.2.1 Materials

Cement: Cement used for the manufacture of pre-cast concrete manhole covers shall be 43 grade Portland cement conforming to IS-8112.

Aggregates: The aggregates used shall be clean and free from deleterious matter and shall conform to the requirements of IS-383. The aggregates shall be well graded and the nominal maximum size of coarse aggregate shall not exceed 20 mm.

Concrete: The mix proportions of concrete shall be determined by the manufacturer and shall be such as will produce a dense concrete without voids, honey combing etc. The minimum cement content in the concrete shall be 410 kg/m³ with a maximum water cement ratio of 0.45. Concrete weaker than grade M-30 (design mix) shall not be used. Compaction of concrete shall be done by machine vibration.

Reinforcement

- (a) The reinforcement steel shall conform to IS 1786. Reinforcement shall be clean and free from loose mill scale, loose rust, and mud, oil, grease or any other coating which may reduce or destroy the bond between the concrete and steel. A light film of rust may not be regarded as harmful but steel shall not be visibly pitted by rust.
- (b) *Fibers Steel:* The diameter/equivalent diameter of steel fibers where used, shall not be greater than 0.75 mm. The aspect ratio shall be in the range of 50 to 80. The minimum volume of fibers shall be 0.5 percent of the volume of concrete.

The reinforced concrete manhole cover and frame shall be designed in accordance with the provisions of IS 456. Clear cover to reinforcement shall not be less than 15 mm.

19.3.2.2 Shapes and Dimensions: Shape, dimensions and tolerance of pre-cast concrete manhole covers and frames shall conform to IS 12592. Outside dimension of cover at top shall match with corresponding frame so that the maximum clearance at top between the frame and the cover all round the periphery is not more than 5 mm and the top surface of the frame and covers, is in level within a tolerance of ± 5 mm.

For facility of removing the cover from the frame, suitable taper matching with taper given for the frame shall be provided to the periphery of the cover.

19.3.2.3 Lifting Device: The minimum diameter of mild steel rod used as lifting device shall be 12 mm for light and medium duty covers and 16 mm for heavy and extra heavy duty covers. The lifting device shall be protected from corrosion by hot galvanising or epoxy coating or any other suitable treatment.

19.3.2.4 Finishing & Coating: To prevent any possible damage from corrosion of steel the underside of the covers shall be treated with anticorrosive paint. The top surface of the covers shall be given a chequered finish.

In order to protect the edges of the covers from possible damage at the time of lifting and handling it is necessary that the manhole covers shall be cast with a protective mild steel sheet of minimum 2.5 mm thickness around the periphery of the covers. Exposed surface of mild steel sheet shall be given suitable treatment with anticorrosive paint or coating. To prevent the top outer edge of frame from possible damages, it shall be protected by 25 mm X 3 mm mild steel flat as part of the frame.

19.3.2.5 Physical Requirements

- (a) *General:* All units shall be sound and free from cracks and other defects which interface with the proper placing of the unit or impair the strength or performance of the units. Minor chipping at the edge/surface resulting from the customary methods of handling during delivery shall not be deemed for rejecting.
- (b) *Load Test:* The breaking load of individual units when tested in accordance with the method described in IS 12592 shall be not less than the values specified in Table 19.4.

TABLE 19.4

<i>Grade of Cover</i>	<i>Type</i>	<i>Load in Tonnes</i>	<i>Diameter of Blocks in mm</i>
EHD - 35	Circular, Square or Rectangular	35	300
HD - 20	Circular, Square or Rectangular	20	300
MD - 10	Circular or Rectangular	10	300
LD - 2.5	Rectangular, Square or Circular	2.5	300

19.3.2.6 Fixing: The frames of manhole shall be firmly embedded to correct alignment and level in RCC slab or plain concrete as the case may be on the top of masonry which shall be paid as extra unless specified otherwise.

19.3.2.7 Measurements: The manhole covers shall be enumerated under relevant items.

19.3.2.8 Rates: The rate shall include the cost of materials and labour involved in all the operation described above except fixing of frames and covers which shall be paid as extra unless specified otherwise in the item.

19.3.2.9 Foot Rests: Foot rests shall be of 20 mm M.S. square or round bars as specified.

19.4 MANHOLES (FIG. 19.3 to 19.8)

At every change of alignment, gradient or diameter of a drain, there shall be a manhole or 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 places and to such levels and dimensions as shown in the drawings or as directed by the Engineer-in-Charge. The size specified shall indicate the inside dimensions between brick faces of the manholes.

Where the diameter of the drain is increased, the crown of the pipe shall be fixed at the same level and necessary slope given in the invert of the manhole chamber. In exceptional cases and where unavoidable, 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 $\frac{2}{3}$ 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. Manholes 1.2 m × 90 cm are generally constructed for main drainage work for depths less than 1.5 m.

Manhole 1.4 m × 90 cm is of the arched type and is generally constructed for main drainage works where depth is 1.50 m or more. The width of manholes 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 channel 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. 19.4 to 19.7. When manholes are constructed on foot path, these shall be provided with cover of 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.

19.4.1 Excavation

The excavation for manhole shall be true to dimensions and levels shown on the plans or as directed by the Engineer-in-Charge.

19.4.2 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 40 mm nominal size) unless required by local authorities. The thickness of the bed concrete shall be 20 cm for manholes up to 4.25 m depth and 30 cm for depths beyond 4.25 m unless otherwise specified or directed by the Engineer-in-Charge. In bad ground, special foundations as suitable shall be provided.

19.4.3 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 manholes 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 be fitted.

The walls shall be built of one brick thickness for depths up to 4.25 m. Below a depth of 4.25 m in ordinary subsoil the wall thickness shall be increased to one and half brick and at 9.75 m below ground two brick thick walls shall be built.

19.4.4 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 manhole 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 manufacturer's specifications. In case Local Authorities/Bye Laws specify 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.

19.4.5 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 19.5.

19.4.6 Foot Rests (Fig. 19.8)

All manholes deeper than 0.8 m shall be provided with M.S. foot rests. These shall be embedded 20 cm deep in 20 x 20 x 10 cm blocks of cement concrete 1:3:6 (1 cement: 3 coarse sand 6 graded stone aggregate 20 mm nominal size). The concrete block with M.S. foot rest 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 19.5

<i>Sizes of drain mm</i>	<i>Top of channel at the centre above bed concrete cm</i>	<i>Depth of benching at side walls above bed concrete cm</i>
100	15	20
150	20	30
200	25	35
250	30	40
300	35	45
350	40	50
400	45	55
450	50	60

Foot rests which shall be of 20 × 20 Sq. M.S. bars as shown in Fig. 19.8 shall be fixed 40 cm apart vertically and staggered laterally and shall project 10 cm beyond the surface of the wall. The top foot rest 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.

19.4.7 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.

19.4.8 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 a cm. The extra depth shall be measured and paid as extra over the specified depth.

19.4.9 Rate

The rate shall include the cost of materials and labour involved in all the operations described above but excludes 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.

Payment for extra depths of manholes shall be made separately under relevant items of work.

19.5 DROP CONNECTION (FIG. 19.8)

19.5.0 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. 19.8. S.C.I. pipes and special conforming to IS 1729 shall be of the same size as that of the branch pipe sewer.

For 150 and 250 mm main line, if the difference in level between the water line (peak flow level) and the invert level of the branch line is less than 60 cm, a drop connection may be provided within the manhole by giving suitable ramp. If the difference in level is more 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 3/4 depth of flow.

19.5.1 Excavation

The excavation shall be done for the drop connection at the place where the branch line meets the manhole. The excavation shall be carried up to the bed concrete of the manhole and to the full width of the branch line.

19.5.2 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 C.I. pipe which shall discharge into 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 lead caulked as described in 18.5.3. The joint between S.C.I. cross and S.W. branch line shall be made with cement mortar 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 wall. The excavated earth shall be back filled in the trench in level with the original ground level.

19.5.3 Measurements

Drop connection shall be enumerated. The depths beyond 60 cm shall be measured in running metres correct to a cm under relevant items.

19.5.4 Rate

The rate shall include the cost of labour and materials involved in all the operations described above but excluding the cost of excavations and refilling.

19.6 OPEN SURFACE DRAIN (FIG. 19.12)

The open drains shall be of the size, as specified in the item and laid to such gradients and in such locations as may be shown in the relevant drawing or as directed by the Engineer-in-Charge.

The size of the drain as specified shall be the width of the drain at the top, measured between the masonry walls. The drain shall be given, as far as possible, uniform slope from the starting point to the discharge point.

The average depths of the various sizes of drains shall be as follows:—

<i>Drain size</i>	<i>Depth</i>
10 cm	20 cm
15 cm	20 cm
25 cm	30 cm

19.6.1 Measurements

The drains shall be measured in running metres, correct to a cm.

19.6.2 Rate

The rate shall include the cost of labour and materials required for all the operations described above, suitable deduction or extra payment, per cm basis shall be made in case there is a variation in average depths from those stated above.

19.7 ROAD GULLY CHAMBER WITH GRATING

19.7.1 Road Gully Chamber with Horizontal Grating (Fig. 19.14)

The chamber shall be of brick masonry of specified class and shall have a C.I. grating with frame fixed in 15 cm thick cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) at the top. The size of the chamber shall be taken as the clear internal dimensions of the C.I. frame. The chamber shall have a connection pipe, the length of which in metre between the road gully chamber and the manhole of the drain shall not be less than one by forty (1/40) times the nominal diameter of pipe in mm (i.e. for 150 mm connection pipe, length shall not be less than 3.7 m and for 250 mm connection pipe length shall not be less than 6.25 m). The chamber shall be built at the location fixed by the Engineer-in-Charge. Generally the spacing of the chambers shall be 18 to 36 m depending upon the grading of the road channel and the area of the drainage. R.C.C. gully grating shall be fixed in cement mortar 1:2 (1 cement: 2 coarse sand) as shown in Fig. 19.13.

19.7.2 Road Gully Chamber with Vertical Grating (Fig. 19.14)

The chamber shall be of brick masonry 12 mm dia round bar shall be fixed in cement concrete block at the bottom. The bars at the top shall be welded or riveted to M.S. flat 40 × 6 mm as shown in Fig. 19.14. The specifications shall be same as described in 19.7.1.

19.7.3 Road Gully Chamber with Horizontal and Vertical Grating

The details of typical road gully chamber of brick masonry shall be same as shown in Fig. 19.14.

19.7.4 Measurements

Road gully chambers shall be enumerated.

19.7.5 Rate

The rate shall include the cost of materials and labour involved in all the operations described above except the cost of excavation and connection pipes.

19.8 BRICK MASONRY GULLY TRAP (FIG. 19.2)

The internal size of the trap shall be 80 × 40 × 46 cm. The height shall be measured from the top of the floor to the top of the cover. 40 mm thick stone baffles shall be fixed 50 mm deep in masonry with cement mortar 1:4 (1 cement: 4 fine sand), as shown in the Fig. 19.2. The connection of open surface, drain with a soak pit shall be invariably through a grease trap.

19.8.1 Measurements

Grease traps shall be enumerated.

19.8.2 Rate

The rate shall include the cost of labour and materials required for all the operations described above.

19.9 SEPTIC TANK (FIG. 19.15 & 19.16)

In unsewered area, every house shall have arrangements for its sewage being treated in septic tank, effluent from which should be given secondary treatment either in a biological filter or on the land, or in a sub-surface disposal system.

Surface and sub-soil water should be excluded from finding way into the septic tank. Waste water may be passed into the septic tank provided the tank and the means for effluent disposal are designed to cope up with this extra liquid. Depending on the location of the water table and the nature of the strata, the type of disposal for the effluent from the septic tank shall be decided.

19.9.1 Dimensions

Septic tanks shall have minimum width of 75 cm, minimum depth of one metre below water level and a minimum liquid capacity of the one cubic metre. Length of tanks shall be 2 to 4 times the width. Suitable sizes of septic tanks for use of 5, 10, 15, 20 and 50 persons based on certain assumptions are given in Appendix II.

19.9.2 Cover and Frame

Every septic tank shall be provided with C.I. cover of adequate strength. The cover and frames shall be 500 mm dia. (M.D.) minimum or 610 mm × 455 mm (LD). The specification for frames and cover given in 19.3.1 shall apply.

19.9.3 Ventilating Pipe

Every septic tank shall be provided with C.I. ventilating pipe of at least 50 mm diameter. The top of the pipe shall be provided with a suitable cage of mosquito proof wire mesh.

The ventilating pipe shall extend to a height which would cause no smell nuisance to any building in the area. Generally the ventilating pipe may extend to a height of about 2 m, when the septic tank is at least 15 m away from the nearest building and to a height of 2 m. above the top of the building when it is located closer than 15 metres. The ventilating pipe may also be connected to the normal soil ventilating system of the building where so desired.

19.9.4 Disposal of Sludge

The sludge from septic tanks may be delivered into covered pit or into a suitable vehicle for removal from the site. Spreading of sludge on the ground in the vicinity shall not be allowed.

19.9.5 Testing

Before the tank is commissioned for use, it shall be tested for water-tightness by filling it with water and allowing it to stand for 24 hours. It shall then be topped up, if necessary, and allowed to stand for a further period of 24 hours during which time the fall in the level of the water shall not be more than 1.5 cm.

19.9.6 Commissioning of Septic Tank

The tank shall be filled with water to its outlet level before the sewage is let into the tank. It shall, preferably, be seeded with small quantities of well digested sludge obtained from septic tanks or sludge digestion tanks. In the absence of digested sludge a small quantity of decaying organic matter, such as digested cow-dung, may be introduced.

19.9.7 Sub-Surface Absorption System

The effluent from septic tank shall be disposed of by soak pit or dispersion trench depending on the position of the sub-soil water level, soil and sub-soil conditions and the size of the installation.

19.9.8 Measurements

Septic tank shall be enumerated.

19.9.9 Rate

The rate shall include the cost of materials and labour involved in all the operation, except Sub-Surface absorption system which shall be paid for separately.

19.10 SOAK PITS 2.5 M DIA × 3 M DEEP (FIG. 19.17)

19.10.1 Construction

The earth excavation shall be carried out to the exact dimensions as shown in the figure. In the soak pit shall be constructed a honey-comb dry brick shaft 45 x 45 cm and 292.5 cm high. Round the shaft and within the radius of 60 cm shall be placed well burnt brick bats. Brick ballast of size from 50 to 80 mm nominal size shall be packed round the brick bats up to the radius of 90 cm. The remaining portion shall be filled with brick ballast of 40 mm nominal size. The construction of shaft and filling of the bats and the ballast shall progress simultaneously.

19.10.2 Cover and Drain

Over the filling shall be placed single matting which shall be covered with minimum layer of 7.5 cm earth. The shaft shall be covered with 7.5 cm thick stone or R.C.C. slab 10 cm wide and 10 cm deep brick edging with bricks of class designation 75 shall be provided round the pit. The connection of the open surface drain to the soak pit shall be made by means of 100 mm diameter S.W. pipe with open joints.

19.10.3 Measurements

Soak pit shall be enumerated.

19.10.4 Rate

Rate shall include the cost of labour and material involved in all the operations described above.

19.11 SOAK PIT 1.2 × 1.2 × 1.2 M

19.11.1 Construction

The earth excavation shall conform to the general specifications for earth work. After the excavation is complete the soak pit shall be filled with brick bats. The brick bats shall be from properly burnt bricks. 10 cm wide and 10 cm deep brick edging with bricks of class designation 75 shall be provided round the soak pit.

19.11.2 Measurements

Soak pits shall be enumerated.

19.11.3 Rate

Rate shall include the cost of labour and materials involved in all the operations.

19.12 DISPERSION TRENCH (FIG. 19.18)

It shall be provided when the sub-soil water level is within 180 cm from the ground level. Dispersion trenches are not recommended in areas where fibrous roots of trees or vegetation are likely to penetrate the system and cause blockages.

19.12.1 Construction

Dispersion trenches shall be 50 to 100 cm deep and 30 to 100 cm wide, excavated to a slight gradient and shall be provided with 15 to 25 cm of washed gravel or crushed stones. Open jointed pipes placed inside the trench shall be made of unglazed earthenware clay or concrete and shall have minimum internal diameter of 75 to 100 mm. Each dispersion trench should not be longer than 30 m and trenches should not be placed closer than 1.8 m.

The covering for the pipes on the top shall be with coarse aggregate of uniform size to a depth of approximately 15 cm. The aggregate above this level may be graded with aggregate 12 to 15 mm to prevent ingress of top soil while the free flow of water is no way retarded. The trench may be covered with about 30 cm of ordinary soil to form a mound and turned over. The finished top surface may be kept at least 15 cm above ground level to prevent direct flooding of the trench during rains.

19.12.2 Measurements

The length of dispersion trench shall be measured in running metres nearest to a cm.

19.12.3 Rate

The rate shall include the cost of materials and labour involved in all the operations described above.

19.13 DESLUDGING OF SEPTIC TANKS

Septic tanks shall be desludged periodically, the intervals of desludging, depending upon the design of the septic tanks and the capacity in relation to its users. Desludging may be done when the sludge level reaches a predetermined level. A portion of the sludge may be left in the tank to seed the fresh deposits.

Desludging shall preferably be carried out by hydrostatic head or by using a portable pump. Manual handling of sludge shall be discouraged.

**A: DIMENSIONAL REQUIREMENT OF CLASS NP2-REINFORCED CONCRETE LIGHT
DUTY, NON PRESSURE PIPES & COLLAR
(Clause 19.2.2)**

Nominal Internal Diameter of Pipe	Barrel Wall Thickness of pipe	Collar Dimensions			Reinforcements in Collar		
		Minimum Caulking Space	Minimum Thickness	Minimum Length	Longitudinal, Mild steel or Hard Drawn Steel		Spiral Hard Drawn Steel
					Minimum Number	Weight Kg/Collar	
mm	mm	mm	mm	mm			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
80	25	13	25	150	6	0.08	0.07
100	25	13	25	150	6	0.08	0.08
150	25	13	25	150	6	0.08	0.10
200	25	13	25	150	6	0.08	0.12
225	25	13	25	150	6	0.08	0.14
250	25	13	25	150	6	0.08	0.16
300	30	16	30	150	8	0.11	0.22
350	32	16	32	150	8	0.11	0.25
400	32	16	32	150	8	0.11	0.27
450	35	19	35	200	8	0.15	0.40
500	35	19	35	200	8	0.15	0.60
600	45	19	40	200	8	0.15	0.70
700	50	19	40	200	8	0.23	1.05
800	50	19	45	200	8	0.23	1.85
900	55	19	50	200	8	0.23	2.05
1000	60	19	55	200	8	0.33	2.25
1100	65	19	60	200	8	0.33	3.09
1200	70	19	65	200	8	0.33	4.11
1400	75	19	75	200	12	0.50	5.08
1600	80	19	80	200	12 or 8+8	0.67	6.55
1800	90	19	90	200	12 or 8+8	0.67	9.00
2000	100	19	100	200	12+12	1.00	12.15
2200	110	19	110	200	12+12	1.00	13.30

Note:

1. If the mild steel is used for spiral reinforcement, the weight specified under col. 7 shall be increased by a factor 140/25.
2. Soft grade mild steel wire may be used as reinforcement for collars of pipes of nominal internal diameter up to 250 mm only, by increasing the weight by a factor 140/84. Where only soft grade mild steel wire is used for making collar cages, the weight of reinforcement shall be total weight or col. 6 and 7 multiplied by 140/84. This is allowed as a process requirement.
3. Internal diameter of collar to suit the actual diameter of pipes with minimum caulking space as given in col. 2

**B: REINFORCED CONCRETE PRESSURE PIPES CLASS P1 TESTED TO 20 m
HEAD, CLASS P2 TESTED TO 40 m HEAD AND CLASS P3 TESTED TO 60 m HEAD**

<i>Internal diameter of pipes (mm)</i>	<i>Barrel dimension</i>		
	<i>Class P1 (mm)</i>	<i>Class P2 (mm)</i>	<i>Class P3 (mm)</i>
80	25	25	25
100	25	25	25
150	25	25	25
200	25	30	35
225	25	30	35
250	25	30	35
300	30	40	45
350	32	45	55
400	32	50	60
450	35	50	70
500	35	55	75
600	40	65	90
700	40	70	105
800	45	80	120
900	50	90	-
1000	55	100	-
1100	60	-	-
1200	65	-	-

Notes :

1. The effective length of barrel shall be 2 m up to 250 mm nominal diameter pipes and 2.5, 3.0, 3.5 or 4.0 m for pipes above 250 mm.
2. Collar dimensions will be same as specified for class NP2 pipes.

RECOMMENDED SIZES OF SEPTIC TANKS

(Clause 19.9)

RECOMMENDED SIZES OF SEPTIC TANKS FOR 5-20 USERS

<i>No. of users</i>	<i>Length</i>	<i>Breadth</i>	<i>Liquid depth (Cleaning interval of)</i>	
			<i>1 year</i>	<i>2 year</i>
	<i>m</i>	<i>m</i>	<i>m</i>	<i>m</i>
05	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Notes :

1. The capacities are recommended on the assumption that discharges from only WC will be treated in the septic tank.
2. A provision of 300 mm should be made for free board.
3. The sizes of septic tanks are based on certain assumptions, while choosing the size of septic tank exact calculation shall be made.

RECOMMENDED SIZES OF SEPTIC TANKS FOR RESIDENTIAL COLONIES

<i>No. of users</i>	<i>Length</i>	<i>Breadth</i>	<i>Liquid depth (Cleaning interval of)</i>	
			<i>1 year</i>	<i>2 year</i>
	<i>m</i>	<i>m</i>	<i>m</i>	<i>m</i>
050	05.0	2.0	1.0	1.24
100	07.5	2.65	1.0	1.24
150	10.0	3.0	1.0	1.24
200	12.0	3.3	1.0	1.24
300	15.0	4.0	1.0	1.24

Notes :

1. A provision of 300 mm should be made for free board.
2. The sizes of the septic tank are based on certain assumptions while choosing the size of septic tank, exact calculation shall be made.
3. For population over 100, the tank may be divided into independent parallel chambers for ease of maintenance and cleaning.

RECOMMENDED SIZES OF SEPTIC TANKS FOR HOSTEL AND BOARDING SCHOOLS

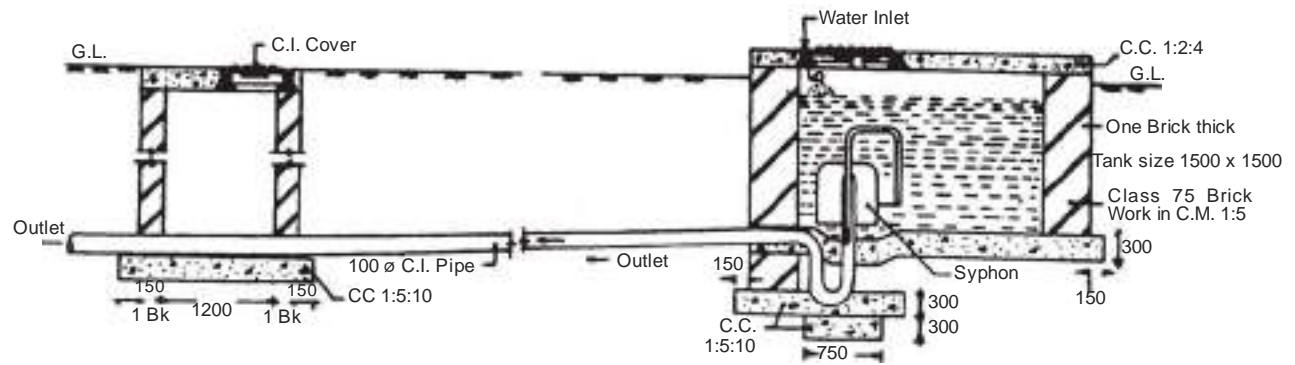
<i>No. of Users</i>	<i>Length</i>	<i>Breadth</i>	<i>Liquid depth (D) for stated Intervals of sludge withdrawal</i>	
			<i>Once in a year</i>	<i>Once in 2 years</i>
	<i>m</i>	<i>m</i>	<i>m</i>	<i>m</i>
50	5.0	1.6	1.3	1.4
100	5.7	2.1	1.4	1.7
150	7.7	2.4	1.4	1.7
200	8.9	2.7	1.4	1.7
300	10.7	3.3	1.4	1.7

Notes :

1. A provision of 300 mm should be made for free board.
2. The sizes of the septic tank are based on certain assumptions while choosing the size of septic tank exact calculation shall be made.
3. For population over 100, the tank may be divided into independent parallel chambers for ease of maintenance and cleaning.

FLUSHING TANK

Sub Head : Drainage
Clause : 19.0

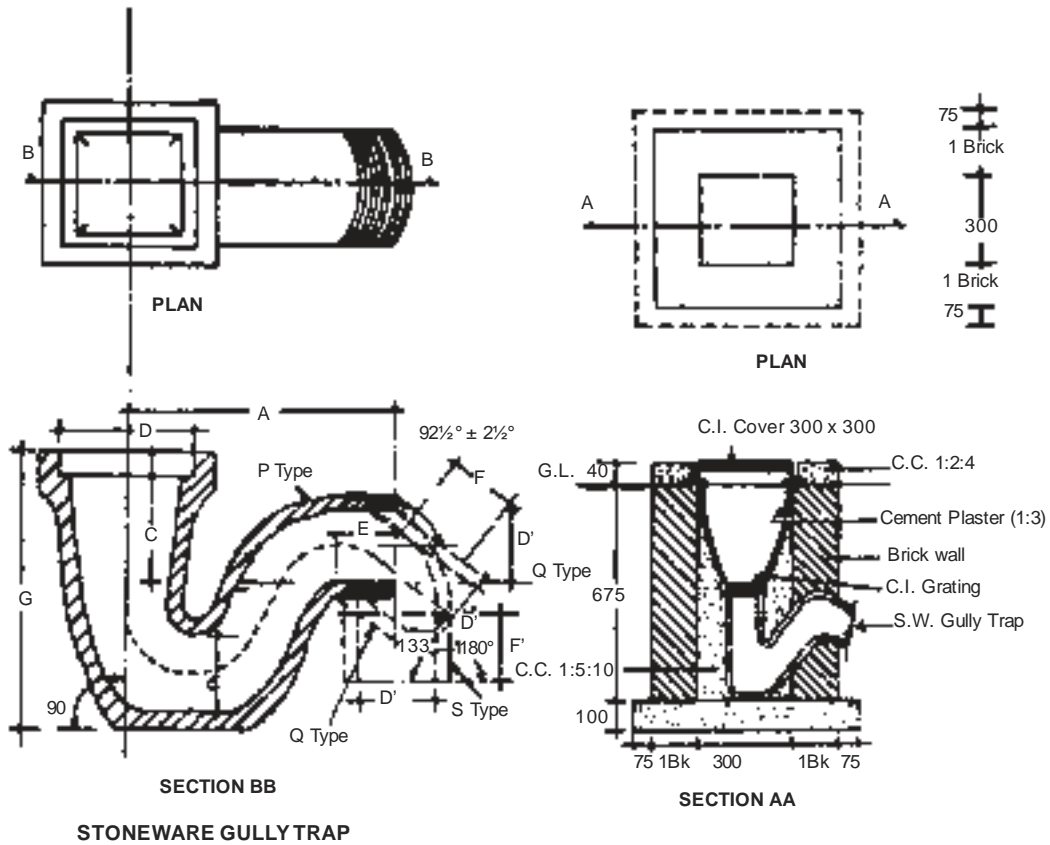


Drawing Not to Scale
All Dimensions are in mm

Fig. 19.1 : Flushing Tank

GULLY TRAP

Sub Head : Drainage
Clause : 19.8



Type	Size	A	C	d	D	D	E	F	F	G
P	100x100	305	175	100	100	100	65	-	-	330
	125x100	265	165	100	125	100	60	-	-	345
	150x100	330	165	100	150	100	75	-	-	346
	180x100	320	200	100	180	100	65	-	-	380
	180x150	405	270	150	180	150	75	-	-	520
Q	125x100	330	165	100	125	100	-	80	-	345
	125x100	290	165	100	125	100	-	-	100	345
S	150x100	330	165	100	150	100	-	-	115	346
	180x150	445	275	150	180	150	-	-	125	520

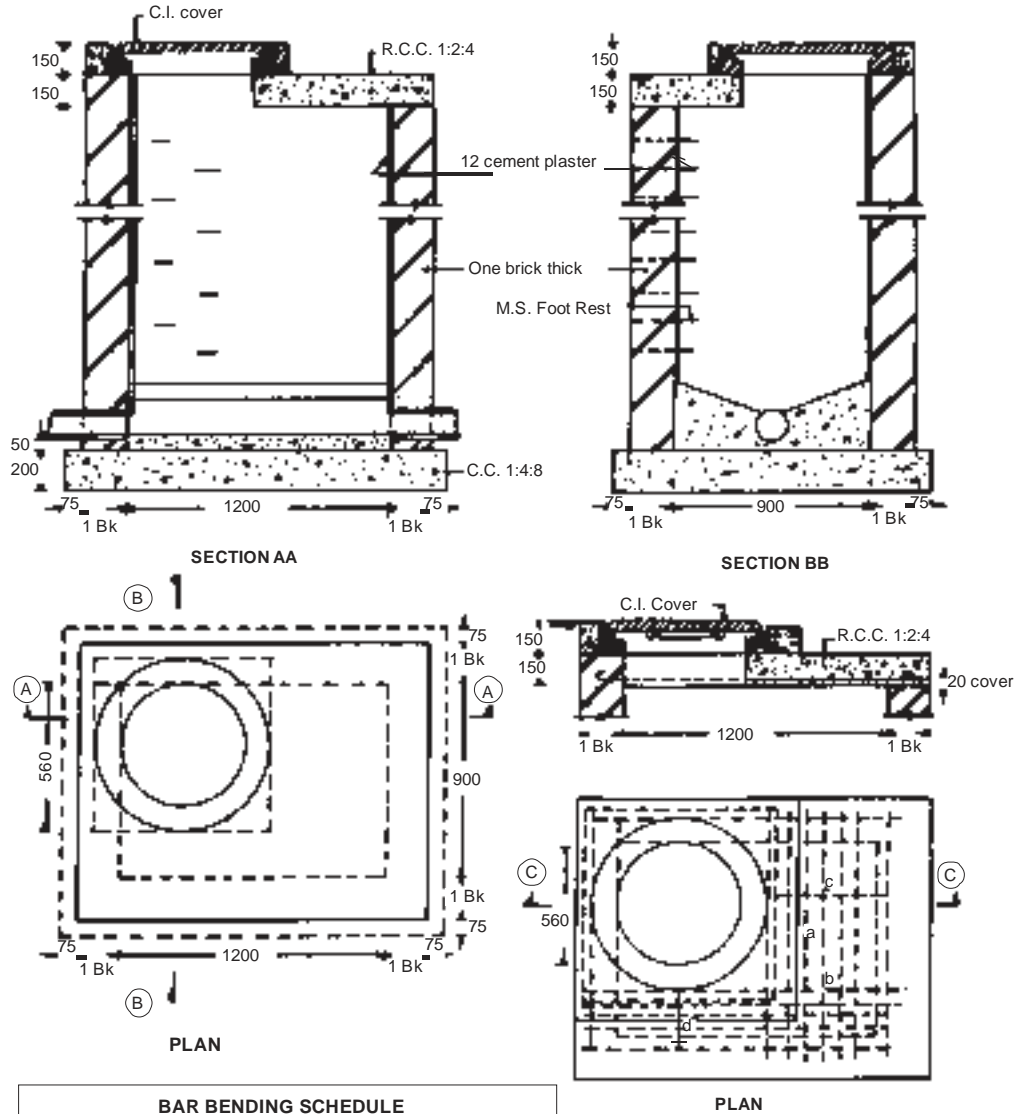
Drawing Not to Scale
All Dimensions are in mm

Fig. 19.2 : Gully Trap

MANHOLE

Sub Head : Drainage
Clause : 19.4

SIZE 1200 X 900 HEAVY DUTY COVER



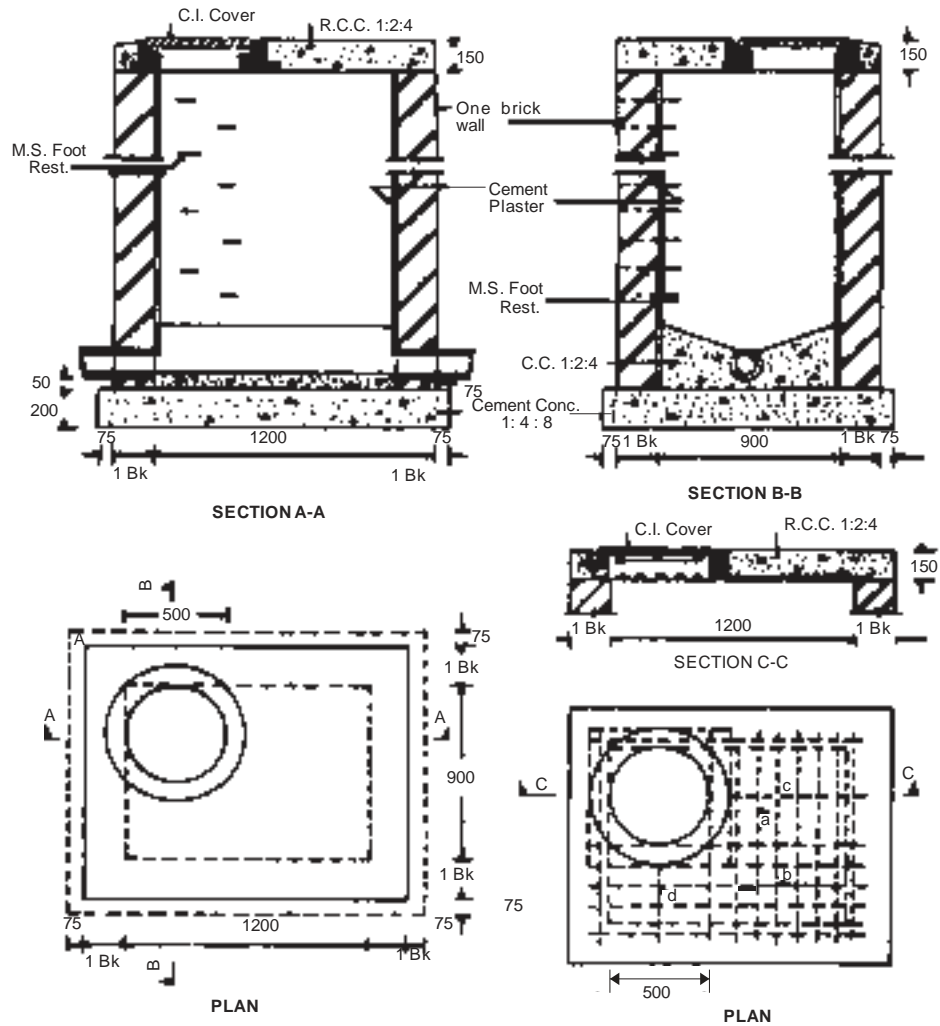
Drawing Not to Scale
All Dimensions are in mm

Fig. 19.3 : Manhole

MANHOLE (Contd.)

Sub Head : Drainage
Clause : 19.4

SIZE 1200 X 900 WITH MEDIUM DUTY COVER



BAR BENDING SCHEDULE				
Mark	Dia MM	No.	Length	Bending
a	12	6	1300	100 \curvearrowright 1100 \curvearrowright 100
b	12	6	1800	100 \curvearrowright 1400 \curvearrowright 100
c	12	1	980	100 \curvearrowright 780 \curvearrowright 100
d	12	1	680	100 \curvearrowright 480 \curvearrowright 100

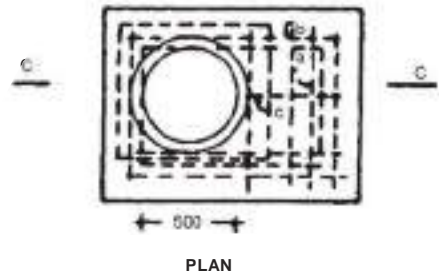
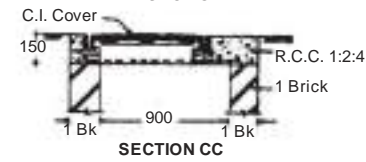
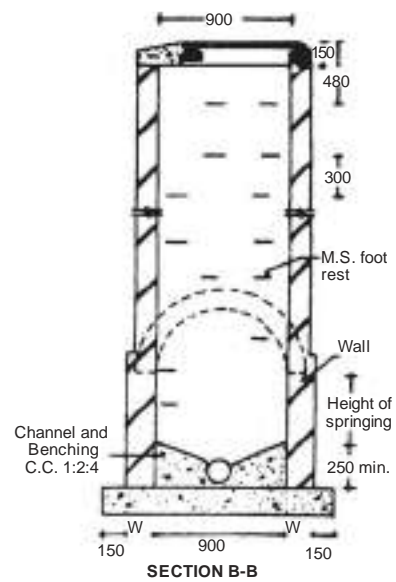
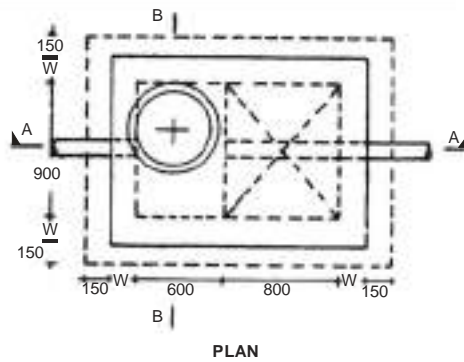
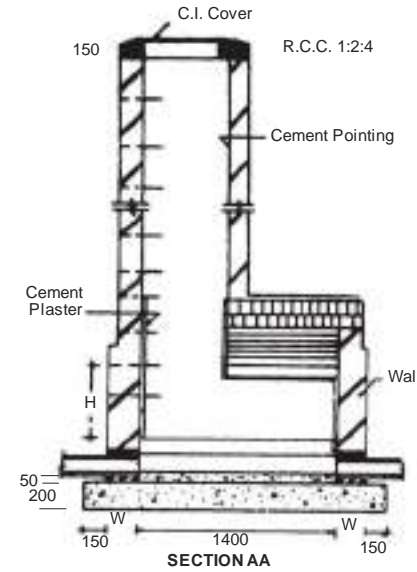
Drawing Not to Scale
All Dimensions are in mm

Fig. 19.4 : Manhole (Contd.)

MANHOLE (Contd.)

Sub Head : Drainage
Clause : 19.4

ARCHED TYPE 1400 X 900



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

Drawing Not to Scale
All Dimensions are in mm

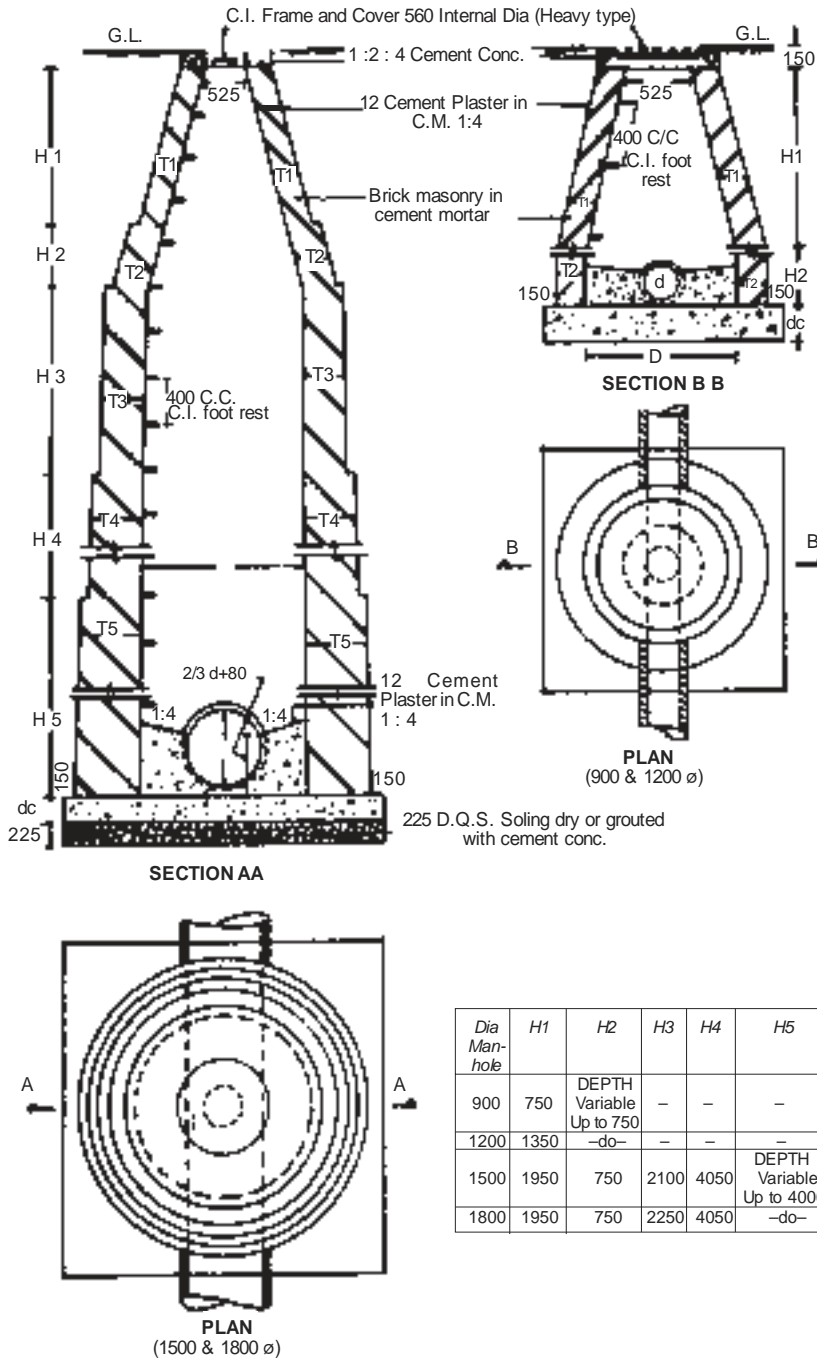
BAR BENDING SCHEDULE					
	Mark	Dia	No.	Length	Bending
For Medium Duty	a	12	5	1000	100 \curvearrowright 100 800
	b	12	3	1300	100 \curvearrowright 100 1100
	c	12	1	680	100 \curvearrowright 100 480
For Heavy Duty	a	12	5	1000	100 \curvearrowright 100 800
	b	12	2	1300	100 \curvearrowright 100 1100
	c	12	1	620	100 \curvearrowright 100 420

Fig. 19.6 : Manhole (Contd.)

MANHOLE (Contd.)

Sub Head : Drainage
Clause : 19.4

MUNICIPAL CORPORATION DELHI DESIGN



H - Height of Wall
T - Thickness of Wall
D - Dia of Manhole
d - Dia of Pipe
dc - Depth of Bed Conc.

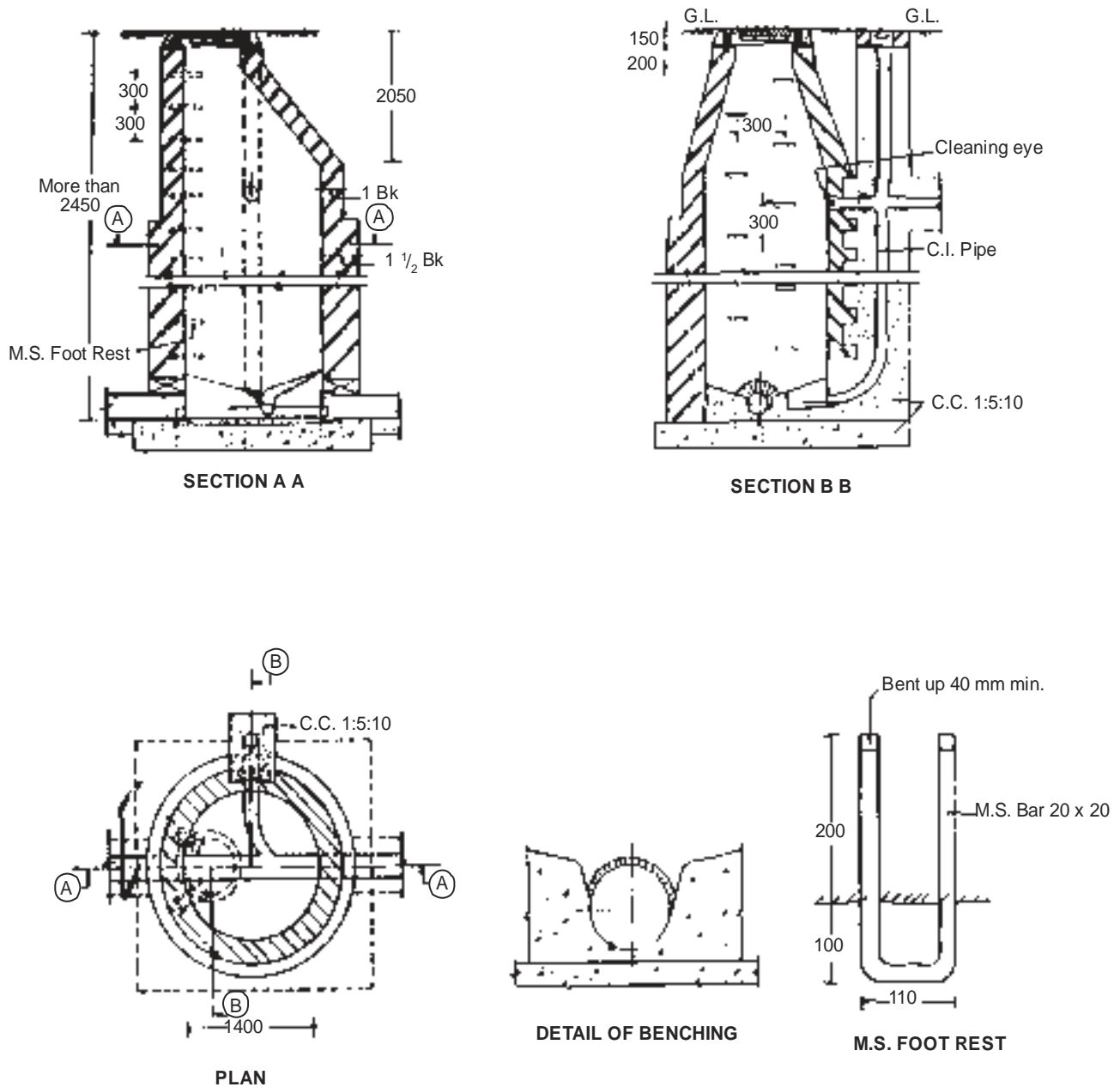
Dia Man-hole	H1	H2	H3	H4	H5	T1	T2	T3	T4	T5	Bed Conc. dc	Remarks
900	750	DEPTH Variable Up to 750	-	-	-	1Bk	1Bk	-	-	-	226	The soling will be provided where the site engineer will feel necessary
1200	1350	-do-	-	-	-	1Bk	1Bk	-	-	-	300	
1500	1950	750	2100	4050	DEPTH Variable Up to 4000	1Bk	1½Bk	2Bk	2½Bk	3Bk	300	
1800	1950	750	2250	4050	-do-	1Bk	1½Bk	2Bk	2½Bk	3Bk	300	

M.C.D. Drg. No DE 404
Drawing Not to Scale
All Dimensions are in mm

Fig. 19.7 : Manhole (Contd.)

