RETS
PRACTICAL GUIDE BOOK SERIES

PLUMBING and PIPE LINE WORK

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RAILWAY ENGINEERING TECHNICAL SOCIETY
PUNE - INDIA

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PLUMBING AND PIPE LINE WORK

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RAILWAY ENGINEERING TECHNICAL SOCIETY

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PREFACE

Water supply and Sanitation has acquired a very important position in the building construction and maintenance field, so much so that it has become a separate discipline and specialists in the field, prepare schemes for building and structures. Development in Plumbing, fixtures and pipes are taking place very fast and new materials and designs are coming to the market every day. The subject gains more importance as more and more vertical rise buildings are being constructed in India. In Indian Railways as also other Government sectors, however the officials aware of the intricacy of the work is generally at quite a low level, many times not well educated to appreciate the modern and systematic steps of working of newer materials and designs .

The Practical Guide book on 'Plumbing and Pipe line work' deals with various design and installation procedures explained in a very simple manner. Chapter-1 is an introduction to the various tools and proper method of handling them. Chapter-2 covers practically all the types of pipes of different materials available, their specifications, joining methods, fittings, laying under ground or over ground, fixing on walls, passing through walls and over obstructions or suspended by means of supports. Chapter-3, is a very illustrative description of 'Fixtures' used in water supply and sanitation, like taps, cocks, mixers tap, modern taps, wash basins, urinals, water closets, flushing cisterns, valves, traps etc. The step by step disassembly and assembly procedures of the fixtures, their installation is a well researched presentation and is expected to be very educative not only for Engineers and supervisors but also the skilled artisans. Chapter-4 is a very simplified approach to design the water supply distribution systems for small colonies and settlements. Apart from explaining the various concepts, several Tables and Nomograms, along with solved examples are provided to assist an engineer of average knowledge to design the water supply distribution system and also analyse the reasons for inadequate pressure or discharge at any supply point and take steps to rectify it. The several forms of available overhead tanks RCC,PSC, Pressed steel, FRP and polyethylene tanks, their comparative merits demerits, specifications, method of fixing etc have been included to help the Engineer make an informed decision to select the right material and form. Chapter-5 'Water supply from Subsurface sources' will help equip the Engineers and Supervisors with knowledge about various techniques of boring the wells, choosing the proper type of pump, manual, diesel operated or electric. Some common problems with the pumps and ways to rectify, will be useful for maintenance Engineers. The basics of 'Rain Water harvesting' along with the data in tabular form shall be helpful for the Engineers and supervisors to design and implement such schemes in comparatively dry areas or way side stations. Chapter-6, the last Chapter gives practical information in regard to 'Drainage of buildings' sewerage and storm water and the Design Tables along with solved examples will enable the Engineer and Supervisors to design the drainage system with out any involved calculations.

The material for the book has been compiled by Shri J. M. Patekari, who is a Post Graduate in Mechanical Engineering, after great efforts and research from the suppliers of fixtures and pipes, the plumbing engineers and contractors, consulting 'Uniform Plumbing Code-India', various IS codes and available printed and material from Internet. Replicating the codes etc has been purposely avoided to keep the matter understandable by any literate person with some interest in the field of 'Plumbing and Pipe Work'. This book should be very useful and a prized possession for all engineers dealing with design, construction or maintenance of water supply or sanitation of small or big colonies. Inspite, of much effort to make it a complete book for practical engineer, on the subject, there would be certain details which have not been covered or are omitted. The book can be improved further by suggestions and contributions from readers, which are welcome.

8-1-2009

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CONTENTS

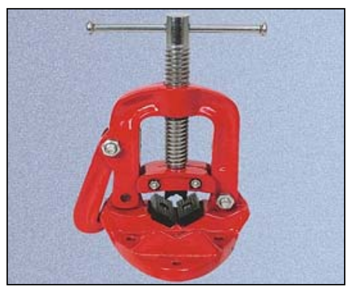
Chapter 1

PLUMBING TOOLS

Plumber requires different tools to perform various operations. The tools includes Bench vice, Pipe vice, Pipe wrench, Chain wrench, Basin wrench, Spud wrench, Pipe cutter, Hack saw, Pipe die set, Pipe reamer, Pipe bending machine, Spanners, Pliers, Screw drivers, Chisels, Hammers, Cocking tools, Files, Taps, Drills and Drill machine, Chain pulley block, etc. Description of these tools is given below.

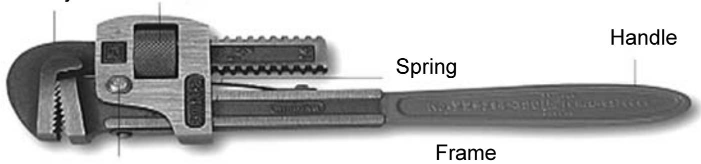
1 Bench vice:- Bench vice is used for holding flat or square work piece. This vice is fixed on the bench as the name indicates. There are two jaws one fixed and other movable. The bench vice are designated according to the length of the jaw. The bench vice are available in the market in various sizes out of which 50mm, 100mm, 125mm, 150mm and 200mm size are commonly used.

2 Pipe vice:- Pipe vice is used for holding the pipe for performing various operations. Jaws of pipe vice are of 'V' shaped unlike the jaws of bench vice which are flat. It is essential tool for plumber. The frame of pipe vice is made out of Malleable Iron. The jaws are made up of hardened carbon steel. Base is fastened to a bench provided with holes. The frame is self locking with all cast components. Pipe vices are available in market in the various sizes for holding pipe size up to 37mm,50mm,63mm,75mm and 100mm.



3 Pipe wrench:- One of the first tools people associate with plumbing is the pipe wrench . It's adjustable and has lots of play in the grip. Its teeth faces inward. Plumber probably won't even have to lift it off the pipe he is turning. Normally, he shall need two pipe wrenches: one to hold the pipe steady and a second to remove the nut or other attachment.

The pipe wrench is an adjustable wrench used for turning iron pipes and fittings with a rounded surface. The design of the adjustable jaw allows it to rock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together. Teeth angled in the direction of turn dig into the soft pipe. They are not for use on hard hex nuts. They are usually made of either steel or aluminium. Teeth, and jaw kits (which also contain adjustment rings and springs) are available as spare parts to repair broken wrenches.



3.1 The common size of pipe wrench used for different diameter pipes is as below:-

Total length when open		Pipe capacity
(INCH)	(MM)	O.D. (MM)
8	200	27
10	250	34
12	300	42
14	350	49
18	450	60
24	600	76
36	900	102
48	1200	141

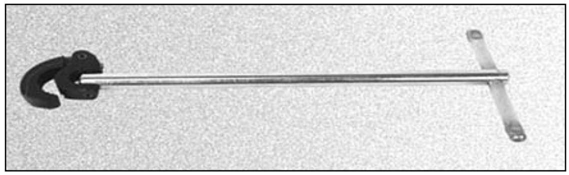
3.2 Important points to be considered:-

- Select a pipe wrench whose opening exactly fits the pipe.
- Do not use pipe extensions to increase the leverage of any pipe wrench.
- Never use a pipe wrench on square stock, such as pipe tap or extractor.
- Do not use a pipe wrench to bend, raise or lift the pipe.

4 Chain wrench:-

Chain wrench tongs are used for turning and fixing large diameter threaded pipes. Jaw with chain is attached to a lever. Chain is rotated around the pipe and the pipe is rotated in either direction. Common sizes of chain wrenches available are for holding up to 50 mm,75mm,100 mm, 150mm, 200mm, 250mm, 300mm pipes.

5 Basin wrench:-



Another handy plumbing tool is the basin wrench which has a spring-loaded jaw and a pivoting head. The basin wrench is useful for getting at faucet nuts in spaces not easily accessible. The size of basin wrench is available for holding nut of size between 10mm to 27mm.

6 Spud wrench:-

Spud wrench features narrow jaws to fit into tight places. Smooth, toothless jaws ideal for square or rectangular pipe or fitting. A spud wrench is good for working on the fittings beneath sinks, such as the nut holding the drain tailpiece in place.

7 Pipe cutter:-

Pipe cutter is used to cut the pipe. The procedure for cutting the pipe is as follows.

It is placed around a pipe and tightens so that it's just tight, it should not be over tightened, which might dent the pipe. Rotate the cutter around the pipe once or twice, then tighten it again. Repeat the process until the cutter breaks through the pipe, leaving a smooth cut.

Normally these are available for cutting of pipe sizes up to 25mm, 50mm, 75mm, 100mm, 150mm.

8 Hack saw:-

Different types of hack saw blades:-

JUNIOR HACKSAW BLADES

A virtually unbreakable blade in normal use of cutting metal and other materials.

CARBON STEEL HACKSAW BLADES

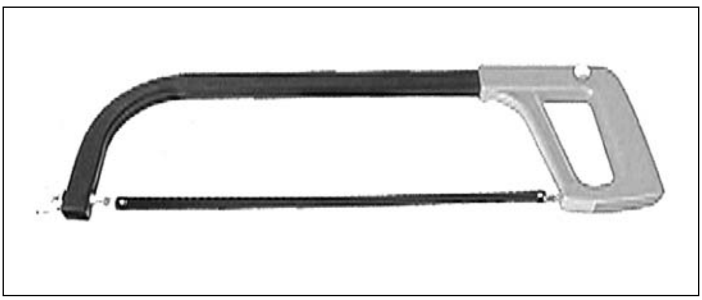
Produced from high quality carbon steel, designed for general purpose cutting of mild steel, aluminium etc.

COPING SAW BLADES

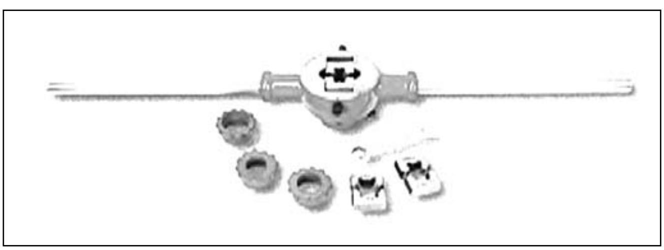
Actually set and shaped teeth to ensure speed of cutting and ease of turning. Out of these blades generally carbon steel hacksaw blades are used by plumbers. Hack saws are used to cut the pipes. All Hacksaw blades are designated by the name, type, nominal length, width, thickness, pitch and the symbol for material as mentioned in IS:2594:1977.

Normally 300 mm long and 10 mm wide blades made up of HSS (High speed steel) are used for pipe cutting.

Tooth per inch (T.P.I) : Is the number of teeth per inch of the cutting edge and is measured from outside base of each tooth. Normally hack saws have 18-22 TPI.



9 Pipe Die set:-



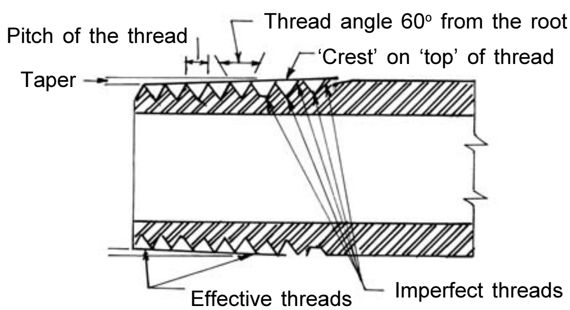
The pipe die set is used for threading external taper threads on pipe. Pipe is fixed in the pipe vice and threading is carried out with the help of die set. The die set is available in the sizes varying between 6.35 mm to 50.8 mm.

Size (MM)
6.35 to 25.4
6.35 to 31.75
12.7 to 31.75
31.75 to 50.8
12.7 to 50.8

9.1 Procedure of threading GI pipe using Die Set

A screwed joint requires that threads be cut on the outside of a pipe (male threads) and the inside of a fitting (female threads) be factory prepared. The threads used for pipe are tapered thread. Beyond a pipe size of more than 25.4 mm, it is common to use powered tools when cutting threads.

Because of the taper, a pipe thread can only screw into a fitting a certain distance before it jams. A simple thumb rule for installing tapered pipe threads, both metal and plastic, is finger tight plus one to two turns with a wrench.



Nominal Bore mm (inches)	Useful length of threads (Effective threads) mm	Recommended length of threading (mm)
15 (1/2")	15	18.6
20 (3/4")	16.3	19.9
25 (1")	19.1	23.7
32 (1 1/4")	21.4	26.0
40 (1 1/2")	21.4	26.0
50 (2")	25.7	30.3
65 (2 1/2")	30.2	34.8
80 (3")	33.3	37.9
100 (4")	39.3	43.9
125 (5")	43.6	48.2
150 (6")	43.6	48.2

Following procedure is adopted for threading of pipes:-

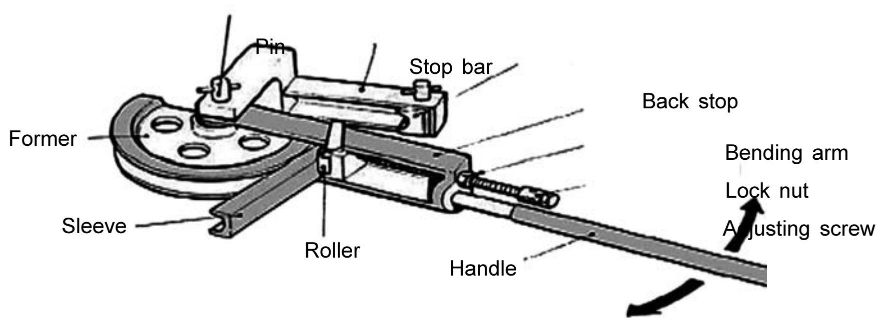
1. For out side threading take the required size of pipe threading die.
2. Fix the GI pipe in the pipe vice tightly.
3. Cut the pipe to required size in exactly right angle. Always use cutting oil for lubrication and removal of cut pieces.
4. Hold the die in right angle to the pipe; put some oil on the pipe.
5. Cut the thread on the pipe with the help of die rotating in clockwise direction. Rotate the die in anticlockwise direction so that cut material will come out. It is important to clean the pipe of any burrs or chips resulting from the cutting process.

10 Pipe reamer:- They are used for de burring, chamfering and boring operations of the pipe. After cutting or threading the pipe the burr or metal parts remain at the inside edge of the pipe. These pieces are removed with the help of pipe reamer.

Pipe reamers have tapered edge which can be rotated by handle. The reamers are designated by the diameter of reamer, number of flutes and angle of reamer such as 12.4 mm, 3 Flutes, 90^0. Various size of reamers are available in the market depending upon the size of the pipe the reamer can be selected.

11 Pipe bending machine:- Pipes are cold bent to minimize the need for expensive connectors and to reduce the cost of installing pipe systems. Bending may be done by hand or machine. The machines may be hand or power operated.

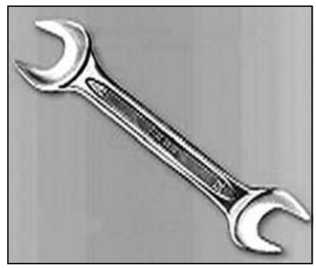
11.1 Procedure for bending of the pipes:-



1. Fix wooden stopper to one end of the pipe.
2. Fill the pipe with the sand completely.

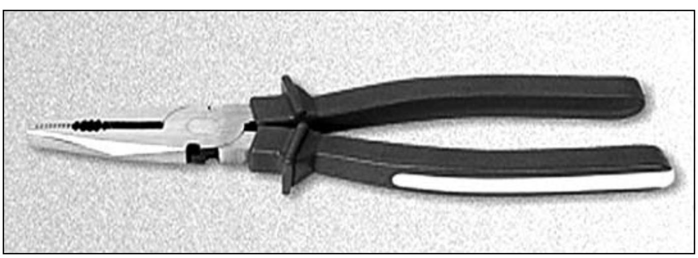
3. Fix the wooden stopper from other side of the pipe.
4. Fix the pipe in the pipe bending machine such that the location of bend comes to the centre of the pulley.
5. Tight the adjustment screw.
6. Bend the pipe with the help of lever.
7. Stop bending when pipe bends through the required angle.
8. Check the bend for correctness.
9. Remove wooden stoppers and sand inside the pipe.

12 Spanners:- Spanners are used for fixing and opening nuts and bolts. Different types of spanners are available such as double ended spanner, ring spanners, socket spanners. The material used are Chrome Vanadium Steel / Carbon Steel. Spanners are available in set of different sizes as given below.



SIZES: 6 X 7, 8 X 9, 10 X11, 12 X 13, 14 X 15, 16 X 17, 18 X 19, 20 X 22, 21 X 23, 24 X 27, 25 X 28, 30 X 32 (mm.)

13 Pliers:- Pliers are hand tools, used primarily for gripping objects by using leverage. Pliers are designed for numerous purposes and require different jaw configurations to grip, turn, pull, or crimp a variety of things. Many types of pliers also include jaws for cutting. Normally these are available in the sizes of 150mm, 175 mm and 200 mm lengths.

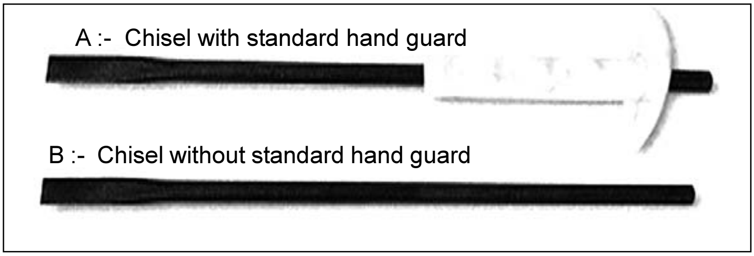


14 Screw drivers:- The screwdriver is a device specifically designed to insert and tighten, or to loosen and remove, screws. The screwdriver comprises a head or tip which engages with a screw, a mechanism to apply torque by rotating the tip, and some way to position and support the screwdriver. A typical hand screwdriver comprises

an approximately cylindrical handle of a size and shape to be held by a human hand, and an axial shaft fixed to the handle, the tip of which is shaped to fit a particular type of screw. The handle and shaft allow the screwdriver to be positioned and supported and, when rotated, to apply torque. Screwdrivers are made in a variety of shapes and sizes. Various sizes available in market are shown below:-

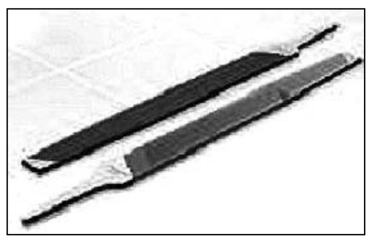
Blade dia. mm	Blade length mm	Tip dimensions mm
2	075	2.0 x 0.4
2	100	2.0 x 0.4
3	075	3.0 x 0.5
3	100	3.0 x 0.5
3	150	3.0 x 0.5
3	200	3.0 x 0.5
3	250	3.0 x 0.5
4	075	4.0 x 0.6
4	100	4.0 x 0.6
4	150	4.0 x 0.6
4	200	4.0 x 0.6
4	250	4.0 x 0.6
5	075	5.0 x 0.7
5	100	5.0 x 0.7
5	150	5.0 x 0.7
5	200	5.0 x 0.7
5	250	5.0 x 0.7
5	300	5.0 x 0.7
6	100	6.0 x 0.9
6	150	6.0 x 0.9
6	200	6.0 x 0.9
6	250	6.0 x 0.9
6	300	6.0 x 0.9
8	150	8.0 x 1.0
8	200	8.0 x 1.0
8	250	8.0 x 1.0
8	300	8.0 x 1.0
8	350	8.0 x 1.0
10	200	10.0 x 1.4
10	250	10.0 x 1.4
10	300	10.0 x 1.4
10	350	10.0 x 1.4
10	400	10.0 x 1.4
10	450	10.0 x 1.4

15 Chisels:- A chisel is a tool with a cutting edge of blade on its end, for cutting a hard material. Chisels are also used to remove waste metal when a very smooth finish is not required or when the work cannot be done easily with other tools, such as a hacksaw, file, bench shears or power tools. In use, the chisel is forced into the material to cut the material. The driving force may be manually applied or applied using a mallet or hammer. Plumbers uses chisels mostly for cutting CI pipes.



16 Hammers:- A hammer is a tool meant to deliver blows to an object. The most common uses are for fitting parts, and breaking up objects. Hammers are often designed for a specific purpose, and vary widely in their shape and structure. Usual features are a handle and a head, with most of the weight in the head. Normally these are available as 115 gm, 225 gm, 340 gm, 450 gm, 675 gm, 900 gm and 1120 gms. etc.

17 Files:- Files are used for filing the surface. Files are manufactured from high carbon steel and heat treated. Files are classified as rough and smooth files according to its tooth and flat, round, half round, square, triangular, knife edge according to its shape. Normally rough files in flat & round of 250 mm length are used for plumbing work.



18 Taps:- Taps are used for cutting internal threads. Proper size hole should be drilled before tapping. Taps are available in a set of three taps. Firstly taper tap, then intermediate and then final tap is used. Taps can be held in tap handle for manual operation. Power handles are also available for operating taps. Normally these are available from 1.4mm to 60 mm (1/16” to 3”) size.

Tap set


Tap handle

18.1 Procedure for cutting internal threads:-

1. Select the size of tap equal to size of thread desired to cut.
2. Fix the tap into the tap handle and tight the handle.
3. Hold the tap right angle to the hole in which threads are to be cut.
4. Rotate the tap clock wise to complete length of threads. Always use cutting oil for lubrication and removal of cut pieces.
5. Remove the tap by rotating anticlockwise.

19 Caulking tools:- Caulking tools are used for strengthening the cocked joints. The shape of the tool is similar to chisel except **S** shaped bend provided to it. Due to its shape, the caulking compound such as lead, cement is forced in to the joint.

20 Drills and drill machine:- A drill is a tool with a rotating drill bit used for drilling holes in various materials. The drill bit is gripped by a chuck at one end of the drill, and is pressed against the target material and rotated. The tip of the drill bit does the work of cutting into the target material, either slicing off thin shavings. Plumbers normally use hand operated drilling machine for drilling holes. All sizes of drill bits are available depending upon the size of hole to be drilled.

21 Chain pulley block:- Chain pulley blocks are used for laying big pipes. The worm and worm wheel arrangement allows lifting heavy items with less effort. Chain pulley block is fitted on the tripod. Normally these are available in 0.5 MT, 1.0 MT, 2.0 MT, 3.0 MT, 5.0 MT, 7.5 MT & 10 MT load lifting capacity. For laying pipes smaller size up to 2.0 MT chain pulley blocks are used.

Chapter 2

PIPES FOR PLUMBING SYSTEM

1.0 Introduction:- Any plumbing system involves use of pipes for either water supply or for drainage system. Selection of proper size and material is an important step to provide proper plumbing system.

The installation of plumbing system deals largely with the joining of pipes and tubes, which are made of various materials. The plumber should be well trained about how to join these materials properly. It is the job of the supervisor to determine by inspections whether or not the plumber has applied his skills properly. Joints and all parts of plumbing system must be both gas-tight and water tight. Improper joints on water piping will result leaks, which can cause a great waste of water, considerable damage to property, and, depending on whether the leak is contamination of the drinking water by infiltration of substances, detrimental to human health.

1.1 Different materials are used for manufacturing pipes in plumbing system. Cast Iron, Mild Steel (GI), Steel, Concrete, Asbestos Cement, Stoneware and different combination of Plastic are commonly used materials for pipes. Type of pipes normally used for various applications are given below:-

General application of pipes

Type of pipe	Location
CI pipes	Used for water distribution main. These pipes are also used for sewage carrying purpose
Mild Steel (GI)	Used for water supply and distribution, generally for smaller diameter GI pipes are used
Steel pipes	Used for water supply main, generally for larger diameter steel pipes are used
Concrete	Used for Water, Sewage carrying
Asbestos cement	Used for carrying water main
Stoneware	Used for carrying sewage
Plastic Pipes	Used for building drainage and also for water supply

2.0 Cast iron pipes:- The C.I pipes are manufactured by centrifugal casting or spinning now a days. Cast iron pipes are made by pouring molten gray iron into revolving water cooled mould in which the molten metal forms on the inside of the mould, producing seamless pipe of even thickness and smooth finish. They have higher resistance to corrosion and have long life. Because of its thickness it can withstand external loads better than other pipes. The pipes have socket at their upper end (upstream end) and spigot at their lower end (down stream end). The pipes are coated with bituminous paint externally.

The spun CI pipes are available in diameter from 80.00 mm to 1050mm and lengths from 3.66 m to 6.0 m.

The spun Cast Iron pipes are used for water and sewage and governed by IS 1536-1976. CI pipes are available with flanged ends or one end with socket and other with spigot.

2.0.1 The classifications according to thickness of pipe are as follows:-

Class of pipe	**Thickness**	**Hydrostatic test pressure after installation**
LA	=10/12(7 +0.02 DN) [DN= nominal diameter of the pipe.]	1.2 MPa
A	10 % more thickness than class LA	1.8 MPa
B	20 % more thickness than class LA	2.4 MPa
C (for special uses)	30 % more thickness than class LA	-
D (for special uses)	40 % more thickness than class LA	-
E (for special uses)	50 % more thickness than class LA	-

Note:-

1) The CI pipes are available either with socket & spigot ends or with flanged ends.
2) The internal diameter of the pipe is same irrespective of the class of the pipe.
3) For flanged pipes the test pressure is slightly less.
4) The standard weights and thickness of pipes and their tolerances for different diameter in mm are indicated in **Appendix-1.**

2.0.2 Use of old CI pipes

1) Old pipes should be thoroughly tested for soundness and cracks , chip outs
2) Scrapping should be done.
3) Holes should be plugged with proper size plug.
4) The pipe should be tested for pressure at least 100m head.
5) The pipe should be applied with food grade bituminus paint.

There are several other methods also available to repair damaged pipes and use of old pipes like fixing mechanical joints over the cracked/ damaged pipes.

2.1 CI pipe fittings: The pipe fittings (bends, heads, offsets, branches, shoes etc.) are sand caste. They shall confirm to the same thickness and dimensions specified for the corresponding sizes of straight pipes. Various CI pipe fittings are shown in **APPENDIX-1(A).**

2.2 Joining of CI pipes: There are various methods of joining CI pipes, as under,

i) Push-on joint for S&S end pipe
ii) Lead caulking joint for S&S end pipe
iii) Cement mortar joint for S&S end pipe
iv) Flanged joint for flange end pipe.

2.2.1 Push-on joint using gasket:-

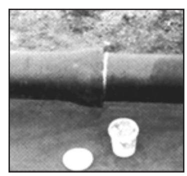
The step wise procedure is described below:-

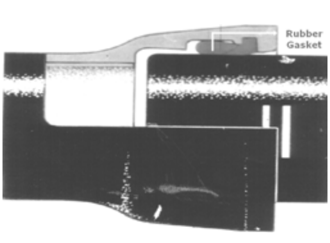
1. Clean completely the socket from outside and inside including groove for gasket. Remove excess paint and foreign material. Also clean the spigot from inside and outside. Check the chamfer is properly provided.

2. Take the correct gasket to be used. Insert the gasket in the groove provided in the socket properly.

3. Take lubricant which is not having petroleum base and apply it on gasket entirely without allowing to drop it on the pipe.

4. Apply the lubricant on the chamfered end of spigot. Use sufficient quantity of lubricant .





5. Align the pipes to proper alignment. Push the spigot end in to the socket until it is ensured that the spigot end reached to proper location.

6. Necessary deflection can be given to the assembly as per design. The finished joint and the cross-section details of the finished joint is shown in adjoining figure.

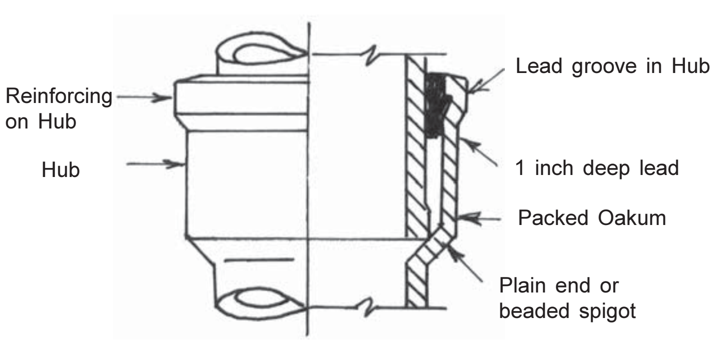
2.2.2 Procedure for connection of CI pipes by lead caulked joint:-

1. Before joining, the interior of the socket and the exterior of the spigot should be thoroughly cleaned and dried.

2. The spigot end is inserted into the socket right up to the back of the socket and carefully centered such that there is uniform annular space for filling with joining material.

3. The annular space between the socket and the spigot is filled with few turns of (Oakum)spun yarn formed into ropes of uniform thickness soaked in neat cement slurry. These are pressed home (rammed) into the socket by means of a caulking tool. No piece of rope should be shorter than the circumference of the pipe. The spun yarn may become infected with bacteria, which may contaminate the water therefore, should be effectively sterilized before use. Alternatively approved proprietary brands of sterilized spun yarn may be used.
4. The jointed pipeline shall be adjusted to required levels and alignment.
5. The lead shall be melted so as to be thoroughly fluid. Any scum or dross which may appear on the surface of the lead during melting, shall be skimmed off or removed.
6. Take a rope and tie a knot at one end of the rope. Cover it with clay. The remaining annular space between the socket and the spigot is filled with the turns of rope covered with clay keeping the knotted end of the rope outside the joint.
7. Cover the joint with clay to form a mould, keeping the knotted end of the rope outside. Pull the rope smoothly holding the knot. Mould will be prepared after complete removal of the rope. Prepare cup shape at the mouth of the mould.
8. The lead should have thoroughly melted by now and the joint shall be filled in one pouring. After lead has been poured into the joint, the lead shall be thoroughly caulked. Any lead outside the socket shall be removed with a flat chisel and then the joint caulked round three times with caulking tool and hammer.

   The cross-section of a finished joint is shown below:



Lead and Oakum joint

The approximate weight of lead and yarn required and the finished depth of lead joint measured from the face of the socket for various sizes of CI pipes are indicated in table below:-

Internal diameter of pipe (mm)	Finished depth of lead joint measured from the face of the socket (mm)	Approximate weight of lead per joint (kg)
80	45	1.8
100	45	2.2
125	45	2.6
150	50	3.4
200	50	5.0
250	50	6.1
300	50	7.2
350	55	8.4
400	55	9.5
450	55	14.0
500	60	15.0
600	60	19.0
700	60	22.0
750	60	25.0
800	65	31.5
900	65	35.0
1000	65	41.0

NOTE:- The quantities of lead given are provisional and a variation of 20 percent is permissible either way.

2.2.3 Cement mortar joint

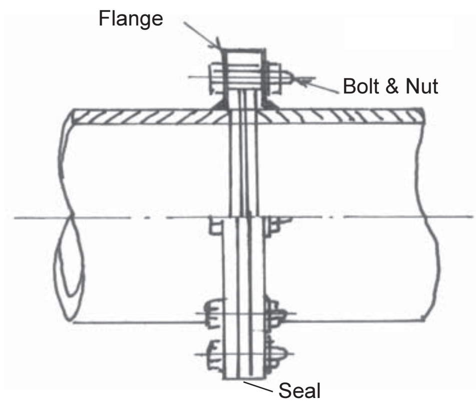
The step wise procedure is given hereunder:

Step1 to 3 are same as for procedure mentioned above for Lead Caulked Joint.

4. The jointed pipeline shall be adjusted to required levels and alignment. The joint shall then be filled with stiff cement mortar 1:2 (1 cement :2 fine sand) well pressed with caulking tool and finished smooth at top at an angle of 45^0 sloping up. The joint must be kept wet for not less than 7 days by tying a piece of gunny bag, four fold , to the pipe and keeping it moist constantly.

2.2.4 Flanged joint:- A flanged joint is available in a large variety of mating surfaces (plain, serrated, grooved, seal, welded or ground and lapped for metal to metal contact) and in either flat face or raised face configurations. Gasket materials must be capable of resisting temperature, pressure and fluid in the pipe. Bolting material also is available in various alloys and sizes. This joint is used to allow disassembly of the pipe when connected to equipment. The steps involved are:

1. A flange is a perpendicular projection of a pipe. Piping is manufactured with flanges or they are to be attached by welding to the pipe as a separate operation.
2. This projection is sufficiently long enough to allow holes drilled in the projection to secure one mating surface to another. Holes are drilled around circumference of flanges.
3. A seal or gasket is placed between two pipe flanges to assure proper seating of the mating surfaces. Bolts are inserted through each projection and pipes are secured by tightening the nuts.



2.3 Field tests:-

- The pipes shall be sound and free from laps, blow holes and pitting.
- All pipes and fittings should ring clearly when struck with light hand hammer.
- The pipe and fittings should be true in shape, smooth and cylindrical.
- Their inner and outer surfaces should be concentric.

All the CI pipes and fittings should be coated from inside and outside with a composition having tar or other suitable base. The coating material shall be smooth, tenacious and hard and should not chip off easily with light scribing by pen knife.

3.0 Ductile iron (D.I.) pipe:-

Ductile iron pipes are improved version of Cast iron pipes. The ductile iron pipes retain all the good qualities of cast iron but has more than double the tensile strength [Cast Iron 180 MPa (min) & Ductile iron- 420 MPa (min)]. Some of the advantages of ductile pipes are listed below:-

1. Strong pipe with high tensile strength and impact resistance
2. Good resistance to handling/transportation damage
3. Can with stand high pressure and impact due to surge
4. Leak- tight joint, impermeable to gas and organic contamination
5. Easier to lay
6. Lower pumping cost due to lower frictional resistance

7. Reliable internal and external corrosion protection
8. Higher durability.

The joining and laying procedure is almost similar to cast iron pipes.

3.0.1 Ductile iron pipes for water conveyance conforming to IS 8329 : 2000. These pipes are available both in socket and spigot or flanged ends. The standard dimensions of pipes and their tolerances for different diameter in mm are indicated in **APPENDIX-2**.

3.1 Coating and lining:- Ductile Iron Pipes & Fittings resist corrosion much better than steel pipes or even Cast Iron Pipes. Still D.I. pipe fittings are normally protected both by internal lining and external coating as additional protection from corrosion giving the pipes & fittings a much longer assured service life.

a) External coatings

External coating could be of bituminous paint or any one of zinc coating and with or without sleeving depending on the external soil conditions:

- Zinc with finishing layer of bitumen
- Zinc rich paint with bitumen finishing layer

Due to bad handling the bituminous paint on the D.I. fittings may be damaged accidentally. But if the fitting is zinc coated the damaged zone becomes cathodic to the rest of the fitting and is progressively covered by zinc corrosion products. This self-healing mechanism is fairly rapid. The zinc coating first works as an active coating capable of restoring the protective layer at damaged points through galvanic protection and then operating as a dense passive coating, which is formed after laying. DI Pipes, Fittings and accessories are normally available with internally lined and externally coated.

b) Internal linings

Any one of the following linings may be applied depending on the type of liquid transported :

- Portland cement (with or without additives) mortar.
- Blast furnace slag cement mortar.
- Sulphate resistant cement mortar.
- High alumina (calcium aluminate) cement mortar (not used for potable water).
- Cement mortar with seal-coat.
- Epoxy coating.

3.2 D.I.fittings:- The D.I. pipes are generally used for water supply and the various fittings are bends, reducers and 'T' junctions. These are similar to CI fittings. The detailed dimensions as available are given in **APPENDIX-2(A)**. The fittings are normally provided with cement mortar lining on the inner side and bituminous coating outside.

a) **Bituminous coating:** Coating with bituminous finishing coat is provided over any ferrous casting to protect it against corrosion. Coating is applied on the fittings after making the surfaces clean and dry. The coating material sets rapidly with good adherence and does not scale off.

   In order that the fittings are to be used for conveying potable water, care is taken so that the inside lining does not contain any constituent soluble in such water or any ingredient which could impart any taste whatsoever to the potable water after sterilization and suitable washing of the mains.

b) **Cement mortar lining**

   The D.I. fittings are provided with cement mortar lining, which has the following advantages:

- Reduces head loss at the fittings, reducing pumping costs.
- Prevents corrosion from inside, thus increases life of pipeline.
- Eliminates red water.

4.0 Galvanised iron (GI) pipes:- GI pipes are mainly used in water distribution system. They are available in Light, Medium and Heavy grades depending upon the thickness of pipe used. They are color coded for identification as Light:- Yellow band, Medium:- Blue band, Heavy:-Red band. Normally 15 mm to 150 mm size GI pipes are used in distribution system. Railway specifications recommend the use of Medium class (Blue band) pipes for water supply. The standard weights and thickness of pipes and their tolerances for different diameter in mm are indicated in **APPENDIX-3**.

4.1 GI pipe fittings:- The detailed dimensions of G.I. pipe fittings are given in **APPENDIX-3(A)**

4.1.1 Socket or coupling:- It is used to connect two straight lengths of pipes. The OD of the pipe, will be equal to the ID of socket, after threading. They are available for nominal bore of 15 mm to 150 mm.

4.1.2 Elbow:- It is a pipe fitting that connects two pipes of same diameter at an angle. The angle is always 90^0 unless stated. These are also available in nominal diameter from 15 mm to 150 mm.

4.1.3 Tee:- A pipe fitting that has one side outlet at right angle to the run or the main pipe.

4.1.4 Union:- It is used for joining the ends of two pipes neither of which can be rotated. They are used extensively because they permit connecting with little disturbance of the pipe position, They are used in long stretches of straight pipes in the beginning of a pipe system and near all appliances along with stop valves, so that the appliance can be taken out for repairs without disturbing the supply to the other parts of the system. Socket unions are used in the system where the appliance to which pipe is to be connected is having male threads. The pipe unions are connected to the locations having female threads.

4.1.5 Reducer:-

It has larger size at one end than at the other, and is used to connect two pipes of different sizes. The reducers are available as i) reducing socket, which is used in a running pipe ii) an elbow, which has one diameter smaller than other and is also used in running pipe if the flow is to be reduced and iii) a reducing tee, which has two different sizes of openings. It may reduce on the run or branch.

4.1.6 Nipple:- It is tubular pipe fitting threaded at both ends and under 30 cm in lengths. If lengths are over 30 cm these are considered as cut pieces. It is used for extending the pipeline unlike unions which are used to connect pipeline or appliances.

4.1.7 Plug:- It is fitting that has an exterior pipe thread and a projecting head by which it is screwed into the opening of the fitting. This is used to plug the flow in the pipe and is placed at dead ends or in the holes in the pipe, which are no longer required.

4.2 Procedure of joining GI pipes:-

1. Apply white lead putty on threaded end. Then tightly wrap spun yarn on threads. Alternatively thread taps can be wrapped.
2. Thread the fitting onto the mating component until hand-tight.
3. Using a wrench, tighten fitting about 4 turns past hand-tight. Due to the wedging effect of the tapered thread, extreme care must be used to avoid overstressing the female component.

5.0 Steel pipes:-

Steel pipes of small diameters can be made from solid bar sections by hot or cold drawing processes and these tubes are referred to as seamless. The large pipes are made by welding together the edges of suitable, curved plates, the sockets being formed later in a press. The thickness of the steel used is often controlled by the need to make the pipe stiff enough to keep its circular shape during storage, transport and laying as also to prevent excessive deflection under the load of the trench back-filling.

The thickness of a steel pipe is, however, always considerably less than the thickness of the corresponding vertically cast or spun iron pipe owing to the higher tensile strength of the steel making it possible for steel pipes to be more than twice the length of CI pipes of the same class, with consequent saving in transport, pipe laying and jointing costs. Specials of all kinds can be fabricated without difficulty to suit the different site conditions. Due to their; elasticity, steel pipes adopt themselves to changes in relative ground level without failure and hence are very suitable for laying in ground liable to subsidence. It must be borne in mind, however, that steel mains need protection from corrosion. The pipes can be lined and out coated with cement concrete. Dense cement mortar is applied by means of centrifugal process. These can be manufactured to any size as per requirement.

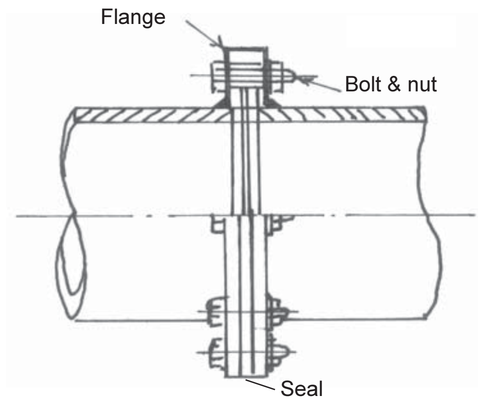
Minimum specified pipe thickness:-

Nominal dia. of pipe mm	Minimum thickness of pipe mm
200 to 400	5
450 to 700	6
800 to 900	7
1000 to 1200	8
1400 to 2000	10

5.1 The steel pipes can be joined by either flanged joints or welding.

5.1.1 Flanged joint:- A flanged joint is available in a large variety of mating surfaces (plain, serrated, grooved, seal welded or ground and lapped for metal to metal contact) and in either flat face or raised face configurations. Gasket materials must be capable of resisting temperature, pressure and fluid in the pipe. Bolting material also is available in various alloys and sizes. This joint is used to allow disassembly of the pipe when connected to equipment.

1. A flange is a perpendicular projection of a pipe. Piping is manufactured with flanges or they are to be attached by welding to the pipe as a separate operation.
2. This projection is sufficiently long enough to allow holes drilled in the projection to secure one mating surface to another. Holes are drilled around circumference of flanges.



3. A seal or gasket is placed between two pipe flanges to assure proper

seating of the mating surfaces. Bolts are inserted through each projection and pipes are secured by tightening the nuts.

5.1.2 Welding of steel pipes

1. The pipes already stocked along the trenches are lowered down into the trenches with the help of chain pulley block.
2. The pipes are laid true to the alignment and gradient before joining. The formation of bed should be ensured for its uniformity.
3. The ends of these pipes are butted against each other. Plain ended pipes may be jointed by butt welds or sleeved pipes by means of fillet welds. For laying long straight, lengths of pipe lines butt joint technique may be employed.
4. A coat of rich cement mortar is applied after welding.
5. Backfilling should closely follow the welding of joints of the pipe so that the protective coating should not be subsequently damaged. Material harmful to the pipeline shall not be used for backfilling. Refilling shall be done in layers not exceeding 300 mm. Each layer shall be consolidated by watering and ramming, care being taken to prevent damage to the pipeline. The filling on the two sides of the pipeline should be carried out simultaneously.

6.0 Concrete pipes:- The concrete pipes are very popular both for water supply and drainage requirements, as they are economical, long lasting and do not deteriorate with age and do not offer much resistance to flow compared to CI or steel pipes. The concrete pipes are manufactured in plain concrete, reinforced concrete or pre-stressed concrete. The concrete pipes are either pressure pipes or non-pressure pipes. The pressure pipes are designated as P1, P2 or P3 capable of water pressure of 0.2 MPa (20m of water head), 0.4 Mpa (40m water head) and 0.6 MPa (60m water head) respectively. Pressure pipes i.e. P1, P2 or P3 pipes are made in R.C.C. and used for water supply whereas non-pressure pipes could be in P.C.C., R.C.C. or P.S.C. and are designated as NP1, NP2, NP3 and NP4.The NP pipes are used for drainage and irrigation use, NP1 for above ground or in shallow trenches, NP2, for cross drains/ culverts having light traffic, NP3 for carrying medium traffic and NP4 for carrying heavy traffic. The non-pressure pipes with P.C.C. have to be cast using vibrated casting process only, and should be capable of withstanding 0.07 MPa (7 m water head) though not used for water supply. The PCC/RCC pipes are manufactured either by vibration casting process or by centrifugal spinning casting method.

6.1 The P.S.C. pipes are designed and manufactured as per specific requirements and can be used for water supply or drainage and irrigation uses. The grade of concrete should be equal or greater than 40 MPa. They are manufactured either as i) Prestressed concrete cylinder pipes or ii) Prestressed concrete non-cylinder pipes.

i) **Prestressed concrete cylinder pipes:-** A cylinder made of mild steel sheet as also the spigot and socket steel rings welded on the cylinder acts as the base for casting the PSC pipe. It is lined with concrete from inside, normally by centrifugal spinning method and after lining has gained sufficient strength, the prestressing wire is wrapped round the circumference and prestressed, adequate to take the internal pressure and external design loads. The steel cylinder and prestressing steel is coated with cement mortar or concrete to protect the steel cylinder and prestressing wires.

ii) **PSC non-cylinder pipes :-** In this pipe the steel cylinder is replaced by a core pipe made in concrete with reinforcement and longitudinal prestress. The circumferential prestressing steel is wrapped round this core and prestressed to withstand internal pressure and external loads. The pipe is then coated with cement mortar or concrete to protect the steel.

The PSC pipes are designed and manufactured as per the requirement based on I.S. 784-2001.

6.2 Pressure pipes (R.C.C.):- The various R.C.C. pressure pipes are manufactured as per I.S. 458-2003, as available and their use is as under,

Type of pipe	Concrete grade	Range of internal Diameter (mm)	Range of Barrel thick-ness (mm)	Length of pipes	Normal use
P1	$\geq$ 35 MPa	80-1200	25-65	2,2.5m (upto250 mm Φ),& 2,2.5, 3m (for more than 250mm Φ)	For gravity mains in water supply, the site pressure not exceeding 13m
P2	-do-	80-1000	25-100	-do-	For pumping mains, water head upto 20m
P3	-do-	80-800	25-120	-do-	For pumping mains, the water head upto 30 m.

6.3 Non-pressure pipes(R.C.C./P.C.C.) :- The various RCC/PCC pipes are manufactured as per I.S.458-2003, as are available and their use is as under:

Type of pipe	Concrete grade	Range of internal diameter (mm)	Range of barrel thickness (mm)	Length of pipes	Normal use
NP1 (PCC)	≥ 50 MPa	80-450	25-35	2,2.5m(upto 250 Φ) & 2,2.5, 3m (for more Φ)	In drainage and irrigation above ground or shallow trench
NP2 (RCC)	≥ 35 MPa	80-2200	25-100	-do-	In drainage or irrigation for cross drain/culvert carrying light traffic
NP3 (PCC)	≥ 50 MPa	300-1800	50-180	1.5,2,2.5 & 3m	In drainage or irrigation for cross drain/culvert carrying medium traffic
NP3(RCC) By spun casting	≥ 35 MPa	80-2600	25-215	2,2.5m(upto 250 Φ) & 2,2.5, 3m (for more Φ)	-do-
NP3(RCC) By vib. casting	-do- MPa	300-2400	50-225	1.5,2,2.5 & 3m	-do-
NP4(PCC) By vib. casting	≥ 50 MPa	300-1800	50-205	-do-	In drainage or irrigation for cross drain/culvert carrying heavy traffic
NP4(RCC) By spun casting	≥ 35 MPa	80-2600	25-215	2,2.5m(upto 250 Φ) & 2,2.5, 3m (for more Φ)	-do-
NP4(RCC) By vib. casting process	≥ 35 MPa	300-2000	50-190	1.5,2,2.5 & 3m	-do-

6.4 Coating and lining:- The concrete pipes normally do not require any coating for external surface or lining for internal surface, unless the pipe is buried in a soil which may corrode the concrete such as sulphates laden soil. In such cases bituminous coating is given to the pipes externally.

6.5 Fittings/ Specials:- The fittings/specials for concrete pipes are fabricated from steel plates. The normal fittings are bends or Tee's.

The steel for fabricated steel plate specials, is cut, shaped and welded so that the finished special has the required shape and internal dimensions. Adjacent segments are jointed by butt welding. Before lining and coating with cement mortar or concrete, the welding of specials should be tested by use of hot oil or dye penetrant according to IS:3658 and defects, if any, be rectified. The steel plate thickness for specials shall be as given in IS:1916.

6.5.1 Lining and coating of fittings:-

Steel plate specials are lined and coated with concrete or cement mortar or other approved materials, as agreed between the manufacturer and the purchaser. The proportion of cement to total aggregate shall not be leaner than 1:3 by mass. For concrete or cement mortar coating, reinforcement shall be suitably welded to the shell. The reinforcement shall be wire rods and spirals or wire mesh or wire fabric.

6.6 Testing of pipes:- All pipes manufactured should be tested at works/ factory for assessing the quality as under,

a) Hydrostatic pressure test

b) Three edge bearing test (for drainage pipes, sewerage and culverts) and

c) Permeability test.

The sample size for testing is as under:

No. of pipes in a lot	PCC/RCC pipes				PSC pipes						
	Dim. tests		Factory tests		i) Pressure & ii) socket dim. spigot test		Other tests	Permitted defects			
	Sample size	Defect permitted	Sam-ple size	Defect permitted	Sample size	Per-mitted Defe-cts	Sample size perme-ability	Coat-ing thick-ness	Dim-ensi-on	Test	3-edge bear-ing test
Up to 50	8	0	2	Nil	All	Nil	3	Nil	Nil	Nil	Nil
51 - 100	13	1	3	Nil	All	Nil	5	Nil	Nil	Nil	Nil
101-300	20	2	5	Nil	All	Nil	8	Nil	Nil	Nil	Nil
301-500	32	3	7	Nil	All	Nil	13	Nil	Nil	Nil	Nil
Above 500	50	5	10	Nil	All	Nil	26	1	1	1	Nil

6.6.1 Dimensional tolerances:- The following tolerances are permitted:

Sl.No. (1)	Dimensions (2)	P.C.C./R.C.C pipes (3)	Prestressed conc. pipes (4)
1.	Overall length	1 % of standard length	1% of standard length
2.	Internal diameter of pipes		
	a) Up to and including 300 mm	$\pm$ 3 mm	-

(1)	(2)	(3)	(4)
	b) Over 300 mm and up to and including 600 mm	± 5 mm	-
	c) Over 600 mm	± 10 mm	-
	A1) Upto 350mm, and length upto 4 m.	-	± 5 mm
	B1) Beyond 350mm and length beyond 4m.	-	± 10 mm
	C1) Upto 900mm, length ≥4m	-	± 6mm*, ± 9mm
	D1) 901-1600mm, length ≥ 4 m	-	± 9 mm* ± 12 mm
	E1) Above 1601mm, length ≥ 4 m.	-	± 12 mm
'*' for upto 600mm from ends of pipe			
3.	Barrel wall/Core thickness: a) Up to and including 30 mm	+2 mm –1 mm	± 5% of design core thickness
	b) Over 30 mm up to and imcluding 50 mm	+3 mm –1.5 mm	-do-
	c) Over 50 mm up to and including 65 mm	+4 mm –2 mm	-do-
	d) Over 65 mm up to and including 80 mm	+5 mm –2.5 mm	-do-
	e) Over 80 mm up to and including 95 mm	+6 mm -3 mm	-do-
	f) Over 95 mm	+7 mm –3.5 mm	-do-
4.	Deviation over 1m straight edge	3 mm	5 mm

NOTE: In case of PCC/RCC pipes with flexible rubber ring joints, the tolerance on barrel thickness near the ends will have to be reduced. Near the rubber ring joints, the tolerance on thickness should be as given in IS 458: 2003.

6.6.2 Finish:-

a) PCC/RCC Pipes shall be straight and free from cracks except that craze cracks may be permitted. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench, no opening between ends in contact shall exceed 3 mm in pipes up to 600 mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter. Pipes should be free from dent or bulge greater than 3mm in depth and extending in any direction over a length twice the barrel thickness.

Pipes may be repaired, if necessary, because of accidental injury during manufacture or handling and shall be accepted if the repairs are sound and appropriately finished and cured, and the repaired pipe conforms to the dimensional tolerances.

b) PSC pipes shall be free from local dents or bulges greater than 5.0 mm in depth extending over a length in any direction greater than twice the barrel wall thickness.

6.6.3 Marking

Each pipe should be marked with the standard mark and the following information is marked on each pipe:

a) Indication of the source of manufacture

b) Class and size of pipe

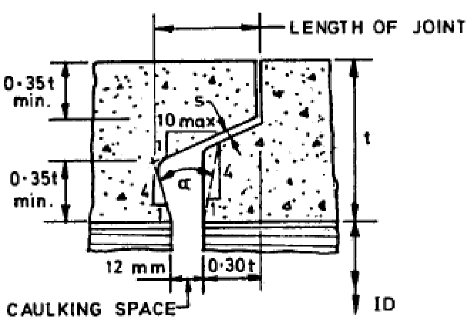
c) The words 'SPUN PIPE' or 'VIBRATED CAST PIPE (UNRE-INFORCED)' or

'VIBRATED CAST PIPE (REINFORCED)' as may be applicable, and

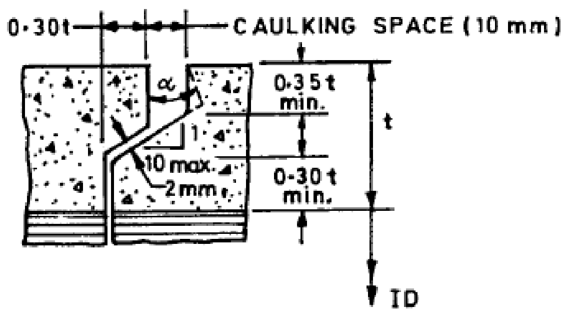
d) Date of manufacture.

The above information is to be clearly marked on outside only for pipes up to and including 350 mm internal diameter, and both outside and inside for pipes above 350 mm internal diameter.

6.7 Joints in concrete pipes:- All concrete pipes whether, PCC, RCC or PSC are provided with Socket and Spigot ends, except the pipes which are used for cross drainage or culverts. The ends of concrete pipes used for road culverts/ cross drains are suitable for flush (NP3 and NP4) or collar joints (NP2) (see Fig below). For pipes of diameter up to 700 mm, external flush joint and for diameters above 700 mm, internal flush joint is recommended.



Internal flush Joint



External flush joint

t = wall thickness.
ID = internal diameter,
s = 0.002 x internal dia or 2 mm, Min.
α = included angle not more than 25° (only for design purpose
not be measured).

For collar jointed pipes, length of pipes should be 2 m or 2.5 m up to 250 mm nominal diameter pipes and 2.5 m, 3.0 m, 3.5 m or 4,0 m for pipes above 250 mm nominal diameter. For Class NP3 and NP4 pipes of internal diameter 900 mm and above, the effective length may also be 1.25 m. as otherwise it may become heavy for handling.

(As per I.S. code requirement only flexible rubber ring joints should be used for the joints in (a) all pressure pipes and (b) all non pressure pipes except when used for road culverts / cross drains. The pipe joints shall be capable of withstanding the same pressures as the pipe.)

6.7.1 As per practice, the cement pipes can be joined in three different ways and are being adopted.

1. Spigot and socket joints (Flexible and rigid)
2. Collar joints (Rigid and semi flexible)
3 Flush joints (External and internal)

The general method of joining pipes is similar to the procedure adopted for cast iron pipes.

6.7.1.1 Joining concrete pipes by spigot and socket joint

a) Flexible joint

The flexible joints with socket and spigot ended pipes are made in two ways v.i.z. Confined 'O' Ring method or Roll-on 'O' Ring method.

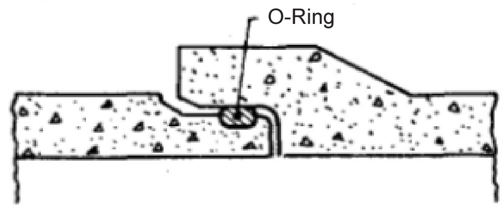
1. An 'O' ring is threaded around the spigot end and placed in the annular notch of the spigot end. The socket end is lubricated with an approved lubricant.

2. The spigot end is inserted into the socket right up to the back of the socket and carefully centered such that there is uniform annular space for filling with joining material. The 'O' ring is confined in the annular space, and the method is known as Confined 'O' ring method.

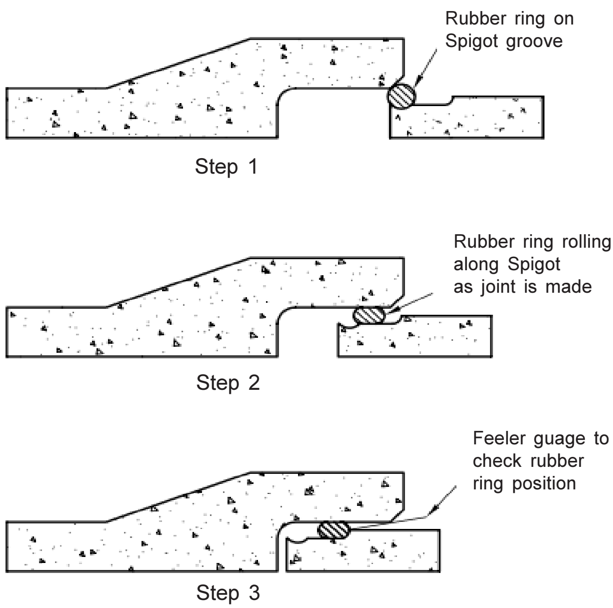
3. The jointed pipeline are then adjusted to required levels and alignment.

4. The joint shall then be filled with stiff cement mortar 1:2 (1 cement and 2 fine sand) well pressed with caulking tool and finished smooth at top at an angle of 45^0 sloping up. The joint must be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly.

5. If the lubrication is not applied to the socket end, then the 'O' ring rolls on to the farthest point of the spigot and the socket sits as shown in figure below. This method is called Roll on 'O' ring method. Other steps of sealing with cement mortar etc. is same as described above.



Confined 'O' Ring Joint (Flexible Joint)

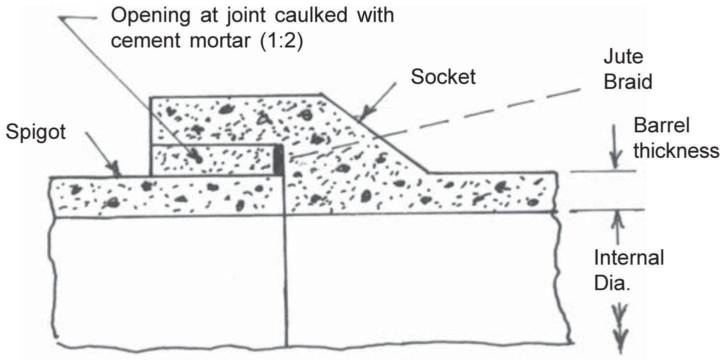


Roll-On 'O' Ring Joint (Flexible)

(**Rubber sealing rings** shall comply with IS 5382. Every sealing ring shall be clearly marked. The marking shall indicate the chord diameter, internal diameter of the ring and name of the manufacturer of rubber sealing rings. In case of splices, each splice shall be thoroughly visually checked by twisting the ring through 360°. Splices showing visible separation or cracks shall be rejected. Not more than two splices in each ring shall be permitted.)

b) Rigid joint

1. Instead of an 'O' ring, jute rope dipped in bitumen is wrapped around the annular notch on the spigot near the end. The spigot end is gently pushed in the socket, as far as it goes and the space is made central by adjustment and aligning. The space is filled with 1:2 cement mortar and pushed with a caulking tool to give a water tight joint.

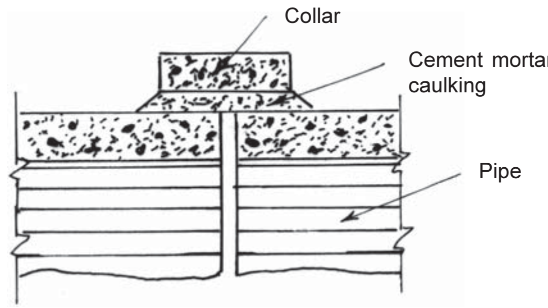


Rigid Joint- Spigot and socket ends

6.7.1.2 Joining concrete pipes (without spigot & socket)

a) Rigid collar joint

1. The two adjoining pipes shall be butted against each other and adjusted in correct position. The collar is threaded on one of the pipes and kept close to the joint.
2. The collar shall then be slipped over the joint, covering equally both pipes.
3. The joint shall then be filled with stiff cement mortar 1:2 (1 cement: 2 fine sand) well pressed with caulking tool and finished smooth at top at an angle of 45^0 sloping up. The joint must be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly.



b) Semi flexible collar joint

1. The two adjoining pipes shall be butted against each other and adjusted in correct position. Each end shall be fitted with a rubber ring.
2. The collar shall then be slipped over the joint, covering equally both pipes. The rubber ring will be compressed and the joint will be sealed.
3. The joint shall then be filled with stiff cement mortar 1:2 (1 cement:2 fine sand) well pressed with caulking tool and finished

smooth at top at an angle of 45^0 sloping up. The joint must be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly.

6.6.1.3 Joining flush pipes

The cement pipes with flush ends for cross drains and culverts are connected by internal flush and external flush joint, depending upon the diameter of pipes, if they are greater than 700mm or less than 700 mm. The arrangement is shown in the figure under para 6.6.

a) **External flush joint**

Where the pipes are 700 mm or less, they are joined by external flush joint. The space for caulking is filled with cement sand mortar in the ratio of 1:2, and water cured for 7 days.

b) **Internal flush joint**

Internal flush joints are used for pipes of diameter above 700 mm. The caulking is done from inside by a man who enters inside the pipe.