MANHOLE (With Drop Connections)

Sub Head : Drainage
Clause : 19.4 & 19.5

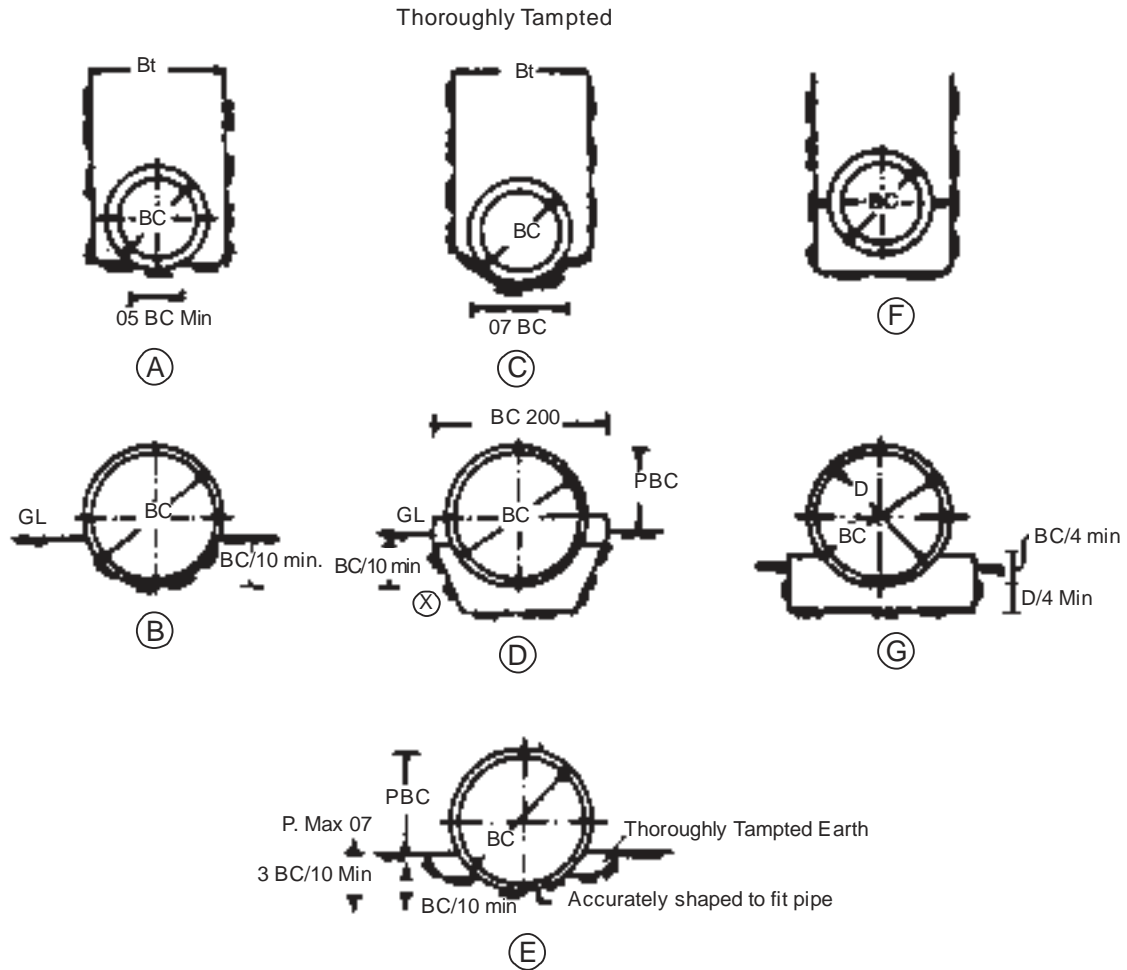


Drawing Not to Scale
All Dimensions are in mm

Fig. 19.8 : Manhole (With Drop Connections)

BEDDING OF PIPES

Sub Head : Drainage
Clause : 19.2.2.1



- D = Internal Diameter
BC = Horizontal Breadth Outside of the Pipes in metres
(i.e., external diameter in case of a circular pipe)
Bt = Horizontal Width of Trench immediately below the
top of the pipe in metres
H = Height of fill above top of pipe in metres
(X) = Min 200 for 'H' < 5000 when 'H' > 5000, 10 for every
250 of 'H'.

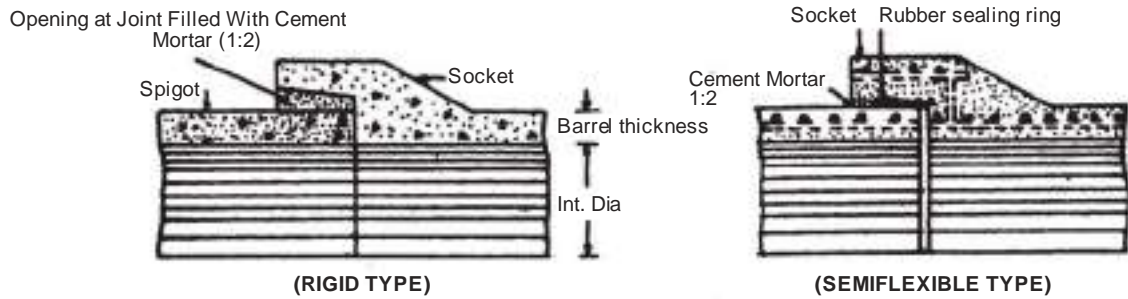
Fig.	Bedding	Load Factor
(A)	Ordinary	1.5
(B)	—do—	—
(C)	First Class	1.9
(D)	—do—	—
(E)	—do—	—
(F)	Concrete Cradle	2.25 to 3.4
(G)	—do—	—

Drawing Not to Scale
All Dimensions are in mm

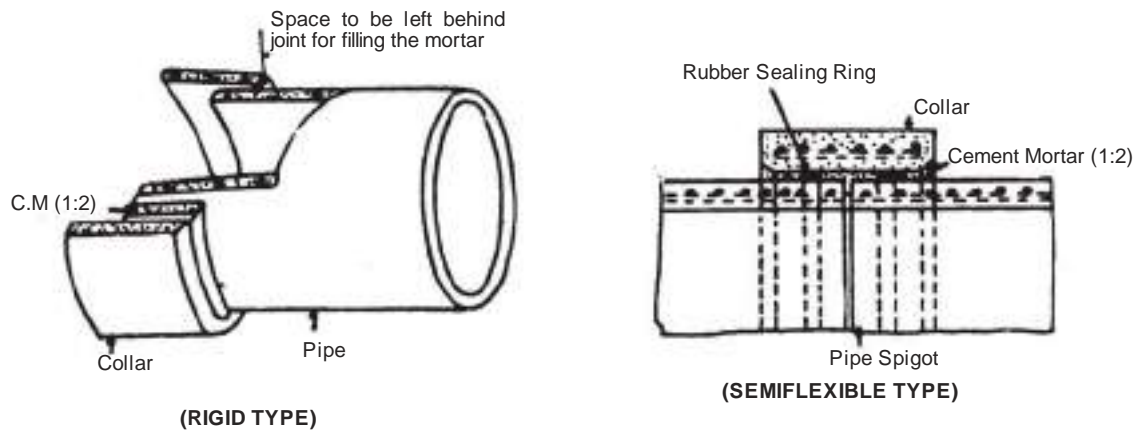
Fig. 19.9 : Bedding of Pipes

JOINTS OF CONCRETE PIPES

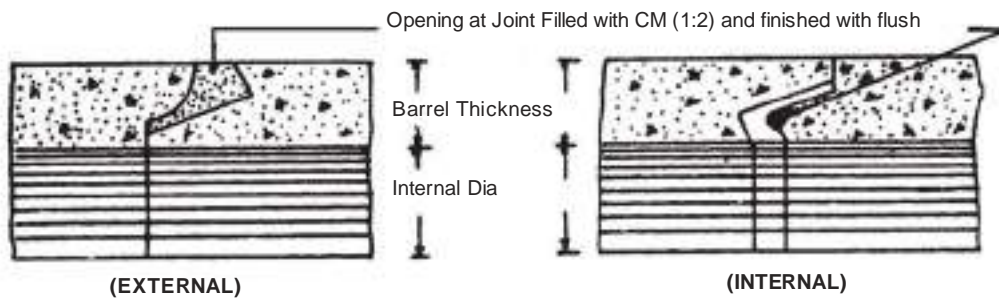
Sub Head: Drainage
Clause : 19.2.2.1



SPIGOT & SOCKET JOINTS



COLLAR JOINTS



FLUSH JOINTS

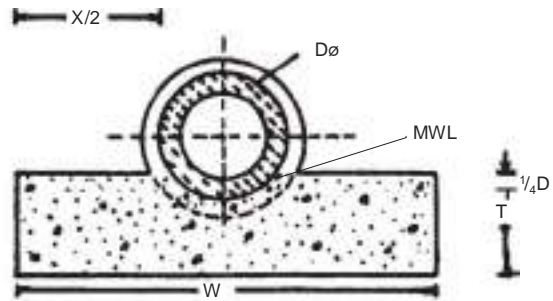
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Fig. 19.10 : Joints of Concrete Pipes

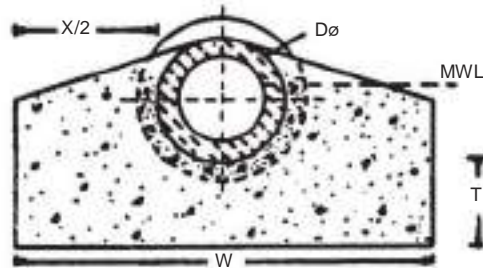
BEDDING/ENCASING STONEWARE PIPES

Sub Head : Drainage
Clause : 19.2.1

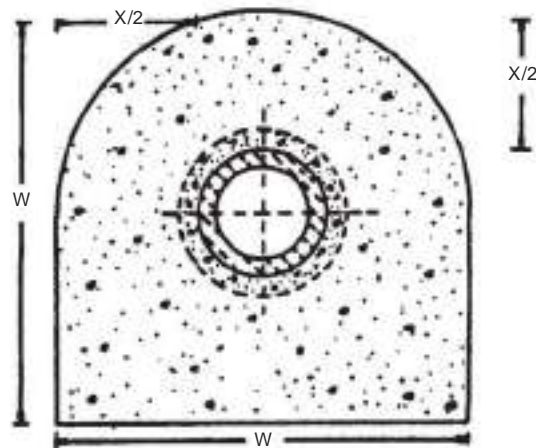
(i) CONCRETE
BEDDING



(ii) CONCRETE UPTO
HAUNCHES



(iii) CONCRETE
ALLROUND



W = $D+X$, Where D is the External Diametre of the pipe

X = $\begin{cases} 300 & \text{up to Trench Depth of 1200} \\ 400 & \text{Trench Depth more than 1200} \end{cases}$

T = 100 for pipes under 150, $\frac{1}{4}$ th Internal dia subject to a min. of 150 mm and max. 300 mm for pipes more than 150 Dia

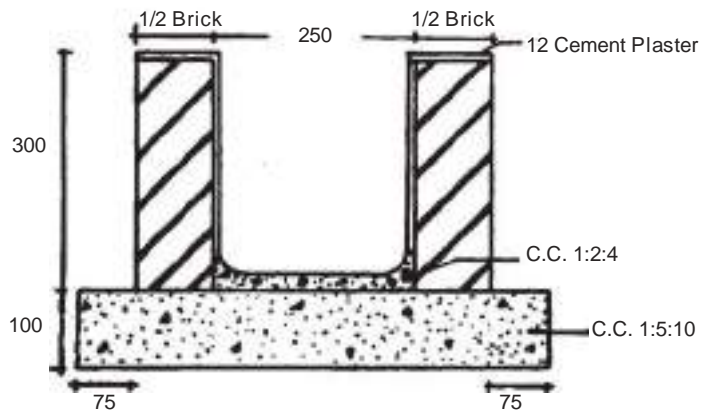
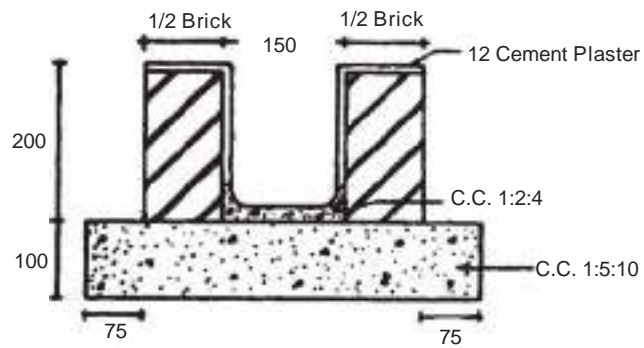
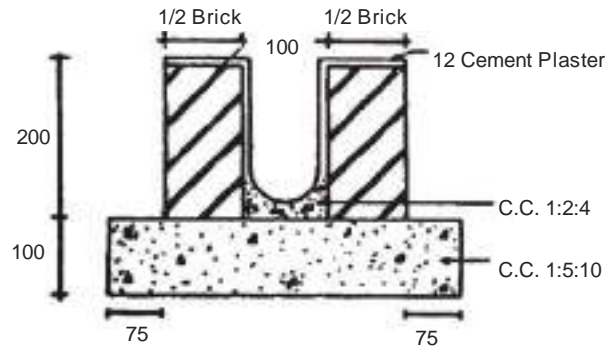
MWL = Maximum water level

Drawing Not to Scale
All Dimensions are in mm

Fig. 19.11: Bedding/Encasing Stoneware Pipes

BRICK MASONRY OPEN SURFACE DRAINS

Sub Head : Drainage
Clause : 19.6

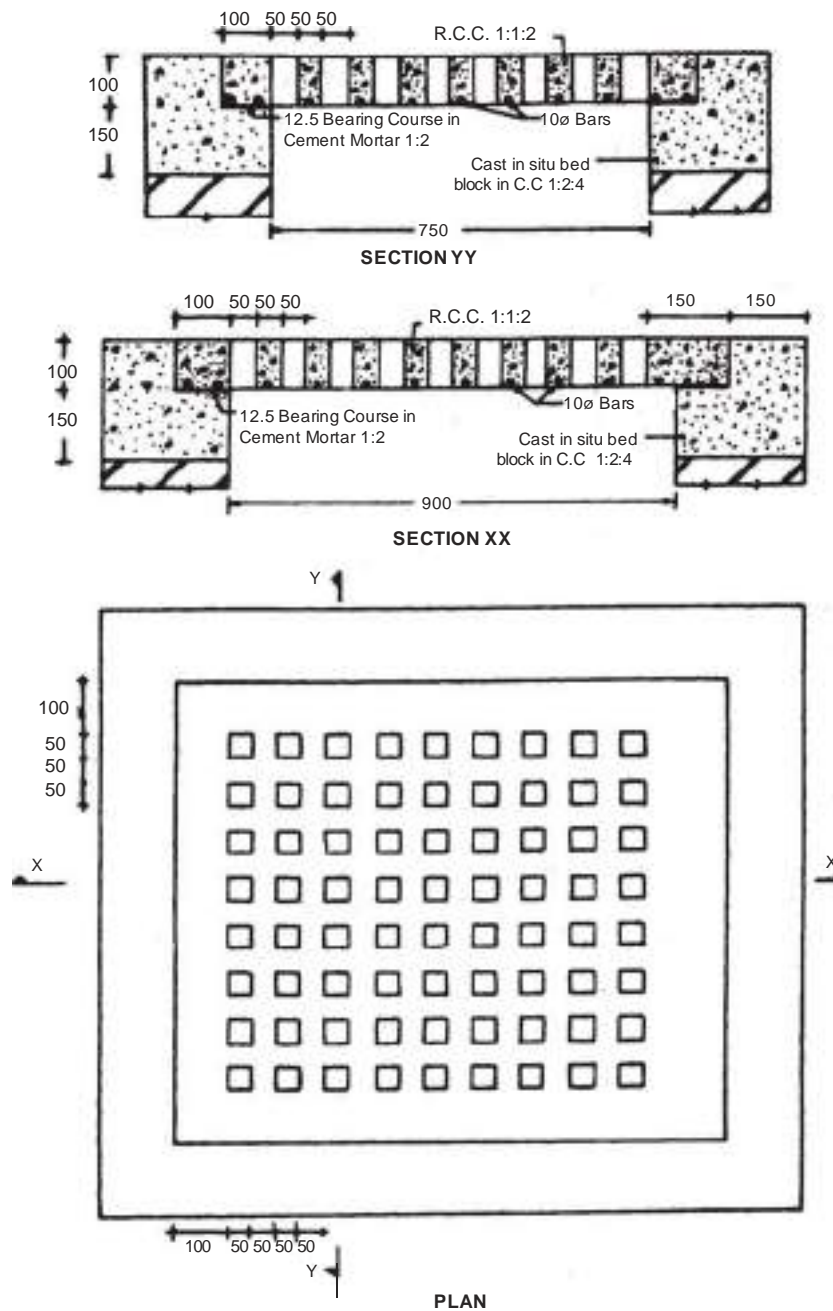


Drawing Not to Scale
All Dimensions are in mm

Fig. 19.12 : Brick Masonry Open Surface Drains

R.C.C. ROAD GULLY GRATING

Sub Head : Drainage
Clause : 19.2.4 & 19.7.1

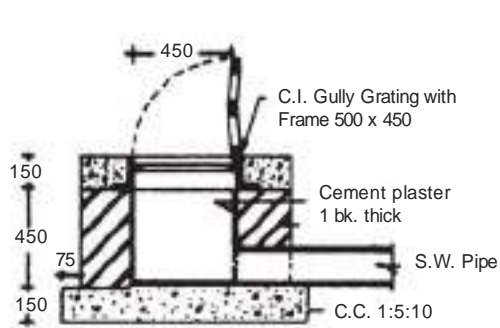


1. Drg. Not to Scale
2. All Dimensions are in mm
3. Clear Cover over Reinforcement shall be 20 mm
4. The Slab Covers shall Cast in R.C.C. 1:1:2
5. The R.C.C.. Cover shall be Properly Cured

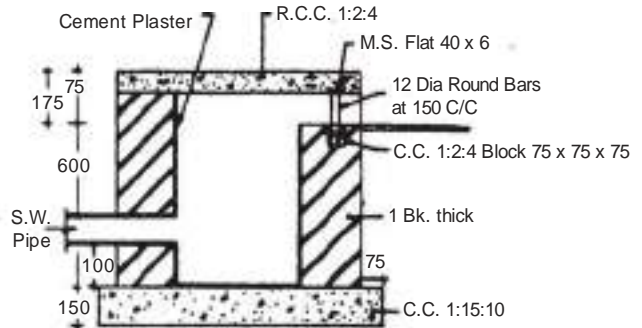
Fig. 19.13: R.C.C. Road Gully Grating

ROAD GULLY CHAMBER

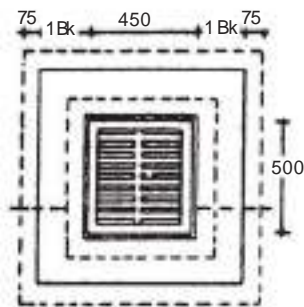
Sub Head : Drainage
Clause : 19.7



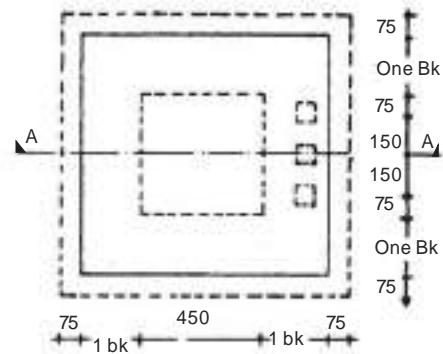
X - SECTION



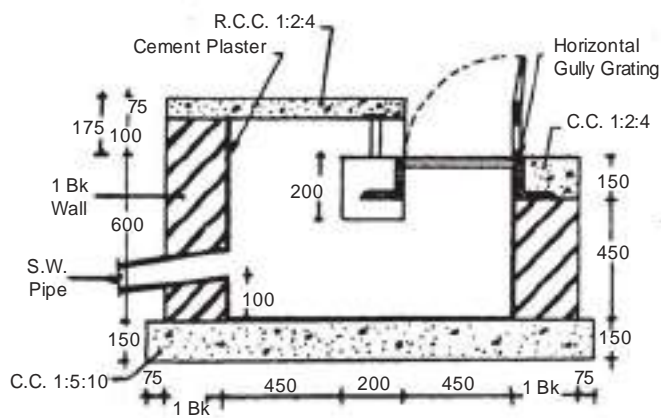
SECTION AA



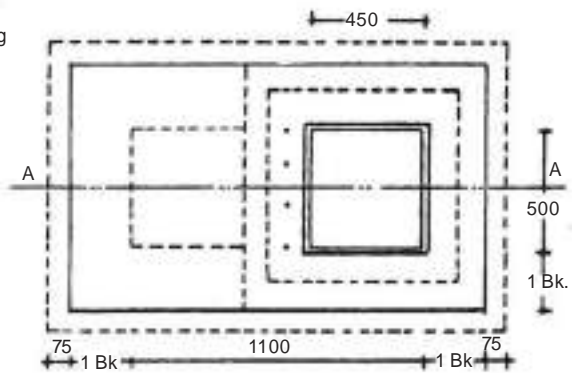
WITH HORIZONTAL GRATING



WITH VERTICAL GRATING



SECTION AA



PLAN

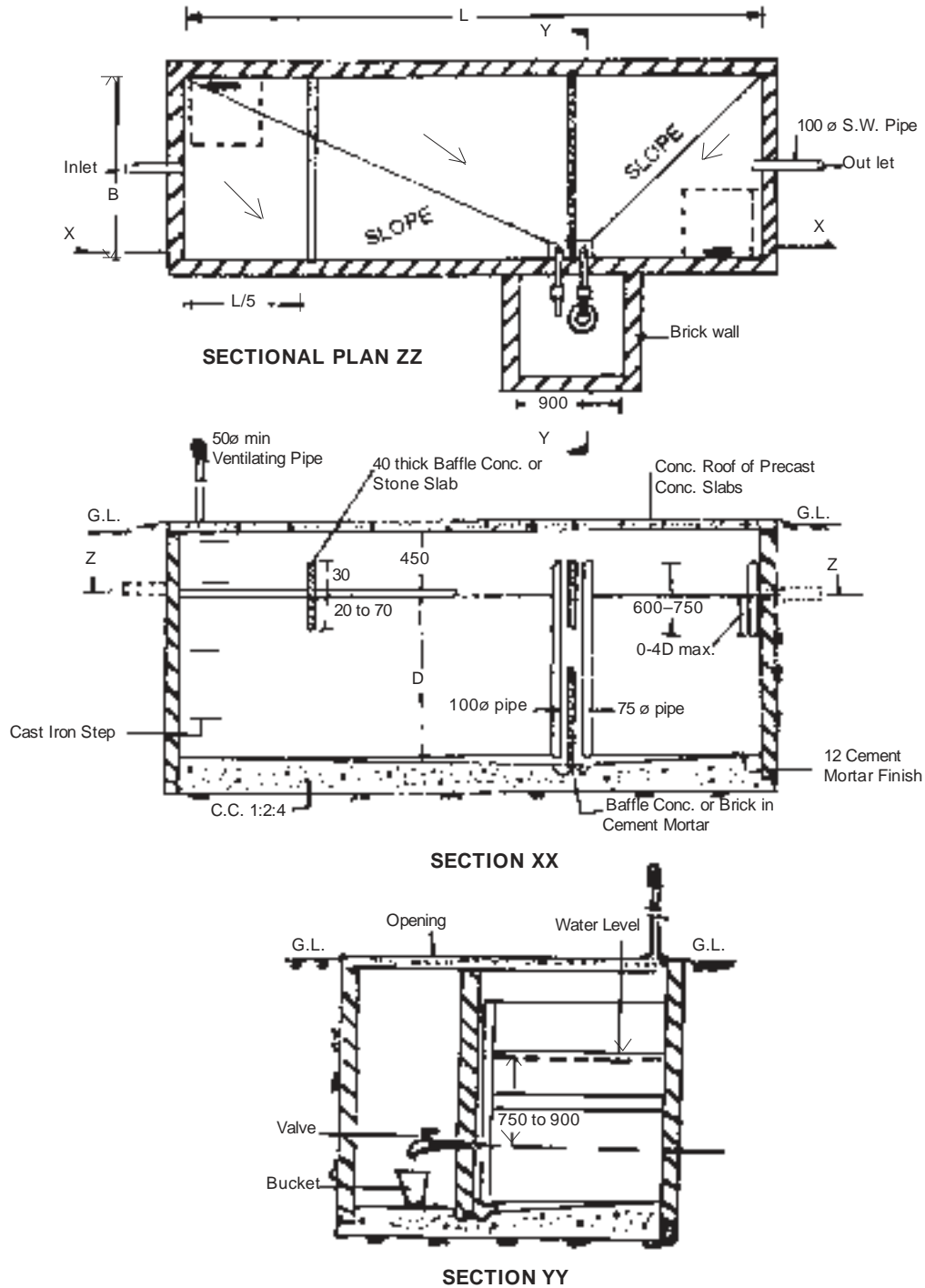
WITH HORIZONTAL AND VERTICAL GRATING

Drawing Not to Scale
All Dimensions are in mm

Fig. 19.14 : Road Gully Chamber

SEPTIC TANK

Sub Head : Drainage
Clause : 19.9

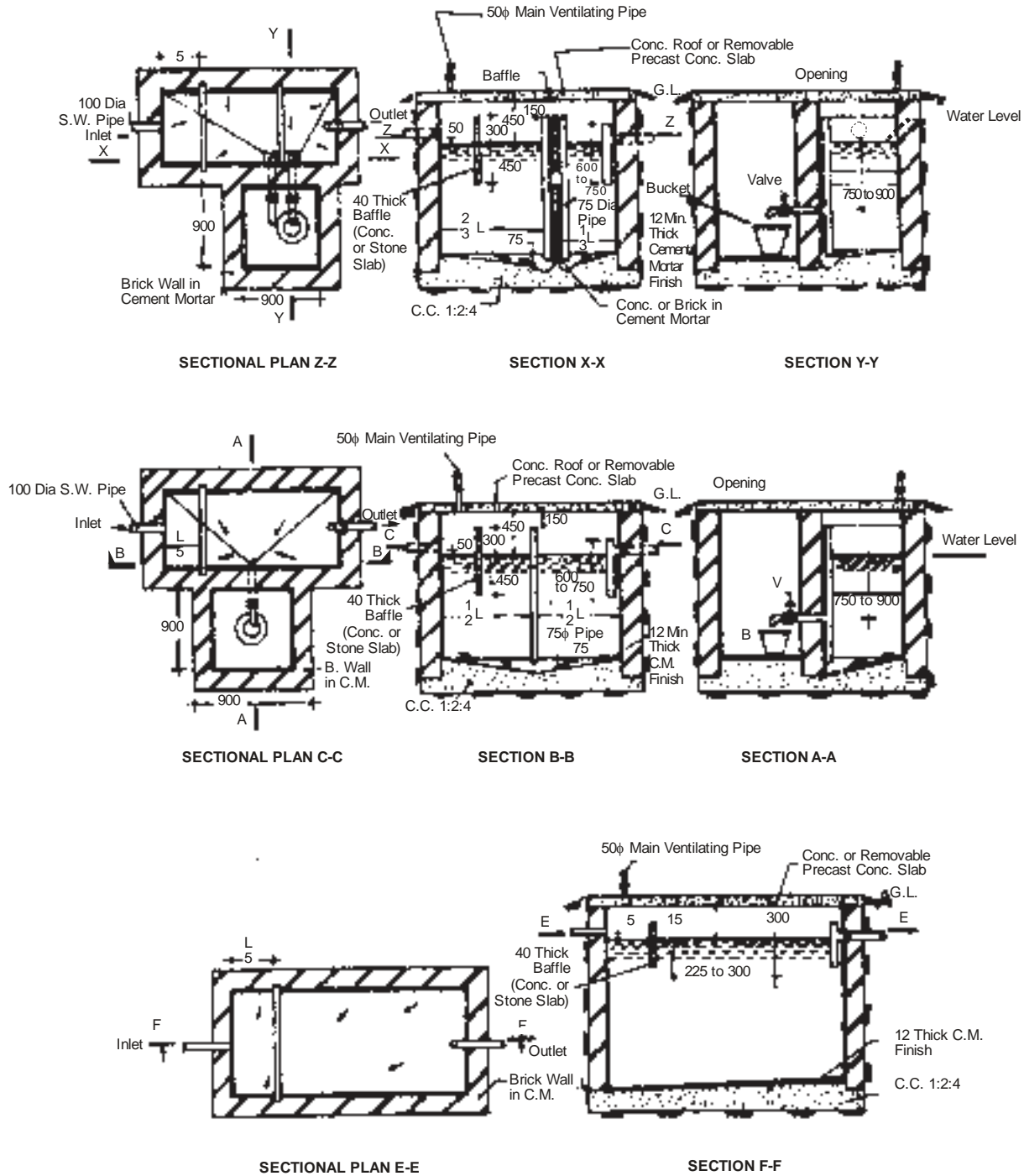


Drawing Not to Scale
All Dimensions are in mm

Fig. 19.15 : Septic Tank

SEPTIC TANK (Contd.)

Sub Head : Drainage
Clause : 19.9

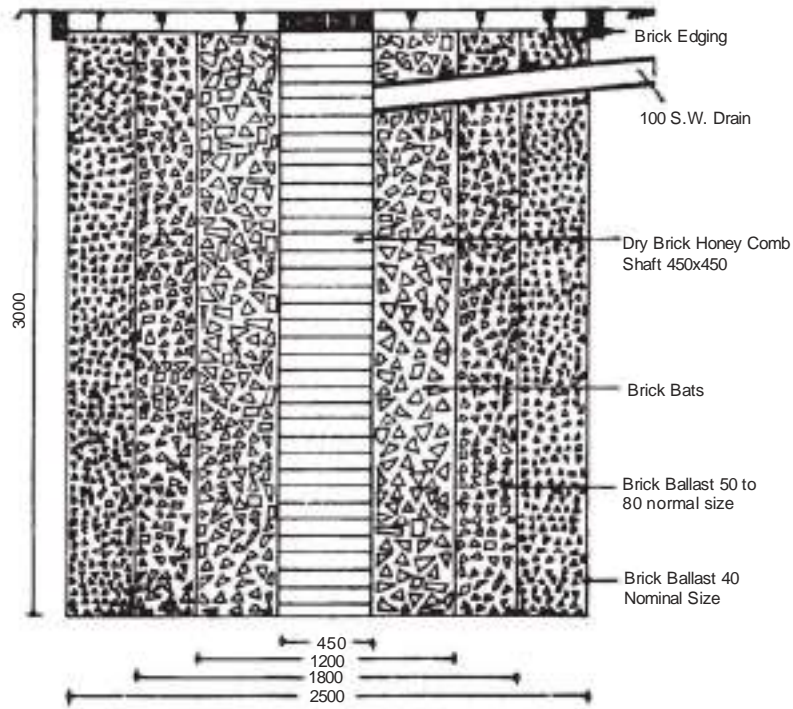


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All Dimensions are in mm

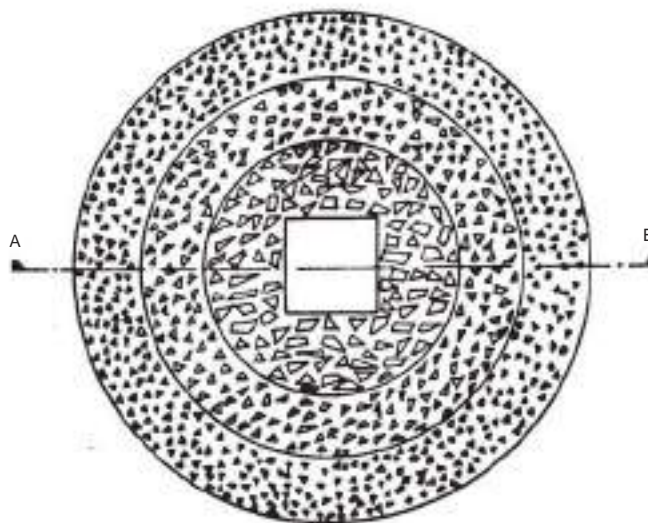
Fig. 19.16 : Septic Tank (Contd.)

SOAK PIT

Sub Head : Drainage
Clause : 19.10



SECTION AB



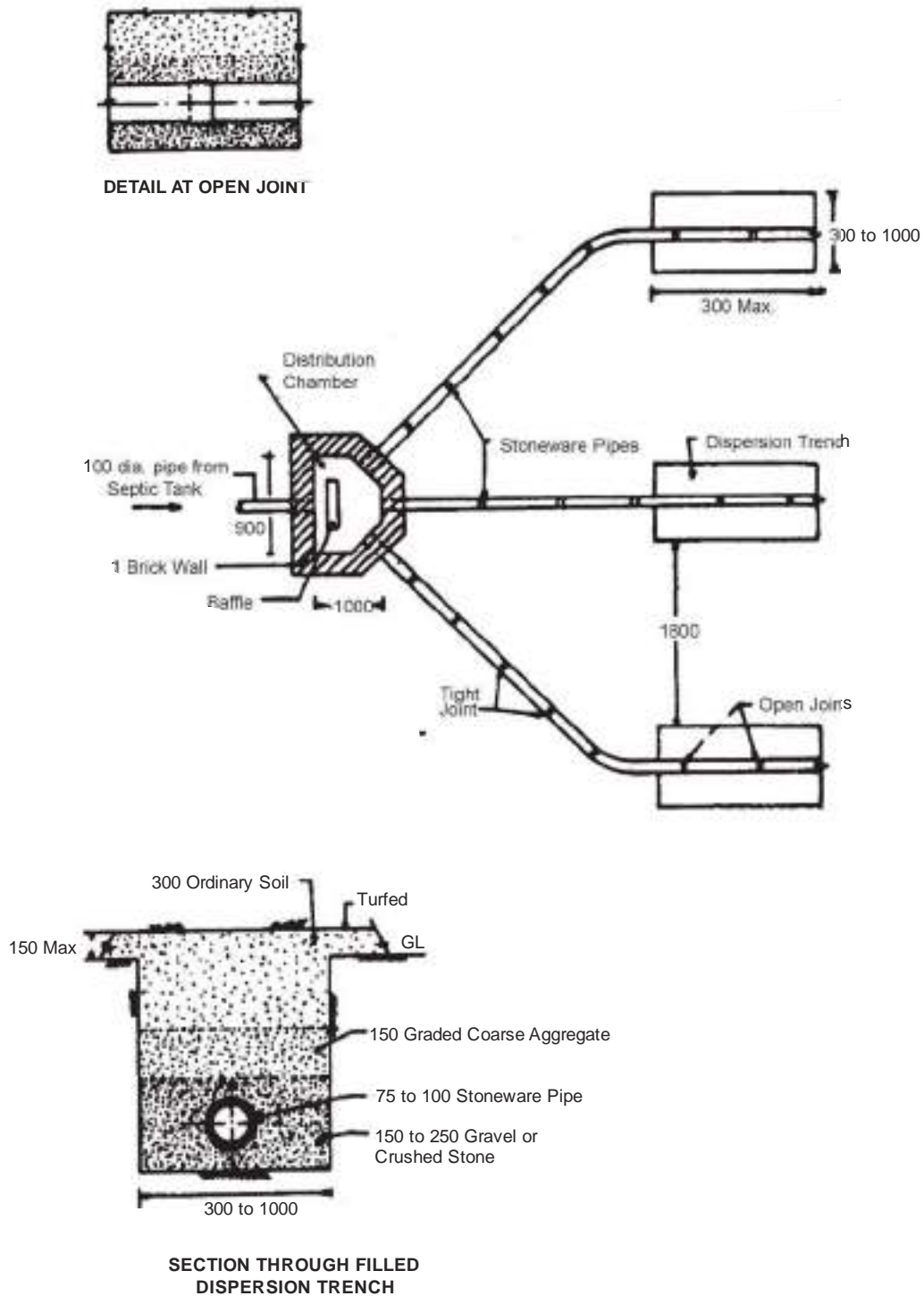
PLAN

Drawing Not to Scale
All Dimensions are in mm

Fig. 19.17 : Soak Pit

DISPERSION TRENCH

Sub Head : Drainage
Clause : 19.12



Drawing Not to Scale
All Dimensions are in mm

Fig. 19.18 : Dispersion Trench

SUB HEAD : 20.0

PILE WORK

CONTENTS

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Appendix B	Equipments for Under-reamed Piles (Manual Construction)	939
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LIST OF BUREAU OF INDIAN STANDARD CODES

<i>Sl. No.</i>	<i>IS No.</i>	<i>Subject</i>
1.	IS-1200 (Part 23)	Method of measurement of building and Civil Engineering Works – Piling.
2.	IS-2911 (Part 1/Sec. 1)	Code of practice for Design and Construction of pile foundation. Driven cast-in-situ piles.
3.	IS-2911 (Part 1/Sec. 2)	Code of practice of Design and Construction of pile foundation. Bored Cast-in-situ piles.
4.	IS-2911 (Part 1/Sec. 3)	Code of practice for Design and Construction of pile foundation. Driven pre-cast concrete piles.
5.	IS-2911 (Part 1/Sec. 4)	Code of practice for Design and Construction of pile foundation. Bored pre-cast concrete piles.
6.	IS-2911 (Part 3)	Code of practice for Design and Construction of pile foundation. Under reamed piles.
7.	IS-2911 (Part 4)	Code of practice for design and Construction of pile foundation. Load test on piles.
8.	IS-5112	Safety Code for piling and other deep foundations.
9.	IS-6426	Specification for pile driving hammer.
10.	IS-6427	Glossary of terms relating to pile driving.
11.	IS-6428	Specification for pile frame.
12.	IS-9716	Guide for lateral dynamic load test on piles.
13.	IS-14362	Pile boring equipments. General requirements.

20.0 PILE WORK

20.0 TERMINOLOGY

Allowable Load: It is load which is applied to a pile after taking into account its ultimate load capacity, pile spacing, Overall bearing capacity of the ground, the allowable settlement, negative skin friction including reversal of loads.

Bearing Pile: A pile formed in the ground for transmitting load of a structure to the soil by the resistance developed at its tips and or along its surface. It is either vertical or batter pile. It may be 'End bearing pile' or friction pile if it supports the load primarily along the surface.

Board Compaction Pile: It is bored cast-in-situ with or without bulb. In this compaction of surrounding ground and freshly filled concrete in pile, bore is simultaneously achieved by suitable method. A pile with a bulb is called a "under-reamed bored compaction pile". Under-reamed pile with more than one bulb is called Multi-under-reamed pile.

Constant Rate of Penetration (CRP) Test: The ultimate bearing capacity of preliminary piles and piles which are not used as working piles.

Constant Rate of Uplift (CRU) Test: The ultimate capacity in tension of preliminary piles and piles which are not used as working piles.

Cut of Level: It is the level where the installed pile is cut off to support the pile caps or beams.

Datum Bar: A rigid bar placed on immovable supports.

Draft Bolt: A metal rod driven into hole bored in timber, the hole being smaller in diameter than the rod.

Drop of Stroke: The distance through which the driving weight is allowed to fall for driving the piles.

Factor of Safety: It is the ratio of the ultimate load capacity of a pile to the safe load of a pile.

Follower Tube: A tube which is used following the main casing tube and it requires to be extended further. The inner diameter of the follower tube should be the same as the inner diameter of casing. The follower tube shall preferably be an outside guide and should be water tight when driven in water-bearing strata or soft clays.

Initial Test: This test is carried out with a view to determine ultimate load capacity and safe load capacity.

Raker or Batter Pile: The pile which is installed at an angle to the vertical. Raker piles are normally provided where vertical piles cannot resist the required applied horizontal forces. The maximum rake to be permitted in piles shall not exceed –

1 in 8 for cast-in-situ piles of large diameter viz. 750 mm dia., and above.

1 in 5 for smaller dia. cast-on-situ piles.

1 in 4 pre-cast piles.

Routine Test: It is carried out with a view to check whether pile is capable of taking the working load assigned to it.

Safe Load: It is the load arrived at by applying a factor of safety to the ultimate load capacity of the pile.

Set: The net distance by which the pile penetrates in the ground due to stated number of blows of the hammer.

Spliced Pile: A pile composed of two or more lengths secured together, end to end to form one pile.

Test Pile: A pile which is selected for load testing and which is subsequently loaded for that purpose. This pile may form working pile itself if subjected to a routine load test with up to one and half time the safe load.

Total displacement (Gross): The total movement of the pile under a given load.

Total Elastic Displacement: This is the magnitude of the displacement of the pile due to rebound caused at the top after removal of given test load. This comprises two components as follows:

- (a) Elastic displacement of the soil participating in load transfer; and
- (b) Elastic displacement of the pile shaft.

Trial Piles: These are installed initially to assess the load carrying capacity, it is either tested to ultimate bearing capacity or twice the estimated safe load.

Ultimate Load Capacity: The maximum load which a pile can carry before failure of ground (when the soil fails by shear) or failure of pile materials.

Working Load: It is a load assigned to a pile as per design.

Working Pile: It is a pile forming part of foundation of a structural system.

20.1 DRIVEN CAST-IN-SITU REINFORCED CEMENT CONCRETE PILES

20.1.1 General

Cast-in-situ piles shall be installed by driving a metal casing with a shoe at the tip and displacing the material laterally. Driven cast-in-situ pile is formed by driving a casing, permanent or temporary and subsequently filling the hole with plain or reinforced concrete.

20.1.2 Equipment

The equipment and accessories used for driven cast-in-situ piles shall depend on type of sub-soil strata, ground water conditions, type of founding material and penetration etc.

Commonly used plants are as per Appendix 'F' and few more are given below:

Dolly: A cushion of hardwood or some suitable material placed on the top of the casing to receive the blows of the hammer

Kent Ledge: Dead weight used for applying a test load to a pile.

Shoe: Pile Shoe should be of material as specified in the item. The pile shoes may be either cast iron or mild steel. Cast iron pile shoes shall be made from chill hardened iron as used for making grey iron casting conforming to IS 210. The chilled iron point shall be free from blow holes and other surface defects. Cast steel piles shoe shall be of steel conforming to IS 2644. Straps or other fastenings to cast pile shoes shall be of steel conforming to IS 1079 and shall be cast into the point to form an integral part of shoe. Different types of pile shoes are shown in Fig. 20.1

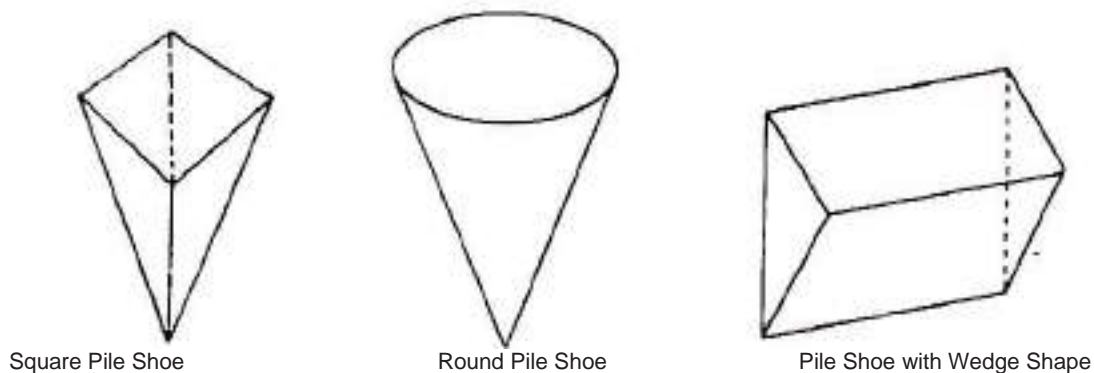


Fig. 20.1: Different Types of Pile Shoes

Drop Hammer (or Monkey): Hammer, ram or monkey raised by a winch and allowed to fall under gravity.

Single or Double Acting Hammer: A hammer operated by steam compressed air or internal combustion, the energy of its blows being derived mainly from source of motive power and not from gravity alone.

Pile Frame (or Pile Rig): A movable steel structure for driving piles in the correct position and alignment by means of a hammer operating in the guides or (leaders) of the frame.

20.1.3 Pile Driving

20.1.3.1 Installation of Piles: Installation of piles shall be as accurate as possible and as per design and drawings. The vertically or the required batter should be correctly maintained. Particular care shall be taken in respect of installing either single pile or piles in two pile groups.

20.1.3.2 Deviation /Tolerance

- (i) The deviation/tolerance should be as per IS 2911 (Part 1/Sec.1). The piles should not deviate more than 75 mm or $D/4$ whichever is less (75 mm or $D/10$ whichever is more in case of piles having diameter more than 600 mm) from their designed position at the working level.
- (ii) In case of a single pile under a column, the positional deviation should not be more than 50 mm or $D/4$ whichever is less (100 mm in case of piles having diameter more than 600 mm). Greater tolerance may be prescribed for piles driven over water and for raking piles.

20.1.3.3 Sequence of Installation: Normal sequence of installation of pile group is from the centre to the periphery of the group or from one side to the other. Particular care shall be taken to avoid damaging the already cast pile while driving a fresh tube nearby before the concrete has sufficiently set. The possibility of the pile getting damaged is more in compact soils than in loose soils.

20.1.3.4 Driving a Group of Friction Piles

- (i) The skin friction increases considerably when the pile bore is driven in the loose sand as the pile tends to compact the sand. Therefore in such cases the order of installation shall be altered so that a compact block is not created where driving further pile bore will not be possible. Similar precaution will have to be taken where stiff clay or compact sand layers will have to be penetrated.
- (ii) However driving the pile bore from centre outwards or commencing at a particular selected edge or even working across the group the problem pointed out in Para (i) above can be avoided.

- (iii) In case of very soft soil it is advisable to start driving the bore hole from outside to inside so that the soil gets restrained from flowing out during operation.

20.1.3.5 Procedure of Pile Driving

- (i) Driven cast-in-situ concrete piles are installed by driving a metal casing with a shoe at the tip/toe and displacing the material laterally.
- (ii) These piles may be cast in metal shells which may remain permanently in place or the casing may be withdrawn which may be termed as uncased driven cast-in-situ cement concrete piles.
- (iii) The metal casing shall be of sufficient thickness and strength to hold in original form and show no harmful distortion when the adjacent casing is driven and the driving core if any is withdrawn.
- (iv) Driven cast-in-situ concrete piles shall be installed using a properly designed detachable shoe at the bottom of the casing.
- (v) Any liner or bore hole; which is temporarily located and shows partial collapse that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer-in-Charge.

20.1.3.6 A proper record of pile driving and other details such as depth driven, sequence of installation in a group, cut off level/working level shall be mentioned in sequence of occurrence worksheet for the inspection of Engineer-in-charge.

20.1.4 Jetting

- (i) Driving of pile may be assisted by preboring holes or by the use of jets or both subject to the approval of the Engineer-in-charge. These may be used essentially to achieve the minimum penetration shown on the drawings where such penetration is not reached under normal conditions of driving. The diameter of the hole shall; not be greater than the diagonal dimension of the pile less 100 mm.
- (ii) The maximum depth of the preboring shall be such that the specified set (or less) is obtained when the toe of the pile is at founding level. Preboring shall be as approved by the Engineer-in-charge and shall not extend beyond one metre above the founding level and the pile shall be driven to at least one metre below the prebored hole. To ensure that the pile is properly supported laterally in the hole, any space remaining around the pile at the ground level after driving is finished shall be backfilled with approved granular material.
- (iii) When the water jetting is used at least two jets shall be attached to the pile symmetrically. The volume and pressure of water at the outlet nozzles shall be sufficient to freely erode material adjacent to the toe of the pile. The maximum depth of jetting shall be such that the specified set is obtained when the toe of the pile is at founding level. Jetting shall cease as directed by the Engineer-in-Charge and shall not proceed beyond one metre above the founding level and the pile shall be driven at least one metre below the prebored hole.
- (iv) To avoid very hard driving and vibration in materials such as sand, jetting of piles by means of water may be carried out in such a manner as not to impair the bearing capacity of piles already in place, the stability of the soil or the safety of any adjoining buildings. Details of arrangement for jetting shall be got approved from the Engineer-in-Charge in advance.
- (v) If large quantities of water are used for jetting it may be necessary to make provision for collection of water when it comes to the ground surface so that the stability of the piling plant is not endangered by the softening of the ground. Jetting shall be stopped before completing the

driving which shall always be finished by ordinary methods. Jetting shall be stopped if there is any tendency for the pile tips to be drawn towards the pile already driven owing to the disturbance to the ground.

20.1.5 Reinforcement

- (i) The design of reinforcing cage varies depending upon the driving and installation conditions, the nature of the sub-soil and the nature of load to be transmitted by the shaft, axial or otherwise. The minimum area of longitudinal reinforcement of any type or grade within the pile shaft shall be 0.4 per cent of the sectional area calculated on the basis of the outside area of the casings of the shaft.
- (ii) The curtailment of reinforcement along the depth of the pile, in general, depends on the type of loading and sub-soil strata. In case of piles subjected to compressive load only, the designed quantity of reinforcement may be curtailed at appropriate level according to design requirements. For piles subjected to uplift load, lateral load & moments, separately or with compressive loads, it may be necessary to provide reinforcement to the full depth of the pile. In soft clays or loose sands, or where there is likelihood of danger to green concrete due to driving of adjacent piles, the reinforcement should be provided up to full pile depth, regardless of whether or not it is required from uplift & lateral load considerations. However, in all cases, the minimum reinforcement specified in Para (i) above should be provided in full length of the pile.
- (iii) Piles shall always be reinforced with a minimum amount of reinforcement as dowels keeping the minimum bond length into the pile shaft below its cut-off level, and with adequate projection into the pile cap, irrespective of design requirements.