7.0 Asbestos cement (AC) pipes:-

The asbestos cement pipe is made of a mixture of asbestos and Portland cement compressed by steel rollers to form a laminated material of great strength and density. Its carrying capacity remains substantially constant particularly in soft water areas. It is not affected by electrolytic action and is light in weight. It can be drilled and tapped from connections but has not the same strength or suitability for threading as iron and any leakage at the thread will become worse as time passes. However, this difficulty can be overcome by screwing the ferrules through malleable iron saddles fixed at the point of service connections as is the general practice. These pipes are not suitable for use in sulphate soils. The available safety against bursting under pressure, though less than that for spun iron pipes, is nevertheless adequate and increases as the pipe ages. Good bedding of small bore asbestos cement pipes is important. The larger diameter pipes have ample beam strength for normal main laying conditions. This pipe can meet general requirements of water supply undertakings for rising main as well as for distribution mains. IS : 1592-1980 should be followed. The sizes range from 80 to 600 mm. The length of pipes for all diameters is 3, 4 or 5 m. Pipes are classified with respect to the hydraulic test pressure as given in table below:

Class	Hydraulic test pressure
5	0.5 MPa (5 kgf/cm^2)
10	1.0 MPa (10 kgf/cm^2)
15	1.5 MPa (15 kgf/cm^2)
20	2.0 MPa (20 kgf/cm^2)
25	2.5 MPa (25 kgf/cm^2)

Note:- The working pressure is not to exceed 50 percent of the test pressure.

7.1 Fittings and fixtures for asbestos cement pipes:- Fittings and fixtures of AC pipes are shown in **APPENDIX-4**

7.2 The AC pipes can be joined by either of two methods:-

i) By C.I. detachable flanges

ii) By AC couplers.

7.2.1 CI detachable flanges

This consists of two CI flanges, a CI central collar and two rubber rings along with a set of bolts and nuts for the particular joint. For this joint, the AC pipe should have flush ends.

Rubber rings positioned between the collar ends and flanges provide compression sealing. Compression is obtained by uniform tightening of the bolts.

7.2.2 AC coupler

This joint consists of an AC coupling with three inner grooves fitted with three special rubber rings. The pipes for these joints have chamfered ends. The rubber rings are positioned in the grooves inside the coupling. Then grease is applied on the chamfered end and the coupling pushed with the help of a jack against the pipe. The mouth of the second pipe is then placed in the mouth of the coupling and then pushed so as to bring the two chamfered ends close to one another. Wherever necessary, changeover from CI pipe to AC pipe or vice-versa is done with the help of suitable adapters.

8.0 Stone ware pipes:-

The pipes and fittings are of two classes, namely, Grade A and Grade AA. Pipes which comply in every respect with the requirement of the standard but of which only 5 percent have been submitted to hydraulic test and found satisfactory are classified as Grade A. Fittings in this class are not subject to hydraulic test. If 100 percent of the pipes and fittings have satisfactorily passed the hydraulic test, they are graded as AA.

The interior and exterior surfaces of the pipes and fittings which remain exposed after jointing shall be glazed. The glazing shall be obtained by the action of the fumes of volatilized common salt on the material of the pipes and fittings during the process of burning. Straight pipes shall withstand an internal hydraulic test pressure of 0.15 MPa (1.5 kgf/cm^2) on the barrels. Fittings shall withstand test pressure of 0.075 MPa (0.75 kgf/cm^2) without showing signs of injury or leakage. The pressure shall be applied on pipes and fittings at a rate not exceeding 0.075 MPa (0.75 kgf/cm^2) in 5 seconds and full pressure shall be maintained for at least 5 seconds.

The pressure test is conducted at manufacturer's works. The pipes and fittings shall also be subjected to an absorption test and the amount absorbed shall be between 6 and 10 percent by weight for pieces 20 to 38 mm thick.

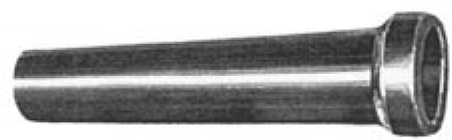
These pipes are used for underground drainage. These shall be sound, free from visible defects such as fire cracks or hair cracks. The glaze of the pipes shall be free from crazing. The pipes shall give a sharp clear tone when struck with light hammer. There shall be no broken blisters. The thickness of pipes shall be as given in the table below:

Internal Diameter mm	100	150	200	230	250	300	350	400	450
Thickness of the barrel and socket mm	12	16	17	19	20	25	30	35	38

Permissible variation in thickness of barrel and sockets

Not exceeding 450 mm Φ :- ± 2 mm

500 and 600 mm Φ :- ± 3 mm



The length of pipes shall be 600,750, 900 mm. The pipes shall be handled with exclusive care to avoid damage. The permissible tolerance on length shall be within ±10 mm for pipes of 600 and 750 mm length and ±15 mm for pipes of 900 mm length.

8.1 Fittings for stone ware pipe:

Fittings and fixtures of AC pipes are shown in **APPENDIX-5.**

8.2 Procedure for connection of stone ware pipes :

The procedure is same as for joining concrete pipes with spigot and socket with cement mortar.

9.0 Plastic pipes:-

Plastic pipes are produced by extrusion process followed by calibration to ensure maintenance of accurate internal diameter with smooth internal bores. These pipes are covered by Indian Standards as follows:

1) Low density polyethylene pipes for water supply- IS : 3076- 1968,
2) High density polyethylene pipes for water supply- IS : 4984- 1978,
3) Unplasticized PVC pipes for water supply - IS : 4985-1968.

   Rigid PVC pipes and high density polyethylene pipes have been used for water distribution systems mostly ranging from 15 to 150 mm diameter and occasionally up to 350 mm.
4) Unplasticized PVC pipes for soil and waste discharge system inside buildings including ventilation and rain water system -IS : 13592-1992 (Reaffirmed 1997).

9.1 Polyethylene pipes for water supply:- These are extruded from a compound consisting of virgin polyethylene in which carbon black and a suitable non-toxic anti-oxidant is evenly dispersed. Low density polyethylene shall have a density not greater than 0.93g/ml and high density polyethylene shall have a density greater than 0.94 g/ml at 27°C.

Classification based on working pressure MPa (kgf/cm²)	**Outside diameter range**	
	Low density polyethylene mm	High Density polyethylene mm
0.20(2.0)	—	75-500
0.25(2.5)	40-140	63-500
0.4 (4.0)	32-140	40-500
0.6(6.0)	20-110	32-500
1.0 (10.0)	12-63	20-500

The pipes are recommended for a maximum temperature of 45°C and 38°C for high and low density polythene pipes respectively. At higher temperature, the strength of pipe reduces and working pressure shall suitably reduce. Deterioration and decomposition of plastic pipes is accelerated by Ultraviolet radiation in sun rays and frequent change in temperature. Therefore, they are not suitable for carrying water or effluent at higher temperature.

The low density pipes are generally supplied in coils of nominal lengths of 25, 50, 100, 150 and 200 metres. The high density pipes are generally supplied either as coils measuring 25 times the minimum dia. of the pipes or in straight lengths of 5 to 20 m.

9.2 Unplasticized PVC pipes for water supply:– The material is substantially poly-vinyl chloride plus necessary additives for getting good surface finish, mechanical strength and capacity. These shall not cause toxicity and no detrimental effect in the composition of water, passing through the pipes. These pipes are manufactured as-

Working pressure MPa (kgf/cm²)	**Outside diameter range mm**
0.25 (2.5)	90-630
0.4 (4.0)	63-630
0.6 (6.0)	40-630
1.0 (10.0)	16-630

9.3 Unplasticized PVC pipes for soil and waste discharge system inside buildings including ventilation and rain water system:-

The pipes are classifieds in following two types:

Type A - for use in ventilation pipe work and rain water applications

Type B - for use in soil and waste discharge systems.

Nominal outside diameter DN of pipes as covered as per IS code are 40, 50, 63, 75,90 ,110, 125, 140 and 160 mm. The outside surface color is dark gray. The dimensions of the pipes are given in **APPENDIX-6.**

9.3.1 Length of Pipe:-

Pipes are supplied in nominal lengths of 2, 3, 4 or 6 meters either plain or with sliding/ grooved socket. Tolerances on specified length are + 10 mm and -0 mm.

9.4 PVC pipe fittings:- The different fittings for PVC pipes are given in **APPENDIX-6A.**

9.5 Pipe-clip spacing distance for PVC pipes:

Size	75	90	110	160
Horizontal (in mt.)	0.9	0.9	0.9	1.2
Vertical (in mt.)	1.8	1.8	1.8	1.8

9.6 Precautions in handling and storage:- Because of their light weight, there may be a tendency on the part of workers to throw for the PVC pipes. PVC pipes are thrown much more than their other counterparts. This should be discouraged and reasonable care should be taken in handling and storage to prevent damage to pipes. On no account should the pipes be dragged along the ground. Pipes should be given adequate support at all times. These pipes should not be stocked in large piles, specially under warm temperature conditions as the bottom pipes may be distorted thus giving rise to difficulty in pipe alignment and jointing. For temporary storage in the field where racks are not provided, care should be taken that the ground is level, free from loose stones. Pipes stored should not exceed three layers and should be so stacked as to prevent movement. It is also recommended not to store one pipe inside the another pipe.

9.7 Joining of PVC pipes

PVC pipes may be joined by -

a. Solvent cement joints

b. By rubber rings

9.7.1 Solvent cemented joints

Solvent cement is a PVC polymer based viscous compound, consists essentially of a solution of vinyl chloride polymer or copolymer dissolved in a suitable volatile mixture of organic solvents. The solvent constituents soften the mating surfaces, which diffuse into one another to form a ‘cold weld’.

It should not be exposed to sun or heat and must be stored under shade in closed container. One kg of solvent cement is adequate for joining about 35 joints of 110 mm diameter pipe. To avoid evaporation, small cans or tubes of solvent cement can be used. Solvent cement joints are permanent in nature and strong in tension.

Solvent cement is available in three grades of viscosity as given below to cover a range of pipe sizes from 20 mm to 630 mm. Sufficient solvent cement shall be applied so that a wet-film thickness adequate enough to fill a gap in a pipe joint is formed. Selection is also dependent on the climatic conditions prevalent at the site.

Pipe size mm	Cement type	Minimum viscosity MPa.s or centipoise (cp)	Minimum wet film thickness mm
Upto 50	Regular bodied	90	0.15
63 to 160	Medium bodied	500	0.3
Above 200	Heavy bodied	1600	0.6

Medium bodied and heavy bodied cements may be used for smaller pipe sizes than that shown in the table above. The reverse does not hold good.

9.7.1.1 Procedure for joining

Step 1

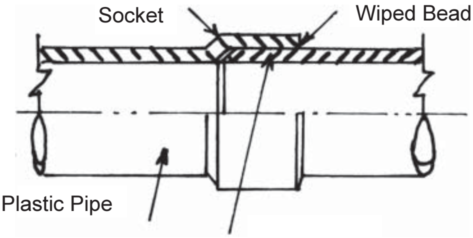
Pipes are supplied with square-cut and de-burned ends. However, if pipes need to be cut to smaller lengths, use a fine-toothed hand saw and a box or a power saw with wood-working blades, with a suitable guide. The cutting must not raise a burr or ridge on the cut end of the pipe. Failure to remove the ridge will result in cement in the fitting or socket being scraped away from the jointing surfaces, leading to a dry joint with probability of joint failure: Remove all burr and ridges with a deburring knife, file, or abrasive paper.

Step 2

Provide an approximately 2 mm wide, 15° chamfer on pipe ends. A chamfer prevents the cement film from being wiped off into the interior of the socket during assembly.

Step 3

Before applying cement, insert the pipe end into the socket of the next pipe or fitting to check that interference occurs at about 1/3 to 2/3 of the socket depth. When the pipe and the socket are at their extreme tolerances, the pipe can bottom (travel fully into) in the socket. In such a case, it should be a snug fit. A loose or wobbly fit will result in joint failure. Another pipe end or the socket should be selected until these conditions are fulfilled. Mark the insertion depth on the pipe end with a felt tip pen or marker.



Step 4

Surfaces to be joined must be free of dust, dirt, oil, moisture and other foreign material. Wipe clean with a dry cloth. If this is not sufficient, use a chemical (such as dichloro-methane, methyl ethyl-ketone or mechanical cleaner). With chemical cleaners, observe safety precautions. Ketones are inflammable.

Step 5

PVC solvent cement is quick drying, therefore it shall be applied as quickly and carefully as possible and in consistence with good workmanship. For larger sizes, it is advisable for two workers to work simultaneously on the pipe and socket. The surface temperature of the mating surfaces should be above O°C but should not exceed 45°C. Water can be used to cool the surfaces, but these should be wiped thoroughly dry before application of cement. Dip the applicator brush in the solvent cement and apply a liberal coat of cement to the end of the pipe up to the insertion depth. Apply a uniform thin coat of cement inside the socket, working axially from the inside of the socket to the outside. Do not apply any cement on the shoulders of the socket (socket-to-pipe transition area). Care should be taken not to apply excess cement inside the socket. Excess cement in the socket will be pushed further into the pipe during assembly and cause the pipe to soften and weaken at that point. Hot and dry climates generally require slightly thicker coatings of solvent cement. In climates with large differences between day and night temperatures, it is advisable to make joints early in the morning or in the evening when it is cooler. Thus, the joints are prevented from being pulled apart if the pipes contract.

Step 6

Within 20 seconds after the last application of solvent cement, insert the pipe into socket in a single steady and every controlled but forceful action. Press it in fully until it bottoms. No hammer blows should be used. If there is any sign of drying of the cement coat before insertion, the surface should be re-coated, avoiding application of excess cement in the socket. Once the insertion is complete, hold in place for 1 min without shifting the pipe in the socket.

Step 7

For large diameter pipes, two or more workers may be needed for this operation. Mechanical equipment such as levers and winches may be used. Care shall be taken to ensure that force is not transmitted to previously made joints. Until the cement is set, the pipe must be prevented from backing out of the socket.

Step 8

Immediately after assembly, wipe the excess solvent cement from the pipe at the end of the socket. A properly made joint will have a uniform bead around its entire perimeter. Any gaps in this bead may be indicative of an improper joint due to insufficient cement or the use of a lighter-bodied cement than the one recommended.

Step 9

Joints should not be handled until the requisite setting time has elapsed. Recommended setting times are a function of the ambient temperature at the job site as given below:

Temperature ^{0}C	Recommended setting times hr.
15 to 40	1
5 to15	2
-5 to 5	4
-20 to -5	6

After the setting time has elapsed, the pipe may be handled carefully for installation. Pressure testing may be carried out only after a curing period of 24 hrs.

9.7.2 Rubber ring joints:- Rubber ring joints can provide a water-tight seal but are not designed to resist pull. In these joints, the rubber and the fluid to be transported should be compatible. The material of rubber rings should conform to IS : 5382- 1969. Where aggressive soils are met with, synthetic rubbers perform better. Generally speaking, rubber ring joints are used for large sized pipes (63 mm and above). Such joints may be provided on pipes which are buried in the ground and supported throughout on a bedding so that they are not subjected to movement and longitudinal pull. The strength of a rubber ring joint to longitudinal forces is not high and for same joints a flange or a shoulder is made on the pipe end to provide the necessary strength in tension. For buried water supply mains, the installed pipes and joints are supported by the continuous bed of the trench and no tensile strength in the joint itself is necessary. However, care shall be taken to anchor the pipe and fittings at bends and at connections to valves. If used above ground, they shall be anchored to provide the required strength. Un-plasticized PVC pipes may be jointed by methods employing a rubber ring to provide the water tight seal.

9.7.2.1 Procedure for connection

Step 1

Pipes are supplied with the spigot end chamfered. However, if pipes have to be shortened for any reason, preparation of the ends will be necessary before assembly.

Step 2

Cutting of pipes, if required, must be done on a jig to ensure that the cut is square to the axis of the pipe. It is recommended that the pipe be marked around the entire circumference prior to cutting. The pipe ends must be chamfered at an angle of 15° with a medium grade file and de-burred.

Step 3

Clean the spigot end of the pipe up to the insertion depth (depth of the corresponding socket). Remove all traces of mud, dirt, grease and gravel. Do not use any chemicals or solvents for cleaning. For stubborn areas of dirt. a very fine grade of emery or sand paper can be used lightly. Wipe the pipe with a clean cloth moistened with water and allow to dry completely.

Step 4

Clean the inside of the socket. Remove all traces of mud, dirt, grease and gravel. Do not use any chemicals or solvents for cleaning. For stubborn areas of dirt, a very fine grade of emery or sand paper can be used lightly. Wipe the inside of the groove with a damp cloth and allow to dry completely.

Step 5

Mark the insertion depth on the spigot of the pipe, if not already applied by the manufacturer. The insertion depth is equal to the depth of the socket of the pipe, measured up to the end of the parallel portion of the socket (excluding the shoulder). This distance is marked on the spigot (excluding the chamfer) with an indelible felt-tip marking pen.

Step 6

Insert the electrometric sealing ring into the groove. Rings to be used are system specific and shall be those supplied by the manufacturer for his own system. Form the ring into a heart shape by pinching a portion of the ring from the inside. Insert into the socket and release to seat into the groove. Ensure proper seating of the ring in the groove. If the ring is wrongly inserted it will lead to leakage. It may also dislocate completely during assembly.

Step 7

Apply lubricant to the outside of the spigot (consult the manufacturer). The lubricant should cover the entire surface of the spigot for at least half the insertion depth, starting from the end of the pipe. The lubricant used should not have any detrimental effect on the pipe, fittings or the elastomeric sealing ring and shall not be toxic, shall not impart any taste or odor to the water or encourage growth of bacteria. Do not use oil-based or solvent-based lubricants.

Step 8

Align the socket and spigot correctly in the horizontal and vertical planes. Ensure that no sand or dirt adheres to the lubricated surfaces of the pipe.

Step 9

Insert the spigot end carefully into the socket. Place a firm wooden block against the other end of the pipe and, using a crow-bar as a lever, push home the spigot up to the insertion depth mark. For larger sizes of pipe, the use of a jointing jack may be helpful. The jack can also be used to extricate a pipe from a socket.

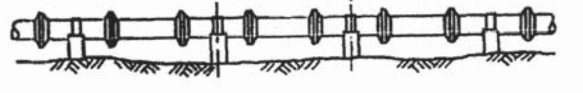
Plastic pipes may also be joined by Mechanical compression joints, Flanged joints, Screwed or threaded joints, and Union coupled joints.

10.0 Guidelines for laying and fixing pipelines

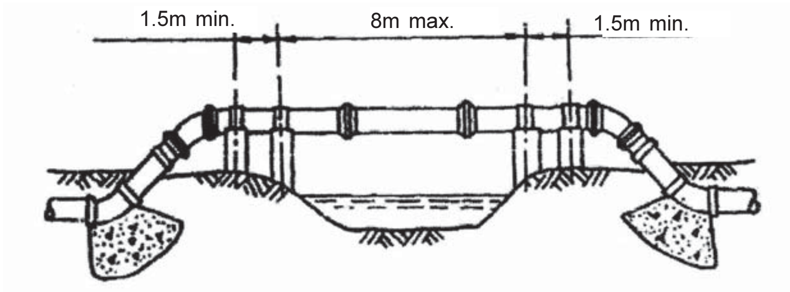
10.1 Pipes laid over ground:

i) Laying of Socket and Spigot joint pipes over the ground:

While laying the socket and spigot joint pipes over a normal ground, proper support should be provided over a distance not more than 8m apart. Similarly while crossing a water way additional support should be provided at a distance of 1.5 m on both the sides of the waterway. Figures shown below displays the supporting positions.



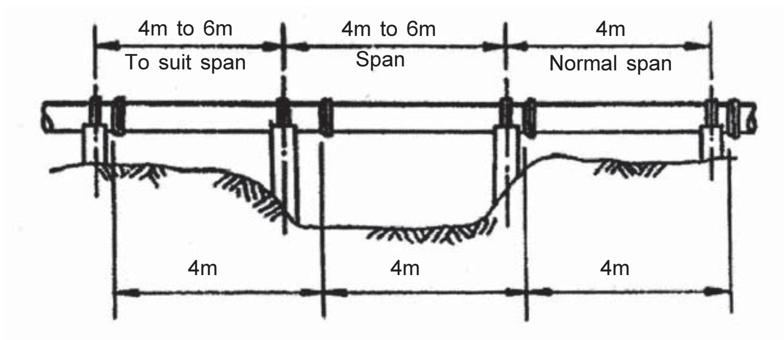
Pipes above normal level



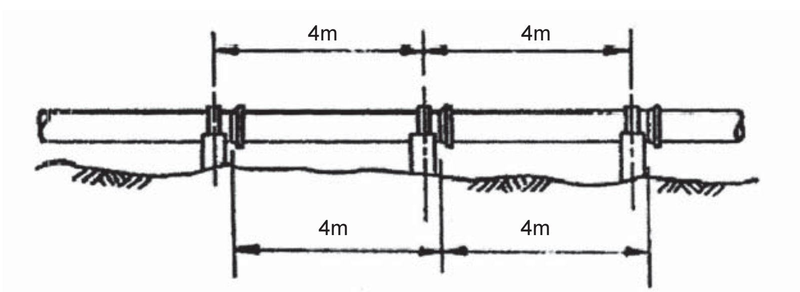
Socket and spigot pipes crossing water course

ii) **Laying of Flanged pipes over the ground:-**

The flanged joints are provided at a distance of 4 m to 6 m apart. The support should be provided near each joint symmetrically. Figures shown below display the supporting positions.



Flanged pipes over normal ground



Flanged pipes over normal ground

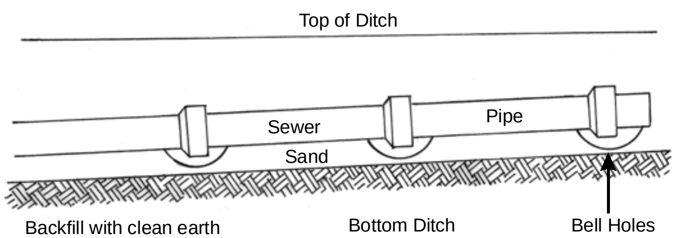
10.2 Under ground pipes:-

Excavations required to be made for the installation of a building drainage system or any part thereof, within the walls of a building, shall be open trench work and shall be kept open until the piping has been inspected, tested and accepted.

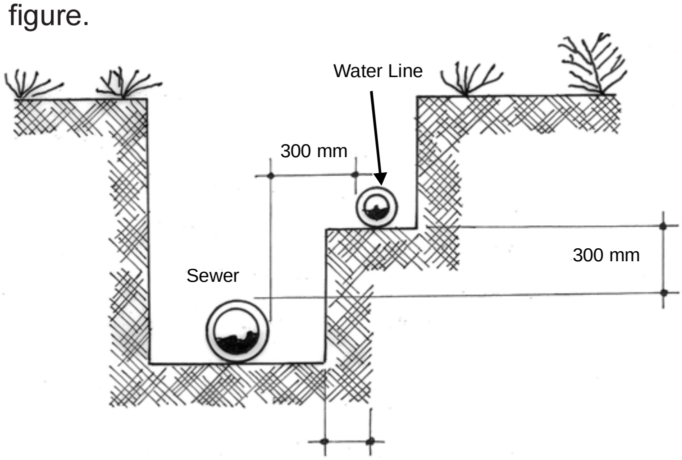
Adequate precaution shall be taken to ensure proper compaction of back filled around the piping without damaging the piping. Trenches shall be backfilled in thin layers of 300 mm above the top of piping with clean earth, which shall not contain stones, boulders, cinder fill construction debris or other materials that would damage or break the piping or cause corrosive action. Mechanical devices such as bulldozers, graders, etc, shall be permitted to then be used to complete backfill to grade.

Grade of horizontal drainage piping:- Horizontal drainage piping shall be run in practical alignment and a uniform slope of not less than 20.8 mm per meter towards point of disposal. Slope for piping equal to or larger than 102mm where slope of 20.8mm per meter can not be provided due to the depth of street sewer or due to structural features, slope not less than 10.4 mm per meter can be provided with prior approval of competent authority.

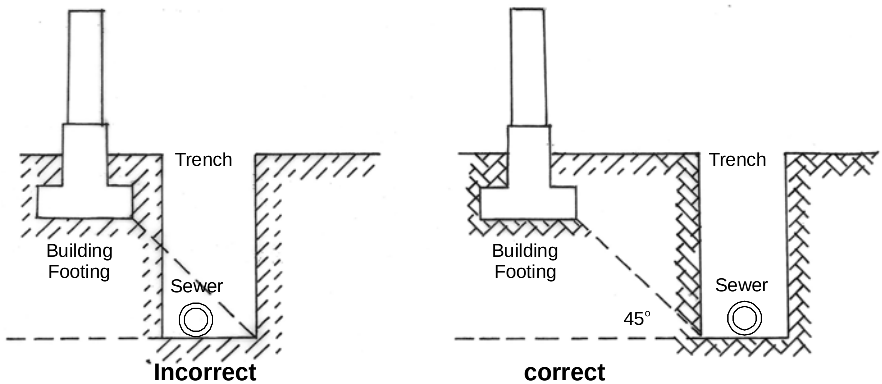
For variety of reasons, either water or drainage piping may develop leaks over a period of time. The fill material around these pipes will become saturated when leak occurs. Therefore, it is essential that potable water and waste piping not be allowed to share a common trench unless the building sewer is constructed of material approved for use within the building. Saturated soil becomes a bridge for bacterial travel between the pipes. Therefore solid shelf for water line is provided 0.3m above and 0.3 m horizontally from the sewer line as shown in the figure.



Support for Under Ground Pipe



Minimum separation when sewer piping



Location of pipe in trenches

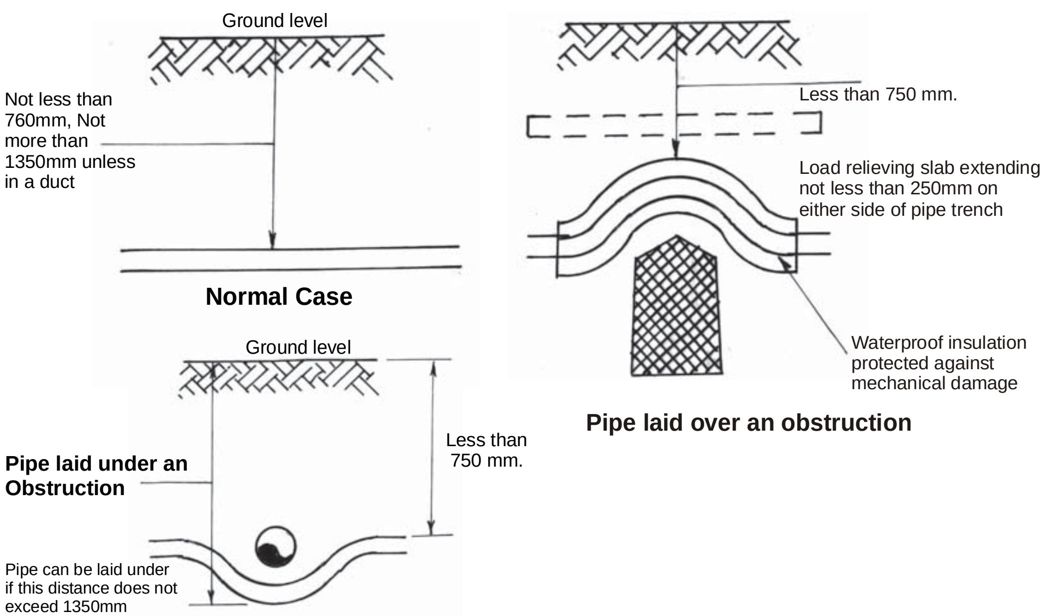
Special consideration must be given to trenches parallel and deeper than footing that supports any building or structure. Tunneling and driving may be done in yards, court and driveways of any building site. Casing pipe must be one pipe size larger than the pipe to be laid. Installation of piping is permitted for closer than the 45 degree angle from the bottom of the building foundation, provided that the soil is extremely stable such as sand stone.

10.2.1 Water fittings laid underground

Wherever practicable and except for pipes laid under a building, the vertical distance between the top of every water pipe installed below ground and the finished ground level should be:

a. not less than 750 mm and,

b. not more than 1,350 mm.



Where compliance with the minimum cover of 750 mm is impracticable, the water fittings should be installed as deep as is practicable below the finished ground level and be adequately protected against damage from any cause.

Water fittings laid underground should be resistant to dezincification and be installed to accommodate any movement.

Water fittings installed underground should not be jointed or connected to any other water fitting by adhesives.

10.2.2 Trenching and grading:- After the pipes have been laid, the next step is to check the grade and align the pipeline. This is very important in installing an underground sewer system. Remember, sewage does not flow uphill, unless of course you are using a pump, such as a lift station does. The pipe should be laid, so the flow of the sanitary waste in each length of pipe flows from the hub end to the spigot end or we could say the hub end is upstream. Each length of pipe should be placed starting at the lowest elevation and working up the grade; therefore, the spigot is inserted into the hub of the length laid previously. Each length should be checked as to its grade and alignment before the next length is placed. Batter boards are placed across the trench at about 25 to 50 feet intervals. Elevations are run, and a mark is placed on the stakes at some even-foot distance above the invert (the lowest point on the inside of the pipe) of the sewer. A nail is then driven in the top of the batter boards, and a cord is stretched from board to board. The center line for the pipe is then transferred from the cord to the bottom of the trench by means of a plumb bob. Grade is transferred by means of a stick, marked in even-foot marks, having a short piece fastened at a right angle to its lower end. Grade is checked by placing the short piece on the invert of each length of sewer pipe and aligning the proper mark on the grade rod to the cord.

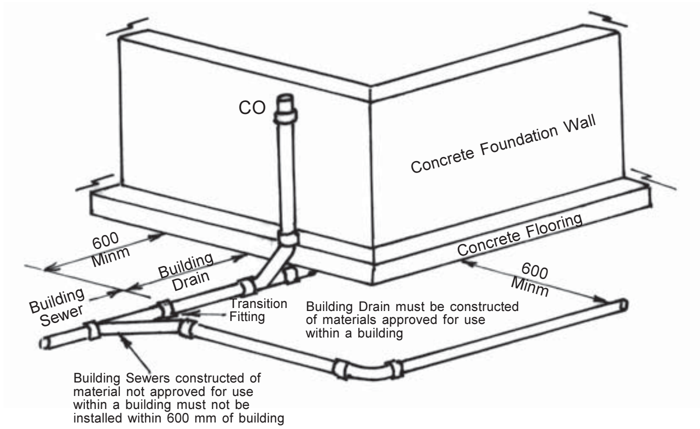
10.3 Pipes embedded in concrete:-

Pipes must not be directly embedded in concrete or masonry. Piping shall be so installed that piping or connections will not be subject to undue strains or stresses, and provisions shall be made for expansion, contraction and structural settlement. No structural member shall be seriously weakened or impaired by cutting, notching.