Note: In some cases the cage may lift at bottom or at the laps during withdrawal of casing. This can be minimized by making the reinforcement “U” shaped at the bottom and up to well secured joints. Also the lifting 5 percent of the length should be considered not to affect the quality of pile.

- (iv) Clear cover to all main reinforcement in pile shaft shall be not less than 50 mm and shall be maintained by suitable spacers. The laterals of reinforcing cage may be in the form of links or spirals. The diameter and spacing of the same is chosen to impart adequate rigidity of the reinforcing cage during the handling and installation. The minimum diameter of links or spirals shall be 6 mm and the spacing of the links or spirals shall be not less than 150 mm. The minimum clear distance between two adjacent main reinforcement should normally be 100 mm for full depth of the cage.
- (v) The reinforcing cage should be left with adequate protruding length above the cut off level for proper embedment in the pile cap. Prior to the lowering of reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials.
- (vi) Reinforcement in the form of cage shall be assembled with additional support, such as spreader forks and lacings; necessary to form a rigid cage hoops, links, or helical reinforcement has to fit closely around the main longitudinal bars and shall be tied by binding wire of approved quality. The ends of the binding wire shall be turned into the interior of the pile. Reinforcement shall be placed and maintained in correct position. The reinforcements shall be joined wherever necessary by welding and the procedure of welding be followed as described in IS 2751.

20.1.6 Concrete

20.1.6.1 Cement : Cement shall be as specified in agreement item or as specified under sub-head 3.0 of CPWD Specifications. However, high alumina cement shall not be used.

20.1.6.2 Water: Water to be used for concreting shall be as specified under sub-head 3.0 of CPWD Specifications.

20.1.6.3 Fine Aggregate: Fine aggregate to be used for concreting shall be as specified under sub-head 3.0 of CPWD Specifications.

20.1.6.4 Coarse Aggregate: For tremie concreting, coarse aggregate having nominal size more than 20 mm should not be used. Natural rounded shingle of appropriate size may also be used as coarse aggregate. It helps to give high slump with less water cement ratio.

20.1.6.5 Chemical Admixtures: Admixtures to be used in the concrete shall be as per IS 9103.

20.1.6.6 Concrete Grades to be adopted

- (i) Concreting of piles shall be done only with design mix of appropriate grade with weigh batching of constituents. The grade of concrete to be kept as per nomenclature of the item.
- (ii) Only concrete Grade M-25 and/or higher grades shall be used for concreting the piles. The exact grade of concrete to be used shall mainly depend upon the nature of work and the general design consideration. However, Concrete Grade M-15 and Grade M-20 shall not be used for concreting piles under any circumstances, even with weigh batching. The minimum cement content shall be 400 kg/m³ in all conditions.
- (iii) When concreting under water or drilling mud 10 per cent additional cement over the minimum cement content for the particular grade shall be used subject to a minimum cement content of 370 kg/cum.

20.1.6.7 Workability of Concrete: The minimum slump shall be 100 mm when the concrete for the piles is being vibrated and when the concrete is not vibrated the maximum permitted slump is 150 mm. The degree of workability in both the cases is considered as very high.

20.1.6.8 Placing of Concrete

- (i) Before commencement of pouring of concrete, it shall be ensured that there is no ingress of water in the casing tubes from bottom. Further, adequate control during withdrawal of the casing tube is essential so as to maintain sufficient head of concrete inside the casing tube at all stages of withdrawal.
- (ii) Wherever practicable concrete should be placed in a clean dry hole where concrete is placed in dry hole and when casing is present, the top 3 m pile shall be compacted using internal vibrators. The concrete should invariably be poured through a tremie, with a funnel so that the flow is directed and concrete can be deposited in the hole without segregation. Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and also while extracting the tube shall be avoided.
- (iii) Where the casing is withdrawn from cohesive soils for the formation of cast-in-situ pile, the concreting should be done with necessary precautions to minimize the softening of the soil by excess water. Where mud flow conditions exist, the casing of cast-in-situ piles shall not be allowed to be withdrawn.
- (iv) The concrete shall be self compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silt clays and other soils with tendency to squeeze into newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into concrete. The placing of concrete shall be continuous process from the toe level to the top of pile to prevent segregation, a tube of

tremie pipe as appropriate shall be used to place concrete in all piles. To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6 m (length of pile) per hour.

- (v) The diameter of the finished pile shall not be less than specified and a continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the length of pile cast. After each pile has been cast and any empty pile hole remaining shall be protected and back filled as soon as possible with approved material.
- (vi) The minimum embedment of cast-in-situ concrete piles into pile cap shall be 150 mm. Any defective concrete at the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the bottom reinforcement in pile cap from top of pile shall not be less than 30 mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately bonded into the pile cap. Exposing such length shall be done carefully to avoid damaging the rest of the pile. In cases where the pile cap is to be laid on ground a leveling course with cement concrete of Grade M-15 and of 100 mm thickness shall be provided.
- (vii) Normally concreting of piles should be uninterrupted. In exceptional case of interruption of concreting, but which can be resumed within 1 or 2 hours, the tremie shall not be taken out of the concrete. Instead it shall be raised and lowered slowly from time to time to prevent the concrete around the pipe from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200 mm for each displacement of the partly set concrete. If the concreting cannot be resumed before final set of concrete already laid, the pile so cast may be rejected.
- (viii) In case of withdrawal of tremie out of concrete, either accidentally or to removed a choke in the tremie, the tremie may be re-introduced to prevent impregnation of laitance scum lying on the top of the concrete already deposited in the bore. The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug should be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm should be filled in the tremie which will push the plug forward and swirl emerges out of the tremie displacing the laitance/scum. The tremie will be pushed further in steps masking fresh concrete sweep away laitance scum in its way. When the tremie is buried by about 60 to 100 cms, concreting may be resumed.
- (ix) The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level for proper embedment into the pile cap.
- (x) Where cut-off level is less than 1.5 metres below the working level concrete shall be cast to a minimum of 300 mm above cut-off level. For each additional 0.3 m increase in cut-off level below the working level additional coverage of 50 mm minimum shall be allowed. Higher allowance may be necessary depending on the length of the pile. When concrete is placed by tremie method concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one metre above cut off level. In the circumstances where cut-off level is below ground water level the need to maintain pressure on the unset concrete equal to or greater than water pressure should be observed and accordingly length of extra concrete above cut-off level shall be determined.

20.1.6.9 Placing Concrete under Water

- (i) Before concreting under water, the bottom of the hole shall be cleared of drilling mud and all soft loose materials very carefully. In case a hole is bored with use of drilling mud, concreting should not be taken up when the specific gravity of bottom slurry is more than 1.2. The drilling mud

should be maintained at 1.5 m above the ground water level. Concreting under water for cast-in-situ concrete piles may be done either with the use of tremie method or by the use of approved method specially designed to permit under water placement of concrete. General requirements and precautions for concreting under water are as follows:

- (a) The concreting of pile must be completed in one continuous operation. Also for bored holes, the finishing of the bore, cleaning of the bore, lowering of reinforcement cage and concreting of pile for full length must be accomplished in one continuous operation without any stoppage.
- (b) The concrete should be coherent, rich in cement with high slump & restricted water cement ratio.
- (c) The tremie pipe will have to be large enough with due regard to the size of the aggregate. For 30 mm aggregate the tremie pipe should be of diameter not less than 150 mm and for larger aggregate, larger diameter of tremie pipe may be necessary.
- (d) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it to prevent mixing of water and concrete.
- (e) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.
- (f) The pile should be concentrated wholly by tremie and the method of deposition should not be changed part way up the pile to prevent the laitance from being entrapped within the pile.
- (g) All tremie tubes should be scrupulously cleaned after use.

When concreting is carried out under water a temporary casing should be installed to the full depth of the bore hole or 2 m into non collapsible stratum, so that fragments of ground cannot drop from the sides of the hole into the concrete as it is placed. The temporary casing may not be required except near the top when concreting under drilling mud.

20.1.7 Testing of Concrete

20.1.7.1 The concrete for the piles shall be sampled in accordance with the norms specified in IS 456. The frequency of sampling is given in Table 20.1.

TABLE 20.1

<i>Quantity of Concrete in the Work m³</i>	<i>Number of Samples</i>
1-5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50m ³ or part thereof.

- Notes:**
- (i) At least one sample shall be taken from each shift.
 - (ii) Where concrete is produced as continuous production unit, such as ready mix concrete plant. The frequency of sampling may be agreed upon mutually by suppliers and purchasers.

20.1.7.2 Test Specimen: Three test specimens shall be made for each sample for testing at 28 days. Additional samples may be required for various purposes such as to determine the strength of concrete at 7 days or to determine the duration of curing, or check the testing error, additional sample may also be required for testing samples cured by accelerated methods as described in IS 9103. The specimen shall be tested as described in IS 516.

20.1.7.3 Test Results of Samples: The test results of the samples shall be the average of the strength of three specimens. The individual variation should not be more than $\pm 15\%$ percent of the average strength. If the variation is more, the test result of the sample is invalid.

20.1.8 Curing

As per IS 456 – 2000, exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, Hessian or similar materials and kept constantly wet for at least 10 days from the date of placing concrete. The period of curing shall not be less than 14 days for concrete exposed to dry and hot weather conditions.

20.1.9 Defective Pile

- (i) In case defective piles are formed they shall be removed or left in place whichever is convenient without affecting performance of the adjacent piles or cap as a whole. Additional piles shall be provided to replace them as directed.
- (ii) Any deviation from the designed location alignment or load capacity of any pile shall be noted and adequate measures taken well before concreting of the pile cap and plinth beam, if the deviations are beyond permissible limit.
- (iii) During chipping of the pile, top manual chipping may be permitted after three days of pile casting pneumatic tools for chipping shall not be used before seven days after pile casting.
- (iv) After concreting the actual quantity of concrete shall be compared with average obtained from observations actually made in the case of a few piles initially cast. If the actual quantity is found to be considerably less, special investigations shall be conducted and appropriate measures taken.

20.1.10 Ready Mix Concrete (RMC)

Alternatively, the contractor can be allowed to use Ready Mix Concrete (RMC) with the permission of Engineer-in-Charge, provided that the manufacturer assures that for RMC supplied for the particular work contains the minimum cement content and it is in conformity of approved design mix. The manufacturer of RMC has also to agree to the sampling and testing procedure as specified under clause 20.1.7 or alternatively he can propose his own sampling and testing procedure which should in turn be approved by the Engineer-in-Charge. Normally, RMC supplied to site are mixed with certain admixtures which enables the concrete to be used within 3 hours of supply at site. In case RMC supplied is not consumed within 3 hours of supply the quantity of RMC remaining unused beyond 3 hours shall be rejected and removed from site.

20.1.11 Measurement

Dimension shall be measured nearest to a cm. Measurement of length on completion shall be along the axis of pile and shall be measured from top of shoe to the bottom of pile cap. No allowance shall be made for bulking, shrinkage, cut off tolerance, wastage and hiring of tools and equipment for excavating driving etc.

20.1.12 Rate

The rate includes the cost of materials and labour involved in all the operations described above including pile embedded in pile cap, except soil investigation, reinforcement, pile cap and grade beam.

20.2 BORED CAST-IN-SITU REINFORCED CONCRETE PILES

20.2.1 General

The piles are formed within the ground by excavating or boring a pile within it with or without the use of temporary casing and subsequently filling it with plain or reinforced concrete. When the casing is left permanently it is termed as cased pile and when the casing is taken out it is termed as uncased pile.

20.2.2 Equipment

The equipment and accessories used for bored cast-in-situ piles shall depend on subsoil strata, ground water conditions, type of founding material and penetration etc.

General requirements of boring equipment are as per Appendix 'D'. The equipment is applicable for bored piles without the use of bentonite.

20.2.2.1 Boring operation shall be done by rotary percussion type drilling rigs using direct mud circulation or reverse mud circulation methods to bail out the cuttings or as specified. In soft clays and loose sand, bailer and chisel method should be used with caution to avoid the effect of suction. Rope operated grabbing tool Kelly mounted hydraulically operated grab are also used. This method of advancing the hole avoids suction. The size of cutting tool shall be as per [IS 2911 (Part I Section 2)] and not less than the diameter of pile by more than 75 mm.

20.2.2.2 Use of drilling mud is stabilizing sides of bore hole where specified shall have properties as defined in Appendix A.

Permanent casing where specified shall be used to avoid aggressive action of water.

20.2.3 Boring for installing Pile

20.2.3.1 Installation of Piles : As described under clause 20.1.3.1

20.2.3.2 Deviation and Tolerance : As described under clause 20.1.3.2.

20.2.3.3 Procedure of Driving Pile Bore

- (i) Bored cast-in-situ concrete piles are installed by making a bore into the ground and removing out the material.
- (ii) The ground shall be roughly leveled and position of pile marked. The boring shall be done with or without the use of temporary casing. The sides of bore hole; shall be stabilized with the aid of temporary casing or with the aid of drilling mud of suitable consistency.
- (iii) The equipment and accessories shall depend upon the type of bored pile chosen for the job, consideration of sub-soil strata, ground water condition, type of founding material. Boring operation normally are done by rotary or percussion type drilling rigs using direct mud circulation on reverse mud tool shall be as detailed in IS 2911 (Part 1/Sec.2).
- (iv) In case permanent/temporary casing is not used then bored pile is stabilised with drilling fluid. Bentonite supplied to site shall conform to IS 2720 (Part V). A certificate shall be obtained by the contractor from the manufacturer showing properties of each consignment and should be submitted to the Engineer-in-charge. Bentonite shall be mixed thoroughly with fresh clean water to make a suspension which will maintain the stability of the pile excavation for the period necessary to place concrete and complete construction. The temperature of the water used in mixing the bentonite suspension and when supplied to bore hole shall not be lower than 5°C. Consistency of the drilling fluid suspension and when controlled throughout the boring as well as in concreting operations in order to keep the hole stabilized as well as to avoid concrete getting mixed up with thick suspension of mud.

Frequency and methods of testing drilling fluid shall be as specified and the test results shall be as specified in IS 2720 (Part V).

- (v) Bored cast-in-situ piles in soils which are stable may often be installed with a small casing length at the top. A minimum of 2.0 m length of top of bore shall; invariably be provided with casing to ensure against loose soil falling in to drilling mud, or a suitable steel casing. The casing may be left in place permanently especially in cases where the aggressive action of the ground water is to be avoided, or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.
- (vi) For bored cast-in-situ piles, casing/liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as directed by the Engineer-in-charge. Materials inside the casing shall be removed progressively by air lift, grap or percussion equipment or other approved means.
- (vii) Where bored cast-in-situ piles are used in soils liable to inflow, the bottom of the casing shall be kept low enough in advance of the boring tool; to prevent the entry of soil into the casing, thus presenting the formation of settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as tight as possible to minimize inflow of water or leakage of slurry during concreting.
- (viii) Boring shall be carried out using rotary or percussion type equipment. Unless otherwise directed by the Engineer-in-charge the diameter of the bore holes shall be not more than the inside diameter of the liner.
- (ix) After the boring has reached the required depth, the steel reinforcement shall be lowered in position maintaining the specified size of cover on all sides. The bore shall then be flushed with bentonite slurry and concreting shall be taken up exactly as described under clause 20.1.6.8.

20.2.3.4 A proper record of pile driving and other details such as sequence of installation of piles, dimension of piles, depth bored, time taken for concreting etc. shall be maintained in sequence of occurrence at site as per clause 20.1.3.6.

While drilling mud is used, the specific gravity of fresh supply and contaminated mud in the hole before concreting is taken up shall be recorded for first ten piles and subsequently at interval of 10 piles or as specified.

20.2.4 Reinforcement

As specified under clause 20.1.5.

20.2.5 Concrete

As specified under clause 20.1.6.

20.2.6 Ready Mix Concrete

As specified under clause 20.1.10.

20.2.7 Measurement

Dimensions shall be measured nearest to a cm. Measurement of length on completion shall be along the axis of pile and shall be measured up to the bottom of pile cap. No allowance shall be made for bulking, shrinkage, cut off tolerance, wastage and hiring of tools, equipment for excavating, driving etc.

20.2.8 Rate

The rate includes the cost of material and labour involved in all the operations described above including pile embedded in pile cap except reinforcement, pile cap and grade beam.

20.3 UNDER-REAMED RCC PILES

20.3.1 General

- (i) Under-reamed piles are bored cast-in-situ and bored compaction concrete types having one or more bulbs formed by suitably enlarging the bore hole for the pile stem. With the provision of bulb(s) substantial bearing or anchorage is available.
- (ii) These piles find application in widely varying situations in different types of soils where foundation are required to be taken down to a certain depth in view of considerations like the following requirements :
 - (a) To avoid the undesirable effect of seasonal moisture changes as in expansive soils.
 - (b) To reach firm strata.
 - (c) To obtain adequate capacity for downward, upward and lateral loads and moments
 - (d) To take foundations below scour level.
- (iv) When the ground consists of expansive soil e.g. black cotton soil, the bulb of the under ream pile provides anchorage against uplift due to swelling pressure apart from the increased bearing capacity.
- (v) In case of filled up or otherwise weak strata overlying the firm strata, enlarged base in the form of under-reamed bulb in firm strata provides larger bearing area and piles of greater bearing capacity can be made.
- (vi) In loose to medium pervious sandy silty strata, bored compaction piles can be used as the process of compaction increases the loads bearing capacity of the piles.
- (vii) Under-reamed piles may also be used under situations where the vibration and noise caused during construction of piles are to be avoided. The provision of bulb(s) is of special advantage in under reamed piles to resist uplift and they can be used as anchors.

20.3.2 Pile Grouping

- (i) For bored cast in situ under-reamed piles at usual spacing of 2 Du, the group capacity will be equal to the safe load of individual pile multiplied by the number of piles in the group. For piles at spacing of 1.5 Du the safe load assigned per pile in a group should be reduced by 10 per cent.
- (ii) In under-reamed compaction piles, at the usual spacing of 1.5 Du, the group capacity will be equal to the safe load on individual pile multiplied by the number of piles in the group.

Note: In order-reamed compaction piles, the capacity of the group may be more than given in Para (i) above on account of compaction effect.

- (iii) In non-expansive soils, when the cap of the pile group is cast directly on a reasonably firm stratum it may additionally contribute towards the bearing capacity of the group.
- (iv) In load bearing walls piles should generally be provided under all wall junctions to avoid point loads on beams. Position of intermediate piles is then decided by keeping door openings fall in between two piles as far as possible.

20.3.3 Equipment and Other Accessories

- (i) The selection of equipment and accessories will depend upon the type of under-reamed piles, site conditions and nature of strata. Also it will depend on economic considerations and availability of manually or power operated equipment.

- (ii) A typical list of equipment for manual construction is given in Appendix B.
- (iii) Bore holes may be made by earth augers. In case of manual boring, an auger boring guide shall be used to keep bores vertical or to desired inclination and in position. After the bore is made to the required depth, enlarging of the base shall be carried out by means of an under-reaming tool.
- (iv) In ground with higher water table having unstable pile bores, boring and under-reaming may be carried out using suitable drilling mud. General guidelines for bentonite drilling mud are given in Appendix 'A'. In normally met soil strata, drilling mud can be poured from top while boring and under-reaming can be done by normal spiral earth auger and under-reamer.
- (v) The level of drilling mud should always be about one meter above water table or the level at which caving-in occurs. In case of very unstable strata with excessive caving-in continuous circulation of drilling mud using suitable pumping equipment and tripod, etc along with modified auger and under-reamer may be used.
- (vi) Some times permeable strata overlying a rim clayey stratum may be cased and normal boring and under-reaming operation may be carried out in clayey stratum.
- (vii) To avoid irregular shape and widening of bore hole in very loose strata at top a casing pipe of suitable length may be used temporarily during boring and concreting.
- (viii) For improved control over the inclination of batter/raker piles a tripod hoist with fixed pulley should be used for lowering in of under-reaming tools.
- (ix) For placing concrete in bore holes full of drilling mud or sub-soil water tremie pipe of not less than 150 mm diameter with flap valve at the bottom should be used.
- (x) For batter/raked under-reamed piles the reinforcement cage should be placed guiding it by a chute or any other suitable method. If concreting is not done by tremie, it should be done by chute.
- (xi) In under-reamed compaction piles, suitable device should be used for guiding the movement of drop weight and specified core assembly for its vertical driving for operating the drop weight and specified core assembly for its vertical driving for operating the drop weights of adequate capacity, suitable winch with hoisting attachment should be used.

20.3.4 Pile Boring

- (i) Under-reamed piles may be constructed by selecting suitable installation techniques at given site depending on sub-soil strata conditions and type of under-reamed piles and number of bulbs.
- (ii) In construction with equipment suggested under Appendix 'B' initially boring guide is fixed with its lower frame leveled for making desired angular adjustment for piles at batter/rake. Boring is done up to required depth and under-reaming is completed.
- (iii) In order to achieve proper under-reamed bulb, the depth of bore hole should be checked before starting under reaming. It should also be checked during under-reaming and any extra soil at the bottom of bore hole; removed by auger before reinserting the under-reaming tool.
- (iv) The completion of desired under-reamed bulb is ascertained by
 - (a) The vertical movement of the handle and
 - (b) When no further soil is cut.

- (v) In double or multi under-reamed piles, boring is first completed to the depth to the first (top) under-ream only and after completing the under-reaming boring is extended further for the second under-ream and the process is repeated.

20.3.4.1 Control of Alignment

- (i) The piles shall be installed as correctly as possible at the correct location and truly vertical (or at the specified batter/inclination). Great care shall be exercised in respect of single pile or piles in two pile groups under a column.
- (ii) As a guide for vertical piles a deviation of 1.5 per cent and for raker piles a deviation of four percent shall not normally be exceeded. In special cases, a closer tolerance may be necessary.
- (iii) Piles shall not deviate more than 75 mm or one quarter the stem diameter, whichever is less (75 mm or $D/10$ whichever is more in case of piles having diameter more than 600 mm) from the designed position at the working level.
- (iv) In case of single pile under a column the positional deviation should not be more than 50 mm or one quarter of the stem diameter whichever is less (100 mm in case of piles having diameter more than 600 mm).
- (v) For piles where cut-off is at substantial depths, the design should provide for worst combination of the above tolerances in position and inclination.
- (vi) In case of piles deviating beyond these limits corrective measures where necessary may be taken in the form of increasing pile size, provision of extras reinforcement in the pile, redesign of pile cap and pile ties. If the resulting eccentricity cannot be taken care of by the above measures, the piles should be replaced or supplemented by; one more additional piles.

20.3.5 Reinforcement in Piles

- (i) The provision of reinforcement will depend on nature and magnitude of loads, nature of strata and method of installation. It should be adequate for vertical loads, lateral load and moments acting individually or in combination. It may be curtailed at appropriate depths only under the advice of the structural engineer. However, provision of reinforcement shall be as specified in drawing.
- (ii) The minimum area of longitudinal reinforcement (any type or grade) within the pile shaft should be 0.4 per cent of the sectional area calculated on the basis of outside area of shaft or casing if used.
- (iii) Reinforcement is to be provided in the full length irrespective of any other considerations and is further subject to condition that a minimum number of three 10 mm dia mild steel or three 8 mm dia high strength steel bars shall be provided. The transverse reinforcement as circular stirrups shall not be less than 6 mm dia. Mild steel bars at a spacing of not more than the stem diameter or 30 cm, whichever is less.
- (iv) For under reamed compaction piles, a minimum number of four 12 mm diameter mild steel or four 10 mm diameter high strength steel bars shall be provided.
- (v) For piles of lengths exceeding 5 m and or 37.5 cm diameter, a minimum number of six 12 mm diameter HSD bars shall be provided.
- (vi) For piles exceeding 40 cm diameter a minimum number of six 12 mm diameter high strength steel bars shall be provided.

- (vii) The circular stirrups for piles of length exceeding 5 m and diameter exceeding 37.5 cm shall be bars of 8 mm diameter.
- (viii) For piles subject to uplift loads, adequate reinforcement shall be provided to take full up lift which shall not be curtailed at any stage.
- (ix) For piles up to 30 cm diameter, if concreting is done by tremie, equivalent amount of steel placed centrally, may be provided at sides.
- (x) The minimum clear cover over longitudinal reinforcement shall be 50 mm. In aggressive environment of sulphates etc. it may be increased to 75 mm.

20.3.6 Concrete

20.3.6.1 Materials : Cement, water, fine aggregate, coarse aggregate and chemical admixtures etc. as described under clause 20.1.6.

20.3.6.2 Concrete grades to be adopted : Same as described under clause 20.1.6.6.

20.3.6.3 Workability of Concrete : Same as described under clause 20.1.6.7.

20.3.6.4 Placing of Concrete

- (i) Same as Para (i) to (x) under clause 20.1.6.8.
- (ii) Concreting shall be done as soon as possible after completing the pile bore. The bore hole full of drilling mud should not be left un-concreted for more than 12 to 24 hours depending upon the stability of the bore hole.
- (iii) For placing concrete in pile bores, a funnel should be used and method of concreting should be such the entire volume of the pile before is filled up without formation of voids and/or mixing of soil and drilling fluid in concrete.
- (iv) In empty bore holes for under-reamed piles a small quantity of concrete is poured to give about 100 mm layer of concrete at bottom. Reinforcement is lowered next and positioned correctly. Then concrete is poured to fill the bore hole. Care should be taken that soil is not scrapped from side if rodding is done for compaction. Vibrators shall not be used.
- (v) If water is confined up to the bucket length portion at the toe & seepage is low, the water should be bailed out and concreting should be done as prescribed in Para (iv) above.
- (vi) In case the pile bore is stabilized with drilling mud or by maintaining water head within the bore hole, the bottom of bore hole shall be carefully cleaned by flushing it with fresh drilling mud and pile bore will be checked for its depth immediately before concreting.
- (vii) Concreting shall be done by tremie method. The tremie should have a valve at bottom and lowered with valve closed at the start and filled up with concrete. The valve is then opened so permit the flow of concrete which permits upward displacement of drilling mud.
- (viii) The pouring should be continuous and tremie is gradually lifted up such that the tremie pipe opening remains always in the concrete. At the final stage the quantity of concrete in tremie should be enough so that on final withdrawal some concrete spills over the ground.

Note: (1) The concrete should be coherent, rich in cement (not less than 350 kg/m^3) and slump not less than 150 mm.

(2) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

(ix) In inclined piles, concreting should be done through a chute or by tremie method.

(x) For under-reamed bored compaction piles, the pile bore is first filled up without placing any reinforcement. Concreting is done as prescribed in paras (iv) depending upon the situation. Soon after the specified core assembly shall be driven and extra concrete shall be poured in simultaneously to keep the concrete up to ground level. If hollow driving pipe is used in core assembly the pipe shall be withdrawn after filling it with fresh concrete which will be left behind.

20.3.6.5 Estimation of Concrete Quantity

(i) The extra quantity required for each bored cast-in-situ under-reamed bulb of 2.5 times the stem diameter may be taken equal to a stem length of 4 to 4.5 times its diameter, depending upon the nature of strata and other site conditions. The volume of concrete actually placed shall be observed in the case of quantities of the concrete and cement for the subsequent piles.

(ii) For under-reamed compaction piles the amount of concrete used is about 1.2 times of the under-reamed cast-in-situ piles.

Note: If the estimates of concrete consumption are on the volume of the bore holes and not on the basis of concrete quantity actually consumed, the concrete used may be found lesser than estimated and cement consumption may work out to be less.

20.3.6.6 Placing Concrete under Water : As described under clause 20.1.6.9.

20.3.6.7 Testing Works Concrete : As described under clause 20.1.7.

20.3.6.8 Curing : As described under clause 20.1.8.

20.3.6.9 Ready Mix Concrete (RMC) : As described under clause 20.1.10.

20.3.7 Pile Cap (Fig. 20.2 and 20.3)

(i) Pile cap are generally designed considering pile reaction as either concentrated loads or distributed loads. The depth of pile cap should be adequate for the shear, diagonal tension and it should also provide the necessary anchorage of reinforcement both for the column and the pile.

(ii) The pile caps may be designed by assuming that the load from column or pedestal is dispersed at 45° from the top of the cap up to the mid depth of the pile cap from the based of the column or pedestal. The reaction from piles may also to be taken to be distributed at 45° from the edge of the pile, up to the mid depth of the pile cap on this basis, the maximum bending moment and shear forces should be worked out at critical sections.

(iii) Full dimension of the cap shall be taken as width to analyse the section for bending and shear in respective direction. Method of analysis and allowable stresses may be according to IS 456.

(iv) The clear overhang of the pile cap beyond the outermost pile in the group shall normally be 100 to 150 mm depending upon the size of the pile.

- (v) The cap is generally cast over a 75 mm thick leveling course of concrete. The clear cover for the main reinforcement of cap slab shall be not less than 75 mm.
- (vi) The pile should project 50 mm into the cap concrete. The design of grade beams if used shall be as given in IS 2911 (Part III).

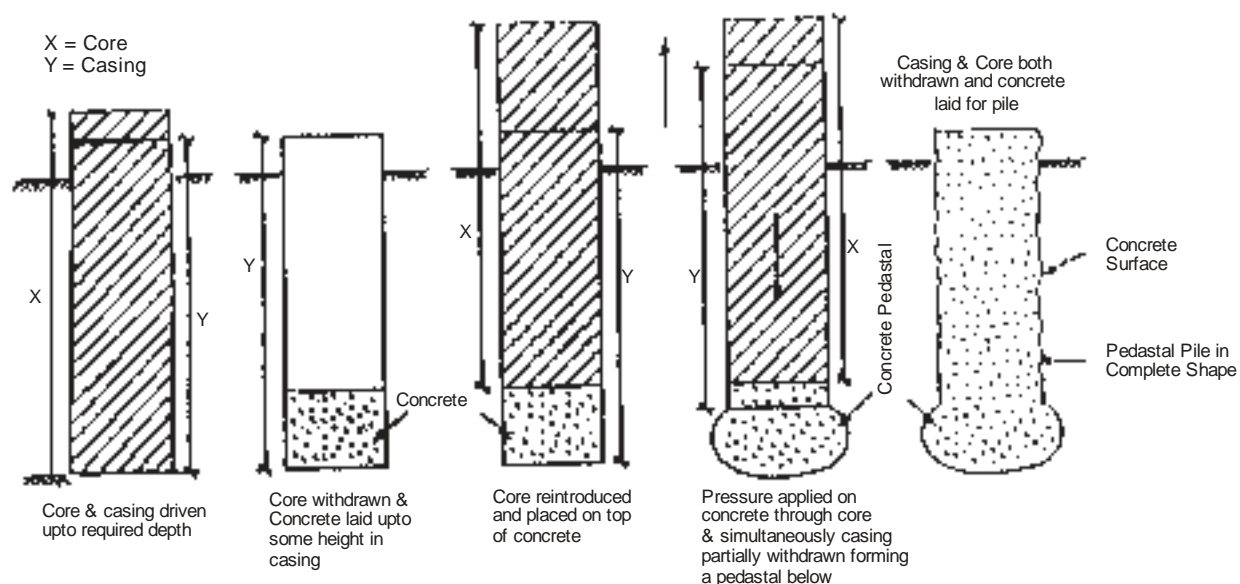


Fig. 20.2 : Pedestal Piles

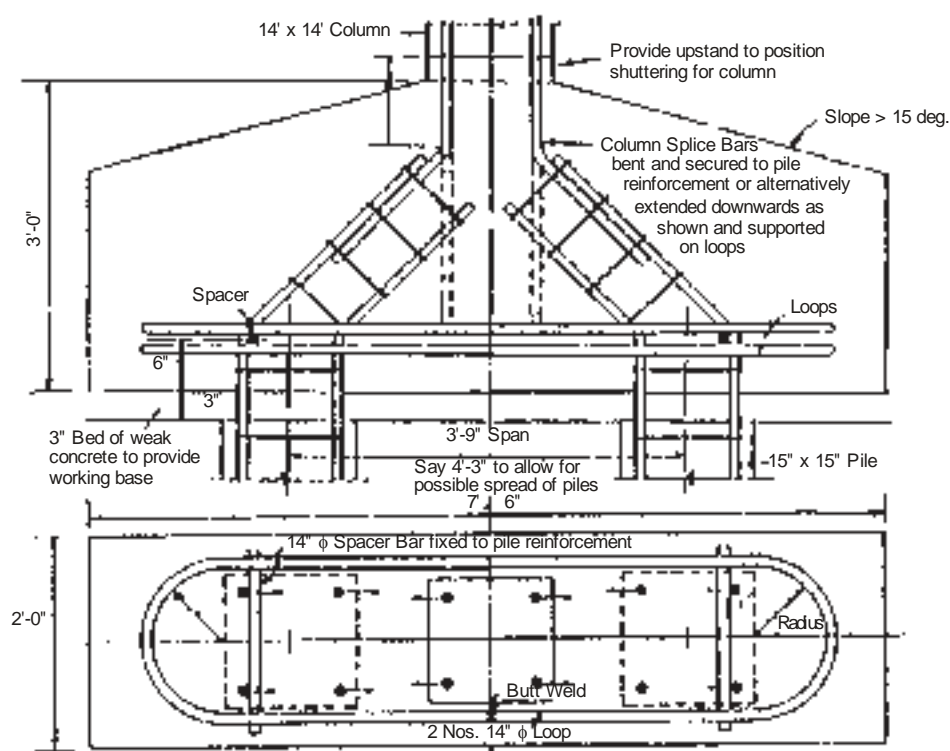
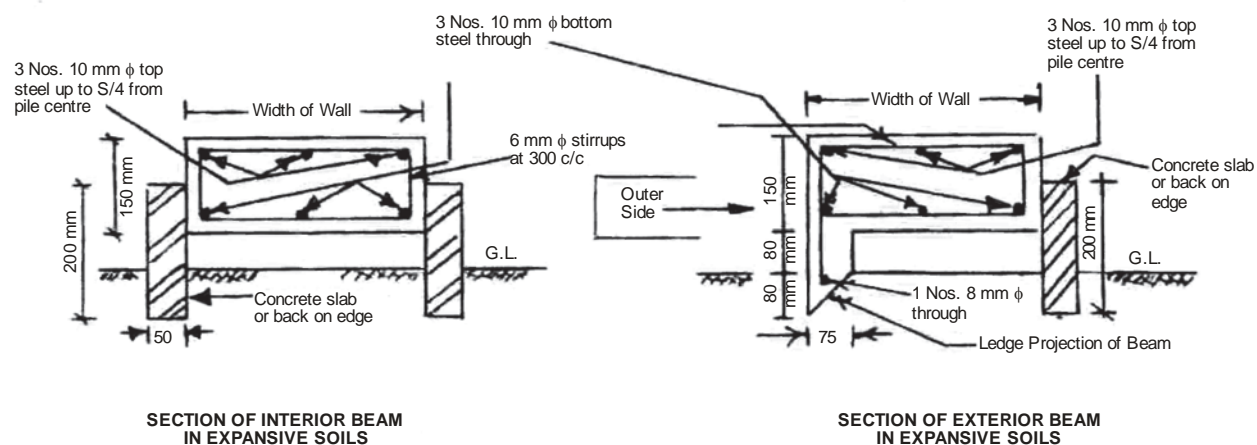


Fig. 20.3 : Cap for Two Piles (Typical)

20.3.8 Grade Beams

- (i) The grade beams supporting the walls; shall be designed taking due account of arching effect due masonry above beam. The beam with masonry due to composite action behaves as a deep beam.
- (ii) The minimum overall depth of grade beams shall be 150 mm. The reinforcement at bottom should be kept continuous in all the beams and an equal amount may be provided at top to a distance of quart span both ways from the pile centre.
- (iii) The longitudinal reinforcement both at bottom and top should not be less than three bars of 10 m diameter mild steel (or equivalent deformed steel).
- (iv) Stirrups of 6 mm diameter bars should be at 300 mm spacing which should be reduced to 100 mm at the door openings near the wall edge to a distance of three times the depth of beam. No shear connectors are necessary in wall.
- (v) In expansive soil the grade beam shall be kept a minimum of 80 mm clear off the ground. In other soils, the beams may rest on ground over a leveling concrete course of about 80 mm as shown. In this case part load may be considered to be borne by ground and it may be accounted for; in the design of piles. However, the beams should be designed as usual.
- (vi) In case of exterior beams over piles in expansive soils a ledge projection of 75 mm thickness an extending 80 mm into ground as shown shall be provided on outer side beam. Typical sections of internal and external beams are shown below.



20.4 DRIVEN PRECAST R.C.C. PILES

20.4.1 General

Driven Precast Concrete Pile is a pile constructed in a casting yard and subsequently driven in the ground with or without jetting, or other technique like preboring (depending on the conditions of soil) when the pile has attained sufficient strength. By driving, the subsoil is displaced and remain in direct contact with the pile. These piles find wide application particularly for structures such as wharves, etc. to act as a free standing pile above the soil/water level or where conditions are unfavorable for use of cast-in-situ piles.

20.4.2 Reinforcement

- (i) The longitudinal reinforcement of specified grade and size shall be provided in the pre-cast concrete piles, for the entire length. All the longitudinal bars shall be of same length and should fit tightly in the pile shoe if the same is provided.

- (ii) Extra bars for supporting the longitudinal steel shall be provided, to resist the local bending moments but the same should be detailed in the drawings prominently so that the sudden discontinuity can be avoided. The non provision of the extra bars may lead to cracks in the pile during heavy driving.
- (iii) As per IS 2911 (Part1/Sec.3) the area of main longitudinal reinforcement shall not be less than the percentages of cross sectional area of the piles as detailed below:
 - (a) Piles with a length 30 times the least dimension: 1.25 per cent
 - (b) Piles with a length 20 to 40 times the least dimension: 1.5 per cent
 - (c) Piles with a length more than 40 times the least dimension: 2 per cent
- (iv) The lateral reinforcements, which are normally in the form of hooks and links of not less than 6 mm diameter TMT bars, has its own particular importance in resisting the driving stresses induced in the pile. The volume of lateral reinforcement shall not be less than the following:
 - (a) At both ends of the pile for a distance of 3 times the least width – not less than 0.6 per cent of the gross volume of pile.
 - (b) At central portions of the pile – not less than 0.2 per cent of the gross volume of pile.
- (v) The spacing of the lateral ties in a pile shall be so arranged that the concrete should have free flow around the reinforcements. The gradual transition of close spacing of lateral reinforcements near the ends to the increased spacing in the central portions of the piles should be accommodated by gradually increasing the spacing of the ties in a length of 3 times the least width of the pile.
- (vi) The cover to reinforcement should be provided to longitudinal bars. In normal conditions the cover thickness to be provided is 50 mm and in case the piles are exposed to sea water or water having other corrosive contents the minimum thickness of cover shall be 75 mm.

Note: Where the concrete of pile is liable to attack of sulphates, chlorides present in ground water a minimum cover thickness of 75 mm shall be provided. In addition, the piles may be coated with some suitable material.
- (vii) Each longitudinal bar shall be in one length as far as possible, also preferably the full length bar shall be used. However, in unavoidable cases if the bars are to be joined, they shall be done by butt welding duly staggering the joints.
- (viii) The hoops or links that are to be tied to longitudinal reinforcement shall be tied with the specified type of binding wire and the free ends of the wire shall be turned into the interior of the pile.
- (ix) Preferably the hoop or link reinforcement shall be welded to the longitudinal bars so as to achieve a tight fitting.
- (x) Temporary or permanent spreader forks spaced at 1.5 m shall be used to keep the longitudinal bar in proper position and spacing.
- (xi) Before concreting, the reinforcements shall be checked by Engineer-in-charge who shall ensure that the reinforcements are tied as per approved design and drawing and shall ascertain that the tying is perfect.

20.4.3 Equipment and Ancillaries

- (i) The selection of equipment mostly depends upon the hardness of the strata. For deriving the size and weight of the pile to be handled, the most important point is the location of work.
- (ii) Generally, the following equipments are necessary for the installation of piles:
 - (a) Movable steel or timber structure duly designed to handle the pitching and driving the piles to the correct position and alignment.
 - (b) Tackles to handle piles from casting/stacking yard.
 - (c) To prevent the head of the pile from being damaged during drilling operation and to distribute the blow over the cross section of the head of the pile. A temporary steel driving cap, normally termed as 'Drive cap' is placed on the top of the pile.
 - (d) A pad, block or packing of hard wood or some suitable resilient material normally termed as "Dolly" is fixed to the upper portion of the cap (helmet) for preventing the shock from hammer on the head of the pile.
 - (e) A single acting" or "double acting" hammer is used depending on whether the hammer is allowed to fall under gravity along or is operated with the source of motive power to derive the energy.
 - (f) Sometimes it so happens that the piles are to be driven below the pile frame leaders, with the result the hammer may not be in a position to reach the pile. Under such circumstances a removable extension piece known as "follower" or "long dolly" is used to transmit the hammer blows over the pile head.
 - (g) When a particular type of soil strata is met with, the driving conditions may require equipments for jetting/pre-boring for installation of piles.
 - (h) When the piles are to be driven in rock, coarse gravel, clay with cobbles, or other soils, which may damage the tip of the pile, flat or coaxial shoes made out of steel or cast iron shall be provided at the tip of the pile.
 - (i) While driving a pile in a uniform clayey soil or sandy soil no advantage can be derived by tapering the tip of the pile hence no shoe need be provided for the tip of the pile while driving piles in such soils.
 - (j) When jetting is to be undertaken a jet tube may be cast into the pile by connecting the same to the pile shoe which is normally provided with jet holes. It is not advisable to provide a central which is likely to be choked.
 - (k) The best results can be achieved by providing four holes in four directions. However, providing two holes in opposite direction may also serve the purpose.
 - (l) Alternatively, two or more jet pipes may be attached to the sides of the pile. The pile may get off loaded if proper balanced arrangement of jet is not made.

20.4.4 Concrete

20.4.4.1 Materials: Cement, water, fine and coarse aggregate, chemical admixtures etc. As described under clauses 20.1.6.

20.4.4.2 Concrete Grades to be Adopted: Same as described under clause 20.1.6.6

20.4.4.3 Workability of Concrete: The degree of workability in this case is “low” as the concrete is placed where the section is not heavily reinforced, also the concrete in the pile is vibrated with both internal as well as external vibrators, and therefore minimum slump should be 25 mm to 50 mm.

20.4.4.4 Form-Work/Mould

- (i) Only steel moulds manufactured out of sturdy steel sections and sheets to cast the required size of the pile are to be used. Timber moulds shall not be permitted, under any circumstances.
- (ii) The mould shall sustain the stresses generated due to the use of immersion/plate vibrators and some time even form vibrator, depending upon the size and strength of the pile to be cast.
- (ii) The manufacturing of the mould shall be so simple that the sides could be opened within 16 to 24 hours of casting by simply loosening the bolts without damaging the edges of the pile.
- (iv) Fixing supports for the sides of the mould shall be done from outside and no use of through bolts through the concrete shall be permitted to support the opposite sides of the mould.
- (v) Proper mechanism shall be introduced to fix the sides to the top of the casting platform so that the plate from vibrators can be operated without disturbing the mould.
- (vi) In case of square piles provision for forming champhers of the pile for the corners shall be made in the mould itself.
- (vii) The mould should be such that when the pile is demoulded all the surfaces of the pile except the side from which the concrete is laid should get form finish. No rendering or finishing shall be permitted on any surface of the concrete after demoulding.
- (viii) Piles whose surfaces are plastered or rendered, edges repaired etc. shall be rejected and removed from site.
- (ix) After every casting, when the sides of the mould are opened the same shall be cleaned nicely and form oil manufactured by reputed company shall be applied over the surface before the mould is adjusted for filling the concrete, for next pile. The normal practice of applying grease mixed with diesel or waste oil instead of the form-oil shall not be permitted.

20.4.5 Casting Concrete Piles (Pre-casting)

- (i) The casting yard shall be so constructed that the piles that are cast can be lifted directly from their beds and transported to the storing yard with minimum handling and avoiding any damage to the pile.
- (ii) The casting yard shall have well drained surface so that the water used for curing the already cast piles do not accumulate on the yard inconveniencing the working on subsequent piles.
- (iii) The size of the casting platform shall be large enough to accommodate the minimum number of piles to be cast for full 11 days depending upon the proposed progress of work per day, as a pile once cast cannot be lifted from the casting bed till the expiry of ten days, therefore no piles can be cast on these spaces till the piles more than 10 days old are shifted.
- (iv) The casting yard shall be well covered not only from top but also from sides to avoid the direct sun-rays falling on the piles that are under set. The pile should also be protected from rain and wind.
- (v) Before taking up actual concreting, the moulds to be concreted for full days work shall be fixed in position and preferably moulds for concreting on the subsequent day shall also be kept ready in advance.

- (vi) If the contractor is permitted to start concrete with lesser number of moulds than that can be cast within a day, the action will prompt the contractor to open the sides of moulds already cast prematurely to continue concreting for the full day, which is not desirable as the quality of the concrete will be hampered.
- (vii) The inner faces of the mould shall be cleaned; form-oil of approved brand and manufacture shall be applied.
- (viii) The reinforcements shall be lowered carefully in the mould and fixed in position with proper cover blocks and spacers on all surfaces.
- (ix) On getting formal approval of the Engineer-in-charge for the fixing of form-work in position and on getting the pre-measurements of the reinforcements recorded, concreting with specified grade shall be taken up. The slump should be checked frequently and constant w/c ratio shall be maintained.
- (x) The piles should be cast from end to end, using immersion, form vibrators, avoiding over vibration. Proper care should be taken to see that the concrete is packed in the mould and consolidated. When the mould is full the top surface of concrete shall be neatly troweled and finished smooth.
- (xi) Proper precaution shall be taken to ensure that the vibration from the adjoining work does not affect the previously placed concrete for piles during setting period.
- (xii) On completing the concreting for a particular pile the following information shall be engraved (not painted) on each pile.
 - (1) Date of casting.
 - (2) Grade of concrete used.
 - (3) No. of lot.
 The lot No. will help to locate the exact position where the particular pile has to be used.

20.4.6 Testing Works Complete

As prescribed under clause 20.1.7.

20.4.7 Ready Mix Concrete

As prescribed under clause 20.1.10.

20.4.8 Curing

- (i) Provision for curing as given under clause 20.1.8 shall be followed in addition.
- (ii) The piles shall not be lifted from the casting bed for a minimum period of 10 days from the date of casting.
- (iii) When the piles are shifted to stacking yard after the expiry of ten days, where the piles will have to be kept for a period of 28 days from the date of casting, the piles in stacks shall be covered with sacks so that the piles do not come in contact with sun rays till they attain full strength.
- (iv) Lastly, the most important factors affecting the time of curing are the method of curing, weather during hardening, probable hardness of driving and the method of lifting and pitching.
- (v) The Engineer-in-charge may fix up the exact period of curing for a particular project considering all the factors mentioned in Para (iv) above.

20.4.9 Storing and Handling

- (i) After the expiry of 10 days from the date of casting, the piles are to be removed from the casting bed and shifted to the stacking yard where the piles shall be kept for a further period of 18 days i.e. 28 days after casting and later till they are carried for driving.

- (ii) The piles shall be stored on a firm ground which will not liable for unequal subsidence or settlement under the weight of the stack of piles.
- (iii) Timber sections of suitable size shall be placed over the level ground to stack the piles on top. The spacing between the timber sections shall be so adjusted that the piles are not subjected to undue bending stresses, while in stack.
- (iv) Spaces shall be left around the piles in the stack so that they can be lifted without difficulty and necessary piles can be cured beyond 10 days.
- (v) The order of stacking the piles shall be such that the older piles can be withdrawn without disturbing the newly placed piles. Separate stacks shall be provided for the piles of different lengths.
- (vi) If ordered by the Engineer-in-Charge or if weather conditions so require arrangements for curing the piles for further period shall be made when the piles are stored in the stack.
- (vii) Care shall be taken to see that the piles are not damaged or cracked at the time of lifting, handling transportation, etc.
- (viii) While transporting the piles from the stocking yard to the site, the piles shall be supported at approximate lifting holes provided for the purpose. In case during transportation if the piles are to be unloaded temporarily they shall be placed on trestles or blocks located at the lifting points.