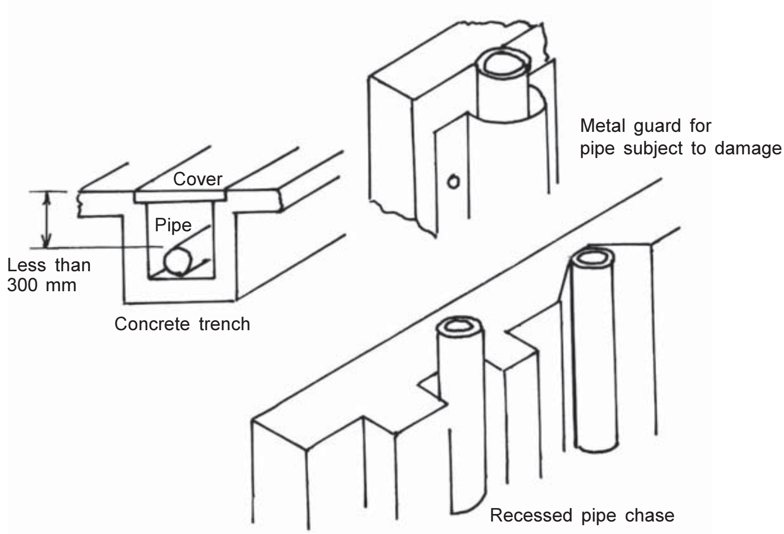
Sleeves shall be provided to protect piping through concrete and masonry walls and concrete floors. Joints at roof around pipes, ducts, or other appurtenances shall be made water-tight by the use of lead, copper, galvanized iron or other approved flashings. Exterior wall opening shall be made water tight.

10.4 Concealed piping:-

a) Pipes are taken up to the bathroom and kitchen through duct provided



Required clearances for piping materials used for building drain and building sewers



Methods of protecting building drains and sewers less than 300 mm below grade

in the building. From this duct pipes are taken to bathroom and kitchen and then concealed in to the wall of bathroom and kitchen.

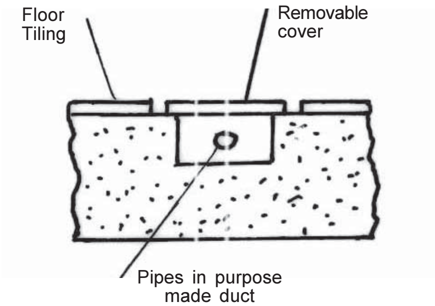
b) For concealing 15mm pipe in bathroom and kitchen it is required to prepare slot on wall 30mm deep so that minimum 15mm plaster cover is always available.

c) If hot water has to flow through the pipe asbestos rope is wrapped around the pipe.

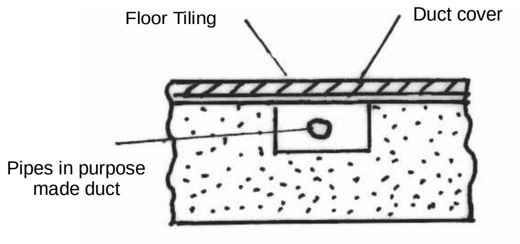
d) Pipes are fixed with the help of clamp.

e) Then the pipe is covered with plaster of 1:4. Then tiling work is carried out.

f) A concealed pipe may also be installed in a pipe sleeve or duct located under or within a solid floor provided that the pipe can be readily removed and replaced.



Pipe placed in a duct with removable cover



Acceptable only if pipe can be withdrawn for examination and if few joints enclosed

Pipe in a duct with no access

10.5 Wall mounted piping:-

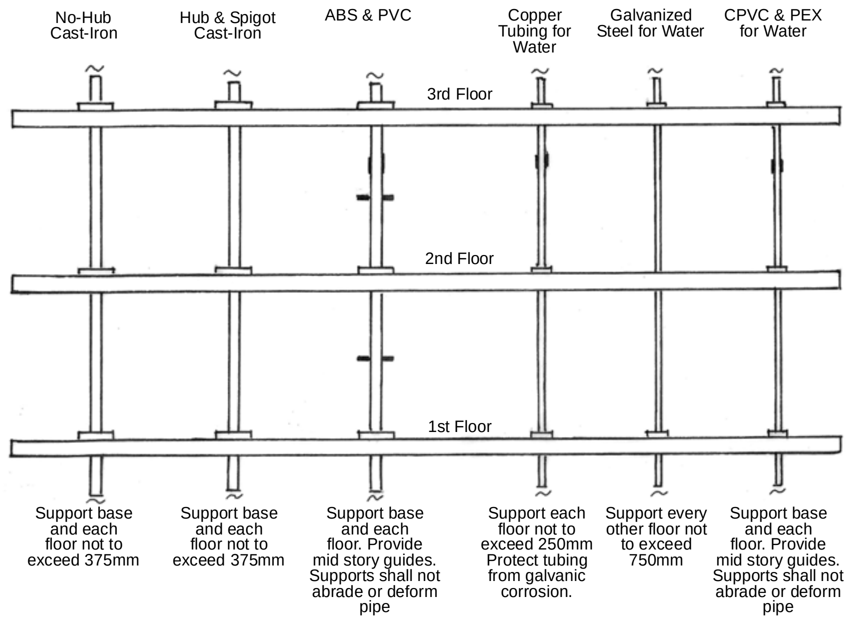
Adequate provision should be made to protect the pipe from corrosion, erosion and mechanical damage when they are installed outside of a building or in an exterior wall of the building. All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed with standard pattern holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screwed bolt, keeping the pipes about 1.5 cm clear of the wall. These clamps shall be embedded in brickwork in cement mortar 1:3 (1 cement: 3 coarse sand), and shall be spaced at regular intervals in straight lengths as indicated in table below. The clamps shall be fixed at shorter lengths near the fittings.

Spacing	**Diameter of pipe (mm)**							
(meter)	15	20	25	32	40	50	65	80
Horizontal Length	2	2.5	2.5	2.5	3	3	3.5	3.5
Vertical Length	2.5	3	3	3	3.5	3.5	5	5

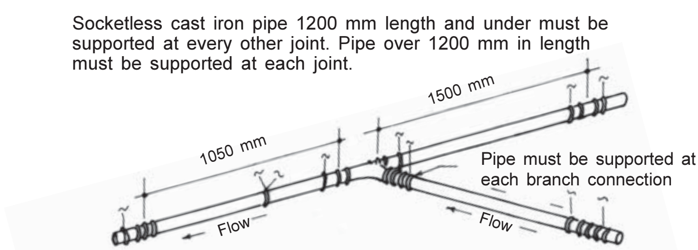
Note: Hub and Spigot also is known as Socket and Spigot

Valves, pipes and fittings must be installed in correct relationship to the direction of flow. This is necessary to avoid damage to the seats and discs and to reduce noise or vibration. Some appurtenances, such as strainers or pressure reducing valves, would not function if the flow is reversed. A check valve would not operate in a vertical position if it was not spring loaded and designed for that purpose and position. Gate valve are not directional, however globe valves are directional and are so designated by a directional arrow located on the body of the valve.

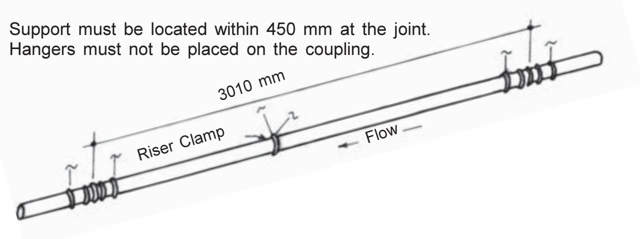
The manufacturer usually places an arrow on the device to indicate the direction of flow. The instructions, catalogue, or manufacturer's literature usually indicate if the device must be mounted horizontally, vertically or either way.



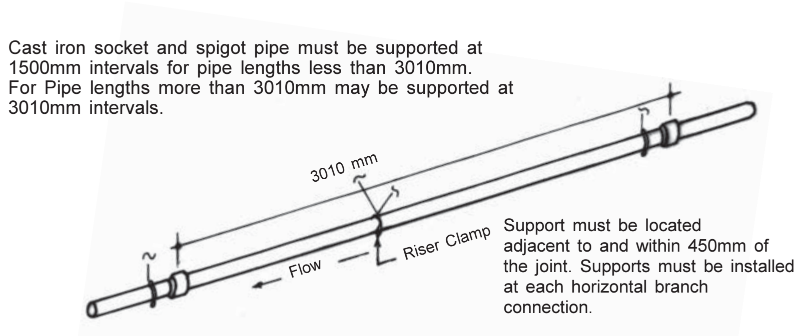
Vertical support requirements for representative pipe materials



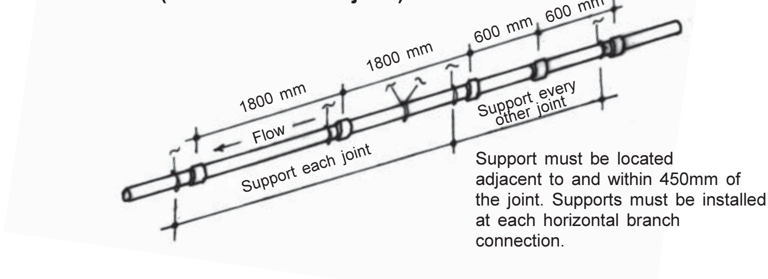
Horizontal support requirements for short lengths & branches of hubless cast-iron pipe



Horizontal support requirements for 3010 mm length of hubless cast-iron pipe



Horizontal support requirements for cast-iron hub and spigot pipe (Lead and Oakum joint)

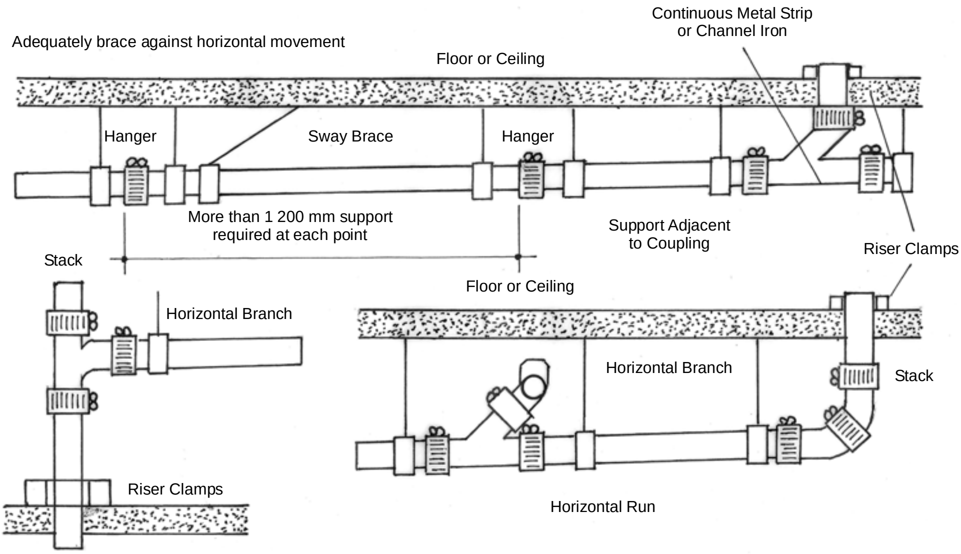


Horizontal support requirements for cast-iron hub and spigot pipe (Compression gasket joint)

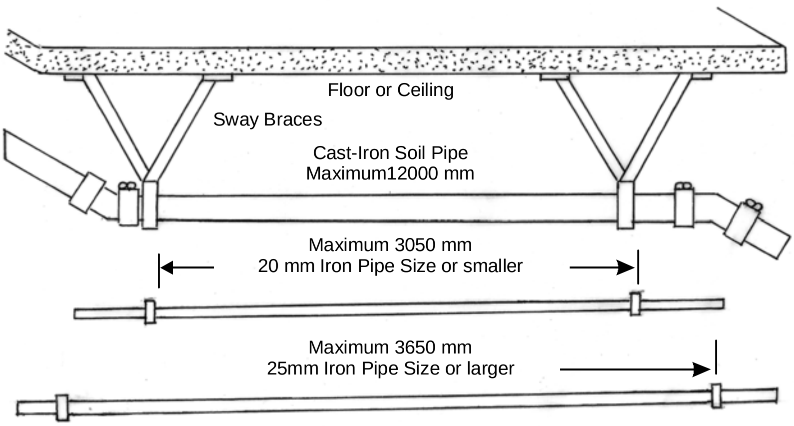
An abrupt drop, equal to 90 degrees from one elevation to another, tends to dissipate the energy gained during its vertical change in elevation as a result of the impact at the base of the drop. Liquid will flow both upstream and down-stream from such vertical impacts, with the resulting likelihood that solids will left behind, and a greater incidence of stoppage will occur.

10.6 Suspended piping:-

Suspended piping shall be supported in such a manner as to maintain its alignment and prevent sagging. Piping in the ground shall be laid on a firm bed for its entire length. Hangers and anchor shall be of sufficient strength to support the weight of the pipe and its contents. Piping for manifold systems shall be supported in accordance with the manufacturer's instructions. Hot and cold water distribution piping shall maintain separation at all points within the system.



Location of C.I. Hangers for C.I. Pipes



Sway Braces for C.I. Pipes

10.7 Connecting waste pipes to the drains

Each unit discharging water must have a waste trap in the pipe before it enters the stack or discharges into a gully or hopper. Typical water traps are:

Appliance	Diameter of trap (mm)	Depth of water seal
Basin	32	75
Baths * Showers *	40	50
Sink Food Waste Disposal Washing machine * Dish washer *	40	75

* Where these units discharge directly into a hopper or gully, the depth of water seal may be reduced to 38mm.

Where there is insufficient space under the appliance to accommodate the required size trap, a running trap may be fitted into the waste pipe run.

Modern regulations require waste water from above ground level to join into the stack pipe, however with the replacement of baths etc where the original waste fed into a hopper, this method may be reused.

At ground level, the waste pipe may feed into a gully connected to the foul water drain - but not a soak away.

When planning the pipe run, work out the best route for the waste pipe from the new appliance to the drain - the stack pipe, gully or hopper (if previously used).

All the pipe runs must have a downhill slope to avoid water collecting in the run, allow for at least a 18mm fall in for every metre of pipe run.

Do not start making the connections and fixing the waste pipe to the walls until plumber have cut all the pipe work and checked the fitting, runs and falls.

10.7.1 Taking the waste pipe through the wall

Having decided where the pipe will go through the wall, carefully check, both inside and out, that there are no obstructions in the way, i.e. cables, pipes etc. It is sometimes difficult to estimate exactly where a hole drilled from the inside will exit on the outside wall, so ‘measure twice, drill once’ or leave a margin so that if you misjudge it by a small amount, it won’t cause any problem.

The easiest way to cut the hole for the pipe through the wall is to use a diamond tipped core drill.

Alternatively, mark the circumference of the pipe on the internal wall and use a masonry drill to drill a series of closely spaced holes around the mark, then use a hammer and cold chisel to remove the centre.

Internally, the hole can probably be larger than absolutely necessary as the wall can be made good and redecorated afterwards.

Externally, it is sometimes neater to remove a brick and then cut and replace it after the pipe work has been completed.

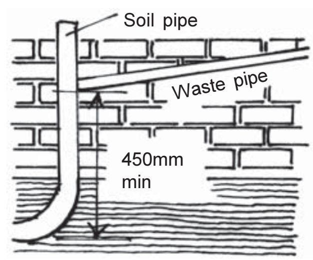
10.7.2 Joining to a stack pipe

Every appliance feeding waste water into a stack must have its own waste trap to provide a water seal.

To ensure that the water seal is maintained, the slope and size of the waste pipe connecting it to the stack pipe depends upon the length of the pipe run, typical figures are:

	Diameter of waste pipe	Maximum length between trap and stack pipe	Fall per metre run
Sink	40mm	3m	18 to 90mm
	50mm	4m	18 to 90mm
Basin	32mm	1.7m	18 to 22mm
	40mm	3m	18 to 44mm
Bath	40mm	3m	18 to 90mm
	50mm	4m	18 to 90mm

Stack pipes should not be joined into less than 450mm above the bottom of the bend at the bottom on the stack pipe underground. This cannot always be determined, however unless connecting for a ground floor waste, this is unlikely to be a problem.



Where running one end of a waste pipe into a stack pipe, fit an access fitting with a detachable cover at the opposite end to enable any blockage to be cleared if necessary.

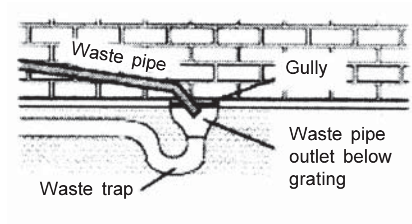
The method used to join into a stack pipe depends on what already exists.

- For a plain round stack pipe, use a strap on boss, as the name suggests, these are straps incorporating a boss to accept the additional waste pipe. A hole is cut in the stack pipe to locate the strap and allow free passage of the waste. Three methods of fixing the strap are available:
  - Screw strap where the ends of the band meet and are secured together by a nut and bolt.
  - Easy fix strap where the ends of the band meet and just click together.
  - Bonded strap where the two arms of the strap are bonded to the stack pipe - this needs the stack pipe to be of suitable material.

  The first two are probably easier to use rather than the bonded strap.

  The strap needs to be fitted the correct way up, they are normally marked 'top' in one position.
- On some existing stack pipes, there may be moulded bosses to accept additional connections. Special inserts need to be purchased to fit these bosses, the pipe at the back of the boss on the stack pipe is cut away, and the insert fitted, normally glued, in place. The insert needs to be inserted the correct way up, they are normally marked 'top' on one side.

10.7.3 Feeding into a gully



The gully used must be connected to the foul water drainage, not a soak away.

If there is doubt whether a gully is connected to the foul water drain, lift the manhole cover nearest to the main sewer (or cess pit, septic tank) to expose the inspection chamber underneath. Then pour a bucket of water down the gully. If water flows through the exposed chamber, the gully is feeding into the foul water drains; if water does not flow, the probability is that the gully is connected to a soak away and should not be used to dispose of household water.

With gullies, it is necessary to terminate the waste pipe below the grating, but above the water level inside.

10.7.4 Cutting pipe

Waste pipe should be cut as near square as possible, so always hold it on a firm surface where it can be firmly held. Wrapping a piece of paper around the pipe so that the edge of the paper lines up will act as a guide to cut square.

Use a file to remove the swarf and rough edges from both the outside and inside of the pipe before fitting it into any connector.

11.0 Procedure for laying CI pipes:- Cast Iron pipes are brittle and laying above ground can damage the pipes by some external load. CI pipes are generally laid below ground level for water supply and drainage purpose. The steps to be followed are as under:

1. Trench is dug either manually or by machine at the required location. When the pipeline is under a roadway, a minimum cover of 1.0 m is recommended for adoption, but it may be modified to suit local conditions by taking necessary precautions. The width of the trench at bottom between faces of sheathing (in case shoring is provided) shall be such as to provide not less than 200 mm clearance on either side of the pipe. In case of rock, clearance of at least 150 mm below and on each side of pipes, valves and fittings for pipes 600 mm in diameter or less, and 200 mm for pipes larger than 600 mm in diameter shall be provided. Refer “common guidelines for laying and fixing pipelines” for further guidelines provided at the end of the chapter.

2. All pipes, fittings, valves and hydrants shall be carefully lowered into the trench, piece by piece, by means of a derrick, ropes or other suitable tools or equipment, in such a manner as to prevent damage

to pipes materials and protective coatings and linings. Under no circumstances the pipe materials should be dropped or dumped into the trenches. Pipes over 300 mm diameter should be handled and lowered into trenches with the help of chain pulley block

3. All lumps, blisters and excess coating material shall be removed from the socket and spigot end of each pipe and the outside of the spigot and the inside of the socket are to be wire-brushed and wiped clean and dry and free from oil and grease before the pipe is laid.

4. Wherever the jointing material specified is cement, six or more lengths of pipe shall be laid in place ahead of each joint before such a joint is finished.

5. When the pipes run beneath the heavy loads, suitable size of casing pipes/culverts may be provided to protect the carrier pipe

6. Where necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted, deflection at joint shall not exceed the following:

Lead joints/Cement joints	2.5^0
Rubber joints	
For nominal bore 80 to 300 mm	5^0
For nominal bore 350 to 400 mm	4^0
For nominal bore 450 to 750 mm	3^0

7. After joining the pipe should be tested for pressure and leakage. The field test pressure to be imposed shall be not less than the greatest of the following:

a) One and a half times the maximum sustained operating pressure,

b) One and a half times the maximum pipeline static pressure, and

c) Sum of the maximum static pressure and surge pressure.

8. For back filling, the layers can be divided in three zones:-

Zone A : From the bottom of the trench to the level of the centre line of the pipe,

Zone B : From the level of the centre line of the pipe to a level 300mm above the top of the pipe.

Zone C : From a level 300 mm above the top.

Back-filling in Zone A shall be done by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width of each side of the pipe, fittings and appurtenances simultaneously.

Back-filling in Zone B shall be done by hand or by approved mechanical methods in layers of 150 mm, special care being taken to avoid injuring or moving the pipe. The type of back-fill material to be used and the method of placing and consolidating shall suit individual locations.

Back-filling in Zone C shall be done by hand or approved mechanical, methods. The types of backfill material and method of filling shall suit individual location.

12.0 Procedure for laying concrete pipes:-

1. The concrete pipes should be carefully loaded, transported and unloaded avoiding impact. The use of inclined plane or chain block is recommended.
2. Trench shall provide sufficient free working space on each side of the pipe which shall not be greater than one-third dia. of the pipe but not less than 15 cm on either side.
3. Laying of a pipe shall proceed upgrade of a slope. If the pipes have spigot, socket joints, the socket ends shall face upstream.
4. Where the natural foundation is inadequate, the pipe shall be laid in a concrete cradle supported on proper foundations, or any other suitable designed structure. If a concrete cradle is used, the depth of concrete below the bottom of the pipes shall be at least one-fourth the internal diameter of the pipe with the range of 10-30 cm. It shall extend up to the sides of the pipe at least to a distance of one-fourth the diameter.
5. If the vehicular traffic is to run on the concrete pipe lines, detailed consideration of the nature of traffic, depth of fill, diameter and class of pipe shall be required to be taken for which IS:783 should be referred to.
6. For the pipes larger than 30 cm diameter, the pipes shall be laid in the concrete bedding.
7. Trenches shall be back-filled immediately after the pipe has been laid to a depth of 30 cm above the pipe subject to the condition that the jointing material has hardened (say 12 h at the most). The back-fill material shall be free from boulders, roots of trees, etc.
8. The tamping shall be by hand or by hand operated mechanical means. The water content of the soil shall be as near optimum moisture content as possible. Filling of the trench shall be carried on simultaneously on both sides of the pipe to avoid development of

unequal pressures. The back-fill shall be rammed in 150 mm layers up to 90 cm above the top of the pipe.

13.0 Procedure for laying AC pipes

1. The AC pipes to be laid are stacked along the trenches on the side opposite to the spoils. Each pipe should be examined for any defects such as cracks, chipped ends, crusting of the sides, etc. The defective pipes are to be removed forthwith from the site to avoid mixing up with good pipes.
2. Before use the inside of the pipes will have to be cleaned
3. Trench shall be dug with uniform width throughout the length and greater than the outside dia of the pipe by 300 mm on either side of the pipe. The depth of the trench is usually kept 1 m on the top of the pipe. For heavy traffic, a cover of at least 1.25 m is provided on the top of the pipe.
4. The lighter pipes weighing less than 80 kg can be lowered in the trench by hand. If the sides of the trench slope are too much, ropes must be used. The pipes of medium weight up to 200 kg are lowered by means of ropes looped around both the ends. One end of the rope is fastened to a wooden or steel stake driven into the ground and the other end of the rope is held by men and is slowly released to lower the pipe into the trench. After lowering, the pipes are aligned for jointing. The bed of the trench should be uniform.

Back filling shall follow pipe installation as closely as possible to protect pipe from falling boulders, eliminating possibility of lifting of the pipe due to flooding of open trenches and shifting pipe out of line by caved in soil. The soil under the pipe and coupling shall be solidly tamped to provide a firm and continuous support for the pipeline. Tamping shall be done either by tamping bars or by using water to consolidate the back fill material.

The initial back fill material used shall be free of large stones and dry lumps. In stony areas the material for initial back fill can be shave from the sides of the trenches. In bogs and marshes, the excavated material is usually little more than vegetable matter and this should not be used for bedding purposes. In such cases, gravel or crushed stone shall be hauled in.

The initial back fill shall be placed evenly in a layer of about 100 mm thick. This shall be properly consolidated and this shall be continued till there is a cushion of at least 300 mm of cover over the pipe.

Balance of the back fill need not be so carefully selected as the initial material. However, care shall be taken to avoid back filling with large stones which might damage the pipe when spaded into the trench.

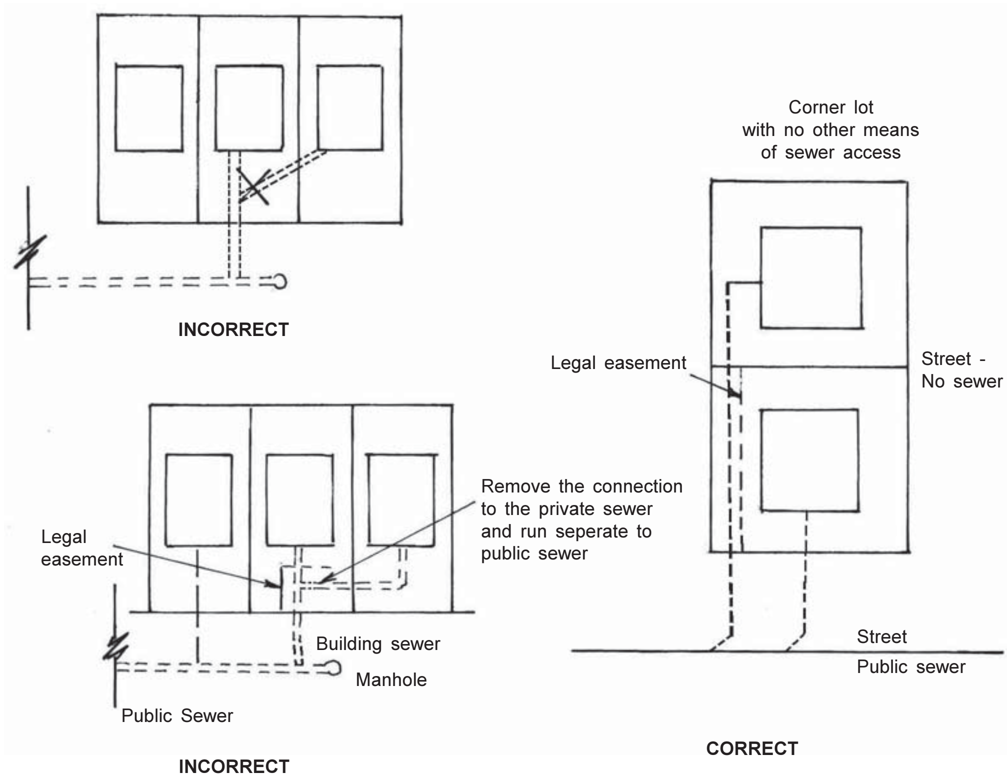
Pipes in trenches on a slope shall have extra attention to make certain that the newly placed back fill will not become a blind drain in effect because until back fill becomes completely consolidated there is a tendency for ground or surface water to move along this looser soil resulting in a loss of support to the pipe. In such cases, the back fill should be tamped with extra care and the tamping continued in 100 mm layers right up to the ground level.

14.0 Laying of plastic pipes:–

1. As a rule, trenching should not be carried out too far ahead of pipe laying. The trench should be as narrow as practicable. This may be kept 0.3 m more than the outside diameter of the pipe and depth may be kept at 0.6-1.0 m depending upon traffic conditions.
2. The trench bottom should be carefully examined for the presence of hard subjects such as flints, rock projections or tree roots. In uniform, relatively soft fine grained soils with the bottom of the trench brought to an even finish to provide a uniform support for the entire length of pipes, they may be laid directly on the trench bottom. In other cases the trench should be cut deeper and the pipes laid on a prepared under bedding which may be drawn from the excavated material, if suitable.
3. Pipe lengths are placed end to end along the trench. The glued spigot and socket jointing technique, as mentioned is adopted.
4. The jointed lengths are then lowered in the trench when a sufficient length has been laid.
5. The trench is filled. If trucks, lorries or other heavy traffic will pass across the pipeline, concrete tiles 60 X 60 cm of suitable thickness and reinforcement should be laid about 2 m above the pipe to distribute the load. If the pipeline crosses a river, the pipe should be buried at least 2 m below bed level to protect the pipe.
6. For bending, the cleaned pipe is filled with sand and compacted by tapping with a wooden stick and the pipe ends plugged. The pipe section is heated with flame and the portion bent as required. The bend is then cooled with water, the plug removed, and the sand poured out and the pipe (bend) cooled again. Heating in hot air oven, hot oil bath, hot gas or other heating devices are also practiced.

15.0 General guidelines for plumbing works:-

15.1 Piping, fixtures or equipment shall not be so located as to interfere with the normal use thereof or with the normal operation and use of windows, doors or other required facilities. Proper access shall be provided to connect a building sewer to available public sewer. Correct locations of plumbing and sewer system is shown in figure.



Location of plumbing & sewers

15.2 It is unacceptable to conceal cracks, holes or other imperfections in materials by welding, brazing or soldering or by using therein or thereon any paint, wax, tar, solvent cement or other leak-sealing or repairing agent.

15.3 Burred ends of pipe and tubing shall be reamed to the full bore of the pipe or tube and chips shall be removed.

15.4 No drainage or vent piping may be drilled or tapped for the purpose of making connections, and no cast iron pipe may be field threaded. There is no sufficient thickness of material in the wall of any type of drainage piping in order to form a tapped thread. Approved adapter fittings are required whenever drainage pipe is joined with dissimilar materials.

15.5 No waste connection shall be made to a closet bend or stub of water closet or similar fixture.

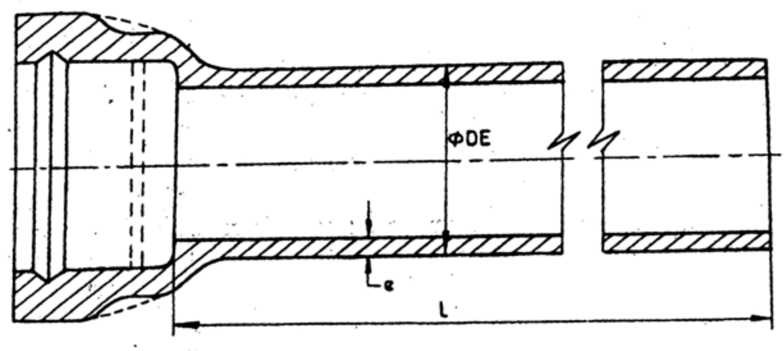
15.6 Except in case of combined waste and vent system, no vent pipe shall be used as a soil or waste pipe, nor shall any soil or waste pipe be used as vent.