20.4.10 Driving Piles

- (i) Though from the consideration of maintaining the time schedule and economy in construction, the pre-cast concrete piles have to be driven without any possible delay, still it shall be kept in mind that the piles chosen for driving should be thoroughly cured and are sufficiently hard. To achieve this proper schedule shall be followed, in the operations of casting, curing, stacking and transportation of piles to site.
- (ii) The heads of the pre-cast concrete piles to be driven shall be protected with packing of resilient material against the possible damage due to the use of heavy hammers. Care shall be taken to see that packing is evenly spread and placed securely. On top of the packing a helmet should be placed and provided with a dolly of hardwood or any suitable material not thickens than the width of the pile.
- (iii) The failure in the pile may occur by compression or tension when the blow of the hammer generates the stress waves which traverses the length of the pile. Failure due to compressive stresses mostly occurs at the heads. Head stresses are independent of ground conditions and mainly depend upon the weight of the hammer, its drop and the stiffness of the head cushion.
- (iv) By using heaviest hammer and softest packing the maximum set for a given stress is obtained. The drop of the hammer however should; be adjusted to suit the allowable stress in the concrete.
- (v) Optimum driving conditions can be maintained only by regular replacement of packing materials as prescribed in Para (ii) above, since the stiffness in head packing materials increases with repeated use.
- (vi) Only in cases of exceptionally hard driving, where theoretically the compressive stresses of toe can reach twice the head stresses, failure in lower portions of the pile can occur. In practice, however, this rarely occurs as the compressive stresses to a great extent tend to be uniform over the considerable length of the pile.

- (vii) Due to reflection of compressive wave to “free end”, the longitudinal tension is caused in the pile. This situation arises at a time when the ground resistance is low and/or when the hammer rebounds due to head conditions mainly because of the use of hard packing and light hammer. In addition, an unsupported long pile negotiating a hard stratum will be subjected to transverse or flexural vibrations in the pile in case the blow from the hammer becomes non-axial or if the pile is not restrained to reduce the effect of a long pile.
- (viii) For driving a pile; any type of hammer can be used provided the pile penetrates to the prescribed depth or attain the specific resistance without getting damaged.
- (ix) The hammer, helmets, dolly and the pile below should be co-axial and should sit perfectly one over the other. However, the heaviest possible hammer should preferably be used and the stroke should be so managed so as not to damage the pile.
- (x) The choice of hammer mainly depends upon whether the pile is to be driven to a given resistance or to a given depth.
- (xi) Normally, for a single acting or a drop hammer the stroke should be limited to 1.2 m but 1.0 m is preferable. Shorter stroke may be used in cases where there is a danger of damaging the pile, a few examples of which are described below:
 - (a) Hard surface has to be penetrated in the early stages when a long pile has to be driven.
 - (b) When there is a soft ground up to a considerable depth, a large penetration is achieved at each blow.
 - (c) The pile suddenly reaches refusal when it meets with rock or other virtually impenetrable soil.
- (xii) If a satisfactory set is achieved for ten consecutive blows with an appropriate hammer and drop the method of driving should be repeated with caution and long continued driving. However, after the pile has almost ceased to penetrate the driving should be stopped especially when the hammer with moderate weight is used.
- (xiii) Sometimes it so happens that the rate of penetration suddenly changes without any satisfactory reasoning or soil conditions. Under such circumstances the pile driving should not be continued till real problem is investigated and remedy thought over.

20.4.10.1 Jetting with Driving Pile

- (i) The jetting operation is effective only in the cohesion less soils such as sand, gravel and fine grained soils with very less percentage of clay. The jetting will be ineffective in clay soils.
- (ii) The main purpose of jetting is to minimize or almost eliminate the resistance at the toe and last the same time the frictional resistance along the surface of the pile shaft also gets reduced.
- (iii) Very hard driving and vibrations can be avoided when the toe resistance is eliminated and also the rate of penetration is increased considerably when compared to the normal driving methods without jetting.
- (iv) Jetting operations shall be carried out only when specifically ordered by the Engineer-in-Charge. Jetting shall be carried in a manner that the stability of soil and the bearing capacity of piles already driven is not in any way impaired. Similarly, the safety of the adjoining structures shall be taken into consideration.
- (v) For effective jetting the quantity of water required is directly related to the cross sectional area of the piles (including external jet pipes). In dense cohesion less soils the quantity of water up to 2 litres per minutes per sq.cm. of pile cross section may be required. Less quantity of water may be needed in loosely compacted soils.

- (vi) The water pressure to be maintained is between 5.6 kgf/cm² to 10.6 kgf/cm² or more. In case large quantities of water are used the draining arrangement for the water that emerges on the ground shall have to be made otherwise the stagnant water may soften the ground endangering the piling equipment resting above.
- (vii) To minimize the risk of blockages, the nozzle should not be positioned at the point of the toe. The arrangement of jets should be balanced to ascertain the penetration of the pile vertically. It is advisable to surge down an independent pile or two pipes may be attached to the opposite sides of the pile for effective jetting operation.
- (viii) The pile shall be allowed to enter the ground gradually after operating the water under the weight of pile and the hammer. Acceptable verticality may be achieved by use of rigid leaders, duly controlling the rate of penetration with a pile winch.
- (ix) On achieving maximum apparent penetration with light driving by the method prescribed above and when the water jets are running the further penetration may be attained in the cohesion less soils. The piles shall be driven to the final position or set when the jetting is complete.
- (x) Before closing the driving operation, the jetting should be stopped and the driving shall be continued by ordinary driving methods. If due to the ground disturbances, the pile tips tend to be drawn towards the piles already driven, jetting should be stopped immediately.
- (xi) The correct working of jets should be tested before the work on driving the pile is commenced. If the pile is not provided with as "built in jet arrangement" independent jet pipes down the outside the pile can be used and to achieve the best result jets working on several faces of the pile can be practical which will also assist maintaining the verticality.

20.4.10.2 Stripping Pile Heads

- (i) Stripping of pile shall be done in such a manner that a minimum 50 mm length of pile projects into the pile cap. Sufficient length of reinforcement from the pile shall be exposed for embedding the same inside the pile cap.
- (ii) The stripping operation or exposing the reinforcement of the pile shall be done very carefully without damaging the pile proper. In case any portion of the concrete cracks, the defective portion shall be cut and the portion repaired with new concrete joining properly with old concrete.

20.4.10.3 Lengthening Piles

- (i) Sometimes the length of a pile has to be increased either before or during driving; this can be done by casing additional concrete over the old pile. In such cases the original head of the pile is cut to expose minimum 200 mm length of bar.
- (ii) The exposed steel should be cleaned properly and shall be held in firm position, while full penetration butt welding is done.
- (iii) In case the conditions on site are not favorable to attempt butt welding, a minimum length of 40 d (40 times the diameter of main bar) of the original pile shall be exposed and the new steel should be overlapped over the exposed steel. The overlap shall be spot welded.
- (iv) On completion of welding/overlapping the reinforcement and tying the spirals, for the extended length of reinforcements the extras portion of the pile can be concreted thus extending the original pile.

20.4.11 Risen Piles

- (i) Sometimes due to ground heave there is a possibility that piles already driven to the final depth may start rising when adjacent piles are being driven; such rising shall be noted at frequent intervals till driving on adjacent piles is in progress.
- (ii) On completion of driving the adjacent piles, the piles that are risen shall again be driven back either to their original level or up to a point of resistance.

20.4.12 Pile Cap

As per clause 20.3.7.

20.4.13 Grade Beam

As per clause 20.3.8.

20.4.14 Measurement

Dimension shall be measured nearest to a cm. Measurement of length on completion shall be along the axis of pile and shall be measured from top of shoe to the bottom of pile cap. No allowance shall be made for bulking, shrinkage, cut off tolerance, wastage and hiring of tools, equipment for excavating and driving etc.

20.4.15 Rate

The rate includes the cost of materials and labour involved in all the operations described above including pile embedded in pile cap, centering, shuttering except reinforcement, pile cap and grade beam.

20.5 LOAD TEST ON PILES

20.5.1 General

The bearing capacity of a single or group of piles shall be determined from test loading. It is most direct method for determining safe load on pile and it is more reliable on account of its being in-situ test. The load test on a concrete pile shall not be carried out earlier than 28 days of its casting. Initial test shall be carried on test pile which is not used as working pile and Routine tests shall be carried out as a check on working pile. Routine test shall be one-half percent to two percent of total number of piles or as specified, applicable to vertical and lateral load. Load Test shall generally conform to provision made in IS 2911 (Part IV) which provides guidelines for determination of safe loads and conducting of different types of tests.

20.5.2 Types of loadings/tests

- (i) Vertical Load Test (Compression)
- (ii) Cyclic Vertical Load Test
- (iii) Lateral Load Test

20.5.3 Vertical Load Test

20.5.3.1 General: Compression load shall be applied to the pile top by means of a hydraulic jack against suitable load frame which is capable of providing reaction and settlement is recorded by suitable dial gauges. The contractor shall apprise of Engineer-in-Charge before test is conducted.

20.5.3.2 Preparation of Pile Head: Pile head shall be chipped off to horizontal plane, projecting steel shall be cut or bent and top finished smooth and leveled with plaster of Paris or similar synthetic material as specified to give a plane surface which is normal to the axis of the pile. A bearing plate with a hole at the centers shall be placed on the head of pile for the jacks to rest.

20.5.3.3 Loading Platform: A proper loading platform is installed as specified. Contractor shall ensure that when the hydraulic jack and load measuring devices are mounted on pile head the whole system will be stable on the maximum specified load. For single pile two dial gauges shall be fixed to the pile and bear on surfaces on reference frame. The dial gauges shall be placed in diametrically opposite positions and be equidistant from the pile axis. Four dial gauges are used for groups, having 0.01 mm sensitivity. The arrangement shall be approved by the Engineer-in-charge.

20.5.3.4 Application of Load: The test is carried out by applying a series of downward incremental load (20 per cent of safe loads on pile). In this method application of increment of test load and taking of measurement or displacement in each stage is maintained till the rate of displacement is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or 2 hours, whichever occurs first. The test load shall be maintained for 24 hours. This method is applicable for both initial and routine test. For testing of raker piles the loading shall be along its axis. Safe load on single pile for initial test is least of following:

- (i) Two-thirds of the final load at which the total displacement attains a value of 12 mm unless otherwise stated, in such case the safe load should be corresponding to total displacement permissible.
- (ii) 50 per cent of the final load at which the total displacement equal 10 per cent of pile diameter and 7.5 per cent of bulb diameter in case of under-reamed piles.

Routine test shall be carried for a test load of one and half times the working load, maximum settlement not to exceed 12 mm or as stated.

Safe load on group of piles for initial test shall be least of the two

- (i) Final load at which total displacement is 25 mm or as stated.
- (ii) Two-thirds of final load at which the total displacement is 40 mm.

Routine test shall be carried for a test load equal to not less than working load, the maximum settlement not to exceed 25 mm.

20.5.3.5 Maintained Load Method: This is applicable for both initial and routine test. In this method application of increment of test load and taking of measurement or displacement in each stage of loading is maintained till rate of displacement of the pile top is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or till 2 hours, whichever occurs first. If the limit of permissible displacement as given in 20.5.3.4 is not exceeded, testing of pile is not required to be continued further. The test load shall be maintained for 24 hours.

Pile test data such as load, displacement and time shall be recorded in suitable prescribed tabular form. Results can be presented by suitable curves.

Test shall be carried out in proper manner and to the entire satisfaction of the Engineer-in-charge. After the test is completed the test cap shall be dismantled and pile surface shall be resorted to original shape.

20.5.3.6 Measurement: Each completed test shall be enumerated for initial test, routine test separately.

20.5.3.7 Rate: The rate includes the cost of labour, material and all the operations described above such as preparatory work including installation of loading platform, applying load, preparing pile head for load test, trimming of pile head etc. complete.

20.5.4 Cyclic Vertical Load Testing

20.5.4.1 General: This process shall be used in case of initial test to find out separately skin friction and point bearing load on single piles of uniform diameter in conformity of provisions of IS Code 2911 (Part 4) for conducting of the test.

20.5.4.2 Preparatory Pile Head: As per clause 20.5.3.2.

20.5.4.3 Loading Platform: As per clause 20.5.3.3

20.5.4.4 Application of Load: Relevant provision as per clause 20.5.3.4 shall be applicable. The test may be continued up to 50 per cent over the safe load.

20.5.4.5 Test procedure given in Appendix E shall be followed.

Test shall be carried out in proper manner and to the entire satisfaction of the Engineer-in-charge.

After the test is completed, the test cap shall be dismantled and pile surface shall be restored to original shape.

20.5.4.6 Measurement: Each completed test shall be enumerated for different load ranges.

20.5.4.7 Rate: The rate includes the cost of labour, materials and all the operations described above such as preparatory work, trimming of pile head etc. complete.

20.5.5 Lateral Load Testing

20.5.5.1 Load Platform: A proper loading platform shall be installed as specified. Hydraulic jack is mounted with gauge between two piles or pile groups under test. Dial gauge tips shall rest on central portion of glass plate fixed on the side of pile.

20.5.5.2 Application of Load: Full load imposed by the jack shall be taken as lateral resistance on each pile or group. Load should be applied in increments of about 20 per cent of the estimated safe load. The next increment shall be applied after the rate of displacement is approximately equal to 0.1 mm per 30 minutes.

20.5.5.3 The safe lateral load on pile; is least of the following:

- (i) Fifty per cent of the final load at which total displacement increases to 12 mm.
- (ii) Final load when total displacement is 5 mm.
- (iii) Load corresponding to any other specified displacement as per requirement.

Pile group shall be tested as per actual conditions as far as possible.

20.5.5.4 Displacements: Displacement is read by at least two dial gauges of 0.1 mm sensitivity spaced at 30 cm and kept horizontally one above the other and displacement is interpolated at cut off level. One dial gauge placed diametrically opposite to jack shall directly measure displacement. Where, it is not possible to locate one of the dial gauges in the line of the jack axes, then two dial gauge may be kept at a distance of 30 cm at a suitable height and the displacement interpolated at load point from similar triangles.

Note: One of the methods of keeping dial gauge on pile surface is to chip off uneven concrete on the side of the pile and to fix a piece of glass 20 to 30 mm square. The dial gauge tips shall rest on the central portion of the glass plate.

Arrangement and test procedure shall be duly approved by the Engineer-in-Charge.

20.5.5.5 Measurement: Each completed test shall be enumerated for different load ranges.

20.5.5.6 Rate: The rate includes the costs of labour, materials and all the operations described above.

BASIC PROPERTIES OF DRILLING MUD (BENTONITE)*[Clause 20.2.2.2 & 20.3.3 (iv)]***A- 1 Properties**

A-1.1 The bentonite suspension used in bore holes is basically clay of montmorillonite group having exchangeable sodium cat ions. Because of the presence of sodium cat-ions, bentonite on dispersion will break down into small plate like particles having a negative charge on the surfaces and positive charge on the edges. When the dispersion is left to stand undisturbed, the particles become oriented building up a mechanical structure at its own. This mechanical structure held by electrical bond is observable as a jelly like mass or jell material. When jelly is agitated, the weak electrical bonds are broken and the dispersion becomes fluid.

A-2 Functions

A-2.2 In the case of granular soil, the bentonite suspension penetrates into the sides under positive pressure and after a while forms a jelly. The bentonite suspension gets deposited on the sides of the hole not penetrate into the soil, but deposits only a thin film on the surface of the hole. Under such condition, stability is derived from the hydrostatic head of the suspensions.

A-3 Specification

A-3.1 The bentonite suspension used for pilling work shall satisfy the following requirements:

- (a) The liquid limit of bentonite when tested in accordance with IS 2720 (Part V) 1965 shall be more than 300 per cent and less than 450 per cent.
- (b) The sand content of the bentonite powder shall not be greater than 7 per cent.
Note: The purpose of limiting the sand content is mainly to control and reduce the wear and tear of the pumping equipment.
- (c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the bentonite solution should be about 1.12.
- (d) The mash viscosity when tested by a Marsh cone should be about 37 second.
- (e) The swelling index as measured by the swelled volume after 12 hours in abundant quantity of water shall be at least 2 times its dry volume.
- (f) The pH value of the bentonite suspension shall be less than 11.5.

EQUIPMENTS FOR UNDER-REAMED PILES (MANUAL CONSTRUCTION)
(*Clause 20.3.3*)

B-1 Equipment

B-1.1 Normally the following equipment will be required in manual operation:

- (a) An auger;
- (b) An under-reamer;
- (c) A boring guide; and
- (d) Accessories like spare extensions, cutting tool, concreting funnel etc.

B-1.1.1 For the piles of size larger than 30 cm and for larger depths additional equipment required will be portable tripod hoist with a manually operated winch.

B-1.1.2 For piles in high ground water table and unstable soil conditions, boring and under-reaming shall be carried out with bentonite slurry using suitable equipment. Tremie pipe shall be used for concreting

- (a) Drop weight for driving the core assembly, and
- (b) Pipe or solid core.

PILE FRAME

Scope

Specification for pile frame shall be in conformity to the one laid in IS 6428. Contractor shall use the proper height of pile frame and which is able to take the weight of hammer safely.

Standard size of pile frame will assist the user in determining the type and size of frame. Damages pile frame which cannot be used for want of spares shall be replaced with sound one.

Size

The size of pile frame shall be designated by its height and the weight of the hammer and the pile it can take.

The pile frame shall be as per the sizes given in table below:

S.No	Size	Height of Pile Frame	Weight of hammer	Weight of pile (Any Type) max
1	I	7.5	1.5	3
2	II	10.5	3	6
3	III	15	5	10
4	IV	20	6	12
5	V	25	6	12

Extension Panels: All pile frames shall be capable of being fixed with extension panels of 1.5, 3 and 4.5 m height without reduction in weight capacity.

Performance: Pile frames with or without extension panels shall be capable of placing piles at the maximum backward rake in 1 in 5 and the maximum forward rake 1 in 10.

PILE BORING EQUIPMENT- GENERAL REQUIREMENT

(Clause 20.2.2)

Scope

Specification for pile boring equipment shall be as per IS 14362. Constructions of bored piles require careful selection of boring equipment. Choice of appropriate equipment will depend upon subsoil conditions, diameter of pile, their depths and other specific requirements of any particular work. Details of equipment and proposed methods of driving the pile shall be submitted by the tenderer for scrutiny and approval by the competent authority

Equipment described herein refers to construction of bored piles on land and without the user of bentonite. The standard nominal diameter of piles shall be 450 mm, 500 mm, 600 mm and the like.

Materials

All materials used in the construction of pile boring equipment shall conform to the requirement of relevant Indian Standard IS 800 'Code of Practice' for general construction in steel.

Pile Boring Equipment

General

The various items comprising pile boring equipment are:

- (a) Winch
- (b) Derrick
- (c) Boring/chiseling tools
- (d) Temporary casings
- (e) Tremie arrangements, and
- (f) Accessories

A typical piling winch consists of the following components as shown below in Fig. D1

- (a) Winch drum,
- (b) Prime mover,
- (c) Transmission system,
- (d) Clutch system,
- (e) Brake system,
- (f) Winch

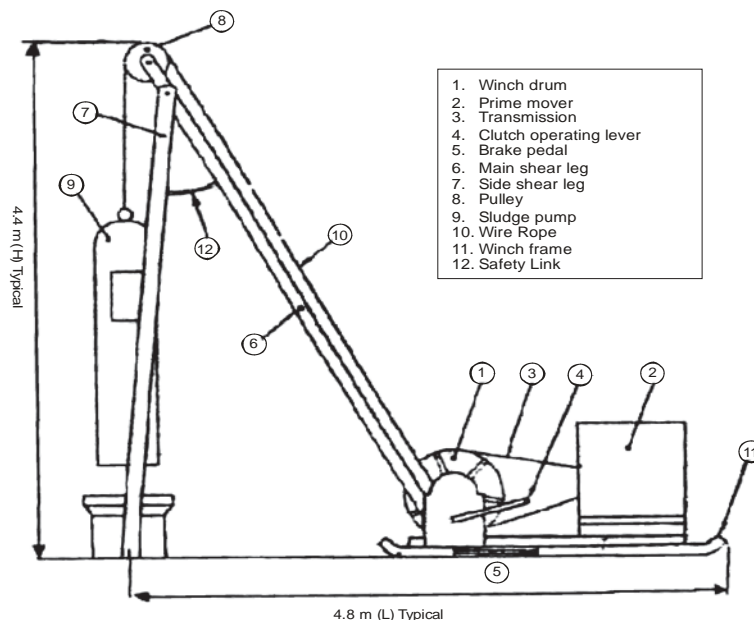


Fig. D1

Winch Drum: This standard capacities (drum rope pull) of the winch drum shall be 5 t. And the drum meter shall not be less than 20 times the diameter of the wire ropes used.

Prime Mover: The prime mover shall usually be a diesel engine of the air cooled type or an electric motor. A suitable reduction gear shall also be provided.

Transmission: The transmission system shall be one of the following :

- (a) Geared drive
- (b) Chain drive, and
- (c) Belt drive (flat belt or V-belt)

The transmission system shall be provided with suitable guard cover.

Clutch System: The clutch system shall consist of a clutch wheel and friction plate(s) or a Friction cone operated by a lever.

Brake System: This shall consist of a brake band connected with the foot brake pedal or brake handle for hand operation.

Winch Frame: A typical winch frame shall be made from structural steel section and shall be either truck-mounted crawler-mounted or skid-mounted. A proper stabilizer shall be provided to transmit the load to the ground smoothly.

Derrick

General: The standard derrick shall consist of the following components:

- (a) Main shear leg,
- (b) Side shear leg,
- (c) Shear leg base,
- (d) Pulley, and
- (e) Safety link.

The hoisting capacity of the derrick shall be at least equal to the maximum drum rope pull and preferably more by 25%.

Main Shear Leg: The main shear leg shall be a box section fabricated according to IS 800-1984 either from two mild steel angle sections or two channel sections. The box section shall have minimum dimensions of 125 mm² and the minimum length of the leg shall be 5.6 m.

Side Shear Legs: The two sides shear legs shall have a minimum box section of 100 mm². One of the two side legs shall be provided with suitable mild steel rings spaced 0.3 m apart up to the top. These legs shall be placed part at as distance of minimum of 3 m.

Shear Leg Base: These shall consist of as steel plate welded to the base of the leg. Additional plates shall be welded on all four sides of the leg for up to 15 mm above the bottom of the leg.

Pulley: The pulley shall be usually provided at the top of the main shear-leg and it shall have a diameter at least 20 times the diameter of the wire-rope used. The pulley shall have a suitable guard and shall be properly lubricated.

Safety Link: An interconnected steel-chain shall be provided near the top of the derrick so as to preclude any accidental increase in the distances between the legs.

Boring/Chiseling Tools

The various tools shall be as follows:

- (a) Sludge pump,
- (b) Bailers,

- (c) Chisels,
- (d) Casings,
- (e) Casing extractor plate,
- (f) Casing extractor bar,
- (g) Casing drive bar, and
- (h) Tiller

Sludge Pump: Boring shall be usually advanced by using a sludge pump (also called shell) as shown in Fig. D-2. Weight of the sludge pump shall vary with the diameter but normally minimum weight shall be 7.5 kN. Sludge pump is a hollow cylindrical steel body with a cutting shoe at the bottom and a lifting hook at its top. It has hinged trap door immediately above the bottom cutting edged and it has an opening (window) near the top for muck removal. Above this window, lead or steel or concrete may be added to increase the weight of the sludge pump for effective boring.

Bailer: The bailer (see Fig. D-3) is used for removal of water or slush from the bore hole. It is made up of a hollow steel cylinder with a lifting hook at the top and a truncated base plate with perforation at the bottom. There is a plunger passing through a central hole of the base plate which acts as a plug valve. This plunger is about 20 cm long and has about 15 cm diameter steel plates welded at its top and bottom. This closes the central hole in the base plate of the plunger and thus retains the slush material for removal.

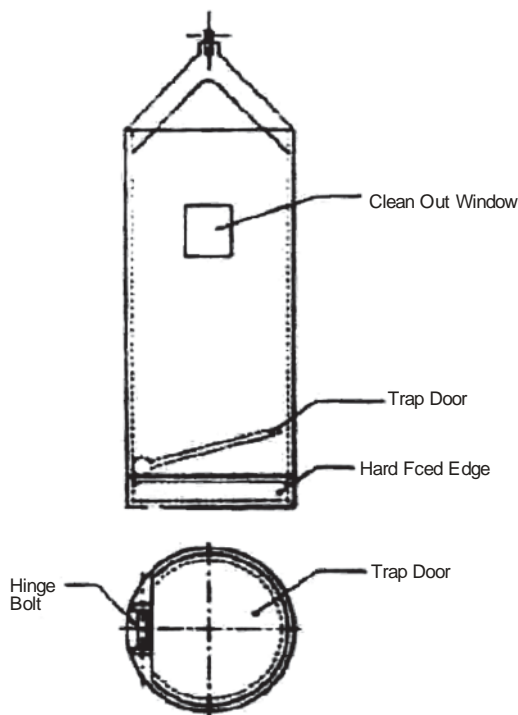


Fig. D-2 : SLUDGE PUMP (SHELL)

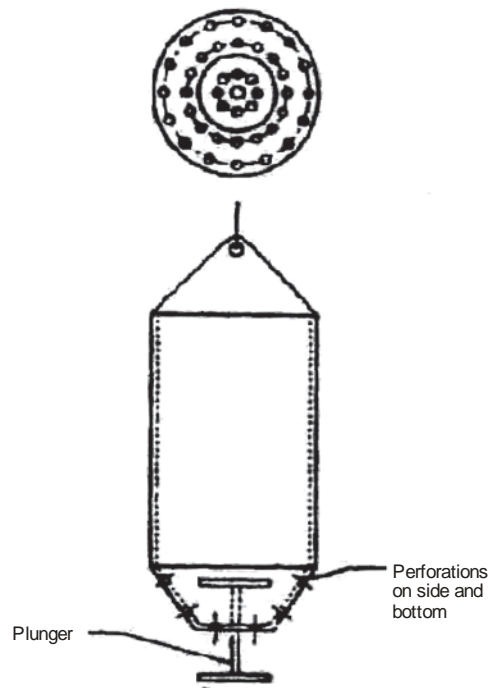


Fig. D-3 : BAILER

Chisels: Hard strata during boring shall be broken by chisels. The chisels shall be made of solid round bar with hard faced edged at the bottom. The chisel shall weigh at least 7.5 kN for 450 mm 12.5 kN for 500 and 600 mm piles.

Casing: These shall be made from 16 mm thick plates and the standard length shall be 1.5 m. The casings shall be threaded on both sides and suitable collar shall be used to protect the threads.

Casing Extractor Plate: A steel plate of suitable size shall be used for the extraction casing after the boring operation is complete.

Casing Extractor Bar: This shall be a round of about 75 mm diameter. It shall be passed through the holes only sides of the casing and through the extractor plate, to enable extractor of casing.

Casing Drive Bar: This shall have a cross-section of at least 75 mm² and shall be used to drive the casing.

Tiller: This gadget shall be used to rotate the casing manually, whenever necessary.

Temporary Casing

This shall consist of the following.

The casing collar shall be attached at the casing top to take the blows during casing driving.

The main casing shall be made from 16 mm thick steel and shall be threaded at one end.

The casing shall be provided with as cutting edge at the bottom to facilitate driving.

Tremie Arrangements

The tremie arrangements shall include the Following:

- (a) Concrete hopper
- (b) Hopper plug
- (c) Tremie pipe
- (d) Holding clamp and
- (e) Hoisting plug.

Accessories

Accessories shall include the following:

- (a) Concrete placer
- (b) Wheel barrow
- (c) Measuring chain
- (d) Bailers
- (e) Crowbars
- (f) Dog-clamps with pins
- (g) Steel measuring tape; and
- (h) Mucking shovel.

CYCLIC LOAD TEST METHOD (Clause 20.5.4.5)

E-1 Method

E-1.1 Alternate loading and unloading shall be carried out at each stage as in 20.5.3.5 and each loading stage shall be maintained as in 20.5.5.2 and each unloading stage shall be maintained for at least 15 minutes and the subsequent elastic rebound in the pile should be measured accurately by dial gauges as in 20.5.5.5. The test may be continued up to 50 per cent over the safe load.

E-2 Analysis of Results for Frictional Resistance

E-2.1 Graphical Method

E-2.1.1 Assuming that there is no compression in the pile, plot a graph relating total elastic recovery and load at the pile top.

E-2.1.3 Draw a straight line parallel to the straight portion of curve I to divide the load into two parts and thereby obtained approximate values of point resistance and skin friction.

E-2.1.4 From the approximate value of skin friction, and knowing the loads of top of pile, compute the elastic compression of the pile corresponding to these loads, by the following formula:

$$\Delta = \frac{(T-F/2)L}{AE}$$

Where

Δ = Elastic compression of pile in cm,

T = Load on pile top in kgf,

F = Frictional resistance in kgf,

L = Length of the pile in cm,

A = Cross-sectional area of the pile in cm², and

E = Modulus of elasticity of the pile material in kgf/cm³

(The value should normally be measured from an exposed portion of pile stem by means of compress meter during the load test itself.)

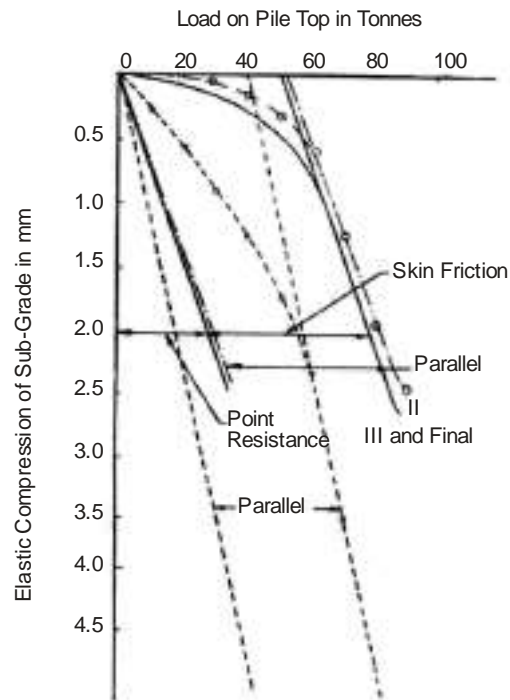
E-2.1.5 Obtain values of the elastic compression of the sub grade by subtracting the elastic compression of the pile from the total elastic recovery of pile, and plot the graph relating these new values the negative value shall be ignored until the value is positive.

E-2.1.6 Repeat the procedures given in E-2.1.3 to obtain new values of skin friction.

E-2.1.7 The process of further approximations covered in E-2.1.6 may be repeated further to any desired extent, but usually the third curve would give sufficiently accurate values for skin friction for practical purposes.

E-2.2 Analytical Method

Analysis of Cyclic Load Test Data for Separation of Skin Friction and Point Resistance.



E-2.2.1 From straight line portion of curve calculate the value of constant from the equation.

$$m = \frac{\Delta s - (\Delta T/AE)L}{\Delta T}$$

Where

m = A constant;

Δs = Change in total elastic settlement of pile

ΔT = Change in applied load = $(T_b - T_a)$ in kgf

L = length of pile in cm;

A = cross-sectional area of pile in cm^2

E = elastic modulus of the material of pile in kgf/cm^2

T = Load on pile top in kgf.

E-2.2.2 Calculate the corrected settlement for different load increment by equation (2)

$$S = mT$$

Where

S = Corrected settlement in cm, and

T = Total load on pile top in kgf.

E-2.2.3 Knowing value of m and S compute skin friction and point bearing by solving simultaneous equation (3) and (4).

$$T = P + F$$

$$S = mP + \frac{(T-F/2)L}{AE}$$

Where

P = point bearing in kgf, and

F = skin friction in kgf.

PILE DRIVING HAMMER

(Clause 20.1.2)

Scope

Specifications for driving hammer shall be in conformity to the one laid in IS 6426. Driving hammer of standard weight and strokes of different types be used.

The object should be to keep weights of hammers to a limited range and standardize weight interval and stroke to facilitate their use with piling rig & piling attachments of different plants.

Piles may be driven with any type of hammer, provided they penetrate to the prescribed depth or attain to ensure a final penetration of not more than 5 mm per blow.

Classification

It is preferable to employ the heaviest hammer practicable and to limit the stroke, so as not to damage the pile. Pile hammers shall be classified as given in the Table below:

<i>Table No.</i>	<i>Classification of Pile Driving Hammers</i>	
<i>S. No.</i>	<i>Class</i>	<i>Weight Kg</i>
(1)	(2)	(3)
(i)	Light Hammers	Up to 500
(ii)	Medium Hammers	Over 500 and up to 2500
(iii)	Heavy Hammers	Over 2500

Sizes

The recommended sizes (weight of ram or striking part) and stroke of different types shall be as given in Table below:

TABLE
Sizes (Weight of Ram or the Striking Part) and Stroke of Different Types of Hammers

<i>S. No.</i>	<i>Type of Hammers</i>	<i>Light (up to 500 Kg)</i>	<i>Medium (over 500 up to 2500 kg)</i>	<i>Heavy (over 2500 kg)</i>
(1)	(2)	(3)	(4)	(5)
1	Drop Hammer	250 to 500 kg at multiples of 125	750 to 2500 kg at multiples of 250	2750 to 4500 kg at multiples of 250
2	Single acting capable of working on steam or air at 5.5 kg/cm ² at the hammer	(a) 25 to 100 kg at multiples of 25 kg at maximum stroke of 20 cm (b) 100 to 500 kg at multiples of 100 kg at maximum stroke of 40 cm.	750 to 2500 kg at multiples of 250, at maximum stroke of 90 cm.	3000 to 7500 kg at multiples of 500 kg at maximum stroke at 120 cm.
3	Double acting capable of working on steam or air at 5.5 kg/cm ² at the hammer	(a) 25 to 100 kg at multiples of 25 kg at maximum stroke of 20 cm (b) 100 to 500 kg at multiples of 100 kg at maximum stroke of 25 cm.	750 to 2500 kg at multiples of 500, at maximum stroke of 45 cm.	
4	Diesel Hammer	500 kg at maximum stroke of 250 cm	Over 500 up to 2500 kg at multiples of 500 kg at maximum stroke of 250 cm.	

SUB HEAD : 21.0

ALUMINIUM WORK

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LIST OF BUREAU OF INDIAN STANDARD (BIS) CODES

<i>Sl. No.</i>	<i>IS Code</i>	<i>Subject</i>
1.	IS 733	Wrought Aluminium and Aluminium Alloys, Bars, Rods and Sections (For General Engineering Purposes) -Specification
2.	IS 737	Wrought Aluminium and Aluminium alloy sheet and strip for general engineering purposes -Specification
3.	IS 1285	Wrought Aluminium and Aluminium Alloy, Extruded Round Tube and Hollow sections (For General Engineering Purposes) - Specification
4.	IS 1868	Anodic coating on Aluminium and its Alloys-Specification
5.	IS 1948	Specification for Aluminium Doors, Windows and Ventilators
6.	IS 3908	Specification for Aluminium equal leg angles
7.	IS 3909	Specification for Aluminium unequal leg angles
8.	IS 3965	Dimensions for wrought Aluminium and Aluminium Alloys bars, rods and sections.
9.	IS 5523	Method of testing anodic coating on aluminium and its alloys.
10.	IS 6012	Measurement of coating thickness by Eddy Current Method
11.	IS 6315	Floor springs (Hydraulically regulated) for heavy doors-Specifications
12.	IS 6477	Dimensions of extruded hollow section and tolerances
13.	IS 12823	Wood products- Pre-laminated particle board –Specifications.
14.	IS 14900	Transparent Float glass- Specifications.

21.0 ALUMINIUM WORK

21.0 TERMINOLOGY

Bar

Any solid section, other than round, with at least one dimension of 10 mm or more.

Rod

Any round solid section with a diameter of 10 mm or greater.

Extruded Round Tube

A circular hollow extrusion of uniform wall thickness not subjected to cold drawing.

Hollow Section

An extruded shape other than round tube, the cross section of which completely encloses a void or voids and which is not subject to cold drawing.

Anodized Aluminium

Aluminium with an anodic coating, produced by an electrolytic oxidation process, in which the surface of the aluminium is covered with a coating, generally an oxide, to give protective and decorative properties.

Pre-laminated Particle Board

A particle board laminated on both surface by synthetic impregnated base papers under the influence of heat and pressure with finished foil under the pressure or pressure and heat depending on type of binder used.

Floor Spring (Hydraulically Regulated)

A device used to close the door so as to slow down its speed before it reaches its closed position.

Single Action Floor Spring (Hydraulically Regulated)

A device used to close the door in one direction only so as to slow down its speed before it reaches its closed position.

Double Action Floor Spring (Hydraulically Regulated)

A device used to close the door in both directions so as to slow down its speed before it reaches its closed position.

Shoe

The device fixed to the bottom of the door leaf in order to hoist it to the floor spring.

Top Centre Pivot

The device to secure the upper portion of the door leaf and the door frame above.

Right Hand Floor Spring

A floor spring suitable for use on an anticlockwise door; an anticlockwise door is one which when viewed from above, rotates in anticlockwise direction about its hinge while opening.

Left Hand Floor Spring

The floor spring suitable for use on clockwise door a clockwise door is one which, when viewed from above, rotates in clockwise direction about its hinge while opening.

Sash

It is a complete window unit whether fixed or open type.

Composite Window

Window unit having two or more sashes joined together with one or more coupling members.

Centre – Hung Ventilator

A ventilator horizontally pivoted at the centre on both sides. Top half opens inwards and bottom half opens outwards.

21.1 ALUMINIUM

21.1.1 Aluminium Sections

Aluminium sections used for fixed/openable windows, ventilators, partitions, frame work & doors etc. shall be suitable for use to meet architectural designs to relevant works and shall be subject to approval of the Engineer-in-Charge for technical, structural, functional and visual considerations. The aluminium extruded sections shall conform to IS 733 and IS 1285 for chemical composition and mechanical properties. The stainless steel screws shall be of grade AISI 304.

The permissible dimensional tolerances of the extruded sections shall be as per IS 6477 and shall be such as not to impair the proper and smooth functioning/operation and appearance of door and windows.

Aluminium glazed doors, windows etc. shall be of sizes, sections and details as shown in the drawings. The details shown in the drawings may be varied slightly to suit the standards adopted by the manufacturers of the aluminium work, with the approval of Engineer-in-Charge. Before proceeding with any fabrication work, the contractor shall prepare and submit, complete fabrication and installation drawings for each type of glazing doors, windows, ventilators and partition etc. for the approval of the Engineer-in-Charge. If the sections are varied, the contractor shall obtain prior approval of Engineer-in-Charge and nothing extra shall be paid on this account.

21.1.2 Anodising

Standard aluminium extrusion sections are manufactured in various sizes and shapes in wide range of solid and hollow profiles with different functional shapes for architectural, structural glazing, curtain walls, doors, window & ventilators and various other purposes. The anodizing of these products is required to be done before the fabrication work by anodizing/electro coating plants which ensures uniform coating in uniform colour and shades. The extrusions are anodized up to 30 micron in different colours. The anodized extrusions are tested regularly under strict quality control adhering to Indian Standard.

21.1.3 Powder Coating

21.1.3.1 Material: The powder used for powder coating shall be Epoxy/polyester powder of make approved by the Engineer-in-Charge. The contractor shall give detailed programme for powder coating in advance, to facilitate the inspection by Engineer-in-Charge or his authorized representative.

21.1.3.2 Pre-treatment: Each aluminium alloy extrusion or performed section shall be thoroughly cleaned by alkaline or acidic solutions under the conditions specified by chemical conversion coating supplier and then rinsed. A chemical conversion coating shall be applied by treatment with a solution containing essentially chromate ions or chromate and phosphate ions as the active components as applicable. The amount of the conversion coating deposited depends on the type used by the conversion coating chemical supplier. The conversion coating shall be thoroughly rinsed either with the solution specified by the conversion coating chemical supplier or with de-mineralized water and then dried at the temperature for the time specified by the conversion coating chemical supplier. The contractor shall submit the detail specifications and application procedure for application of conversion coating for approval of Engineer-in-Charge. The metal surface after the conversion coating pretreatment and prior to the application of the coating shall be free from dust or powdery deposits.

21.1.3.3 Process: The polyester powder shall be applied by electrostatic powder spray method. Before start of powder coating the contractor shall submit detail specification for application of polyester powder from manufacturer of the polyester powder for approval of Engineer-in-Charge. The powder coating shall be applied as per the specification approved by Engineer-in-Charge.

21.1.3.4 Thickness: The thickness of the finished polyester powder coating measured by micron meter shall not be less than 50 micron nor more than 120 micron at any point.

21.1.3.5 Performance Requirements for the Finish

- (i) *Surface appearance:* The finish on significant surfaces shall show no scratches when illuminated and is examined at an oblique angle, no blisters, craters; pinholes or scratches shall be visible from a distance of about 1 m. There shall not be any visible variation in the colour of finished surfaces of different sections and between the colours of different surfaces of same section.
- (ii) *Adhesion:* When a coated test piece is tested using a spacing of 2 mm between each of the six parallel cuts (the cut is made through the full depth of powder coating so that metal surface is visible) and a piece of adhesive tape, approximately 25 mm x 150 mm approved by the Engineer-in-Charge is applied firmly to the cut area and then removed rapidly by pulling at right angles to the test area, no pieces of the finish other than debris from the cutting operation shall be removed from the surface of the finish.

21.1.3.6 Protection of Powder Coated / Anodizing Finish : It is mandatory that all aluminium members shall be wrapped with self adhesive non-staining PVC tape, approved by Engineer-in-Charge.

21.1.3.7 Measurement: All the aluminium sections including snap beading fixed in place shall be measured in running meter along the outer periphery of composite section correct to a millimeter. The weight calculated on the basis of actual average (average of five samples) weight of composite section in kilogram correct to the second place of decimal shall be taken for payment. (Weight shall be taken after anodizing). The weight of cleat shall be added for payment. Neither any deduction nor anything extra shall be paid for skew cuts.

21.1.3.8 Rate: The rate shall include the cost of all the materials, labours involved in all the operations as described in nomenclature of item and particular specification.

21.2 PANELING MATERIAL

21.2.1 Pre-laminated Particle Board

A particles board laminated on both surfaces by synthetic resin impregnated base papers under heat and pressure. Pre-laminated particle boards shall be of two grades, namely, Grade I and II corresponding to IS 3087 & 12823. Each of the grades specified shall be of four types, namely, Types-I, II, III, and IV classified by the surface abrasion characteristics specified in Table 21.1. The grade and types of pre-laminated particle board shall be represented by symbols as follows:

<i>Grade</i>	<i>Type</i>	<i>Designation</i>
Grade I	Type I	PLB-11
	Type II	PLB-12
	Type III	PLB-13
	Type IV	PLB-14
Grade II	Type I	PLB-21
	Type II	PLB-22
	Type III	PLB-23
	Type IV	PLB-24

TABLE 21.1
Physical and Mechanical Properties
(Para 21.2.1)

Sl. No.	Properties	Flat Pressed Three Layer, Multilayer and Graded	
		Grade-I	Grade-II
(i)	Density variation (Max.) Percent	± 10	± 10
(ii)	Water absorption (Max)		
	(a) 2 hours	7.0	15.0
	(b) 24 hours	15.0	30.0
(iii)	Thickness swelling (Max.), percent, 2 hours	5.0	8.0
(iv)	Modulus of rupture (Min) N/mm ²		
	(a) Up to 20 mm thickness	15.0	11.0
	(b) Above 20 mm thickness	12.5	11.0
(v)	Tensile strength perpendicular to surface (Min.) N/m ²		
	(a) Up to 20 mm thickness	0.45	0.3
	(b) Above 20 mm thickness	0.4	0.3
(vi)	Tensile strength perpendicular to surface (Min.) N/mm ²		
	(a) After cyclic test*	0.2	-
	(b) After accelerated water resistance test**	0.15	-
(vii)	Screw withdrawal strength (Min.), N:		
	(a) Face	1250	1250
	(b) Edge	850	750
(viii)	Abrasion resistance (Min.) in number of revolutions		
	(a) Type I	450	450
	(b) Type II	250	250
	(c) Type III	80	80

* *Cyclic Test* : Specimen are immersed in water at $27 \pm 2^\circ \text{C}$ for a period of 72 hours, followed by drying in air at $27 \pm 2^\circ \text{C}$ for 24 hours and then heating in dry air at 70°C for 72 hours. Three such cycles are to be followed and then specimens are tested for tensile strength perpendicular to the surface.

** *Accelerated Water Resistance Test*: Specimens are immersed in water at $27 \pm 2^\circ \text{C}$ and water is brought to boiling and kept at boiling temperature for two hours. Specimens are then cooled in water to $27 \pm 2^\circ \text{C}$ and tested for tensile strength perpendicular to the surface.

21.2.1.1 Particle Board: Synthetic resin bonded flat pressed three layers, multilayer and graded particle board defined in IS 3087 having superfine surface shall be used for production of prelaminated particle board. For ECO Marks the particle board shall also conform to the requirements of ECO Mark specified in IS 3087.

21.2.1.2 Impregnated Base Paper: Printed or plain coloured absorbent base paper having a weight of 60-140 g/m² impregnated in a suitable synthetic resin and dried to a volatile content of 4-8 per cent shall be used for pre-lamination on both surfaces of particle board.

21.2.1.3 Impregnated Overlay: An absorbent tissue, paper having a weight of 18-40 g/m² impregnated in a suitable synthetic resin and dried to a volatile content of 4-8 per cent shall be used for the manufacture of pre-laminated particle board.

21.2.1.4 Manufacture: Particle boards having superfine and closed surface with high face strength and steep density gradient across the thickness is used for making prelaminated particle boards. Impregnated base papers rich in a synthetic resin are placed on either side of the particle board and the assembly is taken inside a short cycle single opening lamination press or a multi day light press. Under heat and pressure the resin flows and forms a permanent bond with particle board.

The top surface of impregnated paper comes in contact with special surface chromium plates or steel caul plates and takes the impression of surface finish of these cauls. Hot boards are extracted out of the short cycle press and cooled in air, whereas cooling of boards is done inside the dress in multiday light type. Care should be taken to keep cycle times low in the press to avoid heat penetration to the centre of the board edge.

The impregnated overlay paper may be used by placing it over the impregnated base paper (IBP) on one surface while using a normal IBP on the other surface and pressure. The impregnated overlay becomes transparent after pressing. Such boards are used for high surface abrasion application.

In case of finished foil particle boards, the finished foil is pasted on both surfaces of particle board after spreading suitable synthetic glue on board's surface and passing the assembly in a roller press or a flat press under the influence of pressure and/or heat depending on the type of binder used.

21.2.1.5 Finish: The finish of the paper overlaid board depends on the surface of caul plates used. Common surface finishes in use are glossy, matt textured (soft, Swede, wood pore and leather), etc. The surface finish of the foil finished boards depends on the original finish of the foil used.

21.2.1.6 Dimensions and Tolerances: Dimensions and tolerances shall conform to IS 12049.

21.2.1.7 Testing: One sample for every 100 sqm. or part thereof shall be taken and testing done as per IS 12823. For quantity less than 100 sqm, the test certificate from manufacturer shall be relied upon. The Engineer-in-charge may ask for testing even if the quantity is less than 100 sqm.

21.2.2 Aluminium Sheet

21.2.2.1 Aluminium Sheets for use as panels shall be 1.25 mm thick aluminium alloy sheet conforming to IS 737. Aluminium alloy sheet for use in general paneling work shall be of types and thickness as specified and conforming to the requirement of IS 737. Aluminium sheets shall be of approved make and manufacturer. Aluminium panel may be prefabricated units manufactured on modular or non-modular dimension.

21.2.2.2 Fixing: The required size of panel, keeping sufficient margin to be inserted inside the section, shall be cut to correct size and fixed firmly in the frame with CP brass or aluminium or stainless steel screws of star headed, counter sunk and matching size groove. Joints sealed with epoxy resin or silicon sealant to make the unit water proof.

21.2.3 Float Glass

21.2.3.1 The glass shall be clear float glass and should be approved by the Engineer in Charge. It shall be clear, float transparent and free from cracks subject to allowable defects. The float glass shall conform to the IS 14900.

21.2.3.2 Thickness : The thickness of float glass shall depend on the size of panel. The tolerance in thickness shall be as under:

TABLE 21.2

<i>Nominal Thickness (in mm)</i>	<i>Tolerance (in mm)</i>
4.0	± 0.3
5.0	± 0.3
6.0	± 0.3
8.0	± 0.6

21.2.3.3 Allowable Defects: The allowable defects shall be as per Table 21.3 below:

TABLE 21.3

Sl. No.	Defects	Central	Outer	Remarks
1.	Gaseous inclusion. Max size, mm	3.0	6.0	Separated by at least 30.0 cm
2.	Opaque gaseous inclusion. Max size, mm	3.0	6.0	Separated by at least 60.0 cm
3.	Knots, dirt and stones, Max size, mm	1.0	1.0	Separated by at least 30.0 cm
4.	Scratches, Rubs and Crush	Faint	Light	Separated by at least 30.0 cm
5.	Bow, percent. Max	0.5	0.5	See 21.2.4.3
6.	Reams, Strings and lines	Light	Light	See 21.2.4.4
7.	Waviness	Nil	Nil	See 21.2.4.5
8.	Sulphur stains	Nil	Nil	
9.	Corner breakage and chip	Not more than nominal thickness of float glass		

21.2.3.4 Allowable Cluster of Defects: The allowable cluster of defects mentioned under Sl. No. 1, 2 & 3 of Table 21.3 shall be as per IS 14900.