APPENDIX-1

Cast iron pipes

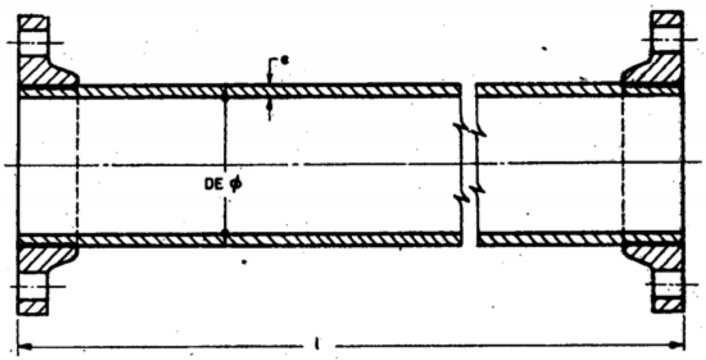
The standard weights and thickness of pipes and their tolerances for different diameter in mm are indicated in table:-

a) Socket and Spigot pipes :-



DN	LA class			A class			B class		
mm	BARREL		Socket	BARREL		Socket	BARREL		Socket
	e mm	Mass for one metre kg	mass kg	e mm	Mass for one metre kg	mass kg	e mm	Mass for one metre kg	mass kg
80	7.2	14.7	5.5	7.9	16.0	5.5	8.6	17.3	5.5
100	7.5	18.6	7.1	8.3	20.5	7.1	9.0	22.0	7.1
125	7.9	24.2	9.2	8.7	26.4	9.2	9.5	28.7	9.2
150	8.3	30.1	11.5	9.2	33.2	11.5	10.0	35.9	11.5
200	9.2	44.0	16.5	10.1	48.1	16.5	11.0	52.1	16.5
250	10.0	59.3	22.9	11.0	65.0	22.9	12.0	70.6	22.9
300	10.8	76.5	29.8	11.9	84.0	29.8	13.0	91.4	29.8
350	11.7	96.3	37.5	12.8	105.0	37.5	14.0	114.5	37.5
400	12.5	116.9	46.3	13.8	128.7	46.3	15.0	139.5	46.3
450	13.3	141.0	56.0	14.7	156.0	56.0	16.0	169.0	56.0
500	14.2	165.2	66.0	15.6	181.0	66.0	17.0	196.7	66.0
600	15.8	219.8	89.3	17.4	241.4	89.3	19.0	262.9	89.3
700	17.5	283.2	116.8	19.3	311.6	116.8	21.0	338.2	116.8
750	18.3	317.2	131.7	20.2	348.9	131.7	22.0	380.6	131.7
800	19.2	354.9	147.8	21.1	389.1	147.8	23.0	423.1	147.8
900	20.8	431.8	182.6	22.9	474.3	182.6	25.0	516.6	182.6
1000	22.5	518.3	222.3	24.8	570.0	222.3	27.0	619.2	222.3
1050	23.6	583.4	309.6	26.0	641.2	309.6	29.0	713.3	309.6

b) Flanged pipes



DN (mm)	DE (mm)	e (mm)	Mass for One meter (kg)	Mass for flange (kg)
80	98	8.6	17.3	4.3
100	118	9.0	22.0	5.0
125	144	9.5	28.7	6.6
150	170	10.0	35.9	8.2
200	222	11.0	52.1	11.4
250	274	12.0	70.6	14.7
300	326	13.0	91.4	18.6
350	378	14.0	114.5	21.2
400	429	15.0	139.5	27.3
450	480	16.0	169.0	32.6
500	532	17.0	196.7	196.7
600	635	19.0	262.9	262.9
700	738	21.0	338.2	71.9
750	790	22.0	380.6	84.4
800	842	23.0	423.1	96.9
900	945	25.0	516.6	113.5
1000	1048	27.0	619.2	134.0
1050	1124	29.0	713.3	169.9

Note:- 1) Tolerance for wall thickness e shall be :- (-) [1+0.05e]

2) Tolerance for length shall be :- ± 100 mm

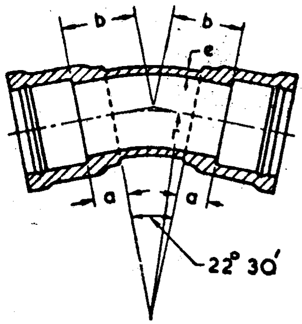
The manufacturer may supply one number of socket and spigot pipes upto 10 % in lengths other than the specified length.

3) Tolerance for mass :- ± 5 %

4) Total mass of pipe can be calculated by multiplying per meter length to total mass plus mass of socket/mass of two flanges.

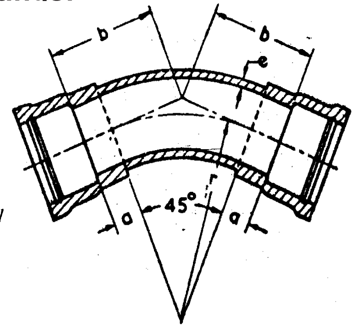
APPENDIX-1A

CI fittings:



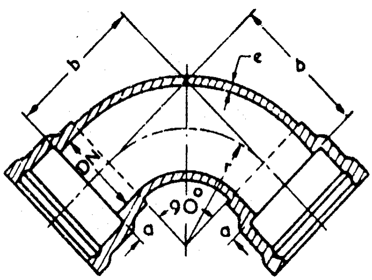
$r = 200 + DN$
$a = 35 + 0.1\ DN$
$b = 74.78 + 0.296\ 9\ DN$
$e = \frac{14}{12}(7 + 0.02\ DN)$

Bend 22.5[0]



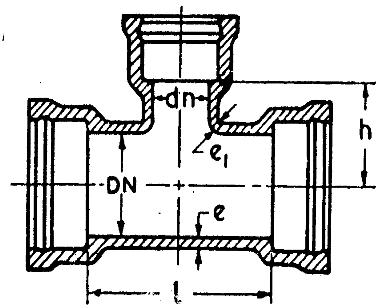
$r = 200 + DN$
$a = 35 + 0.1\ DN$
$b = 117.8 + 0.514\ DN$
$e = \frac{14}{12}(7 + 0.02\ DN)$

Bend 45[0]



$r = 65 + 0.9\ DN$
$a = 35 + 0.1\ DN$
$b = 100 + DN$
$e = \frac{14}{12}(7 + 0.02$

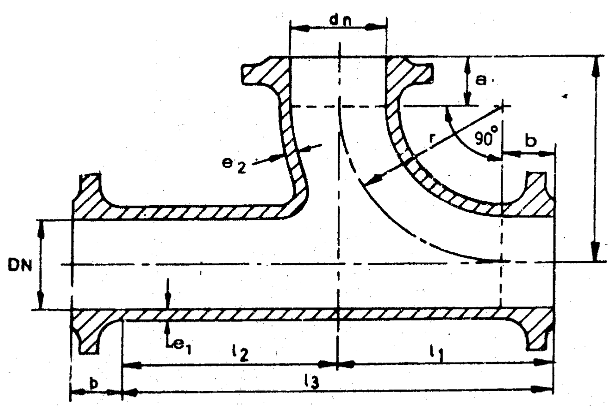
Bend 90[0]



$l + 100 + 1.4\ DN$
$h = 50 + 0.5\ DN + 0.2\ dn$
$e = \frac{14}{12}(7 + 0.02\ DN)$

Tee- Joint

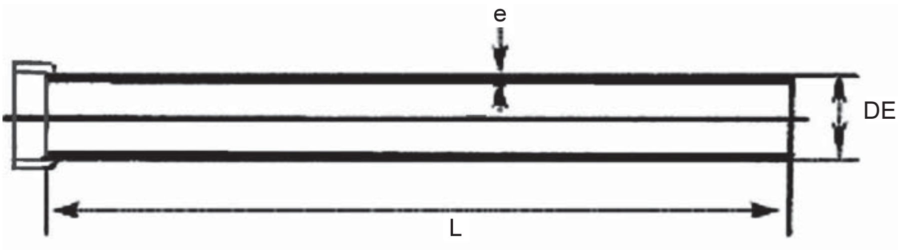
$e = 14/12\ (7 + 0.02\ DN)$
$r = 65 + 0.9\ dn$
$a = 35 + 0.1\ dn$
$b = 35 + 0.1\ DN$
$l_1 = r + b$
$l_2 = 200 + 2\ DN$ (for $DN = 80$ to 300)
$l_3 = 500 + DN$ (for $DN = 350$ to $1\ 000$)
$l_2 = l_3 - l_1$



Tee- Junction

APPENDIX-2

Ductile Iron Fittings:



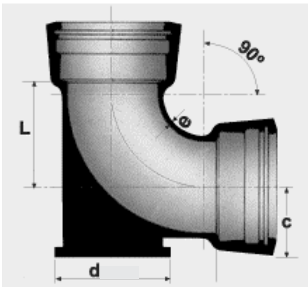
Internal Dia. DN	External Dia. DE		Iron thickness 'e' for class K9. Pressure Bars (K9)		Minimum Works test	Internal Pressure Rating (K9)		
mm	Nominal mm	Tolerance mm	Nominal mm	Tolerance mm		Nominal mm	Tolerance mm	Nominal mm
80	98.0	+1 to - 2.2	6.00	-1.3	50	64	77	96
100	118.0	+1 to - 2.8	6.00	-1.3	50	64	77	96
150	170.0	+1 to - 2.9	6.00	-1.5	50	64	77	96
200	222.0	+1 to - 3.0	6.30	-1.5	50	62	74	79
250	274.0	+1 to - 3.1	6.80	-1.6	50	54	65	70
300	326.0	+1 to - 3.3	7.20	-1.6	50	49	59	64
350	378.0	+1 to - 3.4	7.70	-1.7	40	45	54	59
400	429.0	+1 to - 3.5	8.10	-1.7	40	42	51	56
450	480.0	+1 to - 3.6	8.60	-1.8	40	40	48	53
500	532.0	+1 to - 3.8	9.00	-1.8	40	38	46	51
600	635.0	+1 to - 4.0	9.90	-1.9	40	36	43	48
700	738.0	+1 to - 4.3	10.80	-2.0	32	34	41	76
800	842.0	+1 to - 4.5	11.70	-2.1	32	32	38	43
900	945.0	+1 to - 4.8	12.60	-2.2	32	31	37	42
1000	1048.0	+1 to - 5.0	13.50	-2.3	32	30	36	41

- Pipes are supplied in standard length of 5.5 / 6.0 meters. Short length pipes as per respective standards can also be supplied
- The above dimensions are given for class K9 pipes, Class K7,K8 and K10 classes of pipes are also used.
- The thickness can be determined by the formula – e = K (0.5 + 0.00 1 DN)

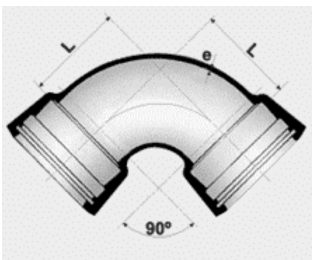
APPENDIX-2A

Ductile Iron Fittings:

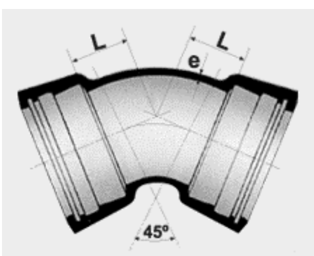
(Available in sizes from 80mm ϕ to 1000mm ϕ)



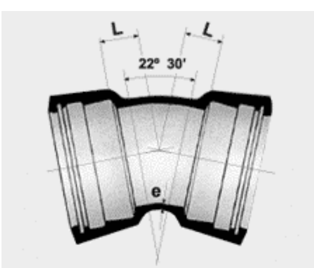
90^0 Double Socket Duck foot Bend



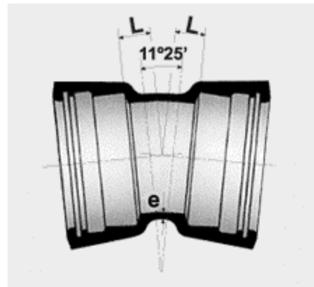
Ductile Socket Bend.



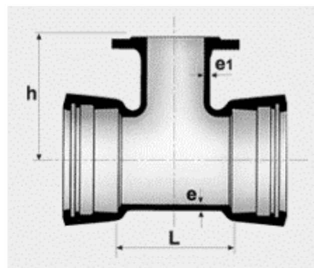
Ductile Socket Bend.



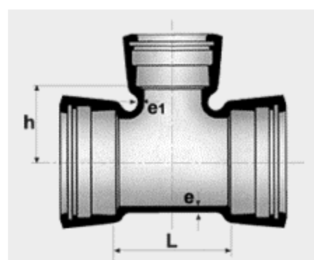
Ductile Socket Bend.



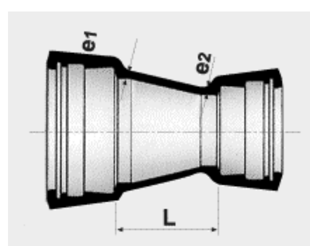
Ductile Socket Bend.



Double Socket and Spigot Tee



All Socket Tee



Double Socket Duck

APPENDIX-3

Galvanised iron pipes

DIMENSIONS OF BLACK AND GALVANISED STEEL TUBES AS PER IS : 1239 [PART1] / 1990

Nominal bore	Class	Outside diameter		Wall thickness	Weight of pipe with Plain ends	Weight of pipe with screwed and socket ends	Maximum permissible pressure
mm (inches)		MIN. mm	Max. mm	mm	kg/m	kg/m	kPa
	L	21	21.4	2	0.947	0.956	—
15 (1/2")	M	21	21.8	2.6	1.21	1.22	1.2
	H	21	21.8	3.2	1.44	1.45	1.2
	L	26.4	26.9	2.3	1.38	1.39	—
20 (3/4")	M	26.5	27.3	2.6	1.56	1.57	1.2
	H	26.5	27.3	3.2	1.87	1.88	1.2
	L	33.2	33.8	2.6	1.98	2	—
25 (1")	M	33.3	34.2	3.2	2.41	2.43	1.2
	H	33.3	34.2	4	2.93	2.95	1.2
	L	41.9	42.5	2.6	2.54	2.57	—
32 (11/4")	M	42	42.9	3.2	3.1	3.13	1.03
	H	42	42.9	4	3.79	3.82	1.03
	L	47.8	48.4	2.9	3.23	3.27	—
40 (11/2")	M	47.9	48.8	3.2	3.56	3.6	1.03
	H	47.9	48.8	4	4.37	4.41	1.03
	L	59.6	60.2	2.9	4.08	4.15	—
50 (2")	M	59.7	60.8	3.6	5.03	5.1	0.86
	H	59.7	60.8	4.5	6.19	6.26	0.86
	L	75.2	76	3.2	5.71	5.83	—
65 (21/2")	M	75.3	76.6	3.6	6.42	6.54	0.86
	H	75.3	76.6	4.5	7.93	8.05	0.86
	L	87.9	88.7	3.2	6.72	6.89	—
80 (3")	M	88	89.5	4	8.36	8.53	0.86
	H	88	89.5	4.8	9.9	10.4	0.86
	L	113	113.9	3.6	9.75	10	—
100 (4")	M	113.1	115	4.5	12.2	12.5	0.69
	H	113.1	115	5.4	14.5	14.8	0.69
	M	138.5	140.8	4.8	15.9	16.4	0.69
125 (5")	H	138.5	140.8	5.4	17.9	18.4	0.69
	M	163.9	166.5	4.8	18.9	19.5	0.5
150 (6")	H	163.9	166.5	5.4	21.3	21.9	0.5

Tolerances

Thickness	Light tubes	:+ Not Limited : - 8%
	Medium & Heavy Tubes	: + Not Limited : - 10%
Weight :	Light Series Medium & Heavy Series	: +10%, - 8% : ± 10%
Length	Light, Medium & Heavy tubes	: Random Length of 4 to 7 meters unless specified otherwise

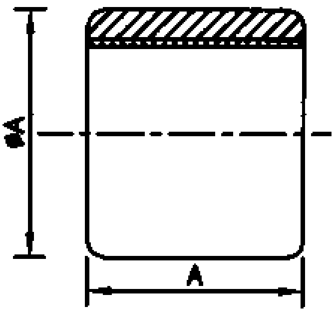
For water supply normally Railway specifications recommend the use of medium class pipes(Blue band)

Nominal bore (MM)	Min. outside dia. (MM)	Minimum length A
15	27.0	32
20	32.5	35
25	39.5	46
32	49.0	51
40	56.0	52
50	68.0	64
65	84.0	76
80	98.0	89
100	124.0	115
125	151.0	140
150	178.0	160

APPENDIX- 3A

G.I. fittings:

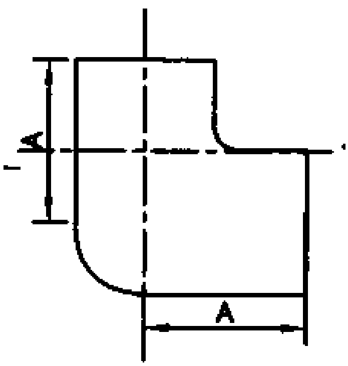
1. Socket or coupling:-



SOCKET

Nominal bore mm	Min. outside dia. mm	Minimum length (A) mm
15	27.0	37
20	32.5	39
25	39.5	46
32	49.0	51
40	56.0	51
50	68.0	60
65	84.0	69
80	98.0	75
100	124.0	87
125	151.0	96
150	178.0	96

2. Elbow:-

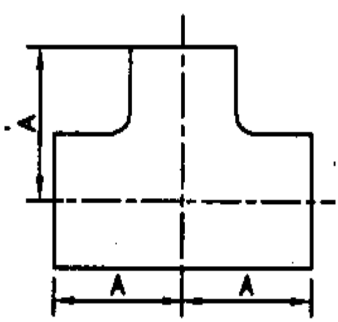


ELBOW, EQUAL

Common dimensions for Elbow equal and Tee equal.

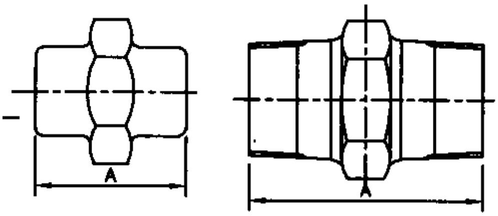
Nominal bore mm	Minimum length (A) mm
15	32
20	35
25	46
32	51
40	52
50	64
65	76
80	89
100	115
125	140
150	160

3. Tee:-



TEE, EQUAL

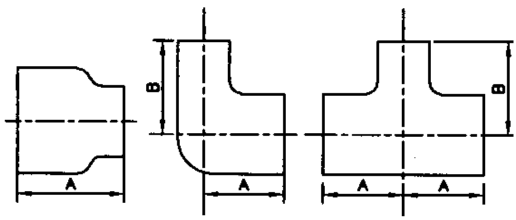
4. Union:-



SOCKET UNION   PIPE UNION

Nominal bore mm	Minimum length (A) mm	
	Socket	Pipe
15	57	115
20	67	120
25	76	125
32	85	135
40	100	140
50	110	150
65	120	165
80	135	180
100	160	205
125	185	215
150	210	230

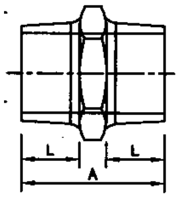
5. Reducer:-



REDUCING SOCKET   REDUCING ELBOW   REDUCING TEE

Nomi. Size of outlets mm	**Minimum length**				
	Reducing socket mm	Reducing elbow		Reducing tee	
		A mm	B mm	A mm	B mm
20X15	41	32	35	32	35
25X15	51	35	43	35	43
25X20	49	38	43	38	43
32X25	56	44	51	44	51
40X25	62	44	52	48	52
50X32	65	52	64	52	64
65X40	73	60	76	60	76
80X50	81	73	89	73	89
80X65	79	-	-	79	89
100X80	98	95	115	95	115
125X100	115	-	-	130	140
150X80	140	-	-	120	160
150X100	140	-	-	135	160

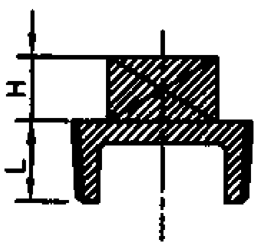
6. Nipple:-



HEXAGON NIPPLE

Nominal pipe mm	Minimum length A mm	Minimum length of threads L mm
15	43	17.5
20	48	19
25	52	21
32	59	24
40	61	24
50	68	27
65	80	32
80	89	35
100	102	40
125	115	45
150	115	45

7. Plug:-

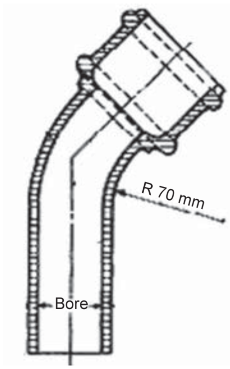


Nominal bore mm	Minimum length mm	
	L	H
15	13.2	10
20	14.5	12
25	16.8	12
32	19.1	16
40	19.1	16
50	23.4	19
65	26.7	19
80	29.8	22
100	35.8	25
125	40.1	29
150	40.1	32

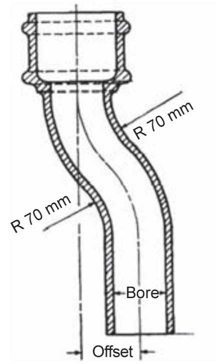
APPENDIX- 4

A.C. pipe fittings :-

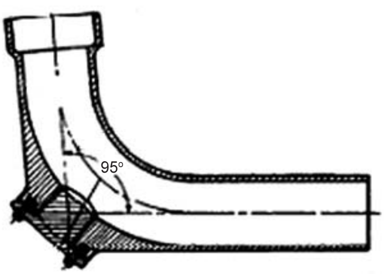
1. Plain Bend



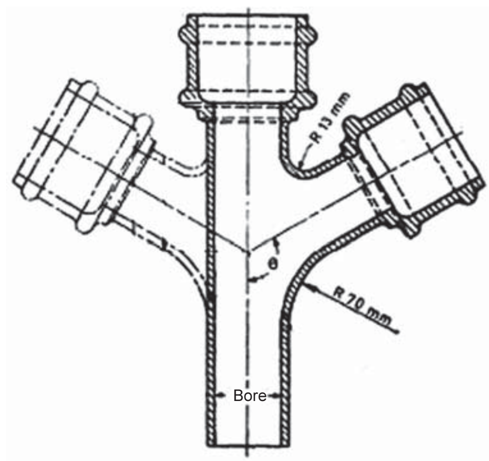
2. Swan Bend



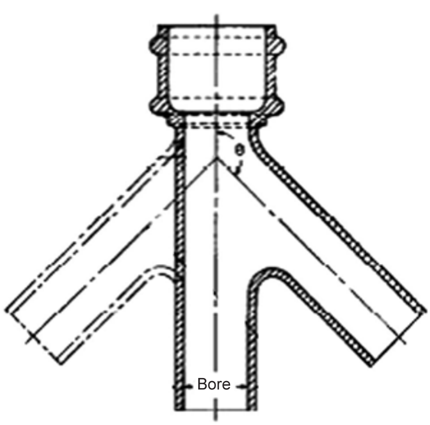
3. Sanitary Bend



4. Single and double equal joints



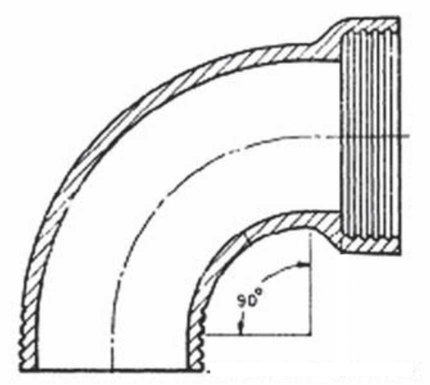
5. Single and double equal joints with inverted junctions



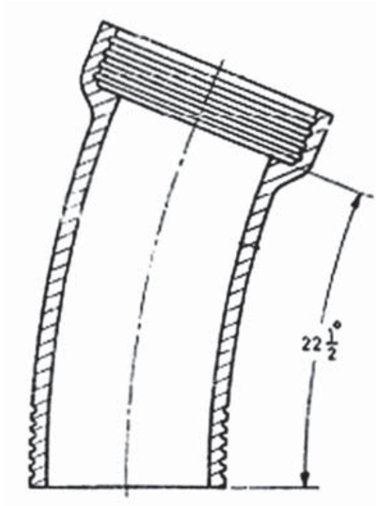
APPENDIX-5

Stoneware pipe fittings

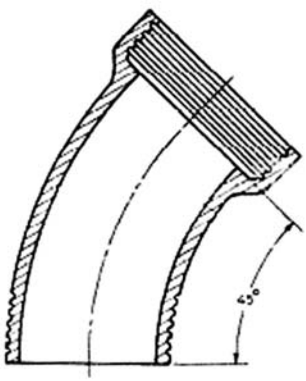
1. One quarter bend:



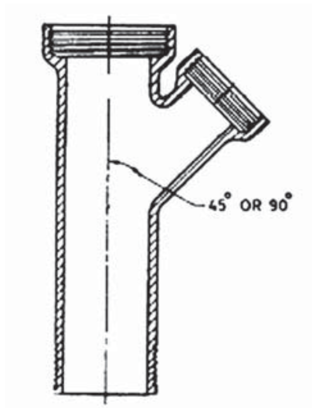
2. One sixth bend:



3. One eighth bend:



4. Half section channel junction



APPENDIX-6

PVC pipes

The dimensions of the PVC pipes are as shown in table:

Diameter	**Mean outside**		**Outside diameter diameter at any point**		**Wall thickness, S Type A**		**Wall thickness, S Type B**	
DN	Min	Max	Min.	Max	Min.	Max	Min.	Max
40	40.0	40.3	39.5	40.5	1.8	2.2	3.2	3.8
50	50.0	5O.3	49.4	50.6	1.8	2.2	3.2	3.8
63	63.0	63.3	62.2	63.8	1.8	2.2	3.2	3.8
75	75.0	75.3	74.1	75.9	1.8	2.2	3.2	3.8
90	90.0	90.3	88.9	91.2	1.9	2.3	3.2	3.8
110	110.0	110.4	108.6	111.4	2.2	2.7	3.2	3.8
125	125.0	125.4	123.5	126.5	2.5	3.0	3.2	3.8
140	140.0	140.5	138.3	141.7	2.9	3.4	3.6	4.2
160	160.0	160.5	158.0	162.0	3.2	3.8	4.0	4.6

Appendix-6A

PVC pipe fittings:


Cleansing Pipe


'T'


Single 'Tee' with door


Double 'Tee'


Double 'Tee' with door


Coupler


Reducer


Single Y


Single Y with door


Double 'Y'


Double 'Y' with door


Bend 87.5^{o}


Bend 135^{o}


Bend with door


Rubber seal Ring


Lip ring for P/Q/S Trap

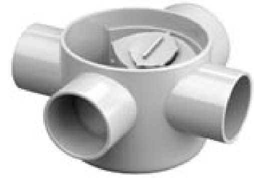

P-Trap


Q-Trap


S-Trap

Nahani Trap and Jali

Vent Cowl



Multifloor Trap

Clips

The fittings are available in sizes suitable to the pipes.

Cleansing pipe:- A fitting provided in a run of pipe with a door allowing the cleaning of pipe when required.

Single 'T':- Single 'T' is used to connect PVC pipe line at 87.5^0 or 92.5^0. These are normally used for sewerage stacks.

Single 'T' with door:- Single 'T' with door is used to connect PVC pipe line at 87.5^0 or 92.5^0 but it is having screwed door for cleaning or flushing.

Double Tee:- Double 'T' is used to connect two adjacent branch PVC pipe lines at 87.5^0 or 92.5^0.

Double Tee with door:- Double 'T' with door is used to connect PVC pipe line at 87.5^0 or 92.5^0 but it is having screwed door for cleaning or for flushing.

Coupler :- For joining pipes of similar diameter couplers are used as an outer fitting.

Reducer :- For joining pipes of different diameters couplers are used as a junction. These are placed as a outside fixture.

Single 'Y':- Single 'Y' is used to connect PVC pipe branch line for sewerage, at 45^0.

Single 'Y' with door:- Single 'Y' is used to connect PVC pipe branch line at 45^0 but it is provided with screwed door for cleaning in case of any blockage occurring in the stack above .These can be either left hand type or right hand type.

Double 'Y':- Double 'Y' is used to connect two PVC pipe branch lines at 45^0.

Double 'Y' with door:- Double 'Y' with door is used to connect two PVC pipe branch lines at 45^0 but it is provided with screwed door for cleaning.

Bends:- Different bends at angles like 45º, 87.5º are used to give required bend to pipe line. It is also used as shoe for rain water drainage line.

Bend with door:- 87.5º Bend is used to give turn to pipe line but it is provided with screwed door for cleaning.

Rubber seal ring:- These are used for joining and sealing the pipes of Spigot and socket ends.

Lip ring for P,Q,S traps:- This is a gasket to make joints leak proof.

WC connector ring for P/Q/S traps: - The connectors join the WC pipe with the sewerage system.

Rubber Ring for WC connector for traps:- The rubber rings are used to make the joints with WC and sewerage leak proof.

P/Q/S traps:- The P/Q/S traps are designated as 125x110 or 110x110, depending upon the socket end connecting the WC outlet being 125mm or 110mm; however the end connecting the stacks or the branch is always 110 mm.

Nahani trap with jali:- This is used in bath room and is having the inlet as 110 mm and out let as 75 mm, and is designated as 110x75.

Vent cowl:- These are used to cover the vent pipes in sewerage system.

Floor trap:- These are used for receiving multi pipes.

Pipe clips:- The clips come as per diameter of pipe and have holes on either end to be fixed with nails or screws to the wall etc.

Chapter 3

PLUMBING FIXTURES

1.0 Taps

Taps fall into three main design categories, wall mounted taps are known as Bib Taps, those mounted directly onto the sink, basin or bath are called Pillar Taps, and thirdly there are Mixer Taps, which have a hot and cold valve linked to a single spout. As per good practice, mains and stored water (hot water from your storage tank) cannot be mixed in a system. This means that all sinks have separate pipes to isolate hot from cold water. The taps or valves are designated by the size of the diameter of the inlet pipe they are connected to.

Traditionally, most taps used the Pillar design. These work by having a Rubber or Nylon (or leather) washer on a threaded pillar/spindle inside the body of the tap. When the tap is closed, the washer would sit on top of the water supply pipe. As the tap is unscrewed the whole pillar unscrews and rises with the washer, allowing the water to pass into the spout. Modern taps most often use a non-rising head, this means that while they work in almost the same way, the threaded pillar and washer rise without turning, reducing wear on the washer. The washers themselves have also evolved, with many modern taps (usually the more expensive brands) using precision ground ceramic discs. These have the advantage of very little wear and also do not suffer from lime scale build up. The taps and valves are made in different materials like brass, iron, alloys, plastic etc. The principal and details of various types of taps and stop valves are given here under:

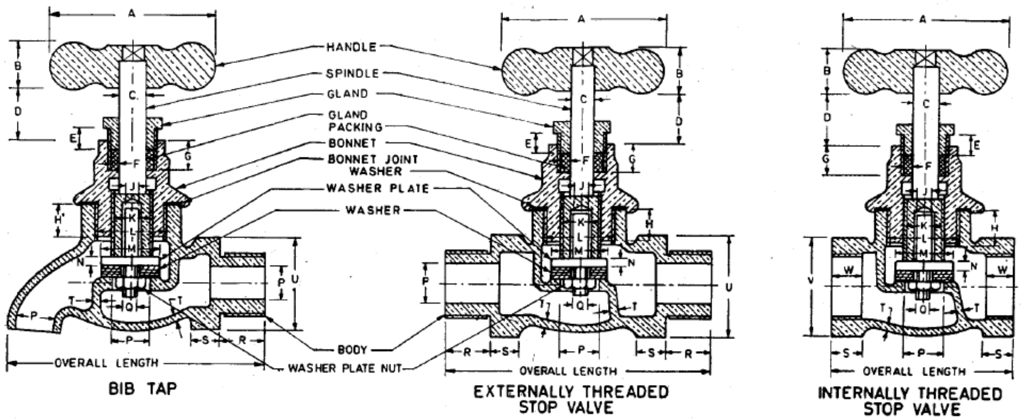
1.1 Bib tap: It is a draw-off tap with horizontal inlet and free outlet. A bib tap is closed by means of disc carrying a renewable non-metallic washer which shuts against the water pressure on a seating at right angles to the axis of the threaded spindle which operates it. The bib taps are provided with threads on the external side and have to be connected to a socket at the pipe out let. The nominal sizes of bib taps are 8, 10, 15, 20 and 25 mm. However for water supply 15, 20 and 25 are used. The bib taps are suitable for working under water pressure of 1 MPa (10 bars or 10m of water head) and ones made of brass are normally for cold water but suitable up to 45 ^{0}C.

The minimum finished mass of bib tap made of brass, as per I.S. 781, made of brass shall be as shown in table

Nominal size of tap(mm)	Minimum finished mass(Kq)
15	0.400
20	0.750
25	1.250

A stop valve is almost identical in function, except that it does not have a spout but it is inserted in a pipe line for controlling or stopping water flow. The stop valves may have both ends threaded outside or else both threaded inside. The stop valves are available in nominal sizes of 15,20,25,32,40 and 50 mm.

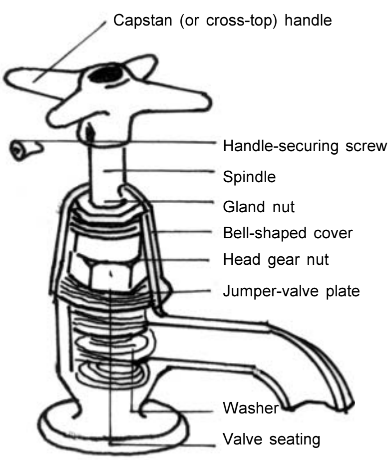
The sketch below shows various parts of a bib tap and stop valve,



The detailed dimensions are given in I.S.-781.

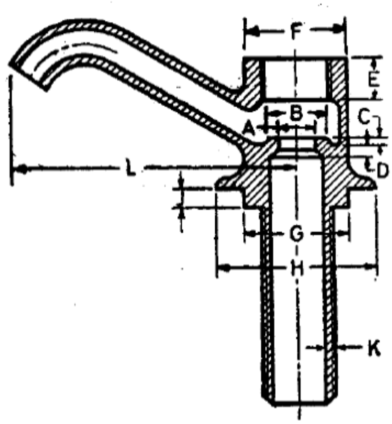
1.2 Pillar taps

The traditional spindle design is commonly used on lower quality, cheaper tap designs. The tap has a spindle through the centre, with the valve seat connected via a screw thread. A standard tap washer (either 15 mm or 20mm) is fixed to the end of the valve seat. As the handle is turned the spindle rotates and the screw thread moves the valve seat up and down to regulate the flow of water.

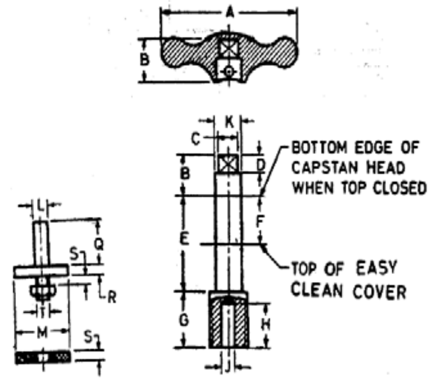


Cross section of pillar tap

The detailed dimensions of a Pillar Tap (15 mm) as per I.S. -1795 are given below.



Body of pillar tap



Spindle of pillar tap

Detail of part	**Dimension (mm)**	**Detail of part**	**Dimension (mm)**
A: length of Capstan head	18.8-18.0	J: size of parallel hole in spindle	6.0-5.8
B: length at C/L of boss of cap. head	14	K: size of plain spindle	9.4
C: dim. of sq. head of capstan	6.7	L: size of steam washer plate	5.7-5.6
D: ht. of sq head	4.7	M: size of outside washer plate	19
E: length of plain head of spindle	35.5	Q: length of washer plate stem	16.3-15.6
F: Distance when close	7.5	R: thickness of W.P.	3.2
G: length of external thread on spindle	20.8	S: thickness of washer	4.0
H: depth of parallel hole in spindle	18.8-18.0		

These taps are very commonly used for all purposes but have following shortcomings,

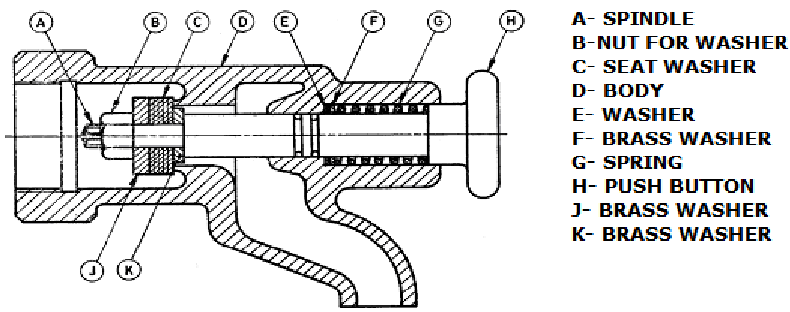
a) Difficult to operate - handle has to be turned many times from off to full on.

b) Higher maintenance - washers will require replacing regularly

c) Less choice of style - cannot be used with modern lever designs.

1.3 Ceramic disc taps:- This technology is commonly used on more expensive taps, as they perform better and last longer. When the handle is turned, two ceramic discs are parted opening the valve and allowing the water to flow. This removes the shortcomings, mentioned above. The one disc is in a fixed position and the other turns up to 90% with the handle. These two discs are aligned in the open position. This type is used in most superior taps and mixer valves, where the operation is by small turn or lift of the knob. The ceramic disc is contained in a plastic cartridge and placed in the assembly. The one disc is in a fixed position and the other turns up to 90% with the handle. These two disc are aligned in the open position.

1.4 Self-closing tap:- A self-closing tap is a draw-off tap which remains in the open position so long as a lever handle is kept pressed up, down or sideways, or a pushbutton is kept pressed in, and closes by itself or when the button or the lever handle is released; the self-closing taps may incorporate a device which closes the tap even without the release of the button or the handle after a fixed quantity is discharged. These types of taps prevents wastage of water and are normally fixed at location where heavy public traffic is expected all the time.



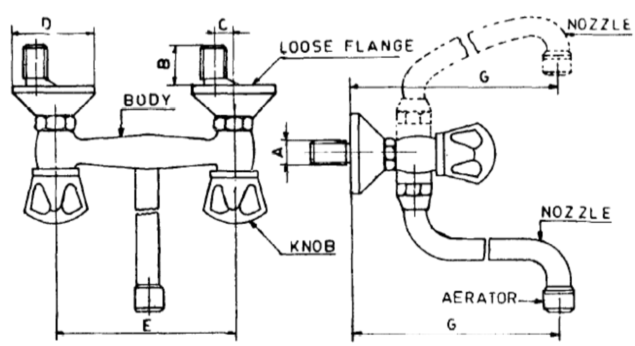
NOMINAL SIZE: - Self-closing taps shall be of the following nominal sizes. Nominal size refers to the nominal bore of the inlet connection.

a) 15 mm, and
b) 20 mm.

The force required for operating the self-closing tap for its full opening should not exceed 70N. For self-closing taps which operate against heads exceeding 2 m, a non-concussive function is essential.

1.5 Mixer valves:

Mixer valves are manufactured as per I.S.1701. As stated earlier, hot and cold water is carried in different pipes and mixed in a mixer valve at the point of discharge, through a common spout. A typical sketch of the arrangement is shown.



1.5.1 Basin pillar taps: Basin pillar taps are single tap bodies, with a 15 mm connection, for use with any two tap hole basin. (i.e. a separate tap for hot and cold). The hot tap is always installed on the left hand side.

Basin pillar tap

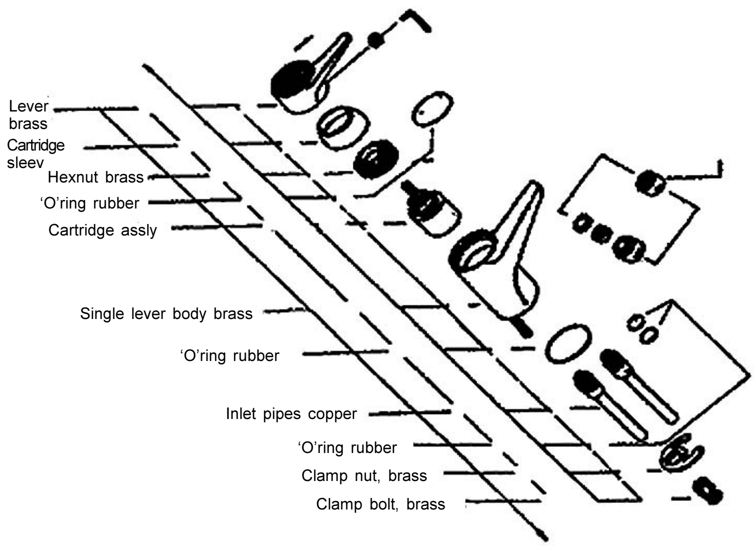
Mono basin Mixer

Tall mono basin mixer

3-hole basin mixer

1.5.2 Mono basin mixers

There are two types of mono basin mixers, single & dual flow. The single flow mixers mix both supplies at the base of the spout and discharge a mixed flow. With dual flow mixers, the hot & cold flow is kept separate until the point of discharge.



Mono basin mixers can either use a lever arrangement with a ceramic disc cartridge, or use twin valves (either standard or ceramic disc) and separate handles to operate the hot & cold independently. The details of single lever basin mixer assembly with disc cartridge is shown in drawing:

1.5.3 Tall mono basin mixers

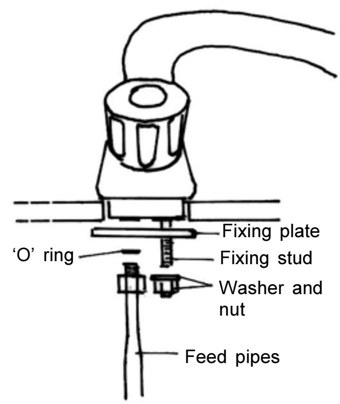
The same as Mono basin mixers, only supplied with an elongated body. These taps are normally installed in conjunction with countertop wash hand basins. Most of the Tall Mono Basin Mixers are of the lever type, utilising ceramic disc cartridges.

1.5.4 Three hole basin mixers

Three hole basin mixers consist of three parts, connected via either rigid or flexible pipe work. The spout is positioned centrally, with the hot & cold controls on either side. TH basin mixers utilise either standard or ceramic disc valves.

1.5.5 Fixing mono-block (single hole) mixer taps

Mono-block mixer taps (single hole) require a 35mm mounting hole and use 10mm screw connections for the water feeds - normally the taps are supplied with 2 short (about 20cm/8 inch) adapter pipes with 10mm screw connectors at one end and with 15mm pipe at the other end for connecting to the plumbing system.



A typical installation is shown to the right.

Steps to be followed:-

- Start by mounting the tap to the surface, typically this uses a 'horse shoe' fixing plate secured by a nut and washer onto a fixing stud screwed into the tap body. The shape of the fixing plate is shown in the illustration below.
- Before finally tightening the nut, ensure that the tap body is lined up with the sink etc.
- Once the tap body is secured, the water feed pipes need to be fitted - but before doing this, work out the pipe length required.
- It is a good idea to use compression fittings for the adapter pipes (rather than solder type) as the actual adapter pipes will need to be rotated if their need to be tightened or removed from the tap body in future.

View showing the 'horse shoe' mounting plate

- Where either the hot or cold water supply is via a storage tank, it is preferred to fit shutoff valves in each supply pipe under the unit before the final pipe run from the compression joints to the taps - this will allow the tap to be repaired or replaced in future without having to empty the tank(s).
- Once decided upon the connections for the pipes, the adapters need to be screwed into the body of the tap using the 'O' rings supplied. Tighten each adapter pipe into the body of the tap using an appropriate sized spanner before connecting the lower ends to the

rest of the plumbing. Do not over tighten, the 'O' rings will compress to provide a seal, over tightening can damage the 'O' rings and cause leaks.

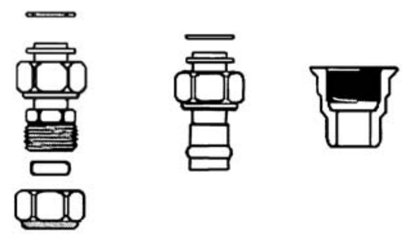
1.5.6 Connecting to taps on baths, hand basins or sinks

This method applies to 15 and 20mm taps (including 2 hole mixer taps). 15mm taps are used on hand basins with 15mm pipe work while 20mm taps are used on baths and sinks with 20mm pipe work. (When fitting a new bath, hand basin or sink, there is a practice for hot tap to be on the left.)

The parts required :-

i) To make the water connection to the taps, pipe to tap fittings are required; these are available in both compression and solder type fittings - both having a fibre washer with a screw fitting to secure to the tail of the tap.

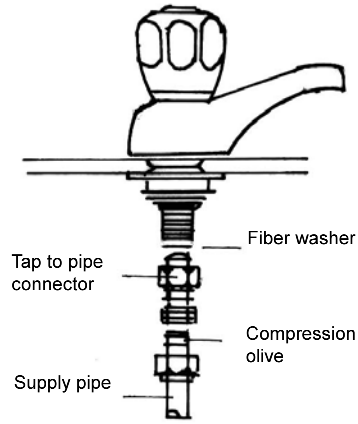
It is good practice to have a compression joint within a short distance of the tap in case it needs to be removed in future - using a solder joint tap fitting with a compression pipe fitting further down the pipe work does have the advantage that access to the compression joint will be easier.



ii) When replacing taps, the new taps may have shorter tails than the original ones; in this event, fitting short tail adaptors to the taps may avoid the need to adjust the existing pipe work.

iii) To make the job of bending the pipe work between the supply pipes and the taps easier, flexible pipes are available. The two common types are hand bendable copper pipe or stainless steel braided type. The former normally has a plain pipe at the bottom which can be joined using either a compression or solder fitting; the stainless steel braided type normally has compression fittings at both ends.

iv) It is worth considering fitting shutoff valves in each supply pipe under the unit - these are especially useful where the feeds are from storage



tanks as future repairs will not require the tank(s) to be drained.

Making the connections to the taps before the unit is in place is often easier as access to the tails of the taps can be very restricted once the unit is in place. It may be necessary to put the unit temporarily in place to establish the lengths and bends for the pipes.

v) If using solder tap fittings, make the joint to a length of pipe (without the fibre washer in place) before fixing the fitting to the tap.

Likewise with compression tap fittings, it is easier to tighten the joint onto the first piece of pipe 'off' of the unit.

Steps to be followed:-

❖ To fit tail adaptors:

- Wrap two or three layers of PTFE tape, or jute fiber after applying plumbers putty around the thread of the tail of the tap, go in the direction of the thread.
- Apply a thin coating of jointing compound to the threads of the adaptor.
- Screw the adaptor onto the tail of the tap and tighten using a tap spanner and a spanner .

❖ To fit the tap fitting to the tap:

- Wrap two or three layers of PTFE tape around the thread of the tail of the tap (or the bottom of the tail adaptor if used), go in the direction of the thread.
- Always use a new fibre washer, fit it onto the flange around the top of the connector.
- Push the connector into the tail and hand tighten the nut.
- Use a tap spanner to tighten the nut onto the tail - grip the body/spout of the tap to make sure that it does not turn on the unit as the connector is tightened.

1.6 Material used for the tap:-

All sanitary appliances and their components shall be durable, impervious, and corrosion resistant and have smooth surface which may be easily cleaned. They shall conform to relevant Indian Standard where they exist, otherwise they shall be of the best quality and workmanship which shall be approved by a competent authority. Taps can be made from a variety of materials of varying quality and cost. A general rule of thumb is that the heavier the tap the better the quality of materials used . Some other materials along with suitable coatings are also used for manufacturing the taps apart from plastic and brass given below.

1.6.1 Plastic

Plastic taps are very cheap and generally low quality. They are very light and are available in a range of colors. 15 mm and 20 mm are the normal sizes of plastic taps available. Now a days superior quality plastic taps are also manufactured with GFN (Glass filled Nylon). They are to be manufactured as per IS:9763 and are suitable for use up to 1MPa pressure and water temperatures 90^0C. However the recommended temperature for use is 65^0C.

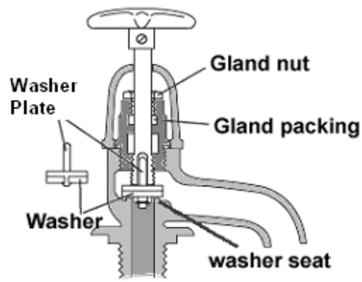
1.6.2 Brass

Standard brass is commonly used to manufacture the bodies of mid-priced, medium quality taps.

Many tap components (such as handles) can be made from plastic. These are cheaper than using brass, and whilst the quality is often very good, brass offers a better finish and longevity.

1.7 Replacing a tap washer (Pillar Tap)

1. First turn off the water supply to the dripping tap, and turn on the tap to release any water in the system feeding it.
2. Before start to dismantle the tap, place the plug in the outlet of the basin or sink - this will prevent any small items you drop from going down the waste pipe.



Pillar tap diagram

3. Remove the top of the tap.
4. Most modern taps have ‘shroud’ knobs with a red or blue marking to indicate if the tap is hot or cold water. These markings are often on a small insert in the centre of the top of the knob, these inserts usually hide the screw which holds the knob on the spindle. Use a small screwdriver to lever off the insert to expose the screw holding the knob.


Removed insert


Exposed screw

5. Remove the screw and the handle should lift off.
6. The next step is to release the tap valve, use a correct sized spanner above the joint and firmly hold the tap spout to prevent the body of the tap turning on the basin or sink - if the tap does move, the connection under the basin/sink may be loosened causing a leak.

7. Undo the valve completely and remove. Not all taps have detachable washer plates.
8. Some valves have a small retaining nut for the washer, as below.

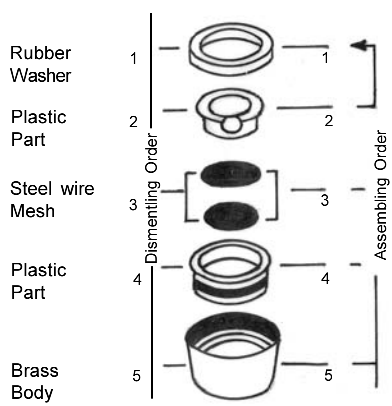
   Others have the washer simply pushed onto a central lug. Either undo the nut to release the old washer or price the old washer over the lug. Each uses the same style of replacement washer.

Nut retained washer

Central lug washer

9. Replace the washer and, if considered necessary, replace the nut.
10. Before replacing the tap valve check to make sure that the tap seat is not damaged, if it is damaged, repair it before replacing the valve. A new washer will not cure a dripping tap if the seat is damaged.
11. Assembly of the repaired tap valve and knob is the reverse of dismantling.

1.8 Cleaning of tap steel wire mesh:- Many taps are provided with aerator with steel mesh at discharge spout. Clogging of this screen causes reduced water flow or complete stoppage of water flow. Following steps are to be followed for cleaning the steel screen:-

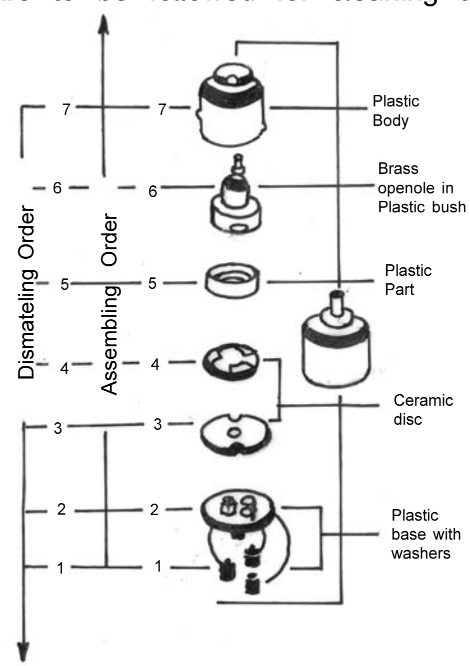


1. Keep the tap in water flow closed position.

2. Unscrew the aerator assembly. For this purpose small slot is provided where spanner of appropriate size can be used. Do not use plier or adjustable spanner.
3. Take out plastic washer, rubber washer and steel wire mesh.
4. Clean all the parts with water, if required by vinegar. Never use acids for cleaning the parts.
5. Assemble the parts as shown in the drawing.

1.9 Cleaning of ceramic disc of tap:- Many taps are provided with ceramic disc, generally all single lever mixer taps are provided with ceramic discs. Clogging of the disc causes reduced water flow, complete stoppage of water flow or hard operating movement of the lever. The disc is provided in cartridge assembly. Following steps are to be followed for cleaning the ceramic disc:-

1. Ceramic discs are placed in the plastic cartridge body on the spindle.
2. Remove the spindle from the cartridge body along with washer and ceramic discs.
3. Clean all the parts with water and if required by vinegar, never use acids.
4. Take special care in handling the ceramic parts as they are extremely fragile. They may crack or break even if it falls from a little height.
5. Assemble the parts as shown in drawing.



Note:- Some taps may have simpler assembly and washer replacement procedure than the procedure given above.

2.0 Wash basins and sinks:-

A Wash basin is made up of vitreous china and is available in wide range of colors, patterns and sizes. Washbasins are of one piece construction including a combined overflow and soap holder . An overflow slot, if provided, shall have a horizontal dimension not larger than 64 mm and an area not less than 500 mm^2. A round overflow of the same area can be an alternate design. The soap recess(es) shall have adequate provision for draining into the bowl. All internal angles are designed so as to facilitate cleaning. The sinks are also the similar construction as wash basins, except that the size of sinks is much larger and the bottom surface is level/flat compared to rounded shape for wash basins.

2.1 Types and construction:- Wash basins are provided with five, three, two or single tap hole, round in shape and symmetrical about the centre line of the basin and either fully punched or semi-punched. The tap holes shall be suitable for fixing pillar taps conforming to IS 1795:1982 or to IS 893:1993. The level of the top of the platform which accommodates the taps is not to be below the spillover level of the basin irrespective of the overflow arrangement.

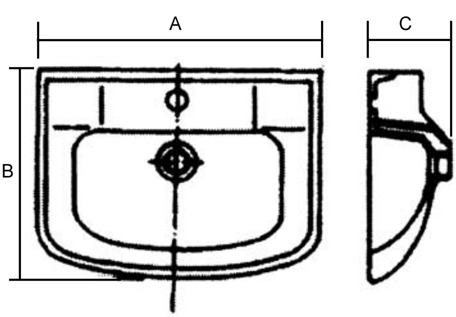
Each basin shall have a circular waste hole. The waste hole shall accommodate a waste fitting having a flange diameter of 64 mm (IS 2963:1979).

Each wash basin has a rim on all sides, except sides in contact with the wall and has a skirting at the back. The entire flat surface should have sloped inside towards the bowl.

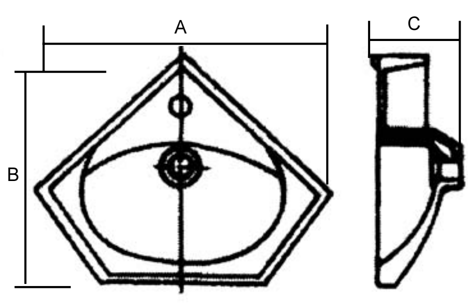
Wash basins can be broadly classified as :-1) Wall hung or 2) Counter fitted. Wall hung wash basins are further classified as i) Flat back, ii) Angle back, iii) Full pedestal and iv) Half pedestal.

Counter fitted wash basin are further classified as i) Under the counter, ii) Over the counter and iii) Counter top.

2.1.1 Flat /Angle back basins:- Wall hung basins are either of flat back or angle back to fit in a corner. The various patterns and sizes of wash basins are shown in figure below:-



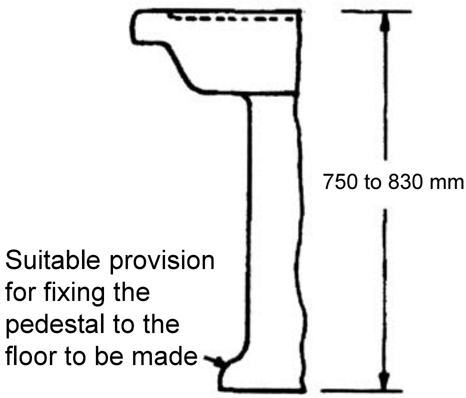
Flat back wash basin
(I.S.2556-Pt.4)



Angle back wash basin
(I.S.2556-Pt.4)

Pattern	Size(mm)	A(mm)	B(mm)	C(mm)
Flat back washbasin (Surgeons Basin)	660 X460	660	460	200
Flat back basin with two tap holes or single tap hole	630X 450 550X400 450X300	630 550 450	450 450 300	290 290 225
Angle back wash basin	600X480 400X400	600 400	480 400	290 290

2.1.2 Full pedestal wash basins:- Pedestal is provided to hide the trap , waste and hot and cold water service pipes to enhance the looks of the wash basin. The pedestals are so constructed as to support the wash basin rigidly and adequately. Suitable provision is to be made to fix the pedestal to the flooring. The bottom of the pedestal is provided with holes for screwing in masonry screws into the floor for fixing.



FULL PEDESTAL

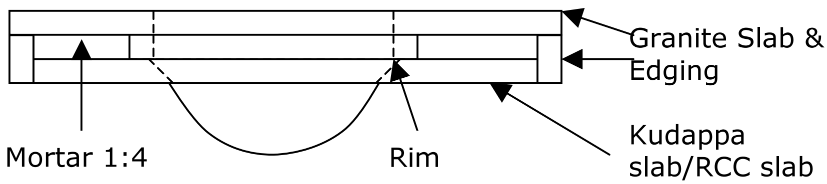
HALF PEDESTAL

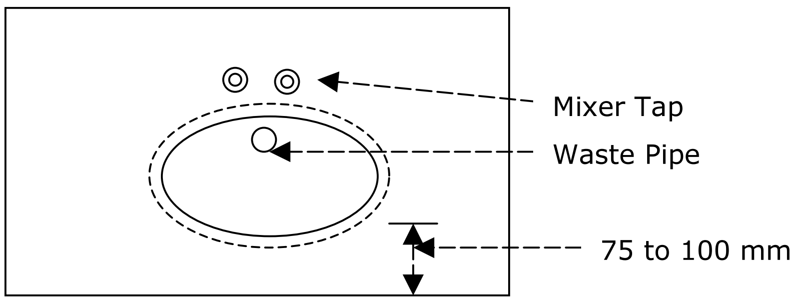
2.1.3 Half pedestal wash basins:- Pedestal is provided up to half the height below the wash basin and the trap, waste and hot and cold water service pipes are hidden below the pedestal. This will permit more floor space below the wash basin. These are fixed to the wall.

2.1.4 Under the counter wash basins:- This is most attractive and becoming more popular wash basins now a days. In this type wash basin is sunk in the counter. Water spilled over the counter will be flown in to the wash basin. Wash basin is first fixed on the kadappa stone platform or RCC platform. Collar of the wash basin is rested on the platform. Then granite is fixed over the platform covering the top surface of the ring of

wash basin and the platform. Only bowl is visible from the top. These are provided , generally in modern bathrooms.

2.1.4.1 Method of fixing under the counter W.B. :-





The counter sunk wash basin is preferably fixed on an RCC platform or Kudappa slab with Granite stone or marble topping. These are provided, generally in modern bathrooms and the counter provides through space for keeping the needful items such as soap cases, bath gel, shampoo etc. The length of the counter should be adequate for arranging these items. The width projecting in front should normally be not more than 100mm but preferably 75 mm and near the wall this can be variable depending upon the space available. Normally a three hole basin mixer tap should be provided on counter sunk wash basins, basin pillar taps are not suitable for such basins. The steps followed to fix a Under the counter WB are as below,

1. A RCC slab or Kudappa stone slab is first to be fixed with supports of brick masonry wall or by embedding in the wall duly cutting the recess. A recess equal to the size of the WB just below the rim is to be cut in the slab. Since this is hidden below the stone slab etc. great precision is not required in cutting the recess hole. Normally arrangement for making this hole is done prior to fixing the slab on the supports etc.
2. After fixing the slab on the supports, the wash basin is placed in the hole, so that the WB is uniformly supported on the rim over the slab.
3. Template of exactly equal size of the wash basin top rim is to be prepared by laying the basin upside down on a piece of thick paper or

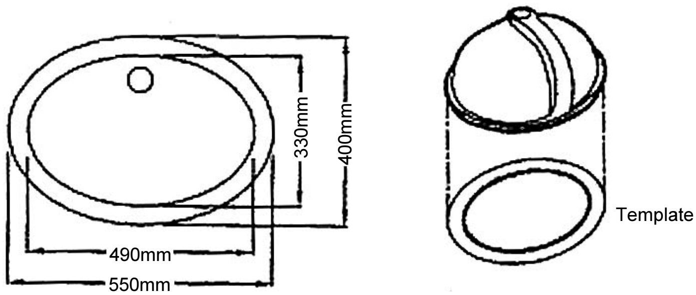
cardboard by drawing the top of wash basin on paper and then cutting it.