21.2.4 Tests

21.2.4.1 Thickness: The thickness of float glass shall be measured with micrometers or a caliper which is graduated to 0.01 mm or with a measuring instrument having an equivalent capacity.

21.2.4.2 Scratches, Rubs and Crush : Place the sample of float glass in a vertical position approximately 50 cm from the viewer's position and look through it using either day light without direct sunlight or a background light suitable for observing each type of defect.

Intensity of Scratches, Rubs, Crush	Intensity Distance Limit
Faint	Shall not be detectable beyond 50 cm
Light	Detectable between 50-100 cm and not beyond 100 cm.

21.2.4.3 Bow : Depending on the side on which bow is present, stand the sample vertically on a wooden plank. Stretch a thread edge to edge. Measure the longest perpendicular. Distance from the thread to the surface of float glass facing the thread and express it as percentage of the length of float glass from edge along the thread.

21.2.4.4 Reams, Strings and Lines : Focus a light projector with a 500 W lamp and an objective lens with an approximate 5 cm aperture and about 30 cm focal length on a flat white projection screen placed about 760 cm from the light source in a dark room. Place the float glass in a vertical position parallel to the screen between the light and the screen. Move the glass slowly towards the screen with a vertical oscillating motion. The shadowgraph read out is the distance at which the distortion just blends with the general shadow of the glass on the screen.

TABLE 21.4

Intensity of Reams, Strings and Lines	Intensity Distance Limit
Light	7.5 cm
Medium	5.0 cm
Heavy	2.5 cm

21.2.4.5 Perspective Distortion: When tested as per test procedure described below it shall not give distorted vision of straight stripe pattern.

Test Procedure for Perspective Distortion

Perspective distortion shall be examined by looking through the specimen glass which may be placed at about 4.5 m distance in such a direction that the incident angle to it is 50 degree (4 mm or above) and by observing a screen set up perpendicularly to the line of vision about 4.5 m further ahead of the specimen over the total width of about middle part of the specimen from the horizontal direction. The specimen glass shall be kept with the drawn direction at manufacture vertical and, on the surface of the screen, the strip pattern of white and black parallel straight lines of 25 mm width and inclined 45 degrees from the vertical shall be provided and its surface shall be luster less.

21.3 EPDM- GASKETS

The EPDM Gaskets shall be of size and profile as shown in drawings and as called for, to render the glazing, doors, windows, ventilators etc. air and water tight. Samples of gaskets shall be submitted for approval and the EPDM gasket approved by Engineer-in-Charge shall only be used. The contractor shall submit documentary proof of using the above material in the work to the entire satisfaction of Engineer-in-Charge.

The EPDM gasket shall meet the requirements as given in Table 21.5 below:

TABLE 21.5

<i>Sl. No.</i>	<i>Description</i>	<i>Standard Follow</i>	<i>Specification</i>
1	Tensile strength Kg.f/cm ²	ASTM-D 412	70 Min.
2	Elongation at break %	ASTM-D 412	250 Min.
3	Modulus 100% Kgf/cm ²	ASTM-D 412	22 Min.
4	Compression set % at 0° CC 22 Hrs.	ASTM-D 395	50 Max.
5	Ozone resistance	ASTM-D 1149	No visible cracks

21.4 SEALANT

21.4.1 The sealants of approved grade and colour shall only be used. The silicone for perimeter joints (between Aluminium section and RCC/Stone masonry) shall be of make approved by the Engineer in Charge.

21.4.2 Method of Application

Surface Preparation : Clean all joints and glazing pockets by removing all foreign matter and contaminants such as grease, oil, dust, water, frost, surface dirt, old sealants or glazing compounds and protective coatings.

21.4.3 Masking

Areas adjacent to joints shall be masked to ensure neat sealant lines. Masking tape shall not be allowed to touch clean surfaces to which the silicone sealant is to adhere. Tooling shall be completed in one continuous stroke immediately after sealant application and before a skin forms and masking shall be removed immediately after tooling.

21.4.4 Application

Install backer rod of appropriate size and apply silicone sealant in a continuous operation using a positive pressure adequate to properly fill and seal the joint. The silicone sealant shall be tooled with light pressure to spread the sealant against backing material and the joint surfaces before a skin forms. A tool with convex profile shall be used to keep the sealant within the joint. Soap or water shall not be used as a tooling aid. Remove masking tape as soon as silicone joint is tooled.

Tolerance: A tolerance of + 3 mm shall be allowed in the width of silicone joints. The depth of the joints at throat shall not be less than 6 mm.

21.5 REFLECTIVE GLASS

21.5.1 Definitions

- (i) **Shading Coefficient:** The shading coefficient is the ratio of total solar transmittance to the transmittance through 3.2 mm (1/8") clear glass. Windows with low shading coefficient values improve comfort for building, lower the total cooling load of the building and help smooth out of the difference in cooling loads between perimeter & core zones.
- (ii) **Luminous Efficacy Constant (Ke)** indicates a windows relative performance in rejecting solar heat-while transmitting day light. It is the ratio of the visible transmittance to the shading coefficient; clear glass which lets in roughly equal amounts of visible light and solar near-infrared energy has a Ke close to 1.0. The solar radiation contains about 50% invisible near-infrared & ultra violet light. Therefore, a perfectly selective glazing, which would all allow visible light pass through while blocking all of the invisible near-infrared & ultraviolet light, would have Ke of about 2.0.
- (iii) **Resistance to Heat Conduction (R-value):** It is a measure of resistance to heat flow that occurs because of temperature difference between the two sides of the windows. The inverse of R-value is termed as U-value.

21.5.2 Reflective Glass

This is an ordinary float glass with a metallic coat to reduce solar heat. Clear glass transmits most of the sunlight that shines upon it, and most of the solar heat as well; the metallic coated glass i.e. reflective glass has better shading coefficients because they reflect rather than absorb infrared energy. However, most of reflective glazing blocks day light more than solar heat.

21.5.2.1 Types of Coatings: There are two types of reflective glass, Pyrolytic (Hard) coated and vacuum (soft) coated.

- (i) **Pyrolytic :** It is a coating applied during glass manufacture. The coating is fused into the glass at 1200°C.
- (ii) **Vacuum Coated Glass:** It involves the deposition of metal particles on the glass surface by a chain reaction in a vacuum vessel. It is often called a soft coat; because the coating is more susceptible to damage than hard coat glass. Where toughening of product is required, the product must be toughened first & then vacuum coated. Vacuum coated products have better shading coefficient values than pyrolytic products.

21.5.2.2 Performance of Reflective Glass: The performance of reflective glass 6 mm of nominal thickness is given below:

Sl.No.	Parameter	Threshold Ratio In %age
1.	Visible Light - Transmittance (%) - Reflectance (%)	15-46 12-24
2.	Total Solar Energy: - Transmittance (%) - Reflectance (%)	16-24 8-12
3.	Ultra Violet Rays: - Transmittance (%)	2-10
4.	U-Value - Summer - Winter	0.58 0.45
5.	Shading Coefficient	0.25-0.35

21.5.2.3 Testing: The reflective glass shall be tested for the followings:

- (i) *Physical/Field Test:* In a true reflective glass, when a pointed pencil is placed, then tip of pencil (physical) & image should coincide.
- (ii) *Lab. Test:* In the lab, the reflective glass shall be tested for the parameter specified in 21.5.2.2 above.

21.5.2.4 Fixing of glass shall be done as specified.

21.6 DOOR, WINDOW, VENTILATOR AND PARTITION FRAMES

21.6.1 Frame Work

First of all the shop drawings for each type of doors/windows/ventilators etc. shall be prepared by using suitable sections based on architectural drawings, adequate to meet the requirement/specifications and by taking into consideration varying profiles of aluminium sections being extruded by approved manufacturers. The shop drawings shall show full size sections of glazed doors, windows, ventilators etc. The shop drawings shall also show the details of fittings and joints. Before start of the work, all the shop drawings shall be got approved from the Engineer-in-Charge.

Actual measurement of openings left at site for different type of door/window etc. shall be taken. The fabrication of the individual door/windows/ventilators etc. shall be done as per the actual sizes of the opening left at site. The frames shall be truly rectangular and flat with regular shape corners fabricated to true right angles. The frames shall be fabricated out of section which have been cut to length, mitered and jointed mechanically using appropriate machines. Mitered joints shall be corner crimped or fixed with self tapping stainless steel screws using extruded aluminium cleats of required length and profile. All aluminium work shall provide for replacing damaged/broken glass panes without having to remove or damage any member of exterior finishing material.

21.6.2 Fixing of Frames

The holes in concrete/masonry/wood/any other members for fixing anchor bolts/fasteners/screws shall be drilled with an appropriate electric drill. Windows/doors/ventilators etc. shall be placed in correct final position in the opening and fixed to Sal wood backing using stainless steel screws of star headed, counter sunk and matching size groove. of required size at spacing not more than 250 mm c/c or dash fastener. All joints shall be sealed with approved silicone sealants.

In the case of composite windows and doors, the different units are to be assembled first. The assembled composite units shall be checked for line, level and plumb before final fixing is done. Engineer-in-Charge in his sole discretion may allow the units to be assembled in their final location if the situation so warrants. Snap beadings and EPDM gasket shall be fixed as per the detail shown in the shop drawings.

Where aluminium comes into contact with stone masonry, brick work, concrete, plaster or dissimilar metal, it shall be coated with an approved insulation lacquer, paint or plastic tape to ensure that electrochemical corrosion is avoided. Insulation material shall be trimmed off to a clean flush line on completion.

The contractor shall be responsible for the doors, windows etc. being set straight, plumb, level and for their satisfactory operation after fixing is complete.

21.6.3 Measurements

All the aluminium sections including snap beadings fixed in place shall be measured in running meter along the outer periphery of composite section correct to a millimeter. The weight calculated on the basis of actual average (average of five samples) weight of composite section in kilogram correct to the second place of decimal shall be taken for payment (weight shall be taken after anodizing). The weight of cleat shall be added for payment. Neither any deduction nor anything extra shall be paid for skew cuts.

21.6.4 Rate

The rate shall include the cost of all the materials, labour involved in all the operations as described in nomenclature of item and particular specification.

21.7 DOOR, WINDOWS AND VENTILATOR SHUTTERS

Material, fabrication and dimensions of aluminium doors, windows and ventilators manufactured from extruded aluminium alloy sections of standard sizes and designs complete with fittings, ready for being fixed into the building shall be as per IS 1948.

21.7.1 Terminology

The components of doors, windows and ventilators shall be defined as in Figure 21.1 below.

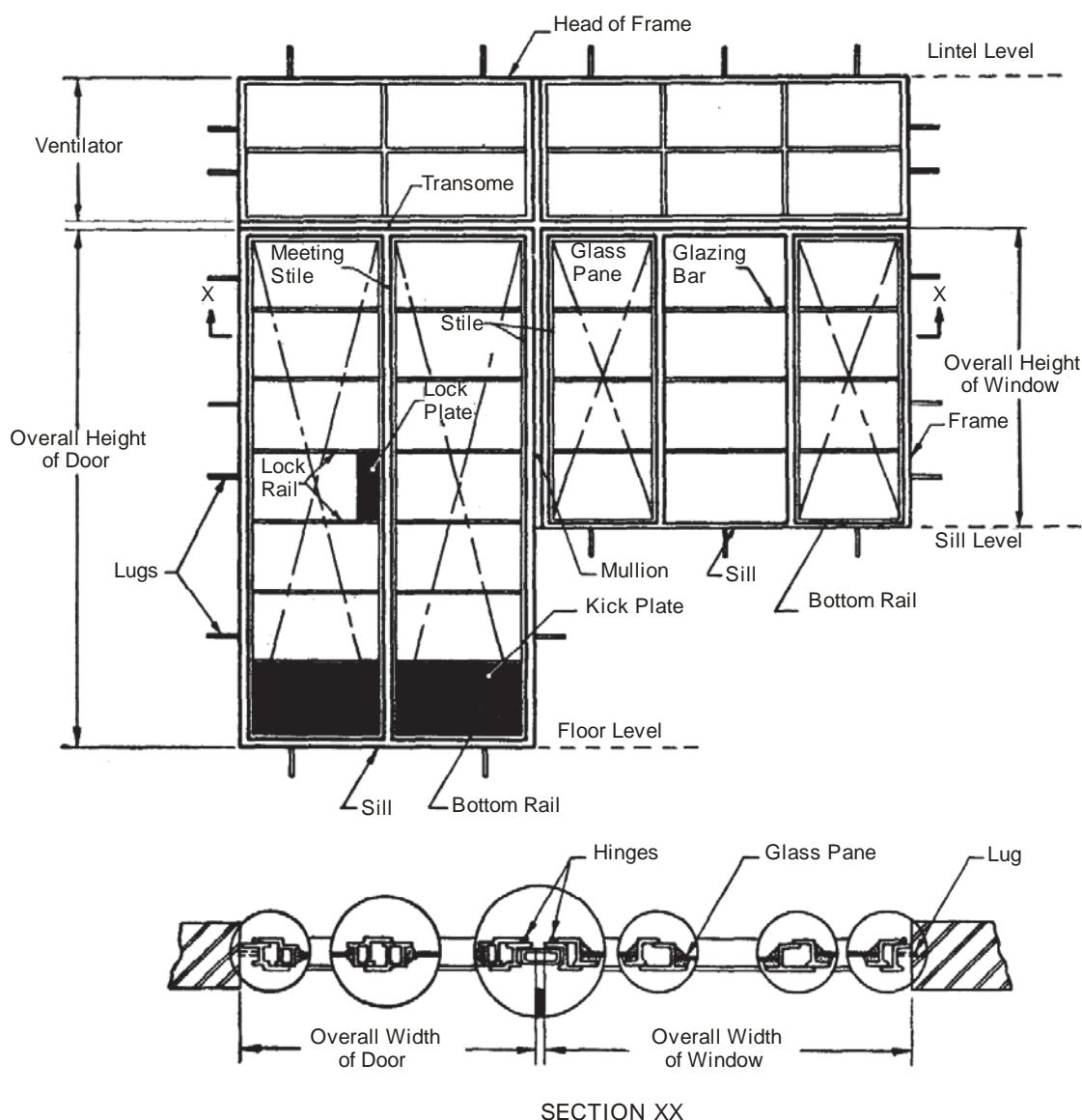
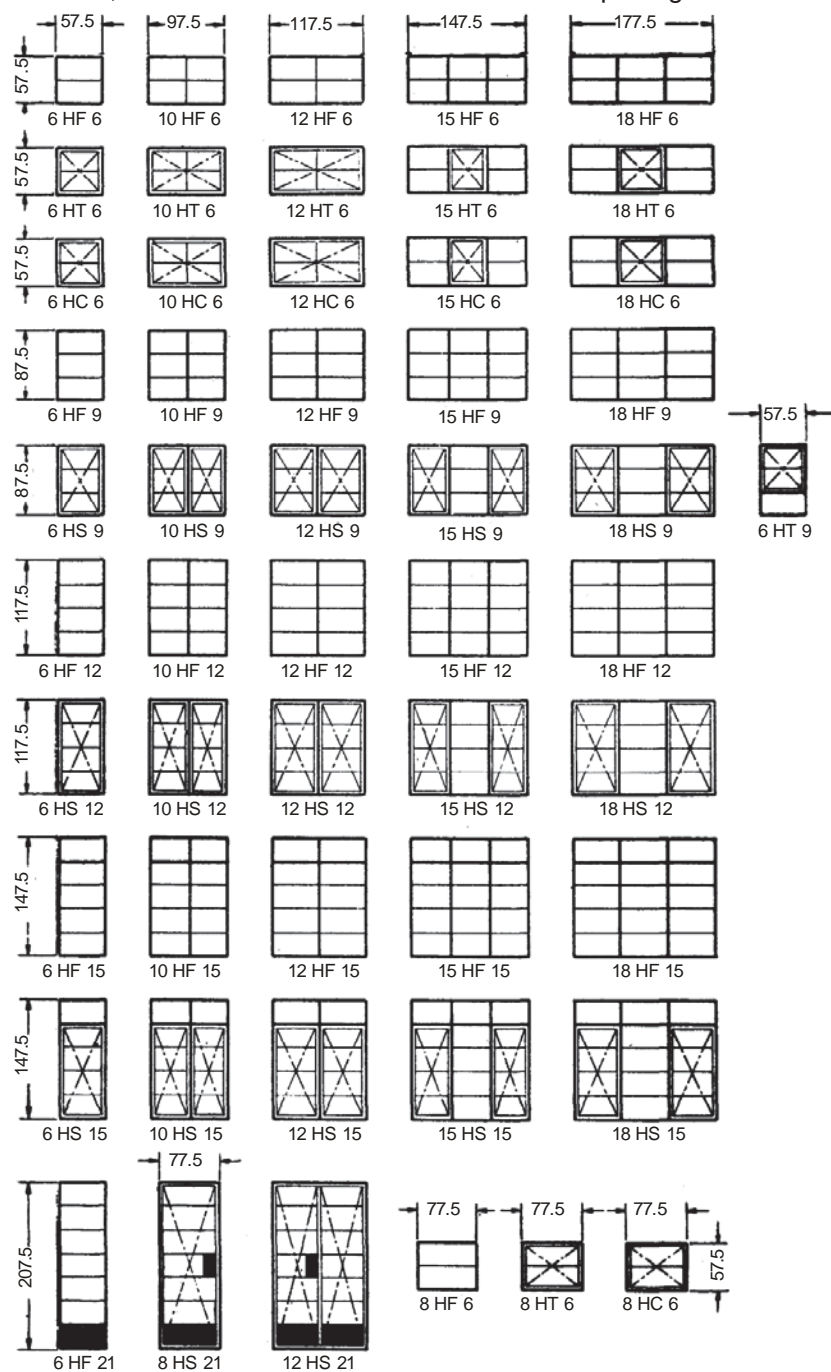


Fig. 21.1 : Terminology for Aluminium Doors, Windows and Ventilators

21.7.2 Standard Sizes, Tolerances and Designations

The types and the overall sizes of aluminium doors, windows and ventilators shall be as given in Figure 21.2. Their sizes are derived after allowing 1.25 mm clearances on all the four sides for the purpose of fitting the doors, windows and ventilators into modular openings.



Note : 1. Windows without horizontal glazing bars shall be designated by 'N' in place of 'H' in the range shown.

Note : 2. Doors and side lights shall only be coupled with 12 module (117.5 cm) high windows.

All dimensions in centimetres

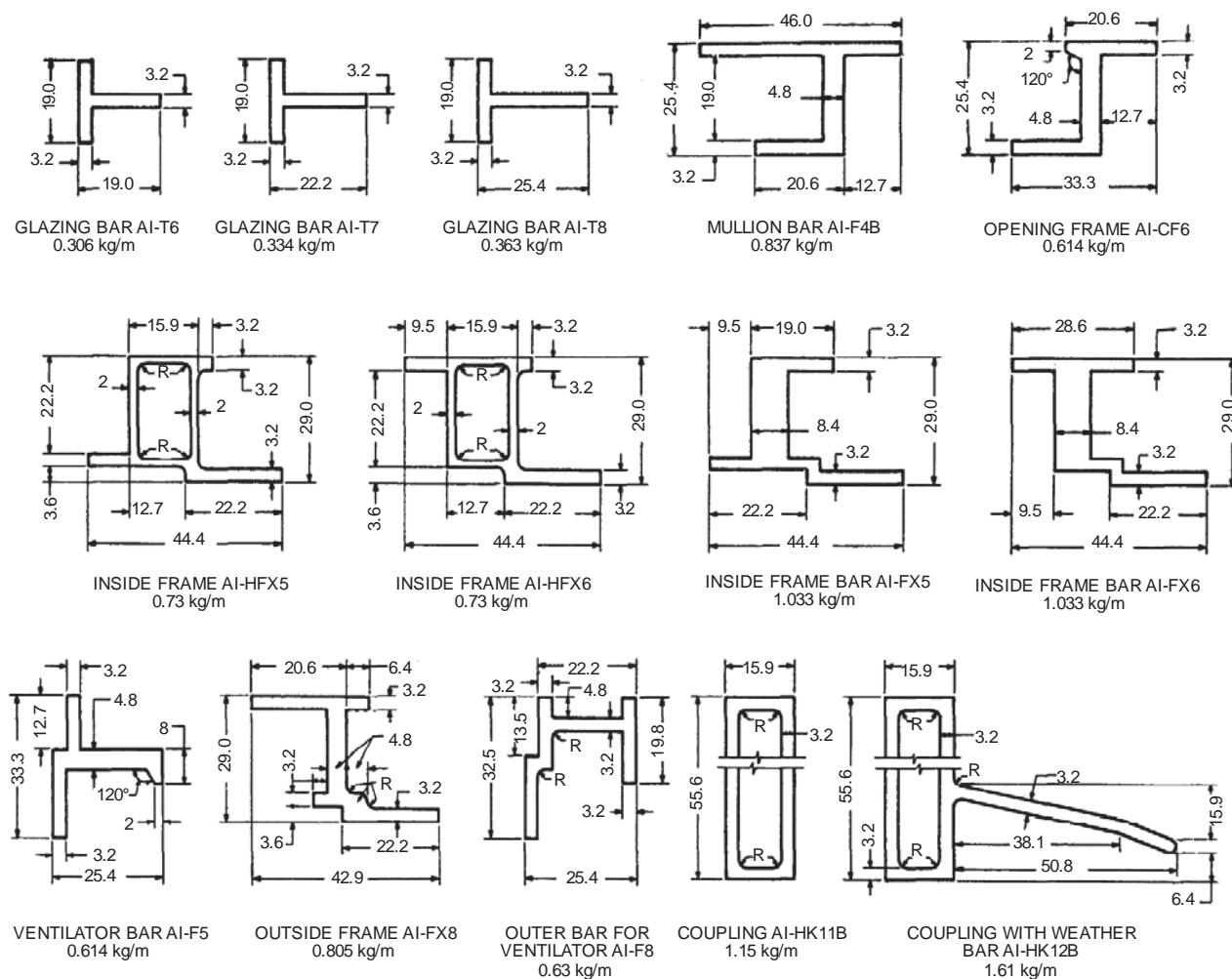
Fig. 21.2 : Types and Size of Aluminium Doors, Windows and Ventilators

21.7.3 Tolerances

The sizes for doors, windows and ventilators frames shall not vary by more than ± 1.5 mm.

21.7.4 Material

Aluminium alloy extruded sections used in the manufacture of extruded window sections shall conform to IS 733. Hollow aluminium alloy sections used shall conform to IS 1285. Dimension and weight per metre run of the extruded sections shall be as given in Figure 21.3.



Note 1 : All radii $R = 1.6$ mm

Note 2 : The weights of sections per metre length as indicated are nominal.

All dimensions in millimeters

Fig. 21.3 : Extruded Aluminium Sections for Doors, Windows and Ventilators

21.7.5 Glass Panes

Glass panes shall weigh at least 7.5 kg/m^2 and shall be free from flaws, specks or bubbles. All panes shall have properly squared corners and straight edges. The sizes of glass panes for use in doors, windows and ventilators shall be as given in Table 21.6.

21.7.6 Screws

Screws threads of machine screws used in the fabrication of aluminium doors, windows and ventilators shall conform to IS 1362.

TABLE 21.6
Glass Sizes (Clearance Allowed)
(Clause 21.7.5)

<i>Designation</i>	<i>Quantity</i>	<i>Glass size Width X Height cm</i>
No Glazing Bar Fixed Type		
6NF6	1	53.0 x 53.0
10NF6	2	45.0 x 53.0
12NF6	2	55.0 x 53.0
15NF6	{2 1	45.0 x 53.0 47.5 x 53.0
18NF6	{2 1	55.0 x 53.0 57.5 x 53.0
6NF9	1	53.0 x 83.0
10NF9	2	45.0 x 83.0
12NF9	2	55.0 x 83.0
15NF9	{2 1	45.0 x 83.0 47.5 x 83.0
18NF9	{2 1	55.0 x 83.0 57.5 x 83.0
6NF12	1	53.0 x 113.0
10NF12	2	45.0 x 113.0
12NF12	2	55.0 x 113.0
15NF12	{2 1	45.0 x 113.0 47.5 x 113.0
18NF12	{2 1	55.0 x 113.0 57.5 x 113.0
6NF15	{1 1	53.0 x 27.0 53.0 x 113.0
10NF15	{2 2	{45.0 x 27.0 45.0 x 113.0
12NF15	{2 2	55.0 x 27.0 55.0 x 113.0
15NF15	{2 1 2 1	45.0 x 27.0 47.5 x 27.0 45.0 x 113.0 47.5 x 113.0
18NF15	{2 1 2 1	55.0 x 27.0 57.5 x 27.0 55.0 x 113.0 57.5 x 113.0
8NF6	1	73.0 x 53.0
6NF21	{1 1 1	53.0 x 84.5 53.0 x 27.5 53.0 x 56.0
No Glazing Bar Top-Hung Type		
6NT6	1	50.0 x 50.0
10NT6	2	44.5 x 50.0
12NT6	2	54.5 x 50.0
15NT6	{2 1	45.0 x 53.0 45.5 x 50.0
18NT6	{2 1	55.0 x 53.0 54.5 x 50.0
8NT6	1	70.0 x 50.0
6NT9	{1 1	50.0 x 51.5 53.0 x 27.5

<i>Designation</i>	<i>Quantity</i>	<i>Glass size Width X Height cm</i>
No Glazing Bar Centre-Hung Type		
6NC6	1	46.0 x 46.0
10NC6	2	42.5 x 46.0
12NC6	2	52.5 x 46.0
15NC6	{2 1	45.0 x 53.0 43.5 x 46.0
18NC6	{2 1	55.0 x 53.0 53.5 x 46.0
8NC6	1	66.0 x 46.0
No Glazing Bar Side-Hung Type		
6NS9	1	50.0 x 80.0
10NS9	2	43.5 x 80.0
12NS9	2	52.5 x 80.0
15NS9	{2 1	43.5 x 80.0 47.5 x 83.0
18NS9	{2 1	52.5 x 80.0 57.5 x 83.0
6NS12	1	50.0 x 110.0
10NS12	2	43.5 x 110.0
12NS12	2	52.5 x 110.0
15NS12	{2 1	43.5 x 110.0 47.5 x 113.0
18NS12	{2 1	53.0 x 27.0 50.0 x 110.0
6NS15	{1 1	53.0 x 27.0 50.0 x 110.0
10NS15	{2 2	45.0 x 27.0 43.5 x 110.0
12NS15	{2 2	55.0 x 27.0 52.5 x 110.0
15NS15	{2 1 2 1	45.0 x 27.0 47.5 x 27.0 43.5 x 110.0 47.5 x 113.0
18NS15	{2 1 2 1	55.0 x 27.0 57.5 x 27.0 52.5 x 110.0 57.5 x 113.0
8NS21	{1 1 1	66.0 x 81.0 56.0 x 27.5 66.0 x 56.0
12NS21	{2 2 1 1	50.5 x 81.0 50.5 x 56.0 50.5 x 27.5 40.5 x 27.5

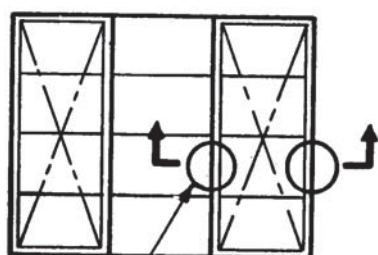
<i>Designation</i>	<i>Quantity</i>	<i>Glass size Width X Height cm</i>
Horizontal Glazing Bar Fixed Type		
6HF6	2	53.0 x 26.0
10HF6	4	45.0 x 26.0
12HF6	4	55.0 x 26.0
15HF6	{4 2	45.0 x 26.0 47.5 x 26.0
18HF6	{4 2	55.0 x 26.0 57.5 x 26.0
6HF9	{2 1	53.0 x 27.5 53.0 x 26.0
10HF9	{4 2	45.0 x 27.5 45.0 x 26.0
12HF9	{4 2	55.0 x 27.5 55.0 x 26.0
15HF9	{4 2 2 1	45.0 x 27.5 45.0 x 26.0 47.5 x 27.5 47.5 x 26.0
18HF9	{4 2 2 1	55.0 x 27.5 55.0 x 26.0 57.5 x 27.5 57.5 x 26.0
6HF12	4	53.0 x 27.5
10HF12	8	45.0 x 27.5
12HF12	8	55.0 x 27.5
15HF12	{8 4	45.0 x 27.5 47.5 x 27.5
18HF12	{8 4	55.0 x 27.5 57.5 x 27.5
6HF15	{1 4	53.0 x 27.0 53.0 x 27.5
10HF15	{2 8	45.0 x 27.0 45.0 x 27.5
12HF15	{2 8	55.0 x 27.0 55.0 x 27.5
15HF15	{2 1 8 4	45.0 x 27.0 47.5 x 27.0 45.0 x 27.5 47.5 x 27.5
18HF15	{2 1 8 4	55.0 x 27.0 57.5 x 27.0 55.0 x 27.5 57.5 x 27.5
8HF6	2	73.0 x 26.0
6HF21	6	53.0 x 27.5
Horizontal Glazing Bar Top-Hung Type		
6HT6	2	50.0 x 24.5
10HT6	4	44.5 x 24.5
12HT6	4	54.5 x 24.5
15HT6	{4 2	45.0 x 26.0 44.5 x 24.5
18HT6	{4 2	55.0 x 26.0 54.5 x 24.5
6HT9	{1 1 1	50.0 x 26.0 50.0 x 24.5 53.0 x 27.5
8HT6	2	70.0 x 24.5

<i>Designation</i>	<i>Quantity</i>	<i>Glass size Width X Height cm</i>
Horizontal Glazing Bar Centre-Hung Type		
6HC6	2	46.0 x 22.5
10HC6	4	42.5 x 22.5
12HC6	4	52.5 x 22.5
15HC6	{4 2	45.0 x 26.0 43.5 x 22.5
18HC6	{4 2	55.0 x 26.0 53.5 x 22.5
8HC6	2	66.0 x 22.5
Horizontal Glazing Bar Side-Hung Type		
6HS9	3	50.0 x 26.0
10HS9	6	43.5 x 26.0
12HS9	6	52.5 x 26.0
15HS9	{6 2 1	43.5 x 26.0 47.5 x 27.5 47.5 x 26.0
18HS9	{6 2 1	52.5 x 26.0 57.5 x 27.5 57.5 x 26.0
6HS12	{2 2	50.0 x 26.0 50.0 x 27.5
10HS12	{4 4	43.5 x 26.0 43.5 x 27.5
12HS12	{4 4	52.5 x 26.0 52.5 x 27.5
15HS12	{4 4 4	43.5 x 26.0 43.5 x 27.5 47.5 x 27.5
18HS12	{4 4 4	52.5 x 26.0 52.5 x 27.5 57.5 x 27.5
6HS15	{1 2 2	53.0 x 27.0 50.0 x 26.0 50.0 x 27.5
10HS15	{2 4 4	45.0 x 27.0 43.5 x 26.0 43.5 x 27.5
12HS15	{2 4 4	55.0 x 27.0 52.5 x 26.0 52.5 x 27.5
15HS15	{2 1 4 4 4	45.0 x 27.0 47.5 x 27.0 43.5 x 26.0 43.5 x 27.5 47.5 x 27.5
18HS15	{2 1 4 4 4	55.0 x 27.0 57.5 x 27.0 52.5 x 26.0 52.5 x 27.5 57.5 x 27.5
8HS21	{1 4 1	66.0 x 24.0 66.0 x 27.5 56.0 x 27.5
12HS21	{2 9 1	50.5 x 24.0 50.5 x 27.5 40.5 x 27.5

21.7.7 Fabrication

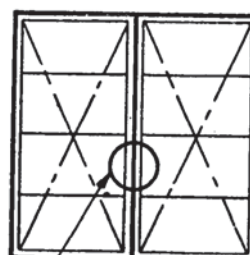
Frames: Frames shall be square and flat, the corners of the frame being fabricated to a true right angle. Both the fixed and opening frames shall be constructed of sections which have been cut to length, mitered and welded at the corners. Where hollow sections are used with welded joints, argon-arc welding or flash butt welding shall be employed (gas welding or brazing not to be done). Subdividing bars of units shall be tenoned and riveted into the frame.

The location of the parts and details of construction of the doors, windows and ventilators are indicated in Fig. 21.4 to 21.11.



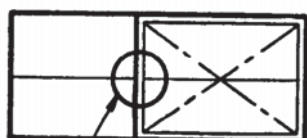
For Detail See Fig. 21.5
Type 15 HS 12

Fig. 21.4(a)



For Detail See Fig. 21.6
Type 12 HS 12

Fig. 21.4(b)



For Detail See Fig. 21.7
Type 6HF6/8HT6

Fig. 21.4(c)



For Detail See Fig. 21.8
Type 6HT9

Fig. 21.4(d)



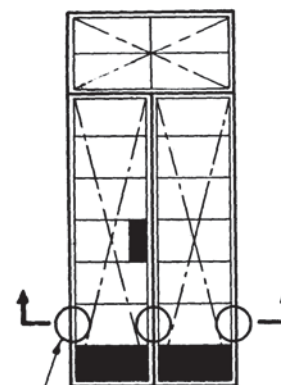
Type 6HF6/6HS12

Fig. 21.4 (e)



For Detail See Fig. 21.10

Fig. 21.4(f)



For Detail See Fig. 21.11

Fig. 21.4(g)

Fig. 21.4 : Location of Parts of Aluminium Doors, Windows and Ventilators for which Details are Shown

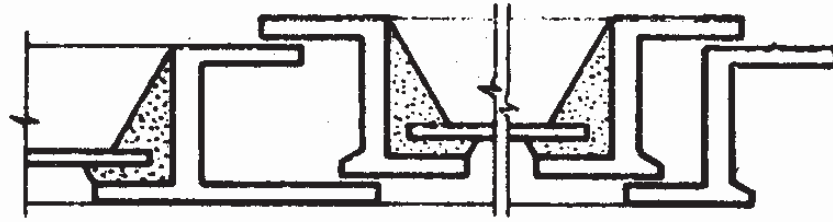


Fig 21.5 : Mullion with Fixed Glass on one Side and Side Hung on Other Side

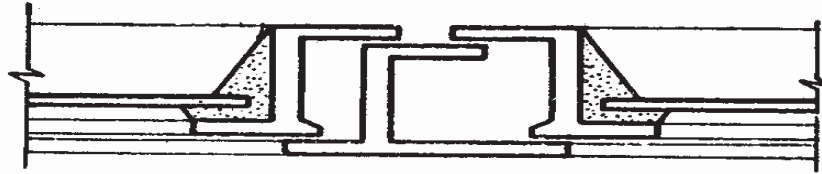


Fig 21.6 : Mullion with Side Hung Shutter Both Sides

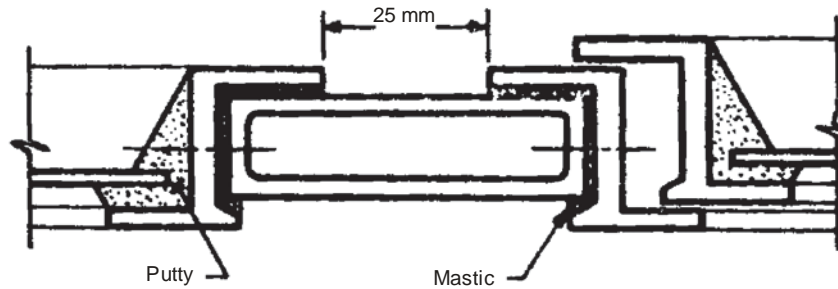


Fig 21.7 : Coupling Section Extruded for Coupling Windows Side by Side

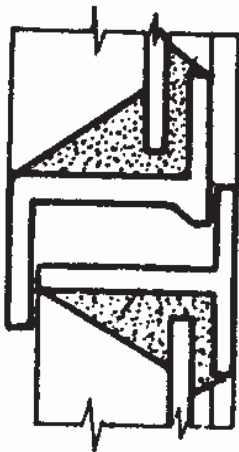


Fig 21.8 : Detail Through Bottom of Top-Hung Ventilator

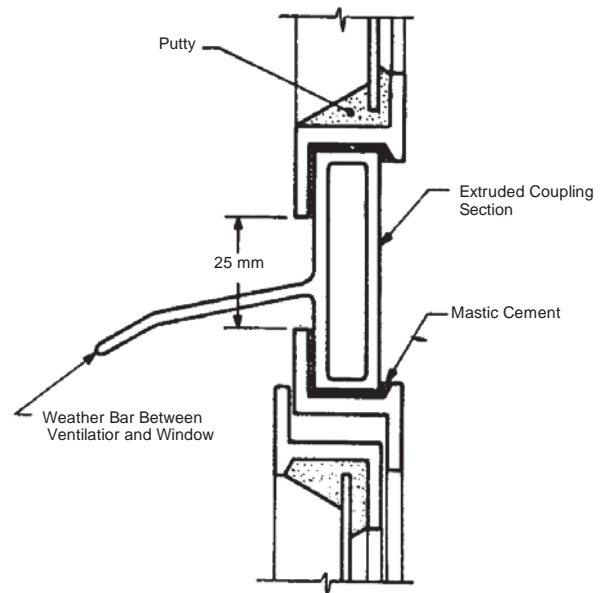


Fig 21.9 : Coupling Section Extruded having Weather Bar Fitted with Ventilators on top of Windows

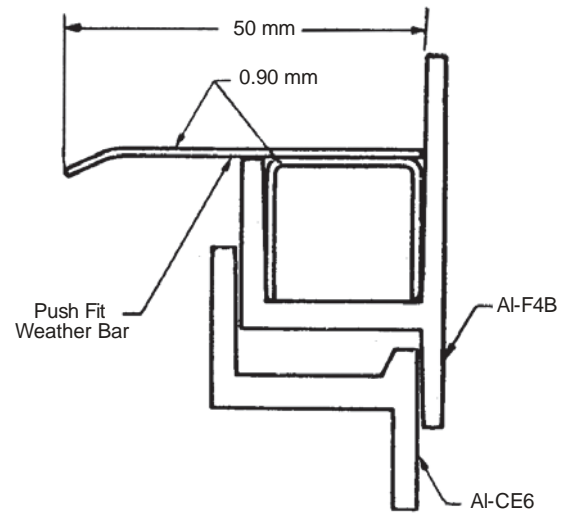


Fig 21.10 : Weather Bar over Extruded Opening Shutter with Fixed Light Above

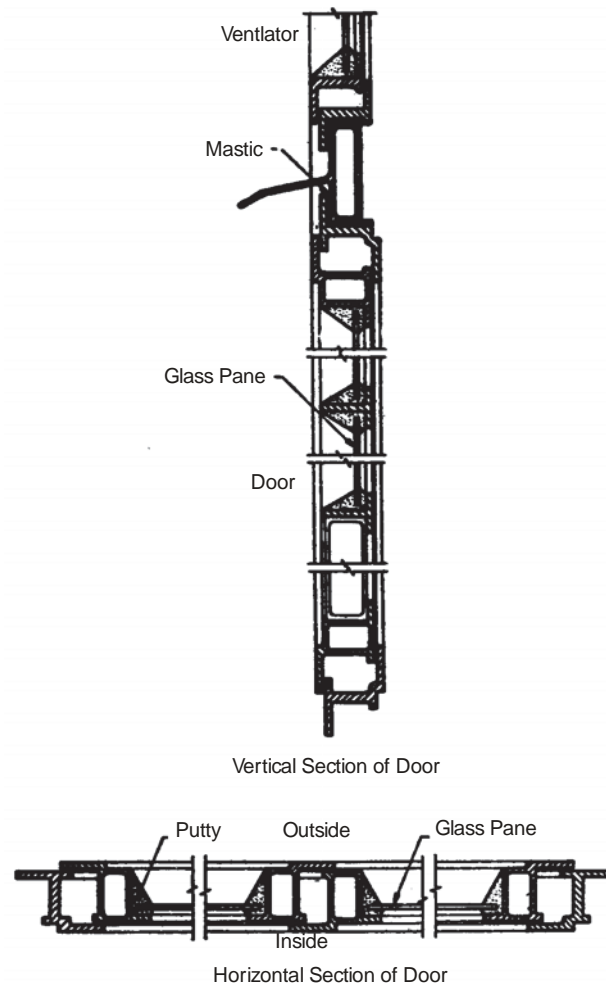


Fig 21.11 : Detail of Aluminium Double Shutter Door

21.7.8 Side-hung Shutters

For fixing aluminium alloy hinges, slots shall be cut in the fixed frame and the hinges inserted inside and may be riveted to the frame. The hinges shall normally be of the projecting type 67 mm wide (Fig. 21.12). The aluminium alloy for cast hinges shall conform to IS Designation A-5-M of IS 617. Specification for Aluminium and Aluminium Alloy Ingots and Castings for General Engineering Purpose and for extruded section of hinges to IS Designation HE10-WP or HE30-WP of IS 733. The pins for hinges shall be of stainless steel of non-magnetic type or aluminium alloy HR30. Irrespective of hinges being anodized or not, the aluminium alloy pins shall be anodized to a minimum film thickness of 0.025 mm shall be sealed with oil, wax or lanolin. Non- projecting types of hinges may also be used where ever required. (Fig. 21.13).

Frictions hinges may be provided for side-hung shutter windows, in which case peg stay may not be required. The working principle of the friction hinges is illustrated in Fig. 21.14.

The handle for side-hung shutters shall be of cast aluminium conforming to IS Designation A-5-M of IS 617 and mounted on a handle plate welded or riveted to the opening frame in such a way that it could be fixed before the shutter is glazed. The handle should have anodized finish with minimum anodic film thickness of 0.015 mm. The handle shall have a two points nose which shall engage with an aluminium striking plate on the fixed frame in a slightly open position as well as in a fast position (Fig. 21.15). The height of the handles in each type of side-hung shutters shall be fixed in approximate position as indicated in Fig. 21.16.

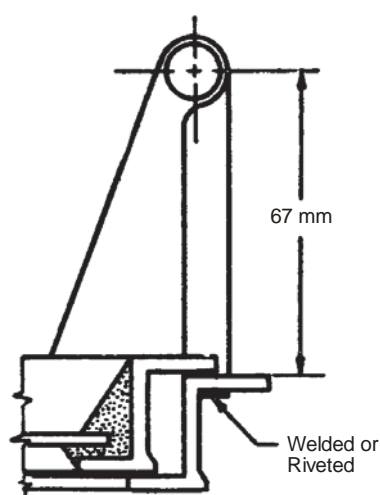


Fig. 21.12 : Typical Projecting Type Hinge for Side-Hung Shutters

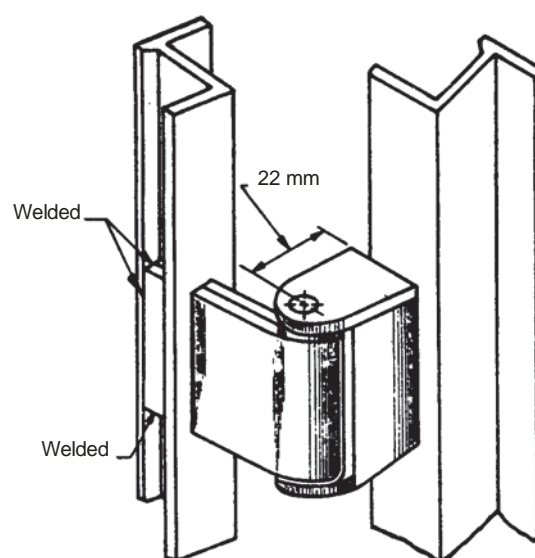


Fig. 21.13 : Typical Non-Projecting Type Hinge for Side-Hung Shutters

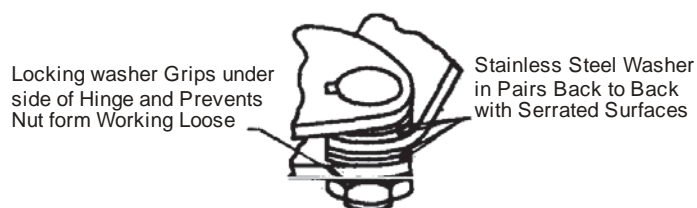


Fig. 21.14 : Illustration Showing Working Principle of Friction Stay

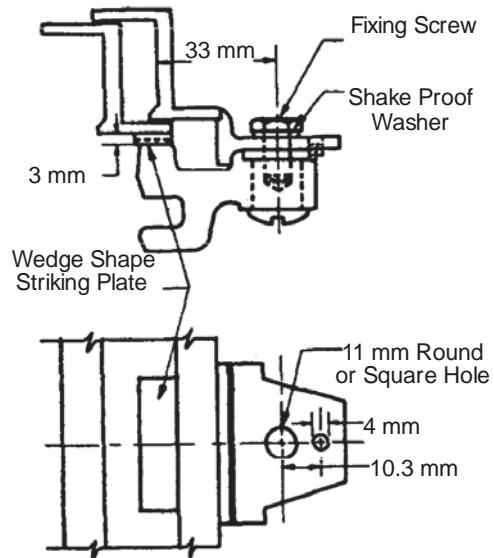


Fig. 21.15 : A Typical Handle for Side-Hung Shutter

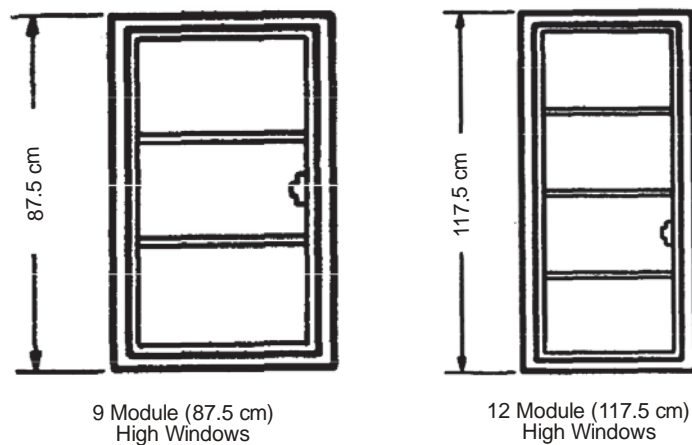


Fig. 21.16: Position of Handle Plates in Relation to Heights of 'HS' Type Windows

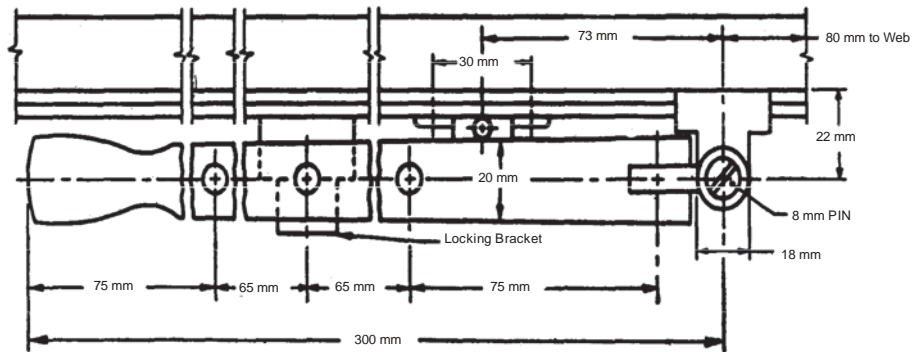


Fig. 21.17 : A Typical Peg-Stay for Side-Hung Shutters and Top-Hung Ventilators

The peg stay shall be either of cast aluminium conforming to IS 617 or folded from IS Designation NS4 aluminium alloy sheet conforming to IS:737 specification for wrought aluminium and aluminium alloys, Sheet and strip. It shall be 300 mm long, complete with peg and locking brackets (Fig. 21.17). The stay shall have holes for keeping the shutter open in three different positions. The peg and locking bracket shall be riveted or welded to the fixed frame.

Alternatively, and if specifically required by the purchaser, side-hung shutters may be fitted with an internal removable fly screen of 0.375 mm wire and equivalent to IS Sieve 100 in a 0.900 mm aluminium alloy sheet conforming to IS Designation NS3-1/2H of IS 737 applied to the outer frame of the shutter by case or extruded aluminium alloy turn-buckle at the jambs (Fig. 21.18) and by aluminium or plated bronze shoes at the sill to allow of the screen being readily removed, and with a rotor operator at the sill to permit the operation of the shutter through an angle of 90° (Fig. 21.19). On fly-screened shutters the peg stay is omitted and the normal handle shall be replaced by a locking handle to hold the shutter in the fast position.

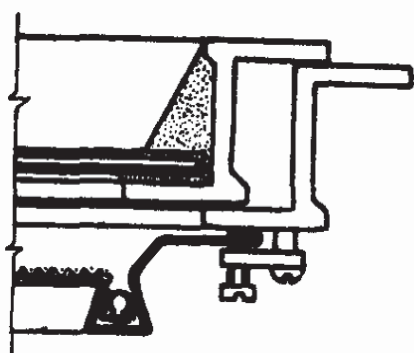


Fig. 21.18 : Detail Through Jamb Showing Turnbuckle

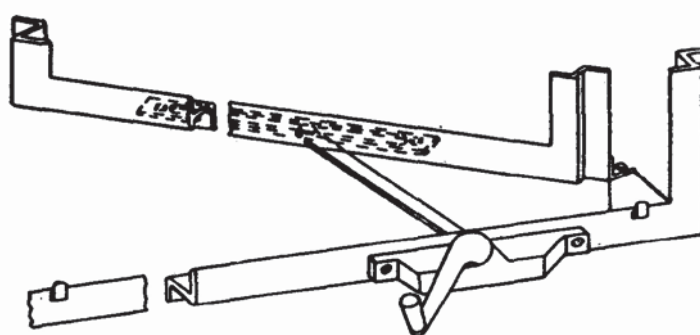


Fig. 21.19 : Typical Rotor Operator for Side-Hung Shutters Fitted with Fly Screens

21.7.9 Top-Hung Ventilators

The aluminium hinges for top-hung ventilators shall be either cast or fabricated out of extruded sections and shall be riveted to the fixed rail after cutting a slot in it. The aluminium alloy for cast hinges shall conform to IS Designation A-5-M of IS 617 and the extruded section of hinge to IS Designation HE10-WP or HE30_WP of IS 733

The pegs stay shall be 300 mm long as in side-hung shutter (Fig. 21.17). The locking bracket shall be fixed to the fixed frame.

21.7.10 Centre-Hung Ventilators (Fig.21.20)

Centre hung ventilators shall be hung on two pairs of cup pivots of aluminium alloy to IS Designation NS-4 of IS 737 and IS Designation A-5-M of IS 617 or on brass or bronze cup pivots which should be either chromium or cadmium plated and riveted to the inner and outer frames of the ventilators to permit the ventilator to swing through an angle of approximately 85°. The opening portion of the ventilator shall be so balanced that it remains open at any desired angle under normal weather condition.

Cast aluminium conforming to IS Designation A-5-M of IS 617 or bronze which shall be either chromium-plated or cadmium-plated spring catch shall be fitted in the centre of the top bar of the ventilators for the operation of the ventilator. This spring catch shall be secured to the frame and shall close into aluminium catch plate riveted or welded to the outside of the outer ventilator frame bar (Fig. 21.21).



Fig. 21.20 : Detail of Horizontal Centre-Hung Ventilator

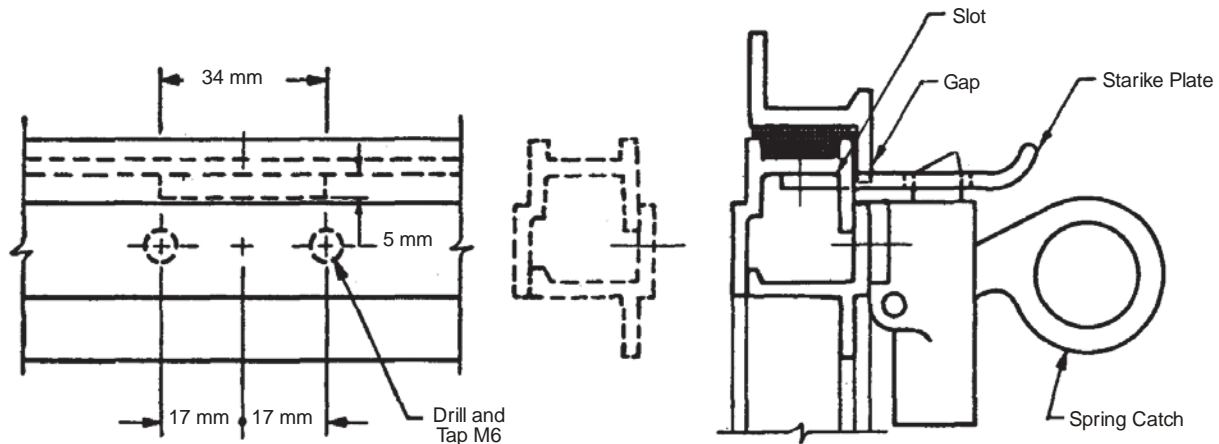


Fig. 21.21: Spring Catch for Centre-Hung Ventilator

Aluminium or cadmium plated brass cord pulley-wheel in an aluminium bracket shall be fitted at the sill of the ventilator with aluminium or galvanized or cadmium plated steel screw or, alternatively, welded together with an aluminium cord eye riveted or welded to the bottom inner frame bar of the ventilator in a position corresponding to that of pulley (Fig. 21.22).

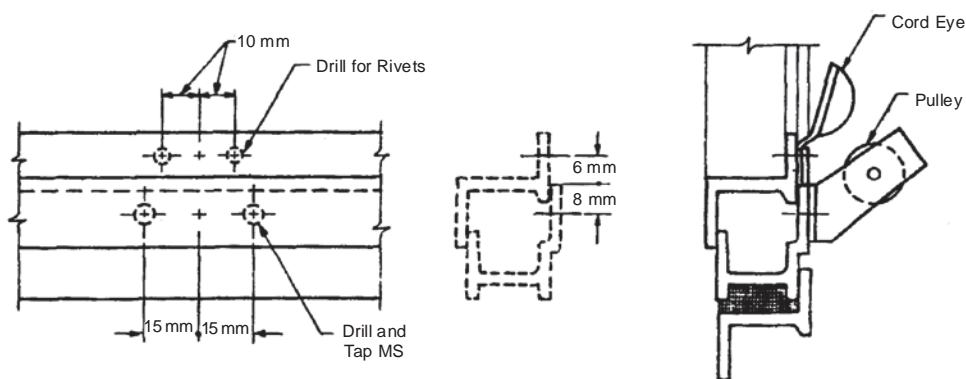


Fig. 21.22 : Cord Eye and Pulley Arrangement for Centre-Hung Ventilator

21.7.11 Doors

The outer fixed frame shall be of section A1-FX8. The shutter frame shall be of either hollow sections A1-HFX5 and A1-HFX6 (Fig. 21.3 and Fig. 21.11).

The kick panels shall be of 1.25 mm aluminium alloy sheet conforming to IS Designation NS3-1/2H of IS 737 specification for Wrought Aluminium and Aluminium Alloys, Sheet and strip and shall be screwed to the frame and the glazing bar.

Hinges –Cast or extruded aluminium alloy hinges for doors shall be of the same type as in the windows but of larger size. The hinges shall normally be of the 50 mm projecting type (Fig. 21.23). Non-projecting type of hinges may also be used (Fig. 21.24).

The handle for doors may be of the design indicated in Fig. 21.25.

A suitable lock for the door operable either from inside or outside shall be provided.

Note: From the point of view of security, the lock which is operable from only one side is better and in the case of such locks, a bolt shall be provided to make them inoperable from the other side.

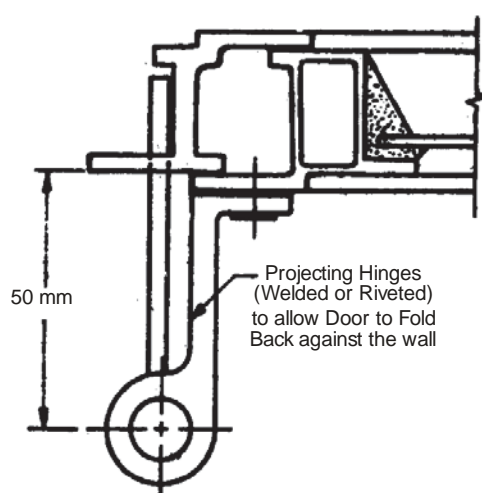


Fig. 21.23 : Typical Projecting Type Hinge for Door

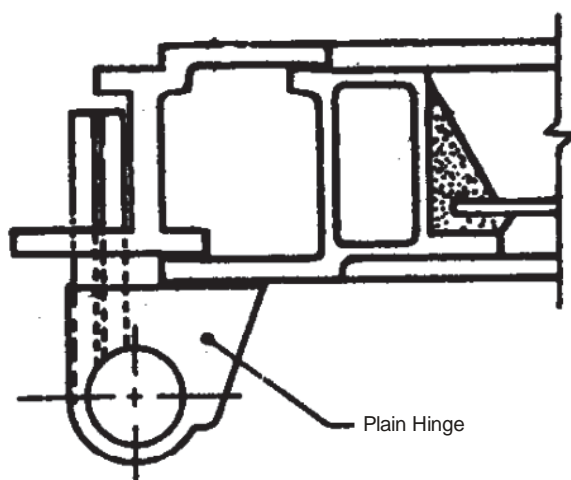


Fig. 21.24 : Typical Non-Projecting Type Hinge for Door

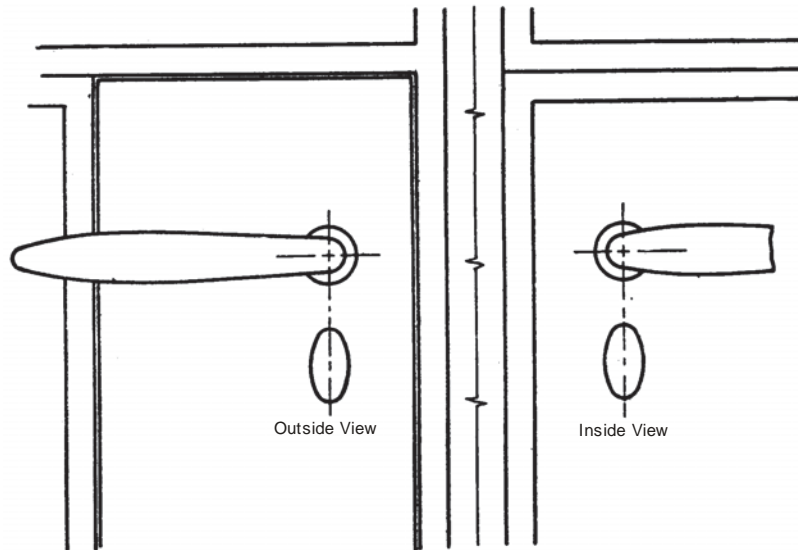


Fig. 21.25 Typical Door Handle

In double shutter doors the first closing shutter shall have a concealed aluminium alloy bolt at top and bottom (Fig. 21.26). It shall be so constructed as not to work loose or drop by its own weight.

Single and double shutter doors may be provided with a three-way bolting device (Fig. 21.27). Where this is provided in the case of double shutter door, concealed aluminium bolts may not be provided.

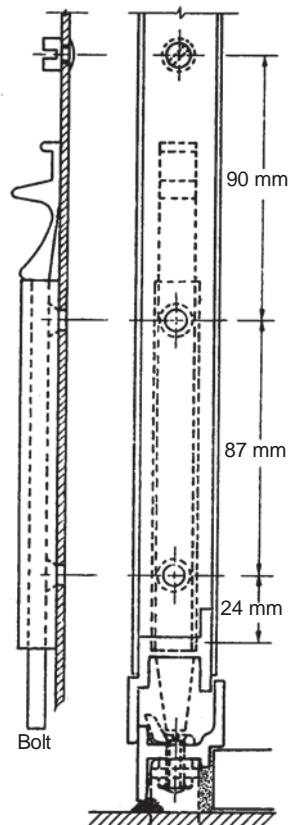


Fig. 21.26 : Typical Vertical Bolt for Double Shutter Door

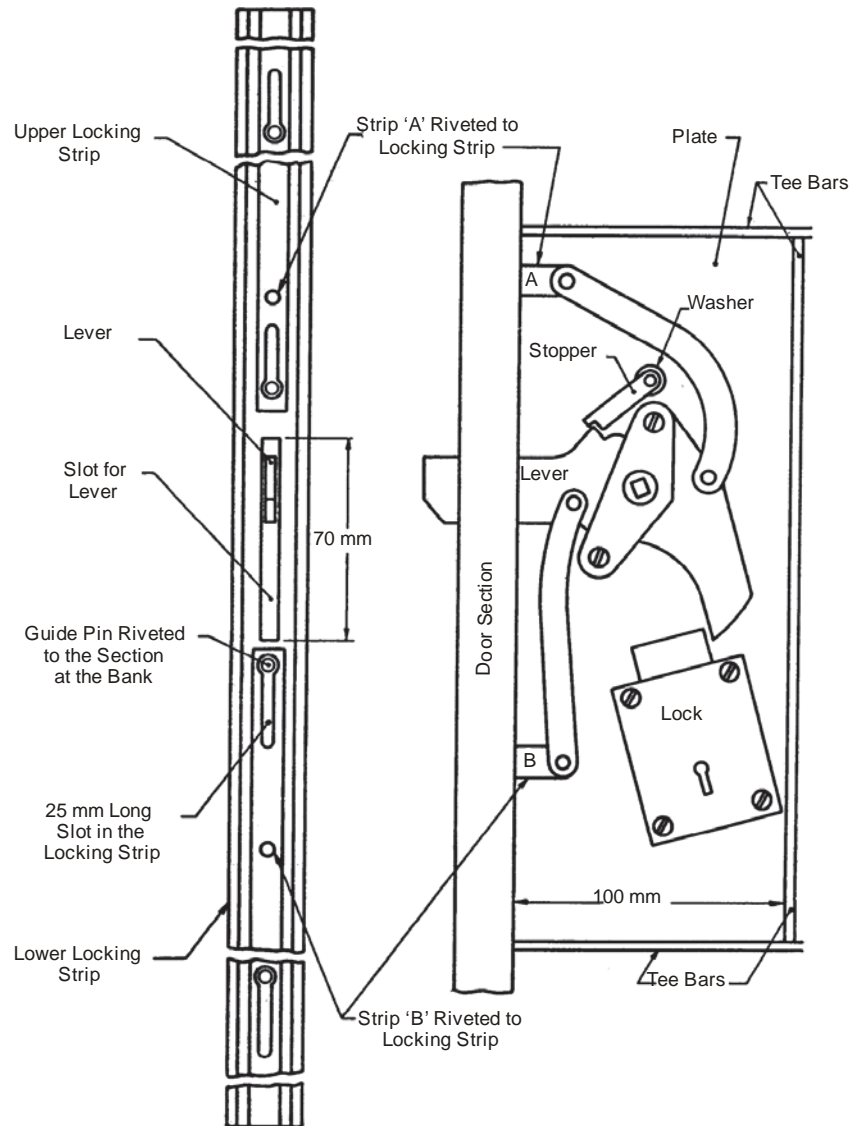


Fig. 21.27 : Typical Three-Way Bolting Device for Doors

21.7.12 Composite Units

The doors shall be coupled to windows or side-lights by extruded aluminium sections made from aluminium alloy conforming to IS Designation HE9-WP of IS 733. The coupling member should conform to the dimensions indicated in Fig. 21.28.

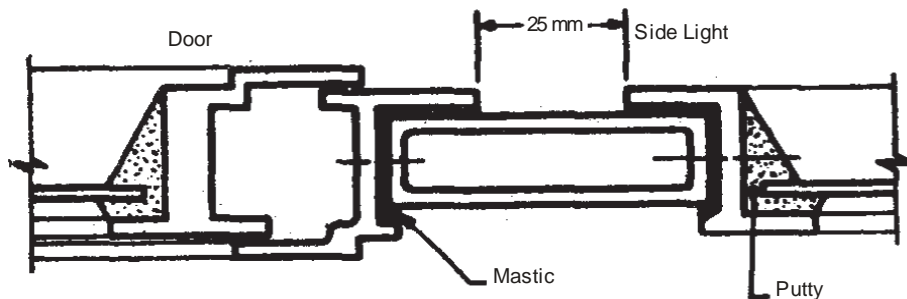


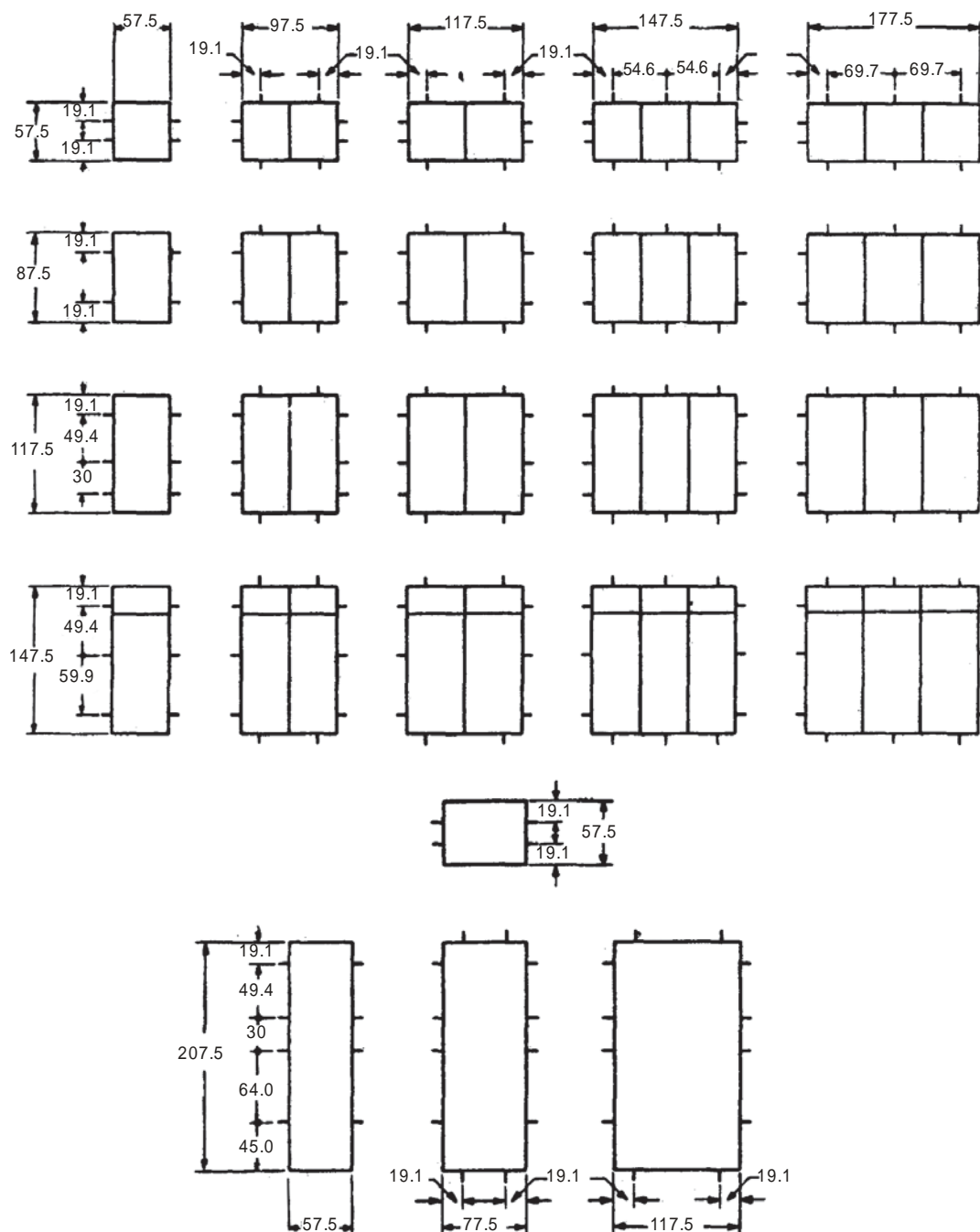
Fig. 21.28 : Coupling Section Extruded for Coupling Door to Window or Side Light

21.7.13 Weather Bar

Where a coupling member is fitted over an external opening shutter, the coupling member should incorporate an integrally extruded weather bar (Fig. 21.9).

21.7.14 Position of Bolts, Fixing Screws and Lugs

Outer frames shall be provided with fixing holes centrally in the web of the sections in the position (Fig. 21.29). Moreover, any steel lugs coming in contact with aluminium should be either galvanized or given one coat of bituminous paint.



All Dimensions in Centimetres.

Fig. 21.29 : Chart Showing Approximate Position of Fixing Holes and Number of Fixing Lugs

The fixing screws and lugs shall be as given in Table 21.7

TABLE 21.7

<i>Sl. No.</i>	<i>Place of Fixing</i>	<i>Size of Screw or Lug</i>
(i)	To wooden frames rebated on the outside	30 mm x No. 10 galvanized wood-screws.
(ii)	To plugs in concrete, stone or brick work rebated on the outside	-Do-
(iii)	To plugs in concrete, stone or brick work not rebated on the outside (that is plain or square jambs)	45 mm X No. galvanized wood-screws
(iv)	Direct to brick work or masonry (that is plain or square jambs)	Slotted steel adjustable lugs (natural finish) not less than 100 x 16 x 3 mm countersunk galvanized machine screws and nuts 19.0 X 6.3 mm
(v)	To steel work	Standard clips and 8 mm galvanized bolts with hexagonal nuts.

21.7.15 Finish

Aluminium doors, windows and ventilators may be supplied in either matt, scratch-brush or polished finish. They may, additionally, also be anodized, if so required by the Engineer-in-charge. If colour anodizing is to be done then only approved light-fast shades should be used.

A thick layer of clear transparent lacquer based on methacrylates or cellulose butyrate, shall be applied on aluminium doors, windows and ventilators by the supplier to protect the surface from wet cement during installation. This lacquer coating shall be removed after installation is completed.

21.7.16 Glazing

Glazing shall be provided on the outside of the frames

If required, glazing clips may be provided as extra fittings. Four glazing clips may be provided per glass pane, except for door type 8HS21 where the glazing clips shall be six per glass pane. In case of doors, windows and ventilators without horizontal glazing bars the glazing clips shall be spaced according to the slots in the vertical members, otherwise the spacing shall be 30 cm.

Note: Glazing clips are not usually provided for normal size glass panes. Where large size glass panes are required to be used or where the door or the window is located in heavily exposed situation, holes for glazing clips have to be drilled prior to fabrication and cannot be done at any later stage. Use of glazing clips, where necessary, shall be specified while placing the order.

21.7.17 Packing

All doors, windows and ventilators shall be dispatched with the opening parts suitably secured to preserve alignment when fixing and glazing.

Fixing lugs, coupling fittings and all hardware shall be dispatched separately.

Composite windows shall be dispatched uncoupled.

21.7.18 Marking

All doors, windows and ventilators shall be suitably marked on the frames with a mark identifying the manufacturer and the type.

The units may also be marked with the BIS Certification Mark.

21.8 FITTINGS

21.8.1 Stainless Steel Friction Stay

The stainless steel friction stays of make approved by the Engineer-in-Charge shall be used. The SS friction stays shall be of grade AISI-304 and of sizes specified in nomenclature of item.

21.8.2 Lockable Handles

The lockable handle shall be of make approved by the Engineer-in-Charge and of required colour to match the colour of powder coated /anodized aluminium window sections.

21.8.3 Hydraulic Floor Spring

The hydraulic floor spring shall be heavy duty double action floor spring of make approved by the Engineer-in-Charge suitable for door leaf of weight minimum 100 kg. The top cover plate shall be of stainless steel, flushing with floor finish level. The contractor shall cut the floor properly with stone cutting machine to exact size & shape. The spindle of suitable length to accommodate the floor finish shall be used. The contractor shall give the guarantee duly supported by the company for proper functioning of floor spring at least for 10 years.

21.8.4 Tubular Handle

The tubular handle bar shall be aluminium polyester powder coated minimum 50 micron to required colour/anodized AC 15. Outer dia of tube shall be 32 mm, tube thickness 3.0 mm and centre to centre length 2115 mm \pm 5 mm.

21.8.5 Measurement

Refer Para 21.6.3.

21.8.6 Rate

Refer Para 21.6.4.

21.9 LOUVERS

Aluminium extruded sections (anodized or power coated) are used for providing Louvers in aluminium door, window & partition for ventilation.

21.9.1 Fabrication

Refer Para 21.6.1.

21.9.2 Measurements

Refer Para 21.6.3.

21.9.3 Rate

Refer Para 21.6.4.

21.10 HERMETICALLY SEALED UNIT

Insulating glass shall be a double glazed unit comprising two sheets of float glass panes separated by a spacer, hermetically sealed using primary and secondary sealants. The design of insulating glass system shall consist of:

(a) Hollow Spacer Bar

The hollow aluminium spacer bar shall be of required size and shape and shall be colour anodized. The spacer bar shall have two lines of perforations in the inner surface.

(b) Desiccant

The desiccant shall be Neftomol 3 A Chemetall or equivalent.

The desiccant filled in the aluminium spacer bar shall be synthesized crystalline compounds of Aluminium Hydroxide, Caustic Soda and Sodium Silicate which absorbs water molecules. The desiccant shall be of 3 A size (A means Angstrom). The quantity of desiccant used shall not be less than 35 gm/m length of spacer bar. Filled spacer bar frame shall not be stored for more than 6 hours before assembly and sealing of the unit to ensure proper functioning of the desiccant. The contractor shall submit documentary proof of using the above material in the work.

(c) Primary Sealant

The primary sealant shall be single component approved by the Engineer in Charge, thermo plastic solvent free sealing compound based on polysosutylene. The sealant surface shall be free from cavities, depression and other defects. The contractor shall submit documentary proof of using the above material in this work.

(d) Secondary Sealant

The secondary sealant in double glazed unit shall be silicone sealant approved by the Engineer in Charge. The contractor shall submit documentary proof of using the above material in this work to the entire satisfaction of Engineer-in-Charge. Before application of silicone/ polysulphide, the surface must be cleaned and free from oil, grease, dust and other loose matter. The surfaces shall be cleaned with alcohol or other suitable solvents. Detergent or soap shall not be used to clean the surfaces. The polysulphide shall be mixed and applied mechanically using automatic mixing machine in the manner approved by Engineer-in-Charge.

Measurement

The height and width of double glazed/single glazed unit (the area of glass unit outside the snap beading shall only be measured) as fixed in place shall be measured correct to one centimeter and area calculated in sqm. correct to second place of decimal shall be taken for payment.

Rate

The rate shall include the cost of all the materials, labours involved in all the operations as described in nomenclature of item and particular specification.

21.11 BRASS LOCK

This should generally conform to IS-2209. The size of the lock shall be denoted by the length of the body towards the face and it shall be 100 mm. the measured length shall not vary more than 3 mm from the specified length. Ordinary lever mechanism with not less than 2 levers shall be provided. False lever shall not be used. Lever shall be fitted with one spring of phosphor-bronze or steel wire and shall withstand the test as provided in IS-2209. Locking-bolt spring and strike plate shall conform to IS 2209. Two keys shall be provided with each lock.

SUB HEAD : 22.0

WATER PROOFING TREATMENT

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LIST OF BUREAU OF INDIAN STANDARDS (BIS) CODES

<i>Sl. No.</i>	<i>IS No.</i>	<i>Subject</i>
1.	IS 73	Paving Bitumen Specifications
2.	IS 702	Specifications for Industrial Bitumen
3.	IS 1322	Specifications for Bitumen felts for Water Proofing and Damp Proofing.
4.	IS 2645	Specifications for Integral Cement Water Proofing Compounds
5.	IS 3370 (Part -1)	Code of Practice for Concrete Structures for the Storage of Liquid: Part -1 General Requirements.
6.	IS 3384	Specifications for Bitumen Primer for Water Proofing and Damp Proofing
7.	IS 7193	Specification for Glass Fibre Bitumen Felts
8.	IS 12200	Provision of Water Stops at Transfers Construction Joints in Masonry and Concrete Dams - Code of Practice.
9.	IS 12432 (Part-3)	Application for Spray Applied Insulation - Code of Practice Part-3 Polyurethane/ Polyisocyanurate

22.0 WATER PROOFING TREATMENT

22.0 TERMINOLOGY

Water Bars

Water bars are preformed strips of impermeable materials which are embedded in the concrete during construction.

Low Partition Walls

Parapet walls of height less than 45 cm.

Expansion Joints

Joints provided in the structure to allow for thermal expansion/construction.

Blended Cement

Cement mixed with water proofing compound in liquid or powder form.

22.1 INTEGRAL CEMENT BASED TREATMENT FOR WATER PROOFING ON HORIZONTAL SURFACE OF UNDER-GROUND STRUCTURE AT ALL DEPTH

22.1.1 Water Proofing of Horizontal Internal Surfaces of Under-ground Structure (Fig. 22.1)

(i) ***Preparation of Surface***

The Water Proofing Treatment over the lean concrete/levelling course surface should adhere to the surface firmly, the surface of levelling course should be roughened properly when the concrete is still green. In case the surface is not made rough before the concrete is set, the work of water proofing should not be executed till proper key is provided for the base layer of Cement Mortar 1:3.

(ii) ***Blending Cement/Water with Water Proofing Compound***

The required quantity of cement bags to be used for a particular portion of work should be emptied on a dry platform. Water proofing compound bearing ISI mark and conforming to IS 2645 should then be mixed properly with the cement. The quantity of water proofing compound to be mixed should be as prescribed by the manufacturer but not exceeding 3% by weight of cement. The quantity of cement and water proofing compound thus mixed should be thoroughly blended and the blended cement should again be packed in bags.

For the water proofing compound in liquid form, the blending is to be done with water. This can be done by taking the just required quantity of water to be mixed in the particular batch of dry cement mortar.

The required quantity of water thus collected per batch of dry cement mortar to be prepared should be mixed with liquid water proofing compound from sealed tins with ISI mark. The water thus mixed with water proofing compound shall be thoroughly stirred so that the water is blended with water proofing compound properly.

(iii) ***Rough Kota Stone 22 to 25 mm Thick***

The stone slabs to be used for this item shall be in thickness of 22 mm to 25 mm. Larger size of stone slabs i.e. 550 mm x 550 mm or 550 mm x 850 mm shall be used to minimise the number of joints.

General requirement of Kota stone shall be as laid down in CPWD Specifications of Kota Stone flooring.

(iv) **Preparation of Cement Slurry**

Cement slurry shall be prepared by using 2.2 kg of blended cement per sqm. area. Each time only that much quantity shall be prepared which can be covered on the surface and the surface in turn would be covered with 25 mm thick cement mortar base within half an hour. Slurry prepared and remained unused for more than half an hour shall be totally rejected.

(v) **Preparation of Cement Mortar**

Cement mortar 1:3 (1 blended cement: 3 coarse sand) shall be prepared with cement/ water duly blended as explained in clause 22.1.1 (ii). Only that much quantity of cement mortar which can be consumed within half an hour, shall be prepared. Any cement mortar that is prepared and remains unused for more than half an hour shall not be used in the work and shall be rejected.

(vi) **Laying Water Proofing Course**

Before laying the base course of cement mortar 1:3, the lean concrete surface shall be cleaned neatly with water. Cement slurry prepared as per clause 22.1.1 (ii), shall be applied only on the area of the concrete surface, that can be covered with the cement mortar (1:3) base course within half an hour. The cement slurry should cover every spot of the surface and no place shall remain uncovered. Just after the application of cement slurry on the surface, the cement mortar prepared as per clause 22.1.1 (v) should be used for laying the base course. Base Course should be laid to a perfect level with wooden/aluminium straight edge of at least 2 mtrs. long. The top surface of cement mortar should be finished neatly and later scratched when green with a suitable instrument before the base course dries and gets hard that is just before the base course takes up initial set.

When the 25 mm thick base course is just getting set the cement slurry prepared as per clause 22.1.1 (iv) should be spread over the base course upto the area that shall be covered with just two to three stone slabs. The cement slurry shall be spread in such a way that the area of base course to be covered immediately shall be covered with slurry without any gap or dry spots. Immediately on applying cement slurry on the base course the Rough Kota Stone slab shall be laid over the base course and pressed gently so that the air gap can be removed. The slurry applied on the surface which gets spread when the stone slab is pressed shall get accumulated in the joints of adjacent stone slabs and if any gap still remains between the stone slabs the same should also be filled with additional quantity of cement slurry. For laying the stone slabs in perfect level, two stone slabs at adjacent concerns/ends shall be fixed firmly to the required level and a string stretched over the two slabs, the intermediate slabs shall then be set to the level of the string.

After filling all the joints of the Rough Kota stone Slabs with cement slurry the area of stone slab shall be laid with cement mortar 1:3. The surface of stone slabs shall be cleaned and lightly watered. Cement mortar 1: 3 prepared as per clause 22.1.1 (iv) shall be used for laying this course. For laying this course 25 mm high wooden strips shall be used and the top surface shall be finished smooth without using additional cement or slurry.

After laying 3rd course and before the mortar layer takes the initial set, Stone aggregate of 10 mm to 12 mm nominal size shall be uniformly spread and lightly pressed into the finished surface @ 8 cu dm./sqm. The aggregates shall not be embedded totally inside the mortar and shall be visible on the top surface.

In cases where slope is to be provided for the water proofing layer, grading with additional cement concrete/cement mortar shall be provided and then the water proofing layer shall be laid on the graded surface. Extra payment shall however be made for the grading course.

(vii) **Curing**

Immediately after completing the fourth layer, arrangements shall be made for the top RCC slab as quickly as possible and in the mean time till the top slab is casted the water proofing treatment shall be kept wet continuously. In case the concreting of slab gets delayed for more than 2 weeks the curing can be stopped after 14 days.

(viii) **Measurement**

Length and breadth shall be measured along the finished surface correct to a cm and the area shall be worked out to nearest 0.01 sqm.

(ix) **Rate**

The rate shall include the cost of all labour & materials involved in all the operations described above. The cost of grading with cement concrete / cement mortar shall be paid for separately.

22.1.2 Water Proofing of Internal Horizontal Surfaces of Under-ground Structure (Fig. 22.2)

Same as in 22.1.1 above except that water proofing courses will be laid on R.C.C. Slab.

22.2 INTEGRAL CEMENT BASED WATER PROOFING TREATMENT ON THE VERTICAL SURFACE OF UNDER GROUND STRUCTURES (FIG. 22.3)

(i) **Preparing the Surface**

The surface of the structure to be treated shall be roughed either by raking of joints in case of brick/ stone masonry or by hacking the cement concrete surface with a specifically made hacking tool just after removing shuttering. Alternately, the surface should be roughened by providing spatter dash key as explained under clause 22.1.1 (i). While doing water proofing to vertical faces from inside, it shall be ensured that water proofing treatment of floor slab is not damaged. Preferably, water proofing of vertical surface shall be done before that of horizontal surface.

(ii) **Blending Cement/Water with Water Proofing Compound**

Same as under clause 22.1.1(ii).

(iii) **Rough Kota Stone Slab**

Same as explained under clause 22.1.1(iii).

(iv) **Preparation of Cement Slurry**

Same as explained under clause 22.1.1(iv).

(v) **Preparation of Cement Mortar**

Same as explained under clause 22.1.1(v).

(vi) **Laying Water Proofing Course**

Same as explained under clause 22.1.1(vi). Further rough kota stone are not sufficiently rough to remain in vertical position held by cement slurry. Therefore, the grip for the stone slab has to be increased and this can be done by planting 12 mm to 15 mm nominal size stone aggregate fixed with araldite on surface of each sand stone slab.

(vii) **Curing**

Same as explained under clause 22.1.1(vii). Further till the water proofing work on vertical face is in progress, the water proofing work done on floor slab shall be kept wet for a minimum period of 14 days. Immediately after completion of water proofing on vertical faces of side walls, the water tank shall be gradually filled with water for testing.

(viii) **Measurement**

Same as explained under clause 22.1.1(viii).

(ix) **Rate**

Same as explained under clause 22.1.1(ix).

22.3 WATER PROOFING TREATMENT TO VERTICAL AND HORIZONTAL SURFACE OF DEPRESSED PORTION OF WC, KITCHEN AND THE LIKE

22.3.1 Before the Water Proofing Treatment

Before the water proofing treatment, the internal plaster of ceiling and walls of WC block leaving the portion for dado/skirting should be completed. Grooving / chasing for doing the concealed work of GI/CI pipes/Electrical conduits should be completed. Cleaning the depressed/sunken portion of WC of all debris, extra mortar sticking to the vertical and horizontal surface etc. Necessary holes for 'P' trap /Nhani trap/Water escape pipe etc should be completed.

22.3.2 Preparing Surface and Fixing Pipes and Fittings

Before the water proofing treatment work, proper key in the concrete surface should be provided. The depressed/sunken portion should be hacked by a hacking tool, after the concrete slab is cast and when this concrete is still green.

The vertical surfaces of the depressed /sunken portion should be hacked with a hacking tool just after the shuttering is removed.

In case of old work, the water proofing treatment on such surfaces shall be permitted after making proper spatter dash key.

Fixing the 'P' trap in position and all other pipes work including the water escape pipe shall be fixed properly and the holes should be plugged carefully before taking up the water proofing work.

22.3.3 1st Course

Cement duly blended with water proofing compound as explained in clause 22.1 shall be used for preparing the cement slurry.

The consistency of the slurry should be such that 4.4 kg. of blended cement with water proofing compound is used per sq. metre area of surface to be treated. The slurry should be started from the vertical faces towards the bottom of the floor as shown in Fig. 22.4. Particular care should be taken to see that the slurry is applied to corners without leaving any gap.

22.3.4 2nd Course

Immediately on applying the blended cement slurry on the surface to be treated cement plaster 20 mm thick in CM 1:3 (1 blended cement: 3 coarse sand) shall be applied both on vertical and horizontal surfaces taking particular care to complete the entire depressed/ sunken portion of WC within a day so that the plaster can be done without any joint. Junctions shall be properly rounded. The surfaces of the plaster shall be left rough but finished in one plain and cured for a week.

On completion of the curing period both horizontal and vertical surfaces shall be cleaned properly and gently and allowed to dry.

22.3.5 3rd Course

Only after the surface is completely dried the blown or residual bitumen shall be applied @ 1.7 kg. of bitumen per sqm area.

22.3.6 4th Course

PVC sheet 400 micron thick shall be spread evenly without any kink immediately, so that the PVC sheet sticks to the surface firmly. PVC sheet shall be continued to be laid over the main slab upto 100 mm.

Overlapping of PVC sheet should be done with a minimum overlap of 100 mm, duly pasting the overlapped sheet with an application of bitumen @ 1.7 kg./ sqm.

The projections of pipes and 'P' trap outlet etc. inside the depressed/sunken portion of WC shall also be cladded with water proofing treatment layer upto a height of 150 mm, using a coat of bitumen with PVC sheet complete.

The surfaces of depressed/sunken portion of WC shall not be left without covering with specified filling material and base concrete, otherwise the PVC sheet layer may be tampered by the labour working in the vicinity.

Fixing up of WC pan, filling specified material and the top base concrete should be done as early as possible and the top horizontal layer of water proofing may be taken up later i.e. just before laying the floor tiles.

22.3.7 Measurement

Length and breadth shall be measured along the finished surface correct to a cm. and area shall be worked out to nearest 0.01 sqm. No payment however shall be made for the 100 mm overlap of PVC Sheet over the roof slab.

22.3.8 Rate

The rate shall include the cost of labour and materials involved in all the operations described above.

22.4 PROVIDING WATER STOPS

22.4.1 Water stops conforming to IS 12200 for construction/expansion joints should be fabrication from a plastic compound, the basic resin of which shall be polyvinyl chloride. The compound shall contain additional resin/ plasticizer inhibitors or other materials such that when the materials is compounded it shall meet the requirement given in IS 15058.

22.4.2 Type of Joints for which Water Bars are Provided

The water bars are provided only for the movement of joints in a water retaining structure.

Different types of movement joints are as described below:

Complete Contraction Joint: This is a movement joint with deliberate discontinuity both in concrete as well as the reinforcement but no initial gap is maintained between the concrete on either side of the joint. This joint is intended to accommodate the contraction of the concrete.

Partial Contraction Joint: This is a movement joint with deliberate discontinuity in concrete but no water bar is provided and no discontinuity is provided in steel. No initial gap is maintained between the concrete on either side of joint.

Expansion Joint: This is also a movement joint with complete discontinuity in both reinforcement and concrete. It is intended to accommodate either expansion or contraction of the structure.

In general such joint requires the provision of an initial gap between the adjoining parts of the structure which accommodates expansion or contraction of the structure.

22.4.3 Types and Performance of Water Bars

Water bars are performed strips of impermeable material which are embedded in the concrete during construction so as to span across the joints and provide a permanent water tight seal during the whole range of joint movement.

The most usual form of water bars are strip with a longitudinal corrugation as shown in Fig. 22.5.

Another form of water bar of metallic type is Z shaped strip.

Water bars of copper, sheet lead, natural or synthetic rubber and plastic such as polyvinyl chloride (PVC) are also used. These bars comprise of central longitudinal hollow tube with thin walls and stiff wings of about 150 mm width.

Out of the metals available copper is most suitable as regards ductility, resistance to corrosion in air, water and concrete. However, it may be attacked by some wastes. If sheet lead is used it should be insulated from concrete by a good coat of bituminous or suitable composition. Natural synthetic rubber and plastics have very considerable advantage in handling, splicing and in making intersections.

Galvanized iron sheets may also be used with the specific permission of the Engineer-in-charge provided the liquid stored or the atmosphere around the liquid retaining structure is not excessively corrosive i.e. sewage.

The strip water bars described as above, while placing in position has to be passed through the end shutter of the first placed concrete with the result the shuttering at this point should be perfectly water tight otherwise cement slurry may escape from the concrete being laid and will ultimately weaken the structure. Therefore to avoid the above problem one can prefer moulded type of water bar.

The design of the moulded water bar with several projections need to be passed through the end shutter while placing the same in position. Another main advantage of this water bar is that since it occupies bigger proportion of the thickness of the joint it would lengthen the shortest alternative water path through the concrete.

22.4.4 It is important to ensure proper compaction of concrete around the water bar. Proper cover to all the reinforcement shall be maintained. Sometimes to increase the bond the holes are provided in the copper water bars but in the long run it proves to be disadvantageous as it shortens the path of water through concrete. Water bars should be placed at the centre of the wall or if it is to be provided away from the centre its distance from either face of the wall shall not be less than half of the width of water bar or as specified/directed by the Engineer-in-charge.

22.4.5 Covers Plates for Joint

Sometimes joint cover plates have to be used for expansion joints mainly to avoid the risk of a fault in the water bar which is embedded. The plates to be used should be either copper or sheet lead. In case the copper plates are to be used, it should be clamped to the concrete face on each side of the joint. To ensure water tightness suitable gasket shall be used. Joint cover plates of sheet lead are also used and fixed on the joints. In this case the edges may return into grooves formed in the concrete and can be made completely water tight by lead caulking. Faces of the concrete to which sheet lead is to be fixed should be painted with bituminous or other suitable composition and the lead sheet should be similarly coated before fixing.

22.4.6 Spacing of Joints

In Reinforced Concrete floors movement joints should be spaced at not more than 7.5 m apart in two directions at right angles. The wall and floor joints should occur at the base of the wall in which case corresponding vertical joint is not important.

In concrete walls, the vertical movement joints should normally be placed at a maximum spacing of 0.75 m in reinforced walls. The maximum length desirable between vertical movement joints will depend upon the tensile strength of the walls and may be increased by suitable reinforcements.

Amongst the movement joints in floors and walls as mentioned above, expansion joint should be normally be provided at spacing of not more than 30 m between successive expansion joints or between the end of the structure and the next expansion joint, all other joints being of the contraction type.

In case of expansion joints the filling of these with bitumen filler, bitumen felt or any such material etc. shall be paid for separately in running metre. The measurement shall be taken upto two places of decimal stating the depth and width of joint.

In case joint cover plates either of copper or sheet lead with ancillaries are provided, these shall be measured and paid for separately.

22.4.7 Measurement

Length shall be measured correct to a cm and net quantities shall be calculated upto two places of decimal.

Each category of water stops/bar such as PVC, copper specifying width, thickness shall be measured and paid for separately.

22.4.8 Rate

The rate shall include all labour and materials in all the operations described above.

22.5 WATER PROOFING TREATMENT IN SUNKEN PORTION OF WCs, BATHROOMS ETC.

22.5.1 Preliminaries to be Attended

The preliminaries shall be attended as described in clause 22.3.1.

22.5.2 Preparing Surface, Fixing Pipes and Fittings

In this case, unlike as described in clause 22.3.2, no hacking of surface need be made, but only extra mortar sticking to the surface should be removed and the surface should be cleaned thoroughly. Fixing 'P' trap etc. shall be done as described in Clause 22.3.2.

22.5.3 Providing and Laying of Slurry for First Layer

The consistency of the slurry should be such as to cover the desired area by using 0.488 kg of blended cement per sqm of area.

On deciding the correct quantity of water required per sqm. area the required quantity of slurry should be prepared which can be applied over the desired surface within half an hour of mixing with 0.488 kg. of grey cement + 0.253 kg. water proofing compound as per manufacturer specifications + x litres of water per sqm. area and the required quantity of slurry thus prepared should only be used for first application.

The first layer shall be applied with painting brushes over the specified and dampened area carefully including the corners, holes on the surfaces and joints of pipes in concrete etc. and the application should continue at least upto 150 mm height of fixtures of pipes from the surface. The surface on application shall be air cured for 4 hours.

22.5.4 Providing and Laying of Slurry for Second Layer

The quantity of slurry required for second application to be covered within an hour of mixing shall be prepared with 0.242 kg. cement + 0.126 kg. water proofing compound + y litres of water per sqm. area and the required quantity of slurry thus prepared should only be used for second application.

The application of 2nd layer of slurry is same as for first layer as detailed in clause 22.5.3.

The applied surface shall be allowed to air cure for 4 hours and thereafter water curing shall be done for full 48 hours.

In case no further work as described above is to be taken up immediately on completion of water proofing treatment due to any reason it is recommended to protect the treated portion with cement plaster 1:4 as a protective layer for which separate payment shall be made to the contractor.

22.5.5 Measurement

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm.

22.5.6 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above. The cost of plastering shall be measured and paid for separately.

22.6 WATER PROOFING TREATMENT ON ROOF SLABS

22.6.1 Before taking up the water proofing work the construction of parapet walls, including finishing should be completed. Similarly, the ancillary items like haunches, khurras, grooves to tack the fibre cloth layer, fixing up of all down take pipes, water pipes and electric conduits etc. should be completed and no such work should be allowed on the area to be treated during the progress of water proofing treatment or even later.

22.6.2 Preparing Surface

There is no necessity of hacking the surface but the surface to be treated shall be cleaned including removing the mortar dropping from the surface.

22.6.3 Providing and Laying of Cement Slurry

The procedure to prepare and apply the cement slurry shall be same as detailed in clause 22.5.3 except that over projected pipes etc. slurry shall be applied just upto 100 mm height instead of 150 mm height. The slurry shall be applied upto a height of 300 mm on parapet walls and in the groove where the fibre glass cloth is to be tucked.

22.6.4 Providing and Laying of Fibre Glass Cloth (2nd Layer)

The fibre glass cloth shall be of approved brand and shall be thin, flexible uniformly bonded mat composed of chemically resistant borosilicate glass fibre distributed in random open porous structure bonded together with a thermosetting resin.

Immediately on applying the slurry on a sufficiently workable area as detailed above in clause 22.6.3 when the slurry applied is still green the fibre glass as specified shall be spread evenly on the surface without any kink and pressed in such a way that no air spaces exist. The fibre glass cloth shall be taken upto a height of 30 cm on parapet walls and tucked in the groove specially prepared at that height.

A minimum overlap of 100 mm width shall be provided when the fibre cloth has to be joined. The joining of 100 mm overlap shall be done with the same slurry used for the application on surface as first layer. The fibre cloth shall also be extended upto a height of 100 mm over pipes projecting from the surface.

22.6.5 Providing and Laying of Cement Slurry for Third Layer

The quantity of water required to prepare slurry which can cover one sqm. area of the surface to be treated shall be calculated as described in clause 22.5.3 and consider this quantity as say x litres/sqm.