4. Cut the same size opening in the counter top Granite stone or marble on which the basin has to be fitted. The edges on the counter slab after cutting should normally be not less than 65 mm. in any direction.

5. The edge of the counter shall not normally be cut at the distance of more than 75 mm from the front side facing the user but in any case not exceeding 100 mm.

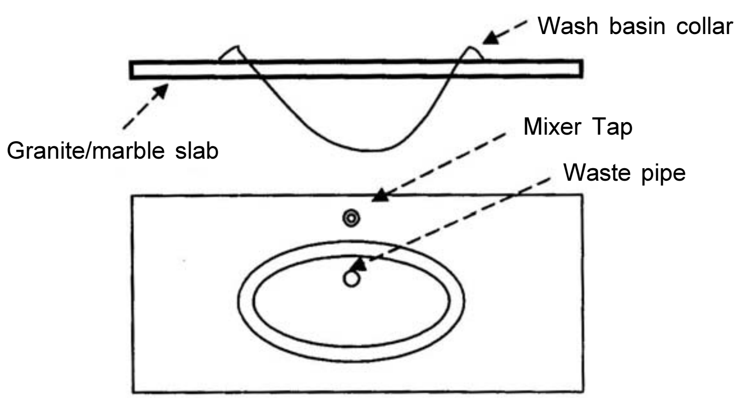
6. Cement mortar (1:4) is placed on the slab upto the height of the rim of WB, leveled and allowed to set for about 6 hours. A layer of cement slurry is spread on the mortar surface and the underside of granite stone also buttered with slurry is placed on the mortar surface and pressed evenly for proper seating.

7. Fit the counter sunk basin in the gap created equal to the template. Put sealant and close the gap if any.



Method of fixing wash basin

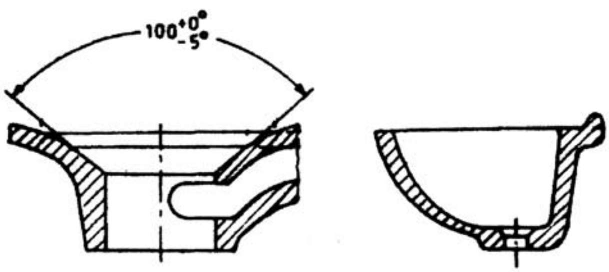
2.1.5 Over the counter wash basins:- Over the counter wash basins are similar to under the counter wash basin, only difference is that the wash basin collar is rested on granite directly. No kaddapa or RCC platform is used. The collar is visible from the top and water spilled on the counter will not be flown to the basin. So this type of basin is not very popular.



2.1.6 Counter top wash basins:-

Counter top wash basins are placed directly on the platform. Hole is cut on the platform for Waste fittings.

2.2 Waste water discharge:- Each wash basin has circular waste hole opening to which the interior of the basins drains. Waste water fitting of brass or stainless steel or any approved alloy is fixed on the waste hole. The discharge of waste water from the fitting directly goes to a flexible pipe to a floor trap or via a bottle trap.

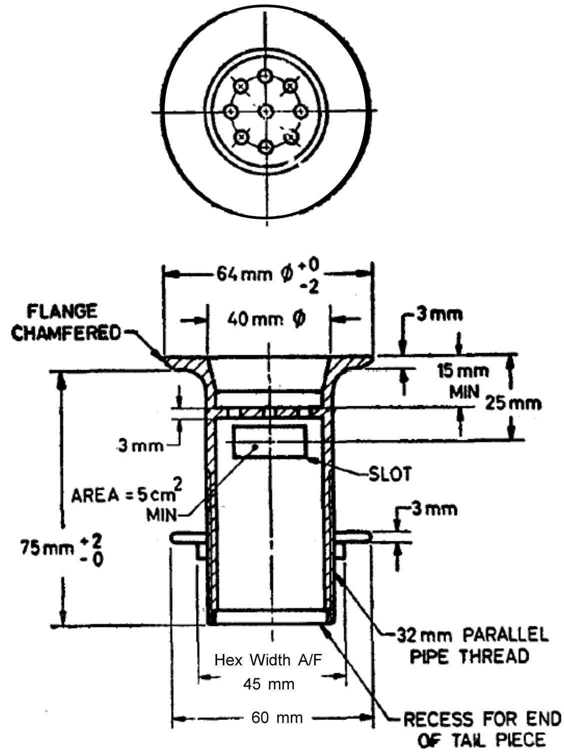


a) **Waste hole:-** The waste hole shall be either rebated or beveled internally as shown in figure. The dimensions are given in IS 712-Pt-IV.

b) **Waste water fitting:-** The waste fitting is normally manufactured from brass or any other corrosion resistant alloy and is fixed over the waste hole. The strainer at the top having holes 6-9 nos. of diameter 6-8mm, stops the solid particles of bigger size but not silt and others. The other end of waste fitting discharges into a floor trap either through a bottle trap or through waste pipe. There is a slot provided on the side of the sleeve pipe for connecting to the over flow slot.

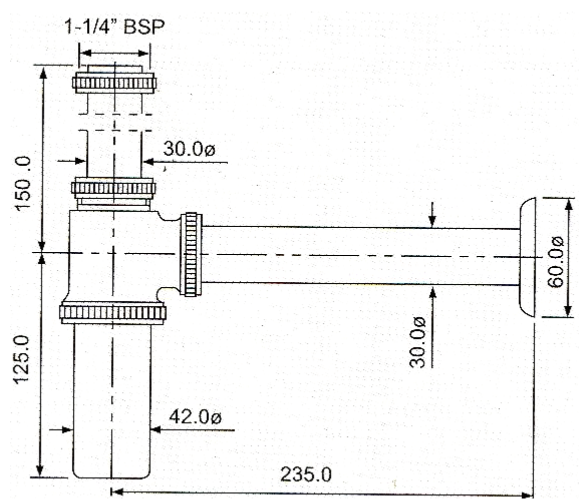
c) **Overflow slot:-** Most of the wash basins and some sinks designed on British standards are provided with an over flow slot in the body of WB or Sink, just below the brim of the WB or sink. In case of chocking of the strainer provided in the fitting or stoppering the fitting outlet for specific purpose like washing clothes or any other like items, the water in the wash basin or sink is not allowed to over flow the brim but passes through the over flow slot through the integral duct provided in the WB or sink, to the outlet pipe via the waste water fitting below the strainer level.

d) **Bottle trap:-** The outlet flexible pipe can be directly attached to the waste water fitting pipe or through a bottle trap. The bottle trap prevents any silt etc to pass to the floor trap and also provides an effective gadget to divert the flexible pipe inside the wall for giving a concealed fitting. This is compulsory for half pedestal wash basins and preferred for all other types. The bottom sleeve of the bottle trap can be unscrewed to clean periodically any deposits there.



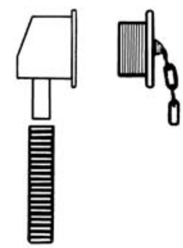
2.3 Procedure for installation of waste water fittings for metal sinks:-

Many of the metal sinks are not provided with inbuilt overflow system. It is therefore required to provide such an arrangement. Modern metal (mainly stainless steel) sinks come without an integral overflow however some old (probably imperial sized) sinks do have a built in overflow, as such, the waste water installation is fairly similar to that shown for hand basins.



To save working in confined areas, it is better to fit the waste fittings (excluding the trap) before the sink is fitted into position. Modern sink waste fittings are fairly standard. On all the waste pipes, a washer is provided under the sink outlet inside the sink, if the washer is not supplied, plumber's sealant can also be used, under the rim of the outlet before inserting, wipe off any excess from inside the sink once the outlet has been tightened. Step wise procedure is given below:-

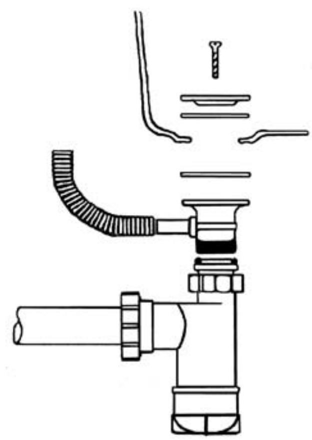
1. The sink waste overflow is normally straight forward, the overflow trellis on the inside of the sink is screwed into the overflow which is connected to a flexible down pipe to the sink waste trap. To tighten it may help to carefully push the jaws of a pair of long nosed pliers into the grille to get something to hold - but do not use too much force as the fitting is often plastic and liable to damage.



A washer is normally fitted between the grille and the sink surface to provide a water seal.

2. A fitting for the sink outlet is the adapter under the sink. This fitting is held in place by a screw through the centre of the grille into a captive nut in the centre of the adapter. The screw needs to be tightened to compress the washers to give a watertight seal.

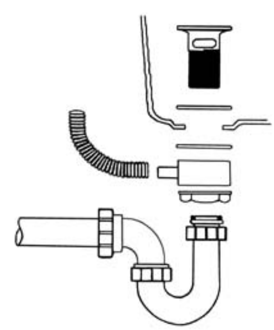
3. Washers are normally placed under the grill in the sink and between the adapter and the underside of the sink. The adapter incorporates an inlet for the flexible pipe from the sink overflow. The illustration to the right shows a bottle trap fitted whereas the Illustration below shows a 'P' traps. The traps are actually completely interchangeable in the applications - even an 'S' trap could be used - the type fitted may depend upon the waste water pipe run direction.



Over flow waste pipe through bottle trap

Alternative procedure-I

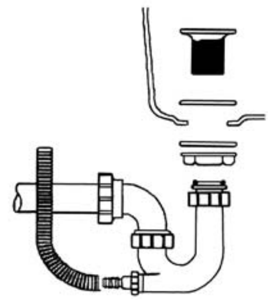
An alternative fitting for the sink waste uses a deep plug hole fitting, with slots in opposite sides to accept the waste from the overflow, and a long threaded body. The banjo from the overflow fits over the plug hole fitting and both are secured by a large nut fitted against the underside of the banjo. Before fitting the large nut, apply plumber's putty to the screw thread on the outlet. Fit the nut so that it traps the plumber's putty in the thread and tighten. The nut needs to be tightened using a spanner to compress the washers to give a watertight seal.



Washers are normally placed under the plug hole in the sink and between the banjo and the underside of the sink.

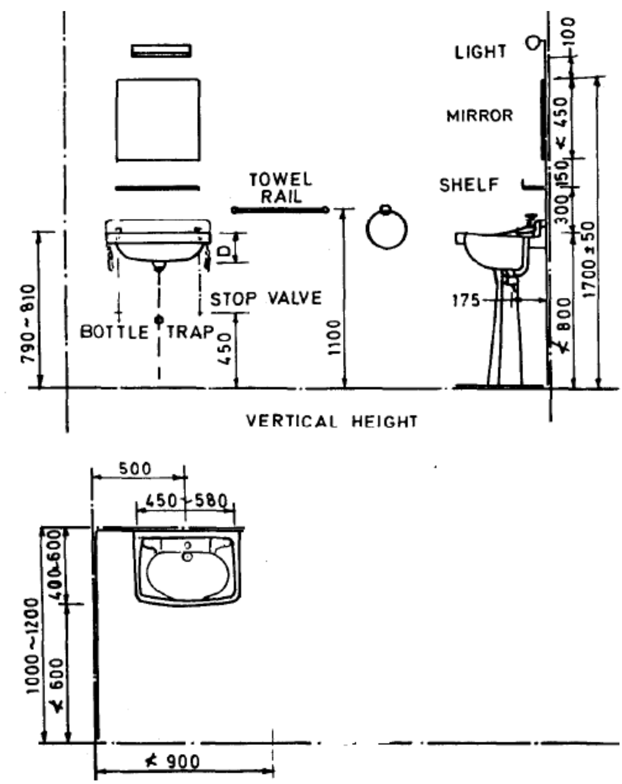
Alternative procedure-II

Another alternative is to use a short sink outlet fitting which is secured to the sink by a nut underneath while the overflow waste pipe goes to an inlet in the actual waste trap. The nut needs to be tightened using a spanner to compress the washers to give a watertight seal. Washers are normally placed under the fitting in the sink and between the nut and the underside of the sink.



2.4 Procedure for installation of wall mounted wash basin:- The procedure for installation of wall mounted wash basin, step wise is described below-

1. The location of wash basin shall be fixed either as per typical layout shown or as per the design of architecture. The clearances shown in the figure shall be maintained. It will be desirable to provide minimum 500 mm distance from the adjacent obstruction / wall to central axis of wash basin and width 600 mm from edge to the opposite/ obstruction point to perform various activities. The spacing shall be measured from the central axis of the wash basin irrespective of size and shape.



Typical layout plan shown in IS 2064 :1993

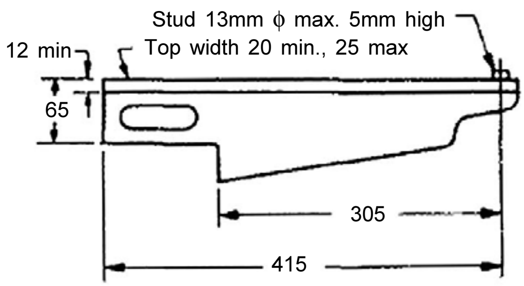
2. Mark an exact horizontal line with the help of tape and plumb bob by taking reading at two or more points at 80 cm from floor with chalk.

The top edge of the wash basin is to match this line above.

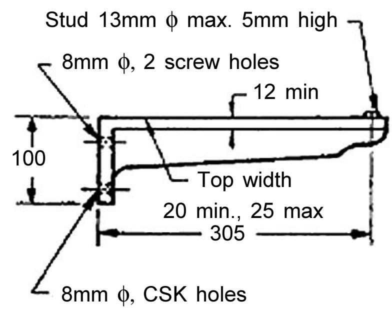
3. Select suitable C.I. bracket to withstand the wash basin. The detail drawings of brackets are given in IS 775-1970. Use of MS angle or tee section as bracket should not be permitted as they tend to corrode and rust formation spoils the walls etc.

Generally two types of brackets are used.

a) CI bracket with lug:- The lug 110 mm long with a slot is to be embedded in wall masonry. The slot provides a key for the mortar to fix the bracket.



a) Bracket with Lug



b) Wall fixing C.I.Bracket

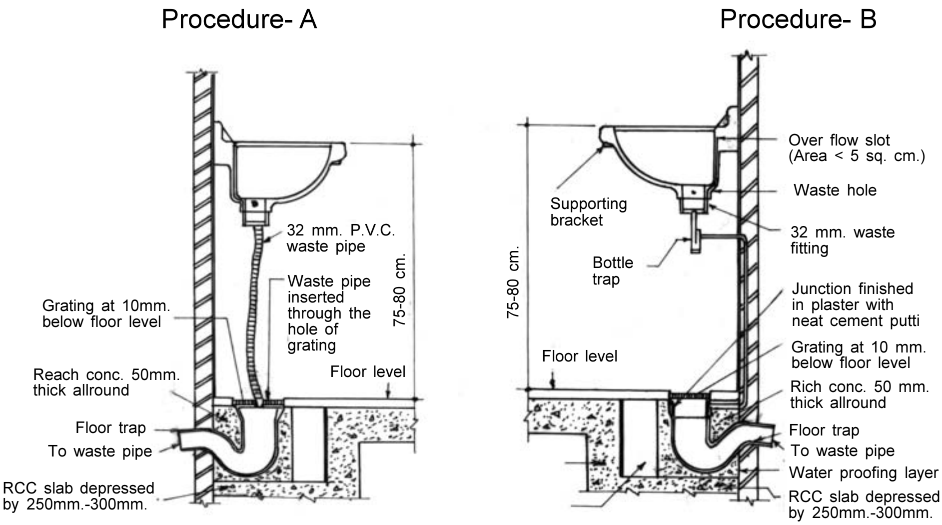
b) Wall fixing cantilever bracket:-

These brackets can be screwed to the wall by means of wood screws into plugs placed in wall masonry. The centre to centre spacing of two brackets supporting the wash basin is 240mm for basins of size 550 X 400 mm or lower and 280 mm for larger basins.

4. Place wash basin on the bracket. Check level of wash basin with the level tube.

5. Connection of the basin discharge:-

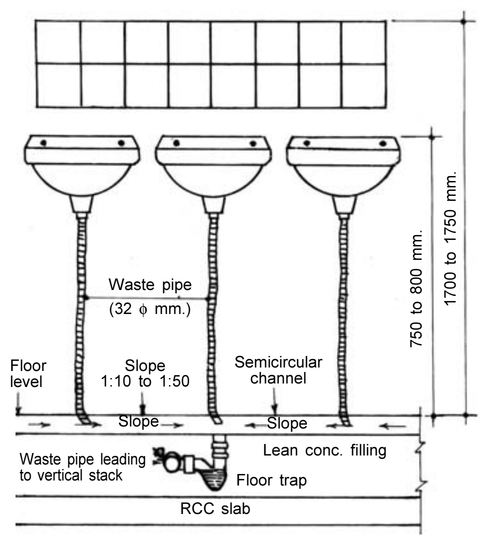
Procedure(A) :-The basin discharge is connected with flexible P.V.C. waste pipe of 32mm as shown in figure. To accommodate floor trap RCC slab is depressed by 250 to 300 mm. Floor trap is fixed with rich concrete 50 mm around. Grating is fixed on the floor trap keeping level of the grating 10mm below the floor level of the bathroom. 32mm waste pipe is inserted through the hole of the grating.



Alternate procedure(B) :- Alternatively discharge can be connected to floor trap through concealed pipe as shown in figure. The other procedure is similar to procedure A above.

2.5 Procedure for installation of multiple wash basins:-

General arrangement of 3 washbasins in a row for use in public places and offices is illustrated in figure. The procedure given in section 2.4 shall be followed for installation of wash basins.

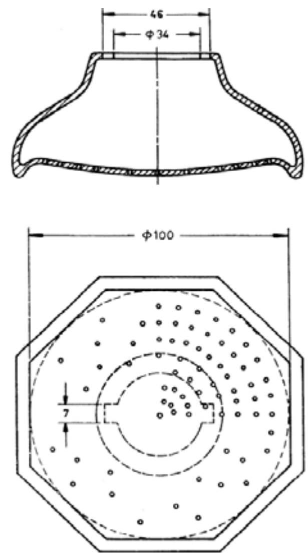


Waste pipes laid horizontally should have gradient not flatter than 1 in 50 and not steeper than 1 in 10.

3.0 Showers

Introduction:- Either ready made shower tray for standing bath or sunken floor for squatting bath can be provided for shower. Sunken bath floor level shall not be more than 60/70 mm below the door bottom. Shower head height is governed by users' height, may be overhead for men only 1750 mm, however, 150 mm clearance shall be provided for above overhead. Minimum 1900 mm is recommended for men; 1830 mm for female and 1675 mm for children; projection of shower will vary according to design and shape. In case of shower, projected from wall, it shall not be more than 450 mm and height not exceeding 2200 mm from floor level. The shower valves or mixing valves are to be placed near entrance to shower.

While choosing bathroom shower faucets there are a variety of things need to be considered, including the style, the finish, the amount of handles, provision of hand shower etc. In western culture there is separate base tray provided below the shower cubical which is not common in India. Details of shower as per IS 2556-part7 is shown in sketch.



The style:- One of the first things to consider when choosing bathroom shower faucets is the style. There are a variety of different styles that are available to choose from. There are some that have lines that are clean, which look great in a contemporary bathroom, and there are also floral and fluting designs that look good for bathrooms with a traditional or elegant style.

Finish of the faucet:- Another thing to consider is the finish of the faucet. As a general rule, most faucets are actually made with brass, but they are plated with another type of material like nickel chromium, colored enamel, or brass.

3.1 Bath/shower mixer:

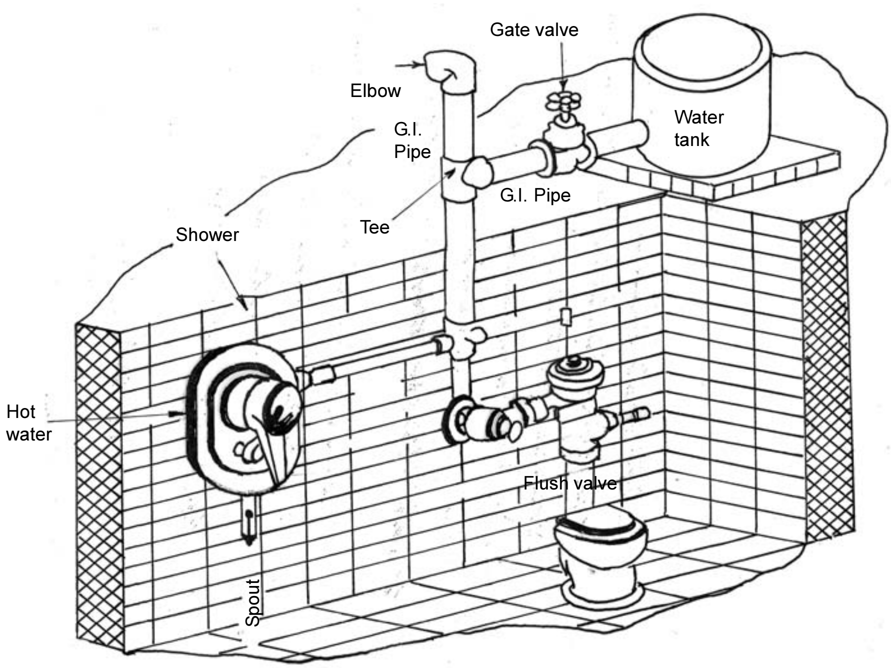
Here, the hose and spray of the shower are combined with a bath mixer tap, which is similar to mixer valve for wash basins and the temperature can be adjusted through the bath taps. The draw back of these types of showers is that the temperature control is low which can prove too inconvenient and it is fiddly to adjust.

3.1.1 Mixers:

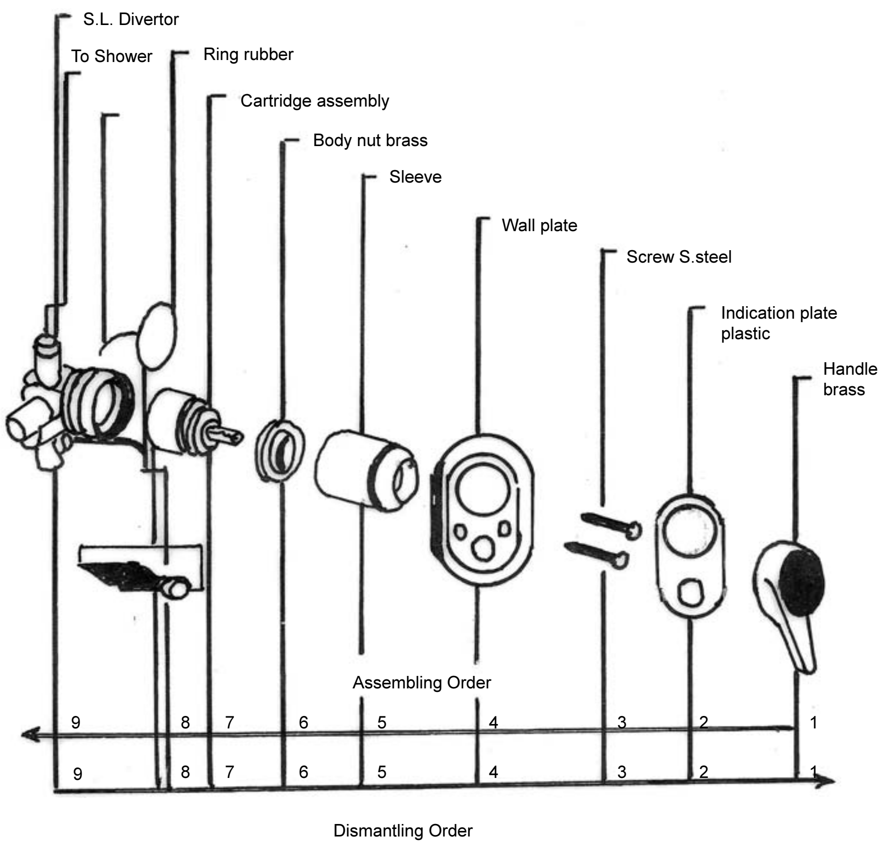
The hose and spray of the shower are part of a wall unit and the hot and cold water supplies are connected to a single valve. The temperature and pressure of the water are controlled either one or a variety of knobs .It's height being part of a wall unit, makes temperature adjustment much more convenient.

3.1.2 Single lever mixer:

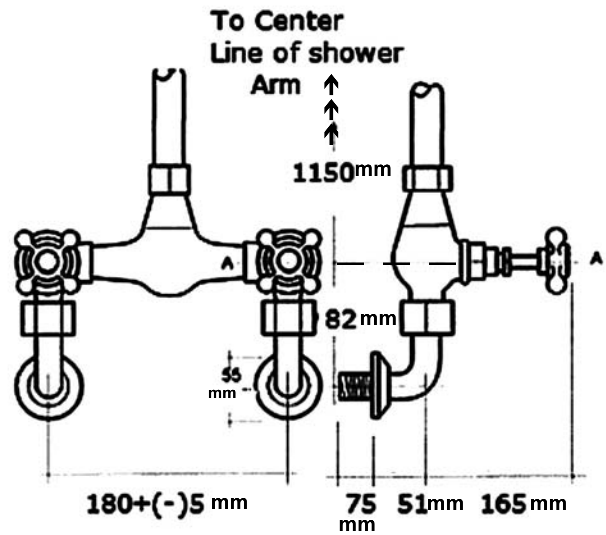
Single lever mixers have only one lever which controls the temperature and flow of the water. The detailed connection with cold and hot water pipes of the mixer is shown in the figure.



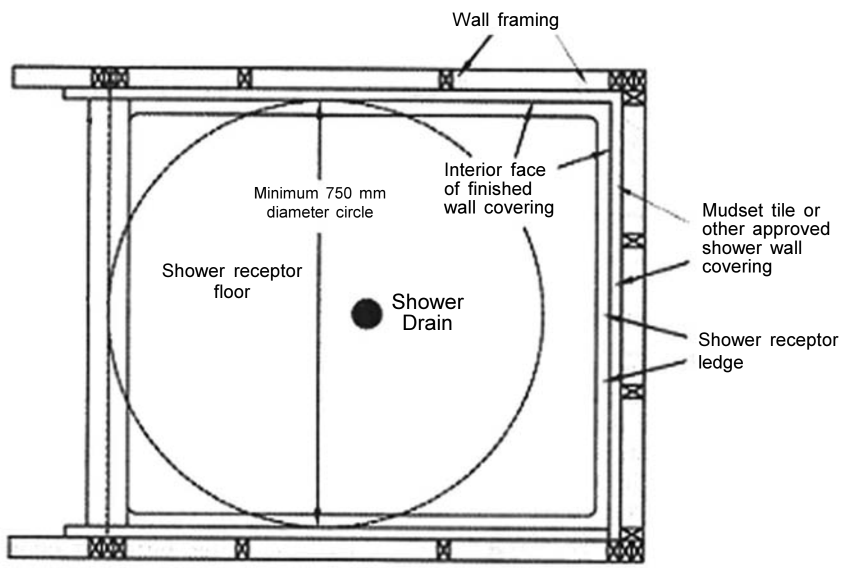
The assembly of various parts of single lever mixer is given below,



3.1.3 Manual mixer:- In manual mixer with two knobs the spacing of the fixture and the location is given below,



3.2 Layout of floor for shower:-



Required area for a shower

3.3 Minimum requirements for fixing a shower:- When planning to install a shower, the main considerations to take into account are the water pressure and the planning of the piping and drainage for the shower.

3.3.1 Piping and drainage:-

It is best to use 15mm diameter supply pipes making the runs to the shower as short and straight as possible. The benefits include maintaining maximum pressure and minimising heat loss. Minimum 3m (10') water head is required for proper functioning of shower. It is therefore preferable to have the shower directly connected to the pipe coming from the tank, as other wise other open taps etc. are expected to reduce water pressure considerably and causing inconvenience.

It is also advisable to minimise the use of elbows for pipe corners as this increases resistance in the flow of the water supply. Instead, it may be worth bending the pipes.

If it is a manual mixer that is being fitted, the cold water supply must be taken directly from the cold water cistern as opposed to a pipe supplying any other tap or cistern in the household, as it would reduce pressure in the shower by multi-bends and fixtures.

In contrast, hot water can be taken from a branch pipe because if the hot water supply is reduced there will only be a reduction in temperature causing temporary discomfort.

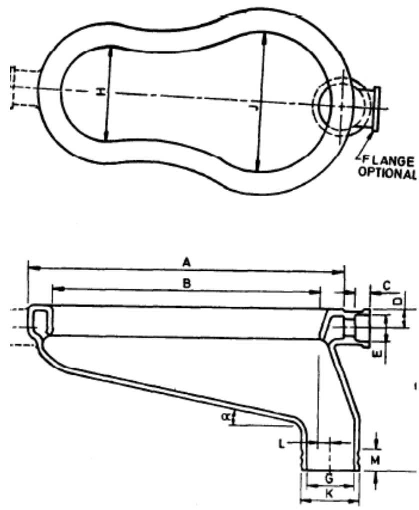
3.4 Installation of shower:-

1. Before fitting the pipes that will eventually supply the water to the shower system, it is important to cut off the water supply. In order to protect the pipes, they should be given a waterproof covering and also isolating valves should be fitted. The pipes can then be recessed into the wall and plastered.
2. Fit the shower head, and fittings.
3. Connect up the main shower control to the pipes that will be supplying the water
4. Reconnect the water supply and test the pipes for any leaks, as some may need tightening.

4.0 Water closet

4.1 Types of WC:- The WC can be broadly classified as 1)Indian or squatting type or 2) European or with seat and 3) Universal type. The Indian type can be further divided as i) Long pattern squatting pan, ii) Orissa pattern squatting pan and iii) Rural pattern squatting pans. European type can be further divided as i) Wash down pattern WC and ii) Syphonic pattern WC.

4.1.1 Long pattern squatting pan:- It is also called as Indian type WC. People use the WC in squatting posture. The arrangement is having two foot rests, kept on either side of the pan. The pan is provided with flushing rim and is connected to flushing system. The inside of pan is glazed but the exterior needs to be rough and non-glazed.