On deciding the correct quantity of water required, the slurry shall be prepared by mixing 1.289 kg/m² of grey cement + 0.67 kg./sqm. of Water Proofing Compound + 1.289 kg./sqm. of coarse sand + x litres of water. Slurry shall be prepared for the area to be covered within ½ an hour of mixing.

The consistency of the slurry shall be such that in one application with a brush 1.5 mm thickness of slurry can be coated on the fibre glass cloth surface.

This slurry shall be applied evenly on the entire surface covered with fibre glass cloth so that a layer of 1.50 mm thickness of slurry is formed.

The application of slurry shall be continued over the 300 mm portion of parapet wall and also the portion tucked in the groove on top.

The entire surface shall be allowed for air curing for 4 hours and later the surface shall be cured with clean water for 7 days.

On completion of curing the grooves where the fibre glass cloth is tucked shall be closed neatly with cement mortar mixed with water proofing compound and the repaired surface should be cured by clean water for 7 days.

Fourth and final layer of brick tiling if required shall be laid and paid for separately.

22.6.6 Measurement

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm. Overlaps and tucking in a flashing grooves shall not be measured. No deductions shall be made for openings or recess or chimney stack, roof lights or Khurras of area upto 0.40 sqm, nor anything extra shall be paid for forming such openings, recess etc. For area exceeding 0.40 sqm. deduction will be made in the measurement for the full opening and nothing extra shall be paid for making such opening.

22.6.7 Rate

The rate shall include the cost of labour and material involved in all the operations described above, however the cost of brick layer with cement mortar shall be paid for separately.

22.7 INTEGRAL CEMENT BASED WATER PROOFING TREATMENT WITH BRICK BAT COBA (Fig. 22.6)

22.7.1 Before taking up the work the preliminaries to be attended shall be exactly same as described in clause 22.6.1.

22.7.2 Preparing the Surface

The surface of the slab should be roughened by scrapping when the slab concrete is still green, however, the surface need not be hacked. In case the slab is already cast and surface fairly finished, the same shall be cleaned neatly of all mortar droppings, loose materials etc with brooms/cloth.

22.7.3 Providing and Laying of Slurry under Base Coat

The quantity of water required to prepare the slurry with 2.75 kg. of blended cement to be painted over an area of 1 sqm. shall be calculated exactly as described in clause 22.5.3.

Depending upon the area of surface that has to be covered, the required quantity of slurry should be prepared using 2.75 kg. blended cement + water per sqm. area to be covered, taking particular care to see that only that much quantity of slurry shall be prepared which can be used within half an hour of preparation i.e. before the initial setting time of cement.

The prepared slurry shall be applied over the dampened surface with brushes very carefully, including the joints between the floor slab and the parapet wall, holes on the surfaces, joints of pipes, masonry/concrete etc.

The application of the slurry should continue upto a height of 300 mm on the parapet wall and also the groove as shown in Fig. 22.6. The slurry should also be applied upto a height of 150 mm over pipe projections etc.

22.7.4 Laying Base Coat 20 mm thick

Immediately after the application of slurry and when the application is still green, 20 mm thick cement plaster as base coat with cement mortar 1:5 (1 blended cement : 5 coarse sand) shall be evenly applied over the concrete surface taking particular care to see that all the corners and joints are properly packed and the application of the base coat shall be continued upto a height of 300 mm over the parapet wall.

22.7.5 Laying Brick Bat Coba

Brick bat of size 25 mm to 115 mm out of well burnt bricks shall be used for the purpose of brick bat coba.

The brick bats shall be properly dampened for six hours before laying.

Brick bats shall be laid to required slope/gradient over the base coat of mortar leaving 15-25 mm gap between two bats. Cement mortar 1:5 (1 blended cement: 5 coarse sand) shall be poured over the brick bats and joints filled properly. Under no circumstances dry brick bats should be laid over the base coat.

The haunches/gola at the junction of parapet wall and the roof shall be formed only with brick bat coba as shown in Fig. 22.6.

In case the brick bat coba is laid on the base coat immediately on initial set there will be no necessity of applying cement slurry over the base coat before laying the brick bat coba. However, if the brick bat coba is to be laid on the subsequent day, cement slurry prepared as described in clause 22.7.3 shall be applied over the top surface of the base coat, then only the brick bat coba shall be laid.

22.7.6 Application of Slurry over Brick Bat Coba

After two days of curing of brick bat coba cement slurry prepared as per clause 22.7.3 shall be applied on the surface of brick bat coba. The application of slurry shall be the same as described in clause 22.5.3 which should cover the haunches/gola, and the remaining small portion of parapet wall and also inside the groove as shown in the figure.

22.7.7 Laying Finishing Layer (Protective Coat)

Immediately on applying the cement slurry over the surface of the brick bat coba and when the slurry applied is still green, the fibre glass cloth as specified in clause 22.6.4 shall be spread evenly on the surface without any kink & pressed to see that no air spaces exist. The fibre glass cloth shall be taken up to a height of 300 mm on parapet walls & tucked in the groove specially prepared at that height. 20 mm thick layer of cement plaster, without leaving any joints shall be applied with cement mortar 1:4 (1 blended cement: 4 coarse sand) over the entire fibre glass cloth including the haunches/gola and the small portion on the parapet wall. The groove in the parapet wall over the haunches shall also be filled neatly packing the mortar firmly in the groove.

The surface of the finishing layer (protective coat) shall be neatly finished with cement slurry prepared as per clause 22.7.3. The finished surface shall be allowed to dry for a while and then pattern of 300 mm x 300 mm groove, 8 mm deep shall be made over the entire surface.

22.7.8 Curing and Testing the Treatment

The entire surface thus treated shall be flooded with water by making kiaries with weak cement mortar, for a minimum period of two weeks.

22.7.9 Measurement

The measurement shall be taken along the finished surface of treatment including the rounded and tapered portion at junction of parapet wall. Length and breadth shall be measured correct to a cm and area shall be worked out to nearest 0.01 sqm. No deduction in measurement shall be made for openings or recesses or chimney stacks, roof lights or khurras of area upto 0.40 sqm., nor anything extra shall be paid for making such openings, recesses etc. For areas exceeding 0.40 sqm., deduction will be made in the measurements for the full openings and nothing extra shall be paid for making such openings.

22.7.10 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above.

22.8 WATER PROOFING TREATMENT WITH BITUMEN FELT

22.8.0 Water proofing treatment with self finished felt shall be four courses or six courses as described in the item. Four course water proofing treatment with self finished felt is a normal duty treatment suitable for buildings where the cost of roof treatment is required to be restricted.

Six course water proofing treatment with self finished felt is a heavy duty treatment suitable for important structures.

22.8.1 Materials

22.8.1.1 Self finished felt (Appendix A and B) shall conform to the type and grade given in the description of the item. This shall be one of the following types:

- (i) Type 3 grade 1 hessian base felt conforming in all respects to IS 1322.
- (ii) Type 2 grade 1 fibre base bitumen felt conforming to IS 1322.
- (iii) Type 2 grade 2 glass fibre base felt conforming in all respects to IS 7193.

22.8.1.2 Bonding Materials: This shall consist of blown type petroleum bitumen conforming to IS 702 or residual petroleum bitumen conforming to IS 73. The bonding material shall be so selected as to withstand the local condition of temperature and gradient satisfactorily. The penetration of bitumen used shall not exceed 40 in any case. Suitable residual type petroleum bitumen of penetration 30/40 (IS grade S-35), residual type petroleum bitumen with higher penetration and low softening point and suitable blown type petroleum bitumen of IS grade 85/25 or 90/15 of approved quality shall be used.

Where proprietary brands of bonding materials are proposed to be used they shall conform in all respects to the specifications in the preceding paras.

		1st course kg/sqm	3rd course kg/sqm	5th course kg/sqm
I.	Four course treatment:	1.45	1.45	—
II.	Six course treatment:	1.45	1.20	1.45
	(a) With type 3 grade 1 hessian base self finished bitumen felt.			
	(b) With felts other than type 3 grade 1 hessian base.	1.45	1.20	1.70

22.8.1.3 Stone Grit and Pea-sized Gravel: Stone grit shall be 6 mm and down size. Where pea-sized gravel is used it shall be hard, round and free from dust, dirt etc. The stone grit or pea-sized gravel shall not be spread over vertical and sloping faces of flashings and at drain mouths. At these places the surface shall be painted with two coats of bituminous solution.

The quantity of stone grit or pea-sized gravel required for the final course of four or six course treatment with hessian base self finished bitumen felt type 3 grade 1 shall be 6 cubic decimeter/ sqm.

22.8.2 Preparation of Surface

22.8.2.1 The surface to be treated shall have a minimum slope of 1 in 120. This grading shall be carried out with cement concrete or cement plaster with coarse sand, as per direction of Engineer-in-charge, to the average thickness required and finished smooth. Such grading shall be paid for separately.

22.8.2.2 Junctions between the roof and vertical faces of parapet walls, chimneys etc. shall be cased by running triangular fillets 7.5 x 7.5 cm size, in cement concrete. At the drain mouths, the fillets shall be suitably cut back and rounded off for easy application of water proofing treatment and easy flow of water. Cement concrete where used shall be 1:2:4 mix (1 cement: 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). The provision of fillets shall be deemed to be covered by the item of water proofing and shall not be measured or paid for separately.

22.8.2.3 In existing roof where gola and drip course are provided at the junction of roof and vertical face of parapet wall, chimney stacks etc., these shall be dressed suitably and finished smooth so as to ensure an easy and gradual turning of the flashing. Any dismantlement or forming and finishing smooth the junction for forming the base of the flashing shall not be measured or paid for separately and shall be deemed to form part of the preparation of the surface in the water proofing treatment.

22.8.2.4 While the grading of roof surface is being done, it shall be ensured that the outlet drain pipe have been fixed and mouth at the entrance have been eased and rounded off properly for easy flow of water.

22.8.2.5 When any pipe passes through the roof to be treated, angular fillet of shape shown in Fig. 22.7 shall be built around it for the water proofing treatment to be taken over it. These fillets shall not be measured or paid for separately.

22.8.2.6 For carrying over and tucking in the water proofing felts into the parapet walls, chimney stacks etc. a horizontal groove 6.5 cm deep, 7.5 cm wide section with its lower edge at not less than 15 cm above the graded roof surface shall be left on the inner face of the same during construction if possible. When such groove has not been left, the same shall be cut out neatly and the base at rear of the groove shall be finished smooth with cement plaster 1:4 (1 cement: 4 coarse sand). Such cutting of the groove and its finishing smooth shall be deemed to be part of the water proofing item and shall not be measured or paid for separately. No deduction shall be made either for not making the groove or when the later has already been left in the masonry by the construction agency.

22.8.2.7 Tucking in the water proofing felt will be required where the parapet wall exceeds 45 cm in the height from the graded surface. Where the height is 45 cm or less, no groove will be required as the water proofing treatment will be carried over the top of the parapet wall to its full thickness. In the case of low dividing walls of height 30 cm or less, outlets therein shall be cut open for full height and the bottom and sides shall be rendered smooth and corners rounded and such treatment shall not be measured and paid for separately.

22.8.2.8 Where expansion joints are left in the slab, the provision of dwarf walls and/or RCC slabs for covering them and finishing the surface smooth shall be the responsibility of the construction agency, which had laid the roof slab and will not be included the operation of water proofing.

22.8.2.9 The graded surface of the roof and concrete fillets and the faces of walls shall be thoroughly cleaned with wire brushes and all loose scales etc. removed. The surface shall then be dusted off. Any crack in the roof shall be cut to 'V' section, cleaned and filled up flush with cement mortar slurry 1:4 (1 cement: 4 coarse sand) or blown type petroleum bitumen of IS grade 85/25, or approved quality conforming to IS 702. Such cleaning of the surface or treating the cracks shall not be paid for separately.

22.8.3 Priming Coat

Where so specified, or required by the Engineer-in-Charge for example under slightly damp conditions a priming coat consisting of a bitumen primer conforming to IS 3384 should be applied with brush on the roof and wall surface at 0.24 litres per sqm to assist adhesion of the bonding material (i.e. bitumen).

Such application of primer shall be paid for separately, unless specifically included in the water proofing item.

22.8.4 Underlay

Where a floating treatment of water proofing with self finished bitumen felt is required i.e. where water proofing treatment is required to be isolated from the roof structure, a layer of bitumen saturated felt (underlay) shall be spread over the roof surface and tucked into the flashing groove. No bonding material shall be used below the underlay in order to keep the underlay free of the structure. The

adjoining strips of the underlay shall overlap to a minimum of 7.5 cm at sides and 10 cm at ends. The overlaps shall be sealed with the same bonding material as used for the self finished felt treatment. Unless specifically included in the water proofing item, the underlay treatment shall be paid for separately.

The underlay shall be of type 1 saturated felt conforming to IS 1322 in all respects and having a total minimum weight of the finished bitumen felt in dry condition with mica dusting powder @ 6.8 kg per 10 sqm. The roll shall not be damaged or crack on being unrolled on a fairly smooth and flat surface.

22.8.5 Treatment

22.8.5.1 The water proofing shall consist of a four or six course treatment, as given in the description of the item, each layer of bonding materials, self finished bitumen felt or stone grit or pea sized gravel being counted as a course.

22.8.5.2 The choice of a four or six course treatment will depend on the climatic condition, the importance of the building, the durability required, cost and other relevant considerations.

22.8.5.3 A four course treatment shall consist of the following layers:

- (a) Initial layer of bonding material applied hot at specified weight per unit area.
- (b) 2nd layer of self finished bitumen felt conforming to the type and grade given in the description of the item.
- (c) Third layer of bonding material.
- (d) Final layer of stone grit of pea sized gravel spread at specified volume of material per unit area.

22.8.5.4 In a six course treatment, the first, second and third layer shall be of the same as in the four course treatment. The fourth and fifth layer shall consist of self finished felt and bonding material respectively. The sixth layer shall consist of stone grit or pea sized gravel.

22.8.5.5 The primer or underlay where required to be provided shall not count against the number of courses specified.

22.8.6 Laying

22.8.6.1 Bitumen bonding material of required grade shall be heated to the working temperature specified for the particular grade by the bitumen manufacturers and conveyed to the roof in buckets or pouring canes in weighed quantities.

Suitable working temperature for different grades of bitumen are as under:

- (i) Blown type petroleum bitumen of IS grade 85/25 or 90/15 - 180 degree C.
- (ii) Residual type petroleum bitumen of penetration 30/40 - 180 degree to 190 degree C (IS grade S-35).

22.8.6.2 Drain outlets shall be given a four or six course treatment as specified for the roof in the description of the item in the manner specified for the flat roof surface. Water proofing treatment shall be carried into the drain pipe or outlets by at least 10 cm. The water proofing treatment laid on the roof surface shall overlap the upper edge of the water proofing treatment in the drain outlets by at least 10 cm.

22.8.6.3 The self finished felt shall be cut to the required length, brushed clean of dusting material and laid out flat on the roof to eliminate curls and subsequent stretching. The felt shall normally be laid in length at right angles to the direction of the slope and laying shall be commenced at the lowest level and worked upto crest. The felt shall not be laid in single piece of very long lengths as they are likely to shrink; 6 to 8 m are suitable lengths. The roof surface shall be cleaned and dried before the felt treatment is begun. Each length of felt shall be laid in position and rolled up for a distance of half its length. The hot bonding material shall be poured on the roof across the full width of the rolled felt as the latter is steadily rolled out and pressed down. The pouring shall be so regulated that the correct weight

of bonding material per unit area is spread uniformly over the surface. Excess bonding material that gets squeezed out at the ends shall be levelled up as laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on the hot bonding material in the same way. Subsequent strips shall also be laid in the same manner. Each strip shall overlap the preceeding one by at least 7.5 cm at the longitudinal edges and 10 cm at the ends. All overlaps shall be firmly bonded with hot bitumen. Streaks and trailings of bitumen near edges of laps shall be levelled by heating the overlap with a blow lamp and levelling down unevenness.

The third layer of bonding material in the four course treatment shall be carried out in a similar manner after the flashing has been completed.

22.8.6.4 In a six course treatment the third and fourth layers of bonding material and self finished felt shall be laid in the manner already described, taking care that laps in the felt are staggered from those in the second layer. The fifth layer of bonding material shall be carried out after the flashing is done (See Fig. 22.7).

22.8.6.5 High Parapet Walls, Chimney Stacks etc.: Felts shall be laid as flashings wherever junctions of vertical and horizontal surfaces occur. Longitudinal laps shall be 10 cm. The lower layer of flashing felt in a six course treatment shall overlap the roof water proofing by not less than 20 cm while the upper layer shall overlap the roofing felt by 10 cm. The minimum overlap of the flashing felt in four course specification over the roofing felt shall be 10 cm.

The flashing shall consist of the same four or six course treatment as for the roof except that the final course of stone grit or pea-sized gravel shall be replaced by an application of bituminous solution of approved quality in two coats on the vertical and sloping faces only, of the flashing. The overlap along the length of flashing shall stagger with those in the second layer of flashing felt (in a six course treatment and with the joints in the roof felt).

The upper edge of the flashing felt shall be well tucked into the flashing grooves in the parapet, chimney stacks etc. to a depth of not less than 6.5 cm. Corresponding applications of bonding material shall also be made. The flashing treatment shall be firmly held in place in the grooves with wood edges at intervals and the grooves shall be filled up with cement mortar 1:4 (1 cement: 4 coarse sand) or cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 6 mm nominal size) and surface finished smooth with the rest of the wall. The cement work shall be cured for 7 days. When dry, the exposed plaster joints of grooves shall be painted with bitumen and two coats of bituminous solution shall be applied on the vertical and sloping surface of flashing (see Fig. 22.7).

After the top flashing felt layer has been fixed, the penultimate layer of bonding material shall be applied over the roofing felt and the horizontal overlaps and vertical and sloping surfaces of the flashings at the specified rate. Stone grit or pea sized gravel shall then be spread uniformly over the hot bonding material on the horizontal roof surface at the specified quantity per unit area and pressed into it with a wooden roller.

22.8.6.6 Low Parapet Walls: Where parapet walls are of height 45 cm or less, bitumen felt flashings shall be provided in the same manner as for flashings in the case of high parapet walls except that the upper edge shall be carried upto the full height of the wall and taken right across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm (see Fig. 22.7).

22.8.6.7 Low Dividing Walls: Where low dividing walls or inverted beams are met with, the same shall be covered with a four or six layer treatment as for the main roof, the latter bearing carried down both sides of the wall and overlapping the roofing treatment as in the case of flashing of high parapet walls (see Fig. 22.7).

Drain outlets where formed in the low dividing walls, shall be given water proofing treatment of the same number of courses as specified for the flat roof surface. The bottom and sides shall be so treated that all overlaps are in the direction of flow of drainage.

22.8.6.8 Expansion Joints: Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing. A typical sketch of an expansion joint with the RCC slabs on either side of the joint turned vertically up and covered with precast RCC cover slabs as given in Fig. 22.7. The cover slabs shall cover the vertical turned up dwarf walls by not less than 7.5 cm and are provided with throatings on their underside along their length. The water proofing treatment shall be taken up the sloping junction fillets and the vertical faces of the walls to the underside of the cover slabs. The cover slabs are given the water proofing treatment like the roof slabs, after the cross joints between adjacent cover slabs are first sealed with 15 cm width of roofing felt struck to them with bitumen. The water proofing treatment shall be carried down the sides of the cover slabs to their full thickness. Care shall be taken to see that overlaps if any in the roofing over the cover slabs stagger with the joints between cover slabs.

The formation of the expansion joints and provision of cover slabs shall be the responsibility of the construction agency. The formation of the junction fillets and the water proofing treatment of the joint and cover slabs shall be carried out by the water proofing agency. No extra shall be paid for the junction fillers or for the sealing of the cross joints in the cover slab with 15 cm width of bitumen strips.

22.8.6.9 Pipes: Where vertical pipe outlets are met with 7.5 x 7.5 cm fillets of lime or cement concrete of the type and section shown in Fig. 22.7 shall be provided and flashing of four or six course treatment, same as for the roofing treatment shall be laid.

The upper edge of the flashing shall be laid sloping down forward and butted against the pipe and annular depression so formed shall be filled with hot bitumen. A circular metal collar in the shape of an inverted truncated cone shall be fixed on the pipe to throw off the rain water clear of the flashing and this shall be paid for separately.

22.8.6.10 Terrace: Where roof surfaces are expected to be used precast cement concrete tiles or 40 mm thick cement concrete shall be laid on the water proofing treatment. In such cases, the final course of stone grit or pea sized gravel shall not be laid in the water proofing treatment. Suitable adjustment in the rates will be effected for not providing the stone grit or pea sized gravel layer. Cement concrete in situ flooring shall be laid in panel not exceeding 0.4 square metres each. Precast tiles or in situ concrete flooring where laid shall be paid for separately unless included in the description of the water proofing item.

22.8.7 Measurements

22.8.7.1 Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

22.8.7.2 Measurements shall be taken over the entire exposed area of roofing and flashing treatment including flashing over low parapet walls, low dividing walls and expansion joints and at pipe projections etc. Overlaps and tucking into flashing grooves shall not be measured.

22.8.7.3 Vertical and sloping surfaces of water proofing treatment shall also be measured under the four or six course treatment as the case may be, irrespective of the fact that the final course of grit or pea sized gravel is replaced by bitumen primer.

22.8.7.4 Primer or saturated felt underlay, where provided, shall also be measured in the same manner as the water proofing treatment and paid for separately. No deduction in measurements shall be made for either openings or recesses for chimney stacks, roof lights and the like, for areas upto 40 square decimetre (0.4 sqm) nor anything shall be paid for forming such openings.

For similar areas exceeding 40 sq. decimetre deductions will be made in measurements for full opening and nothing extra shall be paid for forming such openings.

22.8.8 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above and the particular specifications given under the different items, with the corrections noted in the relevant sub-paras.

22.9 GRADING ROOF WITH CEMENT CONCRETE 1:2:4

22.9.1 Materials

Cement, coarse sand and graded stone aggregate 20 mm nominal size, shall be used as specified in the item.

The specifications for the materials and method of preparation of concrete shall conform in general to the specification described in sub-head 4.0 of CPWD Specifications.

22.9.1.1 Laying: Before laying cement concrete for grading, the level markings to the required slope/gradient shall be made only with cement concrete on the surface of the slab at suitable spacing with the help of string and steel tape (Measuring tape) so that the mason can lay the concrete to the required thickness, slope / gradient easily in between the two level markings.

On getting the level marking approved by the Site Engineer the surface should be sprinkled with thick cement slurry and the concrete should be laid carefully, without throwing from height, in predetermined strips.

The concrete should be consolidated by specially made wooden tamping. After the tamping is done the surface should be finished to required slope/gradient with wooden trowels without leaving any spots of loose aggregates etc.

The mixed cement concrete must be laid in position, within half an hour of its mixing. In case any quantity of concrete remains unused for more than half an hour the same should be rejected and removed from the site.

22.9.1.2 Finishing: The slope of finished terrace shall not be more than 1 in 120 unless a steeper slope is desired by the Engineer-in-Charge.

The minimum thickness of the concrete at its junction with Khurra or parapets shall be 5 cm. The concrete shall be rounded at the junction of roof slab and parapet. It is desirable to provide a haunch/gola/filler at the junction of the parapet wall and the roof slab as shown in Fig. 22.8.

The finished concrete surface shall present a smooth surface with correct slopes and uniform rounding. The concrete should be free from cracks. Excess trowelling shall be avoided.

22.9.1.3 Thickness: Average thickness shall be as per clause 22.9.1.2 as shown in Fig. 22.8.

22.9.1.4 Curing: Curing shall be done either by spreading straw/Hessian cloth over the graded surface, keeping the same wet for full 10 days or flooding the graded area with water by making kiaries with weak cement mortar, for 10 days. Occasional curing by simply spraying water now and then shall not be permitted under any circumstances.

22.9.1.5 Measurement: Length and breadth shall be measured correct to a cm. Area shall be worked out to nearest 0.01 sqm. and the cubical contents shall be worked out to nearest 0.001 cum.

No deduction shall be made for either opening or recesses for chimney stacks, roof lights etc., Khurra for area upto 0.1 sqm. Nothing extra shall be paid either for any extra material or labour involved in forming such opening or recess or in rounding the concrete function of roof with parapet walls, chimney stack, khurra etc.

22.9.1.6 Rate: The rate shall include the cost of all the materials and labour involved in all the operations described above.

22.10 GRADING ROOF WITH CEMENT MORTAR

22.10.1 Materials

Cement and coarse sand shall be as specified in the item of work or as described in sub-head 3.0 of CPWD Specifications.

22.10.1.1 Cement Mortar : Cement mortar 1:3 (1 cement: 3 coarse sand) /1:4(1 cement: 4 coarse sand) specified in the item of work shall conform to the specification described in sub-head 3.0 of CPWD Specifications.

22.10.1.2 Preparation of the Surface: The surface shall be cleaned properly with brooms brush, cloth to remove all dirt, dust, mortar droppings.

22.10.1.3 Laying: Same as described in clause 22.9.1.1, except that cement mortar shall be tamped with wooden and steel trowels and surface finished with steel trowel.

22.10.1.4 Finishing

- (i) The slope of finished surface shall not be more than 1 in 120 unless a steeper slope is specified in the item of work.
- (ii) The finished surface of the grading shall present a smooth surface with correct slopes and uniform roundings wherever they are provided. The mortar surface shall be free of cracks. Excess trowelling shall be avoided.

22.10.1.5 Thickness: The minimum thickness of cement mortar grading at the junction with khurra or parapet wall shall be 20 mm. The cement mortar shall be rounded at the junction of roof slab and parapet. It is desirable to provide a haunch/gola/filler at the junction of parapet wall and the roof slab. The maximum thickness that shall be adopted for grading with cement mortar shall be 50 mm. It is not at all desirable to lay the cement mortar grading for greater thickness and in that case it is advised to go in for grading with Cement Concrete. The average thickness shall be as shown in Fig. 22.9 and 22.10.

22.10.1.6 Curing: Curing for the grading with cement mortar shall be done exactly as described in clause 22.9.1.4.

22.10.1.7 Measurement: Same as specified in clause 22.9.1.5.

22.10.1.8 Rate: The rate shall include the cost of all the labour and material involved in all the operations described above.

22.11 WATER PROOFING TREATMENT WITH APP (ATACTIC POLYPROPYLENE POLYMERIC) MEMBRANE

Water proofing treatment of roofs with APP modified polymeric membrane shall be either five course, seven course as specified in the item. In selecting the combinations of layers of APP membrane, consideration shall be given to the type and construction of buildings, climate and atmospheric conditions and the degree of permanence required. Five course treatment is a normal treatment suitable to moderate rainfall conditions (less than 50 cm.) and seven course treatment is suitable for heavy rainfall (50 cm and above). Seven course treatment with APP modified polymeric membrane 2.00 mm thick and weight 3.00 kg./sqm. to suitable for very heavy conditions of rainfall (more than 150 cm.).

22.11.1 Materials

22.11.1.1 The bitumen primer shall conform to the requirements laid down in IS 3384.

22.11.1.2 APP Modified Membrane: It is a polymeric water proofing membrane manufactured to high standards. It is five layered APP modified polymeric membrane with centre core as 20 micron HMHDPE/100 micron HMHDPE High Molecular High Density Polyethylene Film, is the heart of the membrane and protects against water and moisture. The centre core is sandwiched on both sides by high quality polymeric mix with properties of high softening point, high heat resistance and cold resistively to make it ideal for all water proofing treatment. The polymeric mix is protected on both sides with 20 micron HMHDPE film. The membrane is available in variable thickness and weights. Usual width is 1.0 m.

Important physical and chemical parameter of the membrane shall be as given in Table 22.1 for guidance.

TABLE 22.1

<i>Centre Core</i>	<i>Film</i>	<i>Thickness</i>	<i>Weight</i>
20 micron HMHPDE	20 micron HMHPDE	1.5 mm	2.25 kg/ sqm.
100 micron HMHPDE	20 micron HMHPDE	2.00 mm	3.00 kg./ sqm.

Where proprietary brands Atactic Polypropylene modified polymeric membrane is proposed to be used by the contractor, they shall conform in all respect to the specification in the preceding paras and manufactured by a company of repute.

22.11.1.3 Bonding Material: This shall consist of blown type bitumen conforming to IS 702 or residual bitumen 85/25 conforming to IS 73 heated to the correct working temperature of 180°C. The penetration of the bitumen shall not be more than 40 when tested in accordance with IS 1203, unless otherwise specified each coat of bonding material shall be of blown type bitumen of grade 85/25 heated to a working temperature of 180 degree C and applied @ 1.20 kg. per square metre of the surface area.

22.11.1.4 Surface Finish: Surface finish shall be with brick tiles of class designation 100 grouted with cement mortar 1:3 (1 cement : 3 fine sand) with 2% integral water proofing compound by weight of cement over a 12 mm thick layer of cement mortar 1:3 (1 cement: 3 fine sand) and finished neat, as shown in Fig. 22.11. Surface finish shall be measured and paid for separately.

22.11.1.5 Preparation of Surface: The surface to be treated shall have a minimum slope of 1 to 120. This grading shall be carried out with cement concrete or cement plaster with coarse sand, as desired, to the average thickness required and finished smooth. Such grading shall be paid for separately.

Junctions between the roof and vertical faces of parapet walls, chimneys etc. shall be chased by running triangular fillets 7.5 x 7.5 cm. size, cement concrete. At the drain mouths, the fillets shall be suitably cut back and rounded off for easy application of water proofing treatment and easy flow of water. Cement concrete where shall be 1:2:4 mix (1 Cement: 2 Coarse sand: 4 Graded stone aggregate 20 mm. Nominal size). The provision of fillets shall be deemed to be covered by the item of water proofing and shall not be measured or paid for separately.

In existing roof where gola and drip course are provided at the junction of roof and vertical face of parapet wall, chimney stacks, etc. These shall be dressed suitably and finished smooth so as to ensure an easy and gradual turning of the flashing. Any dismantlement or forming and finishing smooth the junction for forming the base of the flashing shall not be measured or paid for separately and shall be deemed to form part of the preparation of the surface.

While the grading of roof surface is being done, it shall be ensured that the outlet drain pipe have been fixed and mouth at the entrance have been eased and rounded off properly for easy flow of water. When any pipe passes through the roof to be treated, angular fillet of shape shown in Fig. 22.11 shall be built around it for the water proofing treatment to be taken over it. These fillets shall not be measured or paid for separately. For carrying over and tucking in the water proofing felts into the parapet walls, chimneys stacks etc. a horizontal groove 6.5 cm. deep, 7.5 cm. wide section with its lower edge at not less than 15 cm. above the graded roof surface shall be left on the inner face of the same; during construction if possible. When such groove has not been left, the same shall be cut out neatly and the base at rear of the groove shall be finished smooth with cement plaster 1:4 (1 cement: 4 coarse sand). Such cutting of the groove and its finishing smooth shall be part of the water proofing or paid for separately. No deduction shall be made either for not making the groove or when the latter has already been left in the masonry by the construction agency. Tucking in the water proofing felt will be required where the parapet wall exceeds 45 cm. in the height from the graded surface. Where the height is 45 cm. or less, no groove will be required as the water proofing treatment will be carried over the top of the parapet wall to its full thickness. In the case of low dividing walls of height 30 cm. or less, outlets therein shall be cut open for full height and the bottom and sides shall be rendered smooth and corners rounded and such treatment shall not be measured and paid for separately. Where expansion joints are left in the slab the provision of dwarf walls and/or RCC slabs for covering them and finishing the surface smooth shall be the responsibility of the construction agency, which had laid the roof slab and will not be included in the operation of water proofing. The graded surface of the roof and concrete fillets and the faces of walls shall be thoroughly cleaned with wire brushed and all loose scales etc. removed. The surface shall then be dusted off. Any crack in the roof shall be cut to V section, cleaned and filled up flush with cement mortar slurry 1:4 (1 cement : 4 coarse sand) or blown type petroleum bitumen of IS grade 85/25, or approved quality conforming to IS 702. Such cleaning of the surface or treating the cracks shall not be paid for separately.

22.11.1.6 Treatment: The water treatment shall be of five or seven course as specified.

In seven course treatment, the first four courses shall be the same as for five course treatment. The fifth course shall be a layer of APP modified polymeric membrane. The sixth course shall be a coat of bonding material and the top most seventh course shall be of specified surface finish.

22.11.1.7 Laying

- (a) First course shall be a coat of bitumen primer @ 0.40 kg per sqmt followed by subsequent course as per treatment required.
- (b) Drain outlets shall be given a four or six course treatment as specified for the roof in the description of the item in the manner specified for the flat roof surface. Water proofing treatment shall be carried into the drain pipe or outlets by at least 10 cm. The water proofing treatment laid on the roof surface shall overlap the upper edge of the water proofing treatment in the drain outlets by at least 10 cm.
- (c) The APP modified polymeric membrane shall be cut to the required length, brushed clean of dusting material and laid out flat on the roof to eliminate curls and subsequent stretching. The membrane shall normally be laid in length in the direction of the slope and laying shall be commenced at the lowest level and worked up to crest. The membrane shall not be laid in single piece of very long lengths as they are likely to shrink; 6 to 8 m are suitable lengths. The roof surface shall be cleaned and dry before starting the membrane treatment. Each length of membrane shall be laid in position and rolled up for a distance of half its length. The hot bonding material shall be poured on the roof across the full width of the rolled membrane as the latter is steadily rolled out and pressed down. The pouring shall be so regulated that the correct weight of bonding material per unit area is spread uniformly over the surface. Excess bonding material that gets squeezed out at the ends shall be levelled up as laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on the hot bonding material in the same way. Subsequent strips shall also be laid in the same manner.

Each strip shall overlap the preceding one by at least 7.5 cm. at the longitudinal edges and 10 cm. at the ends. All overlaps shall be firmly bonded with a blow lamp and levelling down unevenness. The fourth layer of bonding material in the five course treatment shall be carried out in a similar manner after the flashing has been completed.

- (d) In a seven course treatment the fifth layers of membrane shall be laid in the manner already described, taking care that laps in the membrane are staggered from those in the earlier layer. The sixth layer of bonding material shall be carried out after the flashing is done (See Fig. 22.23).
- (e) *High Parapet Walls, Chimney Stacks etc.:* Membrane shall be laid as flashing wherever junctions of vertical and horizontal surfaces occur. Longitudinal laps shall be 10 cm. The lower layer of flashing membrane in a six course treatment shall overlap the roof water proofing by not less than 20 cm. while the upper layer shall overlap the roofing felt by 10 cm. The minimum overlap of the flashing membrane in five course treatment over the roofing membrane shall be 10 cm.

The flashing shall consist of the same five or seven course treatment as for the roof except that the final course shall be replaced by an application of 12 mm thick cement plaster 1:3 on the vertical and sloping faces only, of the flashing as shown in Fig 22.10. The overlap along the length of flashing shall stagger with those in the second layer of flashing membrane (in a seven course treatment and with the joints in the roof membrane).

The upper edge of the finishing membrane shall be well tucked into the flashing grooves in the parapet, chimney stacks etc. to a depth of not less than 6.5 cm. Corresponding applications of bonding material shall also be made. The flashing treatment shall be firmly held in place in the grooves with wood edges at intervals and the grooves shall be filled up with cement mortar 1:4 (1 cement: 4 coarse sand) or cement concrete 1:2:4 (1 cement: 2 coarse sand : 4 graded stone aggregate 6 mm nominal size) and surface finished smooth with the rest of the wall. The cement work shall be cured for 7 days. When dry, the exposed plaster joints of grooves shall be painted with bitumen and two coats of bituminous solution shall be applied on the vertical and sloping surface of flashing (see Fig. 22.11).

After the top flashing membrane layer has been fixed, the penultimate layer of bonding material shall be applied over the roofing membrane and the horizontal overlaps and vertical and sloping surfaces of the flashing at the specified rate.

- (f) *Low Parapet Walls:* Where parapet walls are of height 45 cm. or less, membrane flashings shall be provided in the same manner as for flashings in the case of high parapet walls except that the upper edge shall be carried upto the full height of the wall and taken right across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm. (see Fig 22.18).
- (g) *Low Dividing Walls:* Where low dividing walls or inverted beams are met with, the same shall be covered with a four or six layer treatment as for the main roof, the latter bearing carried down both sides of the wall and overlapping the roofing treatment as in the case of flashing of high parapet walls (see Fig. 22.7).

Drain outlets where formed in the low dividing walls, shall be given water proofing treatment of the same number of courses as specified for the flat roof surface. The bottom and sides shall be so treated that all overlaps are in the direction of flow of drainage.

- (h) *Expansion Joints:* Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing. A typical sketch of an expansion joint with the RCC slabs on either side of the joint turned vertically up and dwarf walls by not less than 7.5 cm. and are provided with throatings on their underside along their length. The water proofing treatment shall be taken up the sloping junction fillets and the vertical faces of the walls to the underside of the cover slabs. The cover slabs are given the water proofing treatment like the

roofs slabs, after the cross joints between adjacent cover slabs are first sealed with 15 cm width of roofing felt struck to them with bitumen. The water proofing treatment shall be carried down the sides of the cover slabs to their full thickness. Care shall be taken to see that overlaps if any in the roofing over the cover slabs stagger with the joints between cover slabs.

The formation of the expansion joints and provision of the cover slabs shall be the responsibility of the construction agency. The formation of the junction fillets and the water proofing treatment of the joint and cover slabs shall be carried out by the water proofing agency. Nothing agency extra shall be paid for the sealing of the cross joints in the cover slab with 15 cm. width of bitumen strips.

- (i) *Pipes:* Where vertical pipe outlets are met with, 7.5 x 7.5 cm fillets of lime or cement concrete of the type and section shown in Fig. 22.7 shall be provided and flashing of four or six course treatment, same as for the roofing treatment shall be laid.

The upper edge of the flashing shall be laid sloping down forward and butted against the pipe and annular depression so formed shall be filled with hot bitumen. A circular metal collar in the shape of an inverted truncated cone shall be fixed on the pipe to throw off the rain water clear of the flashing and this shall be paid for separately.

22.11.1.8 Measurement: Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal. Measurements shall be taken over the entire exposed area of roofing and flashing treatment including flashing over low parapet walls, low dividing walls and expansion joints and at pipe projections etc. Overlaps and tucking into flashing grooves shall not be measured. Vertical and sloping surfaces of water proofing treatment shall also be measured under the five or seven course treatment as the case may be, irrespective of the fact that the final course is replaced by bitumen primer. No deduction in measurements shall be made for either openings or recesses for chimney stacks, roof lights and the like, for areas upto 0.4 sqm nor anything shall be paid for forming such openings. For areas exceeding 0.40 sqm deduction will be made in measurements for full opening and nothing extra shall be paid for forming such openings.

22.11.1.9 Rate: The rate shall include the cost of all labour and materials involved in all the operations described above. The top most layer shall be paid for separately.

22.12 FIVE LAYERED WATER PROOFING TREATMENT WITH ATACTIC POLYPROPYLENE POLYMER MODIFIED PREFABRICATED MEMBRANE

22.12.1 Atactic Polypropylene Polymer modified prefabricated five layer water proofing membrane shall be of thickness as specified. In selecting thickness of membrane due consideration shall be given to the type and construction of building, climate and atmospheric condition and permanence required. Five layered treatment 2.00 mm thick with glass fibre is with a normal duly treatment suitable for pitched roofs. Five layered 3.00 mm thick with glass fibre matt treatment is suitable for moderate condition of rainfall (50 to 150 mm) and fine layered 3.00 mm thick with non-woven polyester matt treatment is suitable for heavy condition of rainfall.

22.12.1.1 Materials

Bitumen primer for bitumen membrane shall have density at 25°C in the range of 0.87 - 0.89 kg./litre and viscosity of 70-160 CPS primer shall be applied @ of 0.40 litre/sqm.

22.12.1.2 Atactic Polypropylene Polymer Modified Prefabricated Membrane: It is a polymeric water proofing membrane. This shall be one of the following types:

- (i) 2 mm thick with glass fibre matt.
- (ii) 3 mm thick glass fibre matt.
- (iii) 3 mm thick with non-woven polyester matt.

It is prefabricated five layered black finish water proofing membrane comprising of centre core of 50 gsm. Glass fibre matt/170 gsm nonwoven polyester matt sandwiched on both sides by APP polymer modified bitumen which is protected on both sides by 20 micron thermofusible polyethylene sheet. Composite thickness of the membrane including all five layers shall be 2/3 mm with glass fibre matt and 3 mm with non woven polyester matt. It is available in 1 m width and variable lengths.

Physical and chemical parameters of the membrane shall be as given in Table 22.2.

TABLE 22.2

Sl. No.	No. of Layers	Thickness	Elongation at 23° C in longitudinal transverse direction	Joint strength in longitudinal and Transverse direction	Tear strength in longitudinal Transverse direction	Softening Point	Cold flexibility
1	2	3	4	5	6	7	8
1	Five Layered reinforced with fibre glass	2 mm	3 N/5 cm.	350/300 N/5 cm.	60/80 N	150°	-2°C
2	Five layered reinforced with fibre glass	3 mm	3.3 N/5 cm.	350/3000 N/5 cm.	60/80 N	150°	-3°C
3	Five layered reinforced with non-woven polyester matt.	3 mm	40/50 N/5 cm.	650 N/450 N/5 cm.	300/250 N	150°	-2°C

When tested Atactic polypropylene modified black finished is proposed to be used shall conform in all respects to the specification in the preceding paras. The work should be got done through authorized applicator/specification agency.

22.12.1.3 Preparation of Surface: The surface to be treated shall have a minimum slope of 1 in 120 or as specified, provision specified in clause 22.11.5.1 shall apply for preparation of surface except for pitched roof where surface shall be cleaned off any loose material dust etc.

To ensure good adhesion between the surface and water proofing treatment suitable method to dry the surface shall be adopted. All hair line cracks in the surface should be filled with approved sealant.

22.12.1.4 Treatment: The water proofing shall consist of prefabricated five layered 2 mm / 3 mm membrane as shown in Fig. 22.12. The choice of 2 mm or 3 mm membrane will depend on the type of roof i.e. pitched or flat and importance of building, durability, cost and rainfall etc.

22.12.1.5 Laying: Bitumen primer @ 0.40 lts/sqm shall be applied to the prepared roof, drain and all other surfaces where polymer modified membrane is to be laid. The five layered water proofing membrane shall be laid using Butane torch and sealing all joints and preparing the surface complete. Drain outlets shall be given same treatment as specified for the roof in the description of the item in the manner specified for the flat roof surface. Water proofing treatment shall be carried into the drain pipe or outlets by at least 10 cm. The water proofing treatment laid on the roof surface shall overlap the upper edge of the water proofing treatment in the drain outlets by at least 10 cm.

The APP polymer modified prefabricated water proofing membrane shall be cut to the required length. Water proofing membrane shall normally be laid in length in the direction of the slope and laying shall be commenced at the lowest level and worked upto crest. APP water proofing membrane shall be laid in 6 to 8 m lengths. The roof surface shall be cleaned and bitumen primer shall be applied in the correct quantity, over this specified water proofing membrane shall be laid with butane torch after allowing 24 hours for primer to dry. Each strip shall overlap the preceding one by at least 10 cm. at the longitudinal edges and 15 cm. at the ends. All overlaps shall be firmly bonded with bitumen primer and levelled by heating the overlap with butane torch.

If the roof is accessible the treatment is protected by brick tiles laid over 12 mm thick cement mortar of specified grade bedding and joints sealed with cement mortar of which shall be measured and paid for separately.

APP water proofing membrane shall be laid as flashing wherever junction of vertical and horizontal surfaces occur. Longitudinal laps shall be 10 cm. The upper edge of flashing membrane shall be well tucked into the flashing grooves in the parapets, chimney stack etc. to a depth of not less than 6.5 cm; corresponding applications of primer coat shall also be made. The flashing treatment shall be firmly held in the grooves and it shall be sealed with the approved sealant after terminating the membrane.

Where parapet walls are of height 45 cm or less AP water proofing membrane flashing shall be provided in the same manner as for splashing in the core of high parapet walls except that upper edge shall be carried out the full height of the wall and taken right across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm.

Where low dividing walls or inverted beams are met with, the same treatment shall be provided as for the main roof, the lateral bearing carried down both sides of the wall and overlapping the roof treatment.

Drain outlets where formed in the low dividing walls, shall be given water proofing treatment same as for the main roof.

Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing treatment. A typical sketch of an expansion joint with the RCC slabs on either side of the joint turned vertically up and covered with precise RCC cover slabs as given in Fig. 22.7. The cover slabs shall cover the vertical turned up dwarf walls by not less than 7.5 cm and are provided with throatings on their underside along their length. The water proofing treatment shall be taken up the slopping junction fillets and the vertical faces of the walls to the underside of the cover slabs are given the water proofing treatment like the roof slabs, after the cross joints between adjacent cover slabs are first sealed with 15 cm. width of roofing felt struck to them with bitumen. The water proofing treatment shall be carried down the sides of the cover slabs to their full thickness. Care shall be taken to see that overlaps if any in the roofing over the cover slabs stagger with the joints between cover slabs.

The formation of the expansion joints and provision of cover slabs shall be the responsibility of construction agency. The formation of the junctions fillets and the water proofing treatment of the joint and cover slabs shall be carried out by the water proofing agency. No extra shall be paid for the junction fillets or for the sealing of the cross joints in the cover slab with 15 cm. width of bitumen strips.

22.12.1.6 Measurements: Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

Measurement shall be taken over the entire exposed area of roofing and flashing treatment including flashing over low parapet walls, low dividing walls and expansion joints at pipe projections etc. overlaps and tucking into flashing grooves shall not be measured.

No deduction in measurements shall be made for either openings or recesses for chimney stacks, roof lights and the like, for areas upto 40 square decimeter (0.4 sqm.) nor any thing shall be paid for forming such openings. For areas exceeding 0.40 sqm. deductions will be made in measurements for full opening and nothing extra shall be paid for forming such openings.

22.12.1.7 Rate: The rates shall include the cost of all labour and materials involved in all the operations described above.

22.13 EXTRA FOR COVERING OF APP MODIFIED PREFABRICATED MEMBRANE WITH GEOTEXTILE

22.13.1 If the water proofing treatment of flat roof has been done with APP modified five layered membrane and the roof is accessible, a separation layer on top of membrane should be laid before any protected treatment is done. Brick tiles in cement mortar or 25 mm thick cement concrete 1:2:4 shall be laid as final layer as shown in Fig. 22.12.

Geotextile 120 gm. Non woven 100% polyester of thickness 1.0 to 1.25 mm manufactured by a company of repute shall be used.

Geotextile of the specified thickness is bonded to the water proofing membrane with intermittent touch by heating the membrane by Butane torch as per manufacturing recommendations.

22.13.2 Measurements: Length and breadth shall be measured correct to two places of decimal, measurement shall be taken over the entire exposed area of roofing.

22.13.3 Rate: The rate shall include the cost of all labour and material involved in all the operation described above. Final layer of brick tiles or 25 mm thick cement concrete shall be measured and paid for separately.

BITUMEN FELTS (FIBRE HESSIAN BASE)
(Clause 22.8.1.1)

A-1 Weights

The weights of the ingredients used in the manufacture of bitumen felts per 10 sqm shall be not less than those specified in Table A-I

TABLE A-I
Minimum Weights of Bitumen Felts

S. No.	Type of felt	For 10 sqm				
		Untreated Base	Saturant	Coatant	Bitumen content	Total weight of the finished bitumen felt in dry condition with mica dusting powder Min.
		Kg	Kg	Kg	Kg	Kg
	Fibre Base					
(i)	Type 2 grade 1 Hessian Base	5.0	4.5	12.9	12	22.6
(ii)	Type 3 Grade 1	2.3	1.8	17.7	12.1	23
(iii)	Type 3 Grade 2	2.3	1.8	31.8	20.2	37.1

Notes:

1. The weight of the untreated base shall be taken as in the dry condition.
2. Includes allowance for 1.2 kg minimum mica dusting powder in dry condition.

A-2 Testing

A-2.1 Frequency of test shall be decided by the Engineer-in-charge depending on quantum of work. From each of the rolls one piece 3 m long and the full width of the felt shall be cut out for preparing test specimens. The first 2M. of the roll shall not be selected for this purpose. The lengths of felt so selected shall be free from abnormal defects and shall be truly representative of the whole consignment. The selected pieces of felt shall be dispatched without breakage or distortion, wrapped up in water proof paper or other similar materials so as to cause no damage to the material during transit. In case the material has stuck together, no heat shall be applied to separate the layer but the whole roll shall be sent for testing and the fact shall be reported.

The samples, when tested as per IS1322 shall conform to the requirements given in Table A-II.

TABLE A-II

<i>Sl. No</i>	<i>Type of Felt</i>	<i>Breaking strength kg</i>	<i>Pliability Test</i>	<i>Storage sticking tests</i>	<i>Heat Resistance Test</i>	<i>Pressure head test</i>	<i>Water absorption test Max.</i>
1.	Type 2 (all grades)	95 / 60	(i) The roll shall not show cracks on unrolling (ii) Consider any surface rupture exceeding 5 mm in length as failure	The test pieces shall be examined after cooling After release of the load, the layers of felt shall be capable of being separated without damaging the coatant in any way	The test pieces shall show no sign of melting of the bitumen compound -	The test pieces shall show no sign of leakage -	5.0% -
2.	Type 3 (all grades)	135/90	(i) The roll shall not show cracks on unrolling (ii) Consider any surface rupture exceeding 5 mm in length as failure	The test pieces shall be examined after cooling After release of the load, the layer of felt shall be capable of being separated without damaging the coatant in any way	The test pieces shall show no sign of melting of the bitumen compound -	The test pieces shall show no sign of leakage -	2.0% -

GLASS FIBRE BASE BITUMEN FELT

(Clause 22.8.1.1)

B-1 Weight

The weight of the ingredients used in the manufacture of glass fibre felts for 10 square metre shall be not less than those specified in Table B-I.

TABLE B-I
Minimum Weight of Bitumen Glass Fibre Base Felt

For 10 Square Metre

S. No.	Type of Felt	Untreated Base	Treated Base	Coatant	Total weight in dry condition including surfacing materials
		(kg)	(kg)	(kg)	(kg)
1.	Type 2 Gr. I	-	0.4	15.3	18.0

B-2 Tests

The sample, when tested as per IS 7193 shall conform to the requirements given in Table B-II

TABLE B-II
Requirements of Glass Fibre Felts

Sl. No.	Properties	Requirements
(i)	Breaking strength, Min kg	(a) Warp 50 (b) Weft 30
(ii)	Pliability test	(a) Roll shall not show cracks on unrolling (b) Consider any surface rupture exceeding 5 mm in length as failure.
(iii)	Storage sticking	The test pieces shall be examined after cooling. After release of load, the layers of felt be capable of being separated without damaging.
(iv)	Pressure head	The test pieces shall show no sign of leakage.
(v)	Heat resistance	The test pieces shall show no sign of melting of bitumen compound.
(vi)	Water absorption	2 per cent

**Sub Head : Water Proofing Treatment
Clause : 22.1**

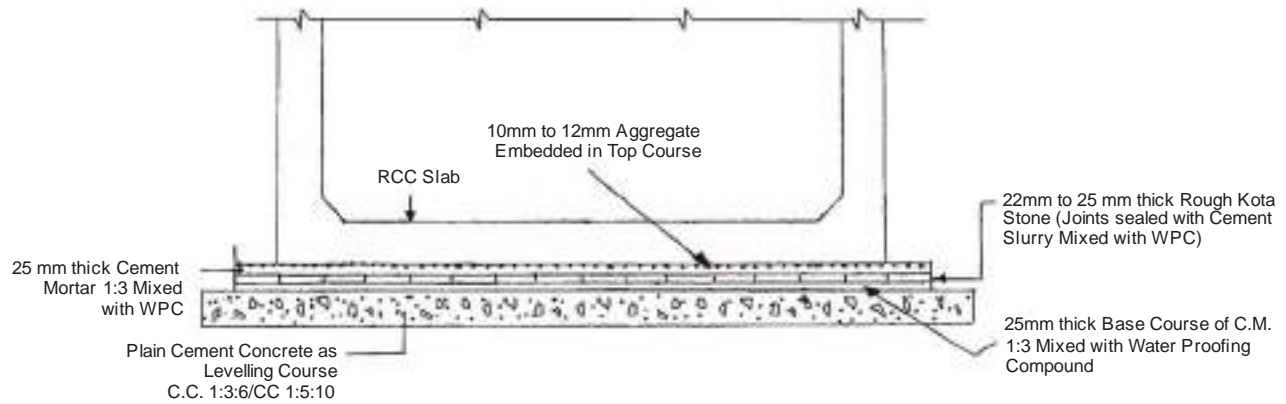


Fig. 22.1 : Waterproofing of Horizontal Surface of U.G. Structure

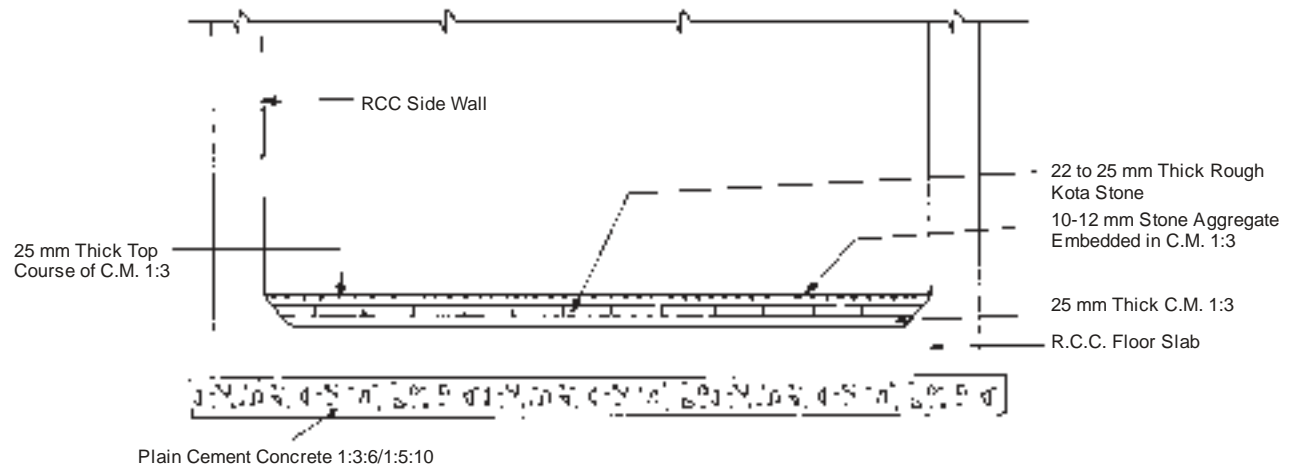


Fig. 22.2 : Water Proofing Horizontal Surfaces from Inside of a U.G. Structure

**Sub Head : Water Proofing Treatment
Clause : 22.2**

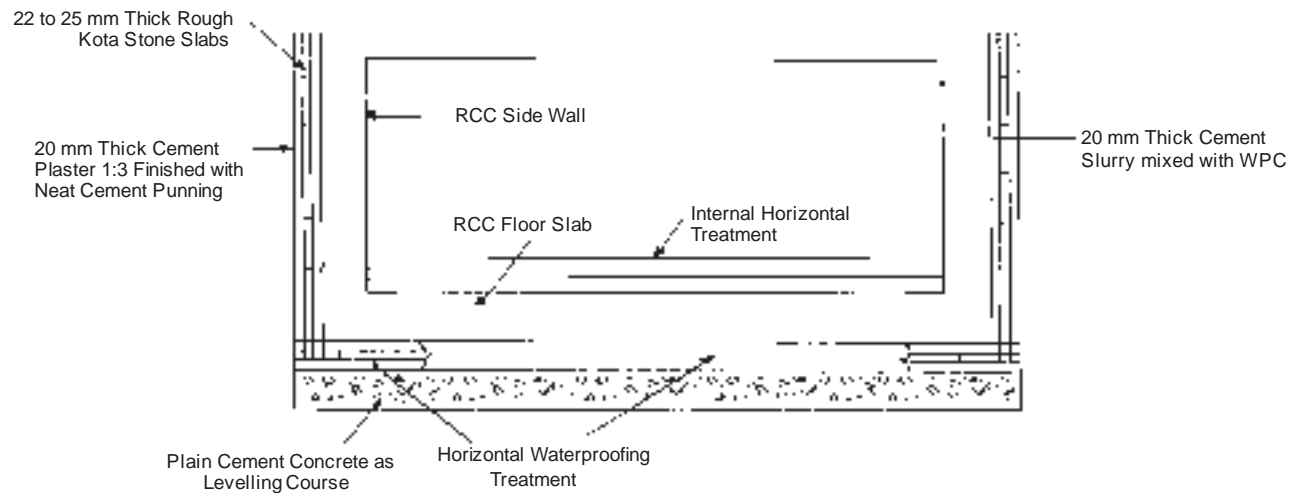
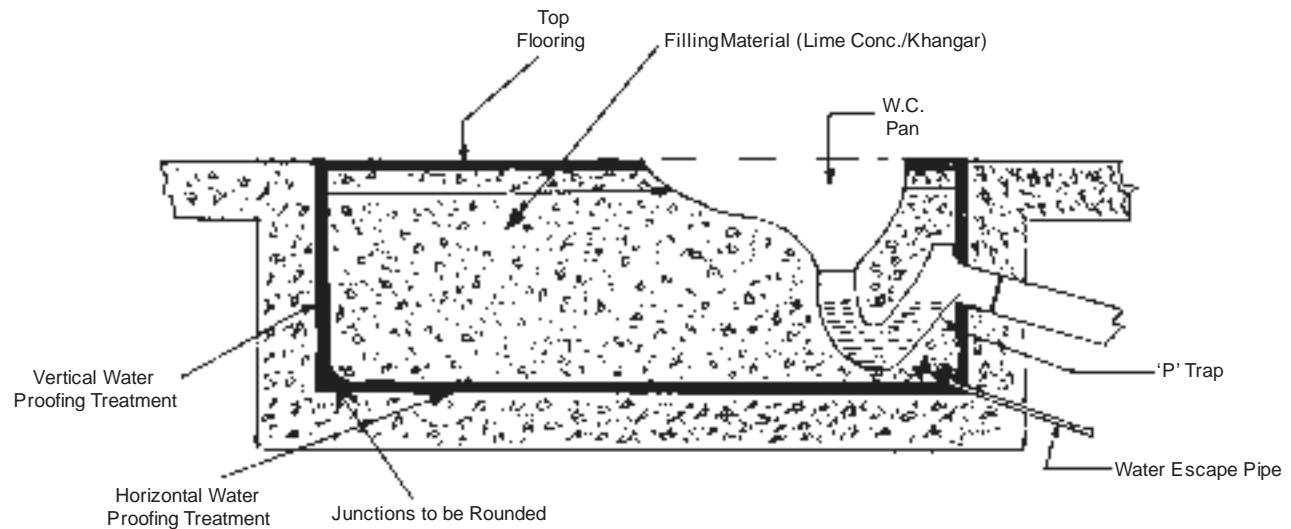


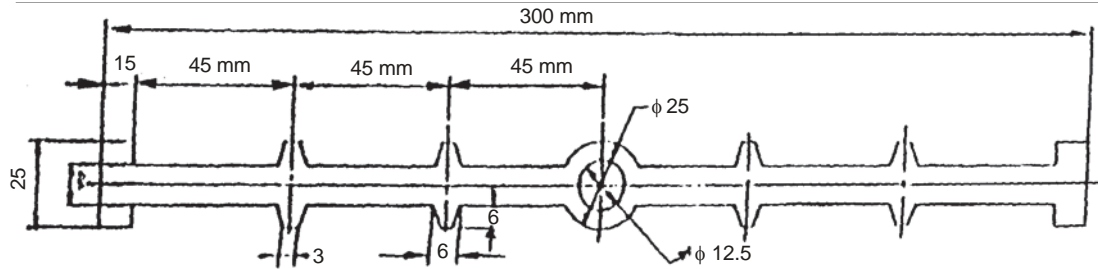
Fig. 22.3 : Waterproofing on Vertical Surfaces of Under Ground Structures

**Sub Head : Water Proofing Treatment
Clause : 22.3**



**Fig. 22.4 : Position of Horizontal and Vertical Waterproofing Treatment
in Sunken Portion of W.C./Kitchen and the like**

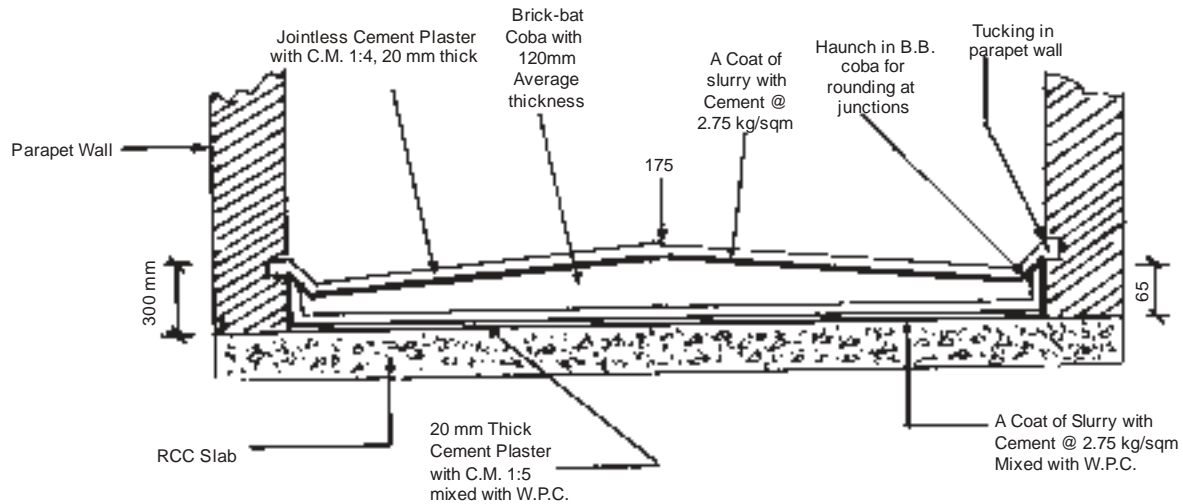
**Sub Head : Water Proofing Treatment
Clause : 22.4**



All dimensions in millimeters

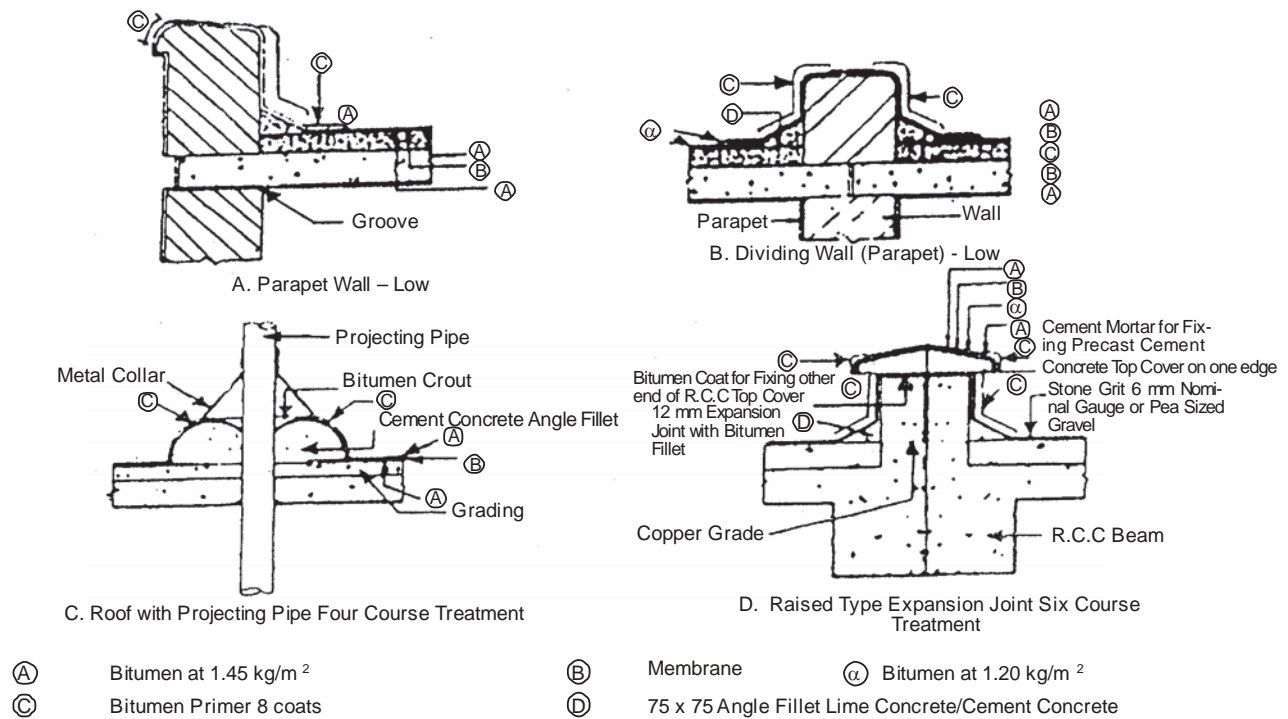
Fig. 22.5 : Typical Cross-Section of PVC Water-Stop

**Sub Head : Water Proofing Treatment
Clause : 22.7**



**Fig. 22.6 : Integral Cement based Waterproofing Treatment with Brick-bat Coba
Over a RCC Slab**

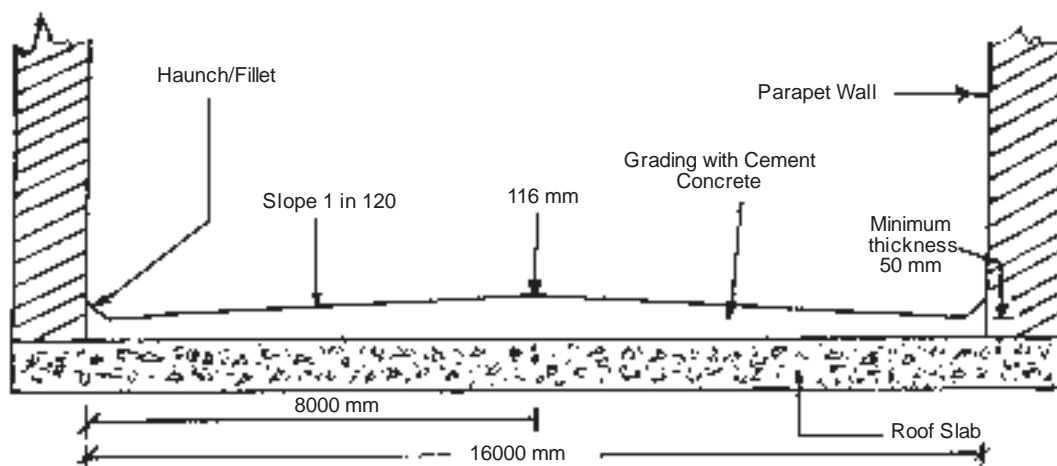
**Sub Head : Water Proofing Treatment
Clause : 22.8**



Diagrams Not to Scale
All dimensions are in mm

Fig. 22.7 : Water Proofing

**Sub Head : Water Proofing Treatment
Clause : 22.9**



Sub Head : Water Proofing Treatment
Clause : 22.10

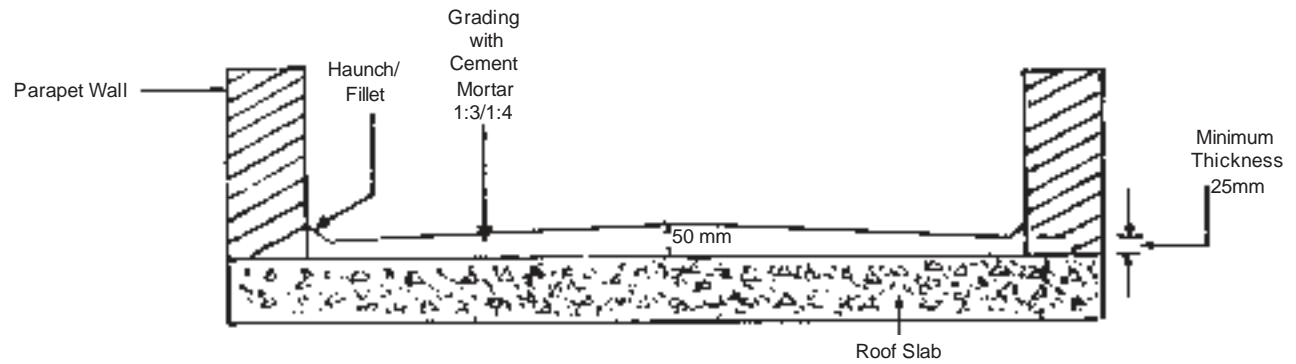


Fig. 22.9 : Grading Roof Slab with Cement Mortar 1:3/1:4

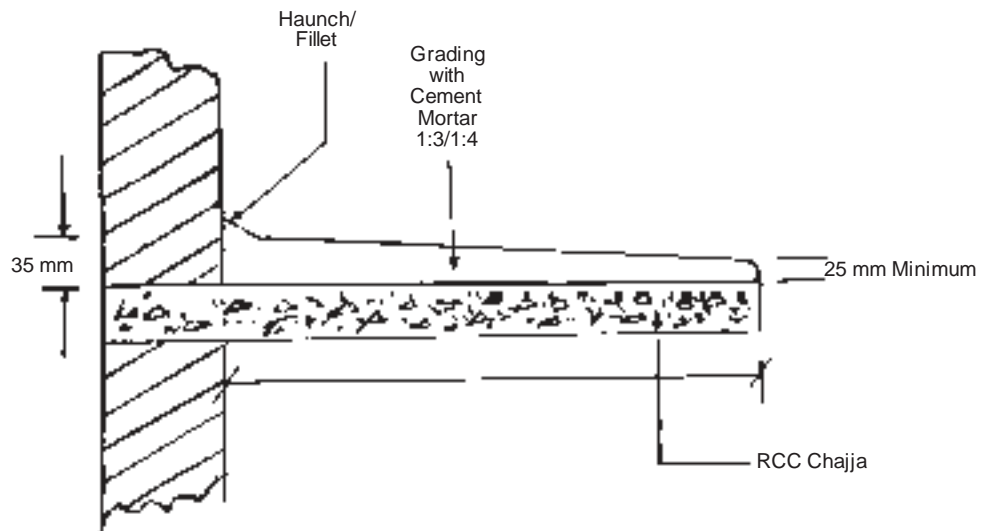


Fig. 22.10 : Grading Chajja with Cement Mortar 1:3/1:4

**Sub Head : Water Proofing Treatment
Clause : 22.11**

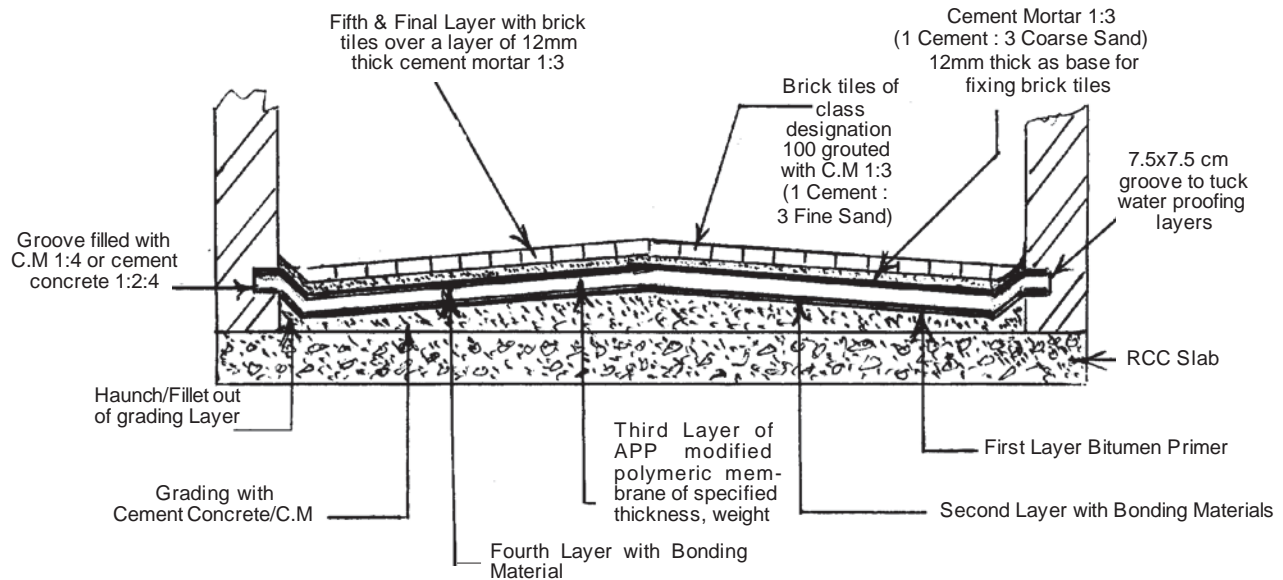


Fig. 22.11 : Five Course Water Proofing Treatment with APP Modified Polymeric Membrane

**Sub Head : Water Proofing Treatment
Clause : 22.12**

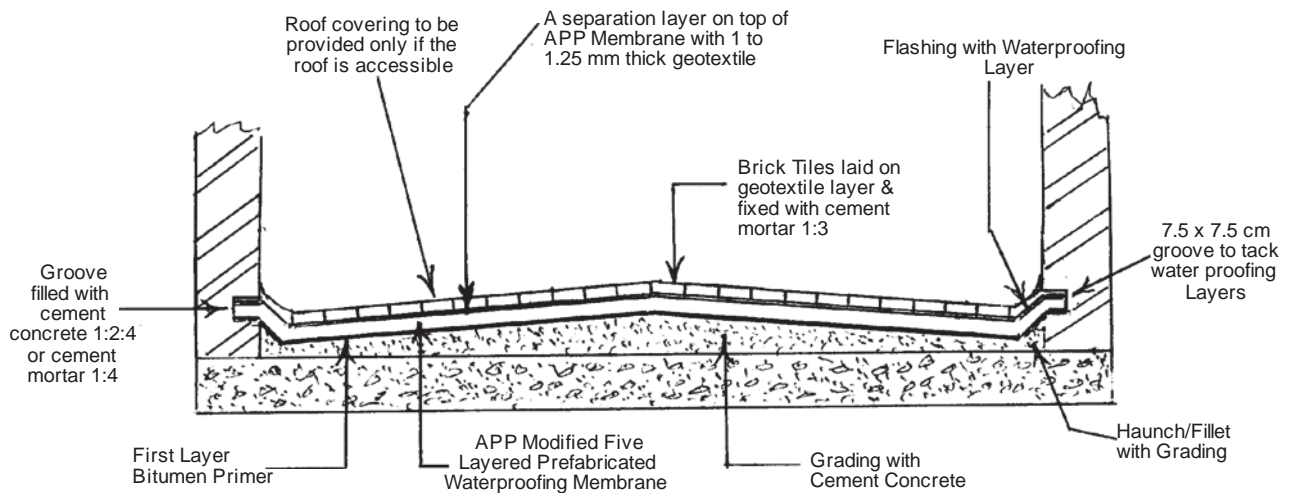


Fig. 22.12 : Five Layers Water-Proofing Treatment with APP Modified Prefabricated Membrane

SUB HEAD : 23.0

**HORTICULTURE
AND LANDSCAPE**

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23.0 HORTICULTURE AND LAND SCAPING

23.0 HORTICULTURE WORK

Horticultural operations shall be started on ground previously levelled and dressed to required formation levels and slopes.

In case where unsuitable soil is met with, it shall be either removed or, replaced or it shall be covered over to a thickness decided by the Engineer-in-charge with good earth.

In the course of excavation or trenching during horticultural operations, any walls, foundations, etc. met with shall not be dismantled without pre-measurement and prior to the written permission of the Engineer-in-charge.

23.1 TRENCHING IN ORDINARY SOIL

23.1.0 Trenching is done in order to loosen the soil, turn over the top layer containing weeds etc. and to bring up the lower layer of good earth to form a proper medium for grassing, regrassing, hedging and shrubbery.

Trenching shall be done to the depth ordered by the Engineer-in-charge. The depth is generally 30 cm for grassing and 60 cm for regrassing in good soil.

23.1.1 The trenched ground shall, after rough dress, be flooded with water by making small kiaries to enable the soil to settle down. Any local depression unevenness etc. shall be made good by dressing and/or filling with good soil.

23.1.2 Weeds or other vegetation which appear on the ground are then uprooted and removed and disposed off and paid.

23.1.3 Trenching

Trenching shall consist of the following operations:

1. The whole plot shall be divided into narrow rectangular strips of about 1.5 m width or as directed by the Engineer-in-Charge.
2. These strips shall be sub-divided lengthwise into about 1 m long sections. Such sections shall be excavated serially and excavated soil deposited in the adjacent section preceding it.
3. In excavating and depositing care shall be taken that the top soil with all previous plant growth including roots, get buried in the bottom layer of trenched area, the dead plants so buried incidentally being formed into humus.
4. The excavated soil shall be straight away dumped into the adjoining sections so that double handling otherwise involved in dumping the excavated stuff outside and in back filling in the trenches with leads is practically eliminated.

23.1.4 Measurements

Length and breadth of the plot shall be taken correct to 0.1 m and depths correct to cm. Cubical contents shall be calculated in cubic meters, correct to two places of decimal. No deduction shall be made nor extra paid for removing stones, brick bats and other foreign matter met with during excavation upto initial lead of 50 m and stacking the same.

23.1.5 Rate

The rate shall include the cost of all labour and material involved in the operations described above, including cost of all precautionary measures to be taken for protections and supporting all services etc. met with during trenching. It does not include the cost of mixing of earth, sludge/manure.

23.2 GOOD EARTH

23.2.1 The earth shall be stacked at site in stacks not less than 50 cm high and of volume not less than 3.0 cum.

23.2.2 Measurements: Length, breadth and height of stacks shall be measured correct to a cm. The volume of the stacks shall be reduced by 20% for voids before payment, unless otherwise described.

23.2.3 Rate: The rate shall include the cost of excavating the earth from areas lying at distance not exceeding one km. from the site, transporting the same at site breaking of clods and stacking at places indicated. The rate shall also include royalty if payable.

23.3 OIL CAKE

23.3.1 Neem/Castor: The cake shall be free from grit and any other foreign matter. It should be undecorticated and pulverized. The material shall be packed in old serviceable gunny bags of 50 kgs capacity approximately. The weight of gunny bag shall be deducted @1 kg per bag and payment shall be made for net quantity. The quality of cake should be got approved by the Engineer-in-charge before supply.

23.3.2 Measurements

The arrangement for weighing shall be made at site of work by the department. The gunny bags shall be the property of the government.

23.3.3 Rate: The rate shall include the cost of labour and material involved in all operations described above, including carriage up to site of work with all lead and lifts, weighing etc.

23.4 SUPPLY AND STACKING OF SLUDGE

23.4.1 It shall be transported to the site in lorries with efficient arrangement to prevent spilling enroute. It shall be stacked at site. Each stack shall not be less than 50 cm height and volume not less than 3 cum.

23.4.2 Measurements

Length, breadth and depth of stacks shall be measured correct to a cm. The volume of the stack shall be reduced by 8% for looseness in stacking and to arrive at the net quantity for payment.

23.4.3 Rate

The rate shall include the cost of labour and material involved in all operations described above, including carriage up to one km. The rate shall also include royalty if payable.

23.5 SUPPLY AND STACKING OF MANURE

23.5.1 Farmyard Manure: Same as 23.4.1.

23.5.2 Measurements: Same as 23.4.2.

23.5.3 Rate : Same as 23.4.3.

23.6 ROUGH DRESSING OF THE TRENCHED GROUND

23.6.0 Rough dressing of the area shall include making kiaries for flooding.

23.6.1 The trenched ground shall be levelled and rough dressed and if there are any hollows and depressions resulting from subsidence which cannot be so levelled, these shall be filled properly with earth brought from outside to bring the depressed surface to the level of the adjoining land and to remove discontinuity of slope and then rough dressed again. The supply and spreading of soil in such depressions is payable separately. In rough dressing, the soil at the surface and for 75 mm depth below shall be broken down to particle size not more than 10 mm in any direction.

23.6.2 Measurements

Length, breadth of superficial area shall be measured correct to 0.1 metre. The area shall be calculated in sqm. correct to two places of decimal.

23.6.3 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above.

23.7 UPROOTING WEEDS FROM TRENCHED AREAS

23.7.1 After 10 days and within 15 days of flooding the rough dressed trenched ground with water, the weeds appearing on the ground shall be rooted out carefully and the rubbish disposed off as directed by the Engineer-in-charge.

23.7.2 Measurements

Length, breadth of superficial area shall be measured correct to 0.1 meters. Superficial area of the weeded ground shall be measured for purpose of payments.

23.7.3 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above.

23.8 FINE DRESSING THE GROUND

23.8.1 Slight unevenness, ups, and downs and shallow depressions resulting from the settlement of the flooded ground, in drying and from the subsequent weeding operations, shall be removed by fine dressing the surface to the formation levels of the adjoining land as directed by the Engineer-in-charge, and by adding suitable quantities of good earth brought from outside, if necessary.

23.8.2 Measurements

Length, breadth and depth of stacks shall be measured correct to a cm. The area shall be calculated in sqm. correct to two places of decimal.

23.8.3 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above.

23.9 SPREADING GOOD EARTH

23.9.1 Good earth shall be removed from stacks by head load and spread evenly over the surface to the thickness ordered by the Engineer-in-charge. It shall be spread with a twisting motion to avoid segregation and to ensure that spreading is uniform over the entire area.

23.9.2 Measurements: The quantity of good earth spread shall be determined by the difference in the volume of good earth in stacks before and after spreading duly reduced for looseness in stacking by 20% of good earth.

23.9.3 Rate: The rate shall include of all the labour and material involved in all the operations described above, but does not include the cost of the good earth which shall be paid for separately unless specifically described in the item.

23.9.A SPREADING SLUDGE/MANURE

23.8.A.1 Good earth shall be thoroughly mixed with sludge or manure in specified proportion as described in the item or as directed by the Engineer-in-Charge. The mixing shall be spread as described in 23.9.1 to the thickness ordered by the Engineer-in-Charge.

23.9.A.2 Measurements

The quantity of good earth and sludge or manure mixed shall be determined by the difference in the volume of good earth and sludge or manure in stack, before and after spreading duly accounted for voids and looseness in stack.

23.9.A.3 Rate

The rate shall include of all the labour and material involved in all the operations described above, but does not include the cost of good earth sludge or manure which shall be paid for separately, unless otherwise described in the item.

23.10 MIXING OF GOOD EARTH AND SLUDGE/MANURE

23.10.1 The stacked earth shall, before mixing be broken down top particle of sizes not exceeding 6 mm in any direction. Good earth shall be thoroughly mixed with sludge or manure in specified proportion as described in the item or as directed by the Engineer-in-charge.

23.10.2 Measurements

The quantity of good earth and sludge or manure mixed shall be determined by the difference in the volume of good earth, sludge or manure in stack, before and after spreading duly accounted for voids and looseness in stack.

23.10.3 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above, but does not include the cost of good earth sludge or manure which shall be paid for separately, unless otherwise described in the item.

23.11 GRASSING WITH SELECT GRASS NO. 1

23.11.0 The area from where the grass roots are to be obtained shall be specified by the Engineer-in-Charge at the time of execution of the work and no royalty shall be charged on this account from the contractor. **Grass is to be arranged by contractor (cost of grass to be paid separately).**

23.11.1 The soil shall be suitably moistened and then the operation of planting grass shall be commenced. The grass shall be dibbled at 10 cm, 7.5 cm, 5 cm apart in any direction or other spacing as described in the item. Dead grass and weeded shall not be planted. The contractor shall be responsible for watering and maintenance of levels and the lawn for 30 days or till the grass forms a thick lawn free from weeded and fit for moving whichever is later. Generally planting in other direction at 15 cm, 10 cm, spacing is done in the case of large open spaces, at 7.5 cm spacing in residential lawn and at 5cm spacing for Tennis Court and sports ground lawn. Rates are including cost of labour and material **(grass shall be paid separately.)**

23.11.2 During the maintenance period, any irregularities arising in ground levels due to watering or due to trampling by labour, or due to cattle straying thereon, shall be constantly made up to the proper levels with earth as available or brought from outside as necessary, Constant watch shall be maintained to ensure that dead patches are replanted and weeds are removed.

23.11.3 Measurements

Length, breadth of the lawn grassed shall be measured correct to 0.1 meter and the area shall be calculated in sqm. correct to two places of decimal.

23.11.4 Rate

The rate shall include of all the labour and material involved in all the operations described above, excluding supply of the requisite quantity of good earth and grass so needed for properly maintaining the levels of the lawns. **(payment of grass to be paid separately).**

23.12 RENOVATION OF LAWNS

23.12.1 The area shall be first weeded out of all undesirable growth. The entire grass shall be scrapped (cheeled) without damaging roots and level of the grounds. Slight irregularities in surface shall be levelled off and the area shall then be forked so as to aerate the roots of the grass without, however up-rooting them.

Specified quantity of sludge or manure shall than be spread uniformly with wooden straight edge (phatti) as directed by the Engineer-in-charge. The area shall then be slightly sprinkled with water so as to facilitate proper integration of the manure or sludge with the soil and later flooded. The contractor shall be responsible for watering, proper maintenance and tending of the lawn for 30 days or till the grass forms a lawn fit for mowing, whichever is later.

During the above operations, all undesirable growths shall be constantly weeded out and all rubbish removed and disposed off as directed by the Engineer-in-Charge.

23.12.2 Measurements

Length, breadth of the lawn renovated shall be measured correct to 0.1 meter and the area shall be calculated in sqm. correct to two places of decimal.

23.12.3 Rate

The rate shall include of all the labour and T&P (excluding RH pipe/grass) involved in all the operations described above, excluding the supply of the requisite quantity of good earth if so needed for proper maintenance of the levels of the lawns. The cost of the sludge or manure shall be measured and paid for separately, unless its supply is specifically included in the description of the item.

23.13 UPROOTING RANK VEGETATION AND WEEDS AND PREPARING THE GROUND FOR PLANTING 'SELECT GRASS NO. 1'

23.13.1 Initially the area shall be dug up to a depth of 30 cm. and weeds and rank vegetarian with roots removed thereon by repeated forking. The whole area then shall be retrenched to a depth of 60 cm in the same manner as described in 23.1. Clods of excavated earth shall then be broken upto the size not more than 75 mm in any direction. The area shall then be flooded with water and after 10 days and within 15 days of flooding, weeds shall be uprooted carefully. The rubbish arising from the above operations shall be removed and disposed off in a manner directed by the Engineer-in-charge, away from the site. The earth shall then be rough dressed and fine dressed as described in 23.6 & 23.8.

23.13.2 Measurements

Length, breadth of uprooted area shall be measured correct to 0.1 meter and the area shall be calculated in sqm. correct to two places of decimal.

23.13.3 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above.

23.14 EXCAVATION AND TRENCHING FOR PREPARATION OF BEDS FOR HEDGE AND SHRUBBERY

23.14.1 Beds for hedges and shrubbery are generally prepared to width of 60 cm. to 125 cm. and 2 to 4 meters respectively.

23.14.2 Beds for hedges and shrubbery shall be prepared in the following manner. The beds shall first be excavated to a depth of 60 cm. and the excavated soil shall be stacked on the sides of the beds. The surface of the excavated bed shall then be trenched to a further depth of 30 cm, in order to loosen the soil, in the manner described in 23.1. No flooding will be done at this stage but the top surface shall be rough dressed and levelled. The excavated soil from the top 60 cm depth of the bed stacked at the site shall then be thoroughly mixed with sludge over manner in the proportion 8:1 by ratio or other proportion described in the item. The mixed earth and manure shall be refilled over the trenched bed, levelled neatly and profusely flooded so that the water reaches even the bottom most layers of the trenched depth of the bed. The surface after full subsidence shall again be refilled with the earth and manure mixture, watered and allowed to settle and finally fine dressed to the level of 50 mm to 75 mm below the adjoining ground or as directed by the Engineer-in-Charge. Surplus earth if any, shall be disposed off as directed by the Engineer-in-charge. Any surplus earth if removed beyond initially lead shall be paid separately. Stones, bricks bats and other foreign matter if met with during excavation or trenching shall be removed and stacked within initially lead & lift, such material as is declared unserviceable by the Engineer-in-charge shall be disposed by spreading and levelling at places ordered by him. If disposed outside the initial lead & lift, then the transport for the extra leads will be paid for separately. If a large proportion of material unsuitable for the hedging and shrubbery operations is met with and earth from outsides is required to be brought in for mixing with manure and filling, the supply and stacking of such earth will be paid for separately.

23.14.3 Measurements

Length, breadth and depth of the pit excavated and trenched shall be measured correct to a cm. The cubical contents shall be calculated in cubic meter correct to two places of decimal.

23.14.4 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above. The rate shall not include the cost of supply & stacking of the manure unless the same is specifically included in the description of the item.

23.15 DIGGING HOLES FOR PLANTING TREES

23.15.1 In ordinary soil, including refilling earth after mixing with oil cake, manure and watering.

23.15.1.1 Holes of circular shape in ordinary soil shall be excavated to the dimensions described in the items and excavate soil broken to clods of size not exceeding 75 mm in any direction, shall be stacked outside the hole, stones, brick bats, unsuitable earth and other rubbish, all roots and other undesirable growth met with during excavation shall be separated out and unserviceable material removed from the size as directed. Useful material, if any, shall be stacked properly and separately. Good earth in quantities as required to replace such discarded stuff shall be brought and stacked at site by the contractor which shall be paid for separately.

The tree holes shall be manured with powdered Neam/castor oil cake at the specified rate along with farm yard manure over sludge shall be uniformly mixed with the excavated soil after the manure has been broken down to powder, (size of particle not be exceeded 6 mm in any direction) in the specified proportion, the mixture shall be filled in to the hole up to the level of adjoining ground and then profusely watered and enable the soil to subside the refilled soil shall then be dressed evenly with its surface about 50 to 75 mm below the adjoining ground level or as directed by the Engineer-in-charge.

23.15.1.2 Measurements : Holes shall be enumerated.

23.15.1.3 Rate: The rate shall include the cost of all the labour and material involved in all the operations described above, excluding the cost of supply and stacking the requisite quantity of manure/sludge and oil cake.

23.15.2 In Soil other than Ordinary Soil

23.15.2.1 Where holes are dug in (a) Hard soil (b) Ordinary rock or (c) Hard rock, the above soils occurring independently over in conjunction with each other and /or ordinary soil in any hole, the different excavated soil shall be stacked separately. Excavation in hard rock shall be carried out by chiseling only.

23.15.2.2 The stack measurement of ordinary rock and hard rock shall be reduced by 50% and of soil by 20% to arrive at the excavated volume. This excavation shall be paid for as extra over the rate for holes dug in ordinary soil above, at rate appropriate to particular soil concerned.

23.15.2.3 Sufficient quantity of good soil to replace the solid volume of stones, brick bats, unsuitable earth and other rubbish, all roots and other undesirable growth, ordinary and hard stacks shall be brought and stacked at site but the supply and stacking of such shall be paid for separately.

23.15.2.4 The useless excavated stuff shall be disposed off by spreading at places as ordered by the Engineer-in-charge. If such places are outside initially leads, carriage for the extra lead shall be paid for separately.

23.15.2.5 The ordinary soil excavated from the hole and the earth brought from outside shall then be mixed with manure screened through sieve of IS designation 16 mm in the proportion specified in the description of the item and filled with the pit and the same watered and finally dressed.

23.15.2.6 Measurements: The pit shall be enumerated. The volume of excavation in soil and other than a ordinary soil shall be determined by reducing the stack volume of the relevant soil with respective percentage for voids specified in 23.14.2.2.

23.15.2.7 Rate: The rate shall include the cost of all the labour and material involved in all the operations described above, including mixing refilling, watering, dressing etc. but shall not include (a)

cost of manure over sludge (b) cost of supplying and stacking of good earth for replacement and (c) the cost of carriage beyond initial lead for disposing off useless materials. The excavation other than that of ordinary soil shall be paid extra over and above the rate if excavation in ordinary soil.

23.16 M.S. FLAT IRON TREE GUARD

23.16.1 M.S. Iron Riveted Tree Guard

23.16.1.1 The tree guard shall be 600 mm in diameter and 2 meter high above ground level and 25 cm in below ground level.

23.16.1.2 The tree guard shall be framed of 4 nos. 25 x 6 mm M.S. flat 2 meter long excluding displayed outward at lower and upto an extent 10 cm and 8 nos. 25 x 3 mm vertical M.S. Flat Rivetted to 3 Nos. 25 x 6 mm Flat iron rings in two halves, bolted together 8 mm dia and 30 mm long M.S. bolts and nuts. The entire tree guard shall be given two coats of synthetic enamel paint of approved brand and manufacturer of required shade over a priming coat of ready mixed steel primer of approved brand and manufacturer. The design of tree guards shall be shown in the drawing.

23.16.1.3 Measurement : The tree guard shall be enumerated.

23.16.1.4 Rate: The rate shall include the cost of all the labour and material involved in all the operations described above.

23.16.2 M.S. Flat Iron Welded Tree Guard

23.16.2.1 The tree guard shall be 600 mm in diameter and 2 meter high above ground level and 25 cm in below ground level.

23.16.2.2 The tree guard shall be framed of 4 nos. 25 x 6 mm MS. Flat 2 metres long excluding displayed outward at lower and upto an extent 10 cm and 8 Nos. 25 x 3 mm vertical M.S. Flat Rivetted to 3 nos. 25 x 6 mm flat iron rings in two halves, bolted together 8 mm dia and 30 mm long M.S. Bolts & nuts. The entire tree guard shall be given two coats of synthetic enamel paint of approved brand and manufacturer of required shade brand and manufacturer of required shade over a priming coat of ready mixed steel primer of approved brand and manufacturer. The design of tree guards shall be shown in the drawing.

23.16.2.3 Measurement : The tree guard shall be enumerated.

23.16.2.4 Rate: The rate shall include the cost of all the labour and material involved in all the operations described above.

23.17 FILLING MIXTURE OF EARTH & SLUDGE OVER MANURE

23.17.0 The separately specified earth and sludge shall be broken down to particles of size not exceeding 6 mm in any directions before mixing. Good earth shall be thoroughly mixed with sludge over manure in specified proportions as directed by Officer-in-Charge. During the process of preparing the mixture as above, trenches shall be flooded with water and levelled.

23.17.1 Measurements

Measurement shall be made in (Length, breadth and height of stacks) cubic meter. The cubical contents shall be worked out to the nearest two places of decimal in cubic meter.

23.17.2 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above, but do not include the good earth, sludge or manure which will be paid separately.

23.18 EXCAVATION OF DUMPED STONE OR MALBA

23.18.1 Excavation operations shall include excavation and getting out water if required. During the excavation stone, brick bats and other foreign material if met shall be removed and stacked within 50

meter leads and lifts. Such material as is declared unserviceable by the Engineer-in-Charge be disposed within 50 m. The excavated surface shall be neatly dressed and levelled.

23.18.2 Measurements

Measurement shall be made in (Length, breadth and height of stacks) cubic meter. The cubical contents shall be worked out to the nearest two places of decimal in cubic meter.

23.18.3 Rate

The rate shall include the cost of all the labour and material involve in all the operations described above.

23.19 EXCAVATION IN BAJRI PATH

23.19.1 All excavated operations shall include excavation and stacking of serviceable and unserviceable material. Excavated surface of Bajri path shall be removed and stacked upto 50 meter lead and disposed material neatly dressed.

23.19.2 Measurements

Same as 23.18.2.

23.19.3 Rate

Same as 23.18.3.

23.20 EXCAVATION OF WATER BOUND MACADAM

23.20.1 All excavated operations shall include excavation, stacking of serviceable and unserviceable material. Excavation shall be straight and uniform in width. Soling stone and aggregate obtained from excavation of W.B.M. shall be stacked separately and unserviceable material disposed off with lead upto 50 meter and lift upto 1.50 meter and neatly dressed.

23.20.2 Measurements

Measurement shall be made in (Length, breadth and height of stacks) cubic meter. The cubical contents shall be worked out to the nearest two places of decimal in cubic meter.

23.20.3 Rate

The rate shall include the cost of all the labour and material involved in all the operations described above.

23.21 FLOODING THE GROUND WITH WATER AND MAKING KIARIES

23.21.1 The water for flooding shall be of soft water and free from chemical and good for growing the trees and shrubs etc. Before flooding the kiaries shall be made in required size and shape as per directions of Officer-in-charge. After uprooting weeds from the trenched area and uprooting vegetation, kiaries shall be dismantled.

23.21.2 Measurements

Measurement shall be made in sqm. of area.

23.21.3 Rate

The rate shall be for 100 sqm of area and include the cost of all the labour and material involved in all the operations described above.