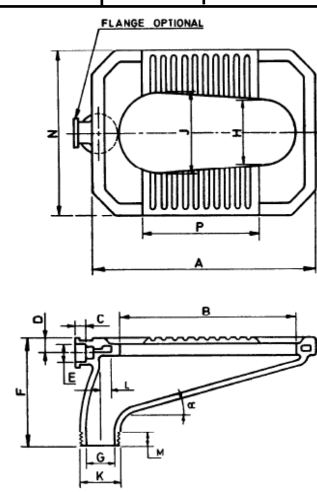


The Indian type squatting W.C. is made in two standard sizes viz 580 mm and 630 mm long (Dimension ‘A’ shown in above figure) with length of opening as 480 and 530(Dimension ‘B’ shown in above figure) respectively. The gradient at the bottom is 15 deg. for ease of cleaning and maintaining the flow of water at adequate velocity. The height of the pan is 300 mm and 320 mm in the two sizes. The outlet for the soil is 80 mm I.D. and 110 mm O.D. This is connected to a soil pipe of 110 mm I. D. through a matching P, or S-traps. The foot rests are not integral to the W.C. pan but are to be provided separately. The salient dimensions as per I.S.2556 Pt.3, are as under,

Type	A (mm)	B (mm)	Slope (deg)	Ht. (mm)	H (mm)	J (mm)	Outlet I. D. mm
I	580	480	15	300	170	260	80
II	630	530	15	320	170	260	80

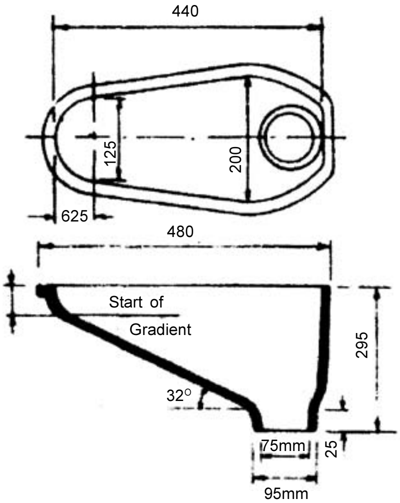
4.1.2 Orissa pattern squatting pan: It is similar to long pan squatting pan except the footrests are integral part of pan. The Orissa pans are made in two sizes, 580x440 and 630x450 mm. The salient dimensions as per I.S.2556 Pt-3,are as under,

Type	A (mm)	B (mm)	N (mm)	Slope(deg)	Ht (mm)	H (mm)	J (mm)	Outlet I.D.(mm)
I	580	470	440	15	300	180	210	80
II	630	500	450	15	320	180	220	80

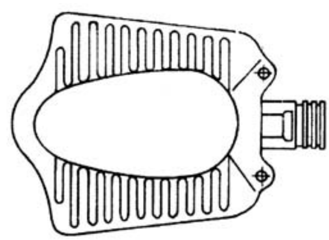


This type of pan gives a more elegant appearance and is available in colours also. The pedestals may be raised above the pan or flush with the pan level i.e. with the floor. The interior of the pan is glazed but exterior is to be rough and non-glazed.

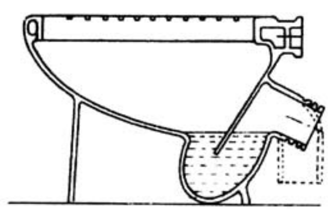
4.1.3 Rural pattern squatting pan:- In the rural parts where there is no flushing system available, rural pattern of pans are only used. In rural pattern squatting pan sharp gradient of 32 deg. is given to facilitate hand pour flushing. In this type no flushing ring is provided. These are made in vitreous china as available in market but can also be cast in cement mortar (1:3) by a skilled mason using a sand cast. Railway has been using such cement mortar squatting pans for way side stations where water supply is not provided in the toilets. The thickness of the wall can be increased from 20 mm to 25 mm for such pans made in cement mortar. The detailed dimensions are given IS:2556 Pt. 3.



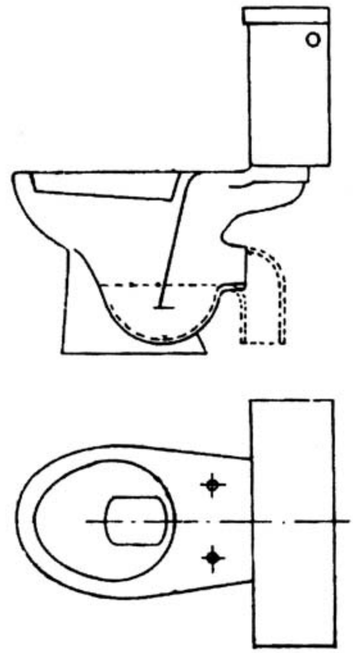
4.2.4 Universal WC pan:- This type of WC is suitable for both squatting as well as sitting posture. It can be used as squatting pan by lifting seat below which foot rests are provided. It can also be used in sitting posture by putting hinged seat. This functions just like a Wash down W.C. These can be attached to either P or S trap. The P trap is made integral with the WC but S trap may be integral or supplied separately. The outlet I.D. is 80 mm and O.D.110 mm.



These are manufactured in two sizes i) Length = 570 mm, Width = 460 mm and height = 380 mm and ii) Length = 650 mm, Width = 460 mm and Height = 380 m. The detailed dimensions are given IS:2556 Pt. 15



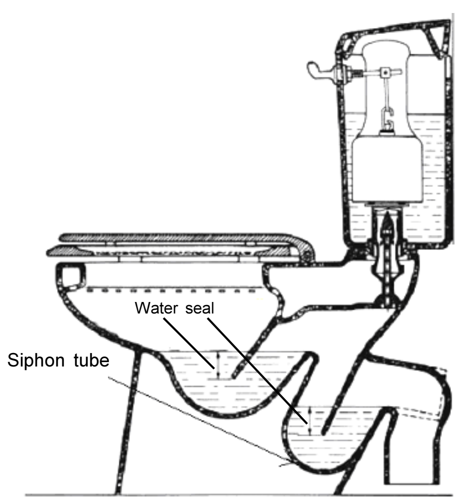
4.2 Wash down pattern WC: - The wash down closet is probably the most inexpensive, European W.C. and has been widely used in India. Wash down WCs is the simplest in design. They take the form of a ‘funnel’ shape, with a broad opening at the top narrowing to a smaller outlet connected to a soil pipe through a P or S trap. Wash down pans have almost vertical surfaces at the back of the pan and more gently sloping fronts to allow the outlet of the pan to be directly beneath the anus of a seated user to prevent soiling of the bowl. The wash down W.C. can be either integral type where the water cistern is integrated in the design of the WC or the cistern is mounted separately and connected to WC. In both the cases, the inlet from the water cistern is connected to a flushing ring under the W.C. rim, and the water is discharged through the holes in the flushing ring and the soil in the W.C. is washed down by the water into the trap and then the soil pipe. The sketch shows an integral type Wash down WC. The



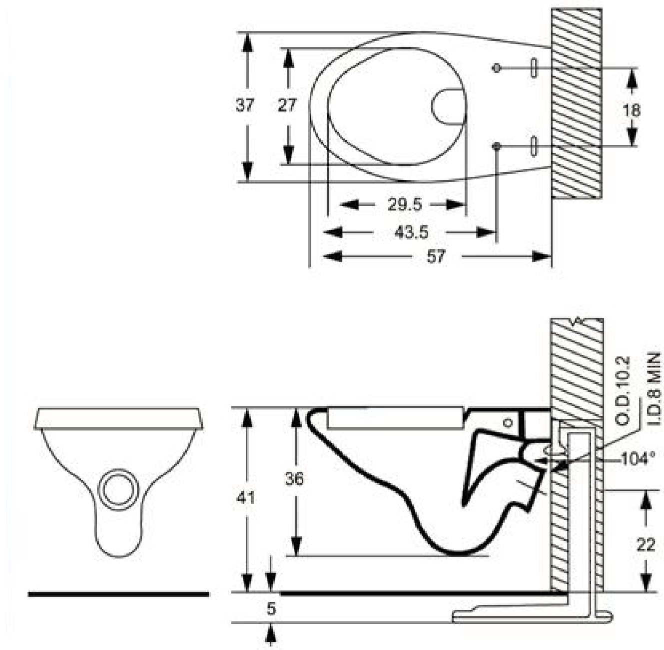
functional dimensions of all European WCs are similar except for the external looks and the method of connecting the cistern and the outlet and the trap being P or S. The name is derived from the method of clearing of the WC. The height of all European WCs is 390 mm and width 360 mm. The depth of water seal is 50 mm. The opening at the top is 290x240 mm. The I.D. of the outlet is 80 mm and O.D. 102 mm. The C.I. pipe connecting the P or S trap which is integral to the WC therefore is of 102 mm I.D.

4.3 Syphonic pattern WC: - The siphon-jet or Syphonic water closet is claimed to be the most efficient. The trap way, located at the rear; is larger than that in the reverse-trap closet. The water surface is almost as large as the rim opening, thus reducing the fouling area. Water discharges from the flushing rim, cleaning the bowl and creating a whirlpool which draws the water and waste down to the bottom by strong centrifugal force. Then a powerful jet is formed by siphon action from the bottom, which forces the contents of the bowl up into the outlet passage i.e. acting as a siphon tube, to complete the flushing.

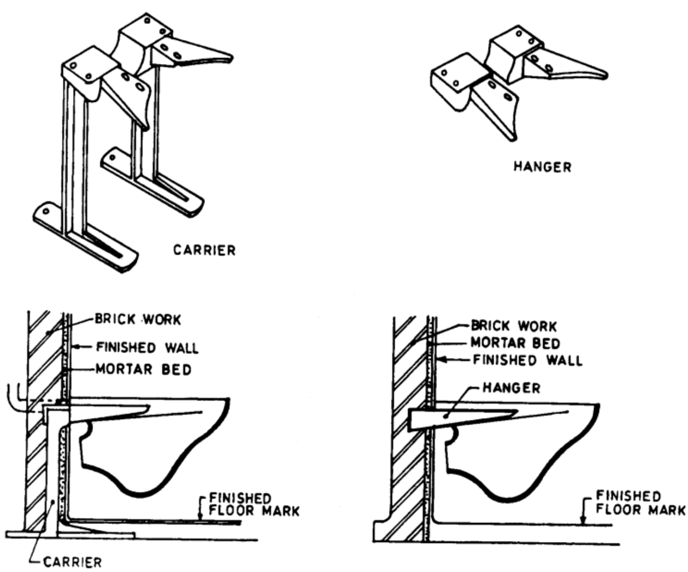
The closet has a built-in siphon, usually visible as a curved pipe protruding from the back .Normally, the bowl contains a small amount of water which is enough to form an air trap inside the siphon pipe, preventing foul air escaping from the sewer. When the toilet is used, liquid flows slowly through the siphon pipe as waste matter is added, but the flow volume is too small to fill the siphon. To flush the toilet, the user activates a flushing mechanism which pours a large quantity of water quickly into the bowl. This creates a flow large enough to fill the siphon tube, causing the bowl to empty rapidly due to the weight of liquid in the tube. The flow stops when the liquid level in the bowl drops below the first bend of the siphon, allowing air to enter which breaks the column of liquid.



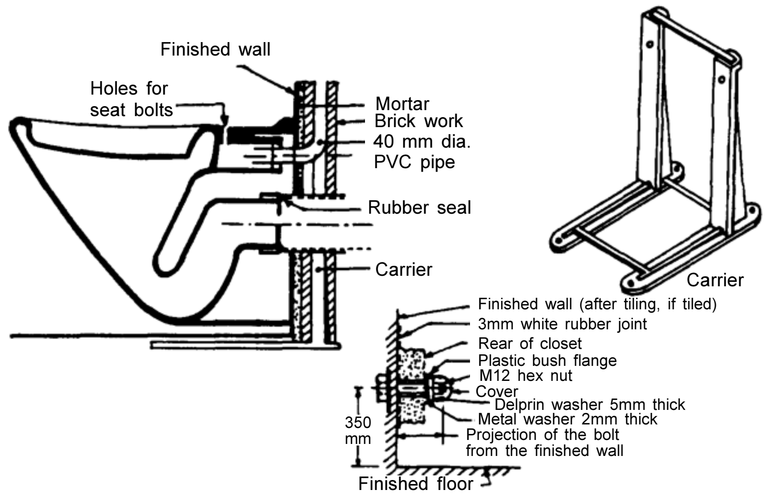
4.2.5 Wall mounted WC pan:- These type of WC gives good appearance and they are mounted on the wall. There are two designs available for wall mounted W.C.s namely, i) W.C. with concealed out let and ii) W.C. with fixing arrangement on top of bracket. Different type of fixing brackets are available for two design of W.C.s. The two types are shown in sketch below. Bracket for WC is first fixed to the wall and the floor. The brackets are chair bracket or cantilever bracket. The WC is then fixed to the bracket. The salient dimensions of height, width and length are similar in both designs. Special connectors are required to connect the out let to the drainage system in design 1.



All dimensions in cm.



Pattern-1 frame used for design of W.C. with concealed outlet

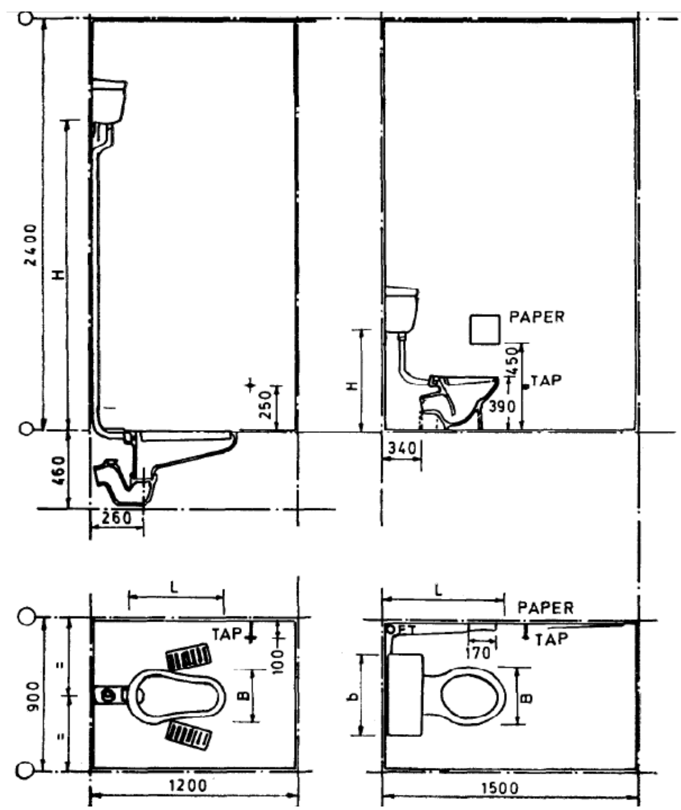


Pattern-2 frame used with 2nd design of W.C. fixing it over the frame

4.3 Outlet location:-

Manufacturers of WC furnish sketches and measurements which are very complete and easy to understand. Not only is it necessary to consider the measurements from the front and the back of the water closet to the wall, but also it requires to plan on the distances of the sides from the wall, from other fixtures, and from the bathroom door. Some bathrooms may be quite small.

Still another point to remember is that the water closet tank/cistern is some 300 mm wide. It cannot be jammed the tank up against another



Typical layout for WC shown in IS 2064

fixture and so must not move it so far from the door that it is against the lavatory. All of these points have a direct bearing on the location of the water closet outlet.

It must also plan the exact height of the finished floor, which is normally done after fixing the W.C., especially in case of Indian Pan. If tile is to be laid, its height should be taken into account. A typical layout shown in IS:2064 is shown in figure.

4.4 Installation of the water closet

4.4.1 Installation of squatting type WC:-

1. This type of WC has to be fixed much below the floor level to accommodate the height of P or S trap and the height of the pan, in such manner that the top surface of the finished floor matches the top of the pan. Normally the floor slab in the Indian type WC is kept lower than rest of the building by about 500-600 mm. The finished floor level should be marked on the walls of the toilet room, giving adequate slope of 1 in 30 from the door bottom.
2. Prepare cushion of cement concrete of 1:5:10. Use material in the proportion of 1 cement, 5 fine sand and 10 bricks ballast of 20 mm nominal size. Lime concrete of the above grade is more preferred. The thickness of layer is kept as 150 mm average, however actual requirement should be worked out, based on height of the pan including the trap. To avoid any leakage through the floor, the concrete should be well rammed.
3. Place the trap in proper orientation on the brick Koba concrete matching with the opening in the floor or wall for S-Trap or P-trap as the case may be. Join the soil pipe of 100 mm ϕ C.I. pipe with the trap outlet. Normally 400 mm length of pipe is adequate, to go out of wall or floor.
4. Place the Indian type WC pan. Adjust the level of the WC pan so as to flush with the top of the floor level. Caulk the joint of the trap and the WC outlet and trap and the CI pipe, with cement mortar of 1:3. Temporarily support the WC pan in position till the joint gains strength.
5. Fill the height with brick koba concrete leaving a gap of about 100 mm (75 mm base concrete+ 25 mm IPS) or 115mm in case tiles are to be fixed.
6. Fix the foot rest at both sides of the pan with cement mortar. In Orissa type squatting pan, the footrests are integral part of the pan.

4.4.2 Installation of European type WC:-

1. Check the spacing of the foundation holes provided in the WC. Lay two countersunk bolts of size 6.5 mm diameter and 57 mm length in the holes kept in the floor with threaded portion up side.

2. Place the gasket provided over the bottom of the bowl on the bolts. If gasket is not provided use asbestos gasket or felt.

3. Put the water closet right side up and place it down to see whether it fits over the bolts properly. If it does, make its outline on the floor with chalk or pencil, and then lift it off

4. The WC bowl shall be fixed with cement mortar 1:3 (1 cement and 3 fine sand).

5. Put washers and nuts on the bolts, and tighten each one gradually, first one a few turns and then the other a few turns and wipe out extra material. The trap is in-built in the WC. The out let of the trap has to be joined with soil pipe as done in Indian type pan, however this can be done after fixing the pan and even the cistern. The center of hole either in the floor or wall for receiving the extension pipe from the trap has to be about 300 mm to 350 mm from wall for S-trap and 125 mm to 150 mm above finished floor level in the wall for P-Trap. However these distances should be confirmed from the manufactures of the WC and Cistern as they will vary for different models and different manufacturers.

NOTE:- The procedure given above is for fixing the WC before tiling. After fixing the tiles, the WC can be fixed by drilling hole on the tiles and fixing the WC with the help of screws.

4.4.4 Installation of WC on CI soil pipe:-

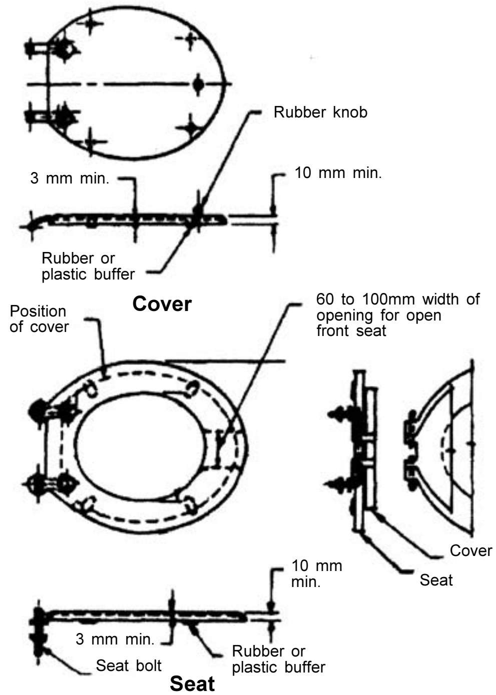
1. Take a piece of cast iron pipe 100 mm dia. about 700 mm to join the W.C. out let for a P-trap (horizontal outlet), which should come out of the hole made in the wall. After it is temporarily joined and it is scored (marked with chisel) after leaving 25 mm beyond the outer face of finished wall, which can be done with a cold chisel and hammer. The extra length if any should be cut with chisel.
2. A C.I bend with socket on both ends is to be used at the cut end of pipe and the other pipe leading to the stack pipe. The C.I. pipe length required to connect the stacks with the bend be measured and pipe cut with chisel according to requirement.
3. The joints of the bend with the WC outlet pipe and the pipe leading to stack is caulked. The joint with the 'Y' joint in the stack is also caulked.
4. Plumber can now attach the water closet.

   Some plumbers prefer to join the WC pipe first and caulk the joint with stacks in the end.

4.5 Installation of plastic seat cover for WC :-

In most cases the toilet seat does not come with a water closet but must be purchased separately.

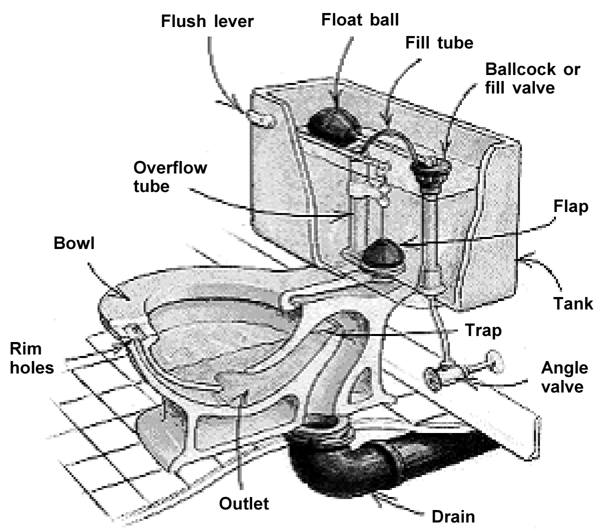
1. Then put on rubber washer, metal washer, and locknut in this order.
2. Screw the nut tight enough to hold the seat firm, but not so tight that it strip the threads or crack the bowl.
3. Rubber washers fit around the bolts and help hold the bolts firmly in the seat post holes.



The details as per IS:2548 part-I is shown.

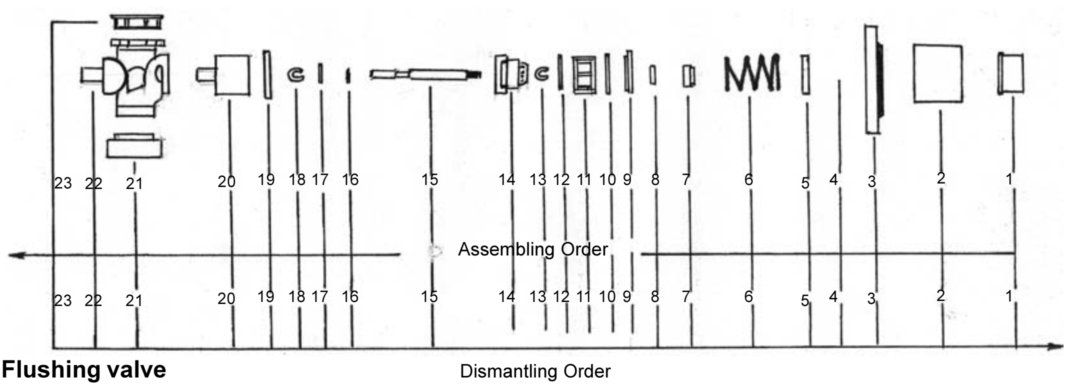
5.0 Flushing cisterns

Many years ago most water closets had their tanks/ flushing cisterns near the ceiling, 2 m. or more above the water closet. Now tanks either rest against the back of the water closet or are hung from the wall with their bottoms just a few cms. above the closet or even resting on the W.C. Still another type has a flush valve on the flush pipe and no tank is provided, but it is not practical for most homes because, in many cases, the water volume is insufficient to make it operate properly.



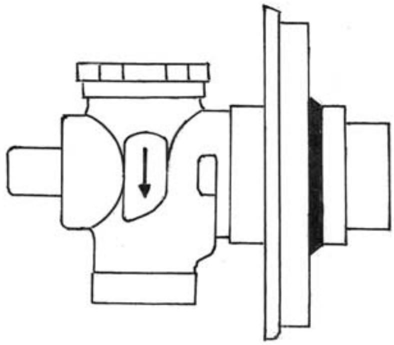
5.1 Flushing valves:- Flushing without water cisterns is achieved using Flush valves. These flushing valves are being used in some public lavatories, with push type and self closing valves, to save on the water consumption. However, this system can be adopted where continuous water supply is available. These are open till one keeps them pushed and close on releasing them. In case these valves are directly connected to potable water supply and in the event of chocking of the soil pipe or the W.C. outlet, there is a danger of cross connection of potable water with the soiled water due to back suction through the valve. It is therefore essential that AVB (Atmospheric Vacuum Breaker) is inserted in the flush pipe.

The flush valve body is concealed in the recess in the wall. 32mm pipe line is required at inlet as well at outlet of the valve. The arrow is embossed on the valve showing the direction of water flow. The valve should be fitted according to the direction of water flow coinciding the arrow on the valve. Centre line of the pipeline should be at minimum 35mm and maximum 75 mm inside from the finished face of the wall. Minimum working pressure for push type flushing valve should be 0.15 bar and maximum pressure should be 3.0 bar. The detail of the push type flush valve is shown in figure.



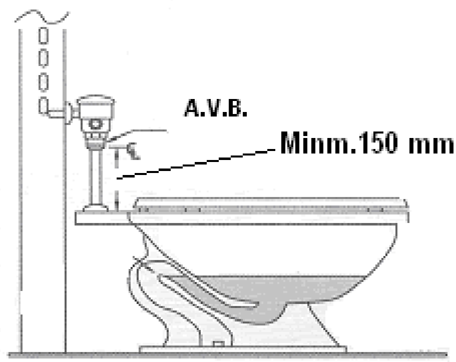
Flushing valve

Sr. No.	Part name	Material	Sr. No.	Part name	Material
1	Push control cock	Brass	13	Lock	Copper
2	Sleeve	Brass	14	Sealed piston	Plastic
3	Wall flange	Brass	15	Spindle	Brass
4	Lock	Copper/S.Steel	16	O-Ring	S. rubber
5	Spring cap	Plastic	17	Washer ring	Plastic
6	Spring	S. Steel	18	Lock	Copper
7	Gland nut	Plastic	19	Body O-Ring	S. rubber
8	Seal washer	S. rubber	20	Housing	Plastic
9	Body nut	Brass	21	Thread cap-A	Plastic
10	O-Ring	S. rubber	22	Body	Brass
11	Stopper bush	Plastic	23	Thread cap-B	Plastic
12	O-Ring	S. rubber			



Flushing valve

5.1.1 Atmospheric Vacuum Breaker:- An Atmospheric Vacuum Breaker (**AVB**) is a backflow prevention device used in plumbing to prevent backflow of non-potable liquids into the drinking water system. If the pressure in the "upstream side" is reduced to atmospheric pressure or below, the poppet valve drops and allows air to enter the system, breaking the siphon.



Flusho-meter valve
Location (A.V.B.)

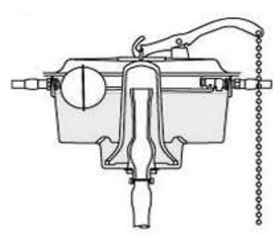
The AVB should be installed at least 150mm above the highest use downstream.

The AVB is for "Low Hazard" applications only and should not be used with continuous pressure on the device, as the poppet would likely stick and the AVB would no longer function properly. A shutoff valve should never be placed downstream of any AVB, as this would result in continuous pressure on the AVB. The AVB is not a testable device.

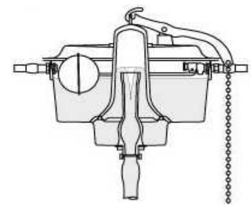
5.2 Bell type cistern:

The Burlington, or bell, style cistern is only suitable for high level cisterns and is now considered old fashion but can still be found in old houses.

These cisterns are normally made from cast iron and are easily recognized by the 'well' in the base into which the 'bell' sits. The flow-down pipe to the lavatory pan is positioned within the bell with the open top just above the normal cistern water level.



When the cistern chain is pulled, the lever at the top of the cistern lifts the bell drawing the water

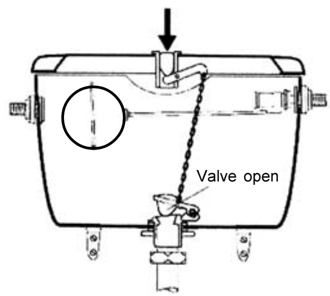


under the bell upwards into the top of the open flow-down pipe, once the water starts down the pipe, it starts a siphon effect drawing the rest of the water from the cistern until air is drawn under the bottom of the bell.

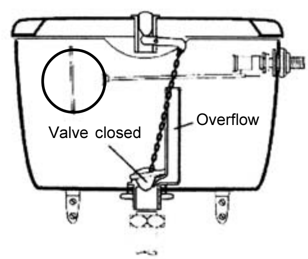
The Burlington bell style cistern does not have any parts to wear and so is highly reliable. Their weaknesses are:

If the water level is set too low, insufficient water goes down the pipe when the chain is pulled, it will not start the siphon effect. Low water levels can be remedied by adjusting the float controlling the water inlet valve. 'Burlington bell style cisterns tend to be mechanically noisy as the top lever pivots and lifts the cast iron bell.

5.3 Flap flush, push button, lavatory cisterns



Valve open



Valve closed

This flap flush valve directly controls the flow of water from the cistern. The down pipe to the lavatory pan is attached to the outlet under the flap and mounted at the bottom of the cistern, the moving part of the valve simply sits in the outlet from the cistern, it is normally sealed by the pressure of water above it. Some flap flush assemblies include an integral overflow which discharges any excess into the pan.

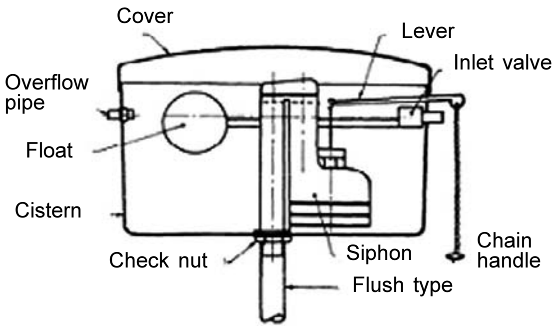
To operate a flap flush valve cistern, a button (normally fitted to the top of the cistern cover) is pushed to lift the valve by means of a chain or lever. With the flap opened, the water flows down the pipe to the lavatory pan.

Release of the button, allows the flap to close and the water, as it fills the cistern, seals the flap against its seat.

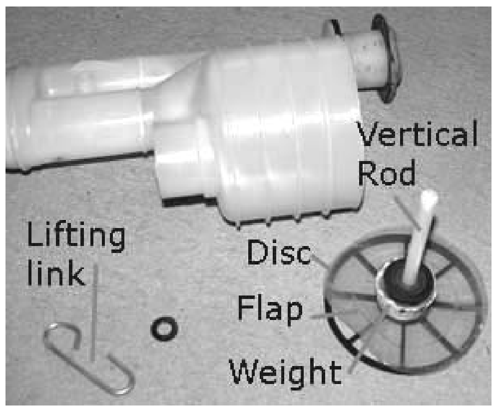
Flap flush valves are also available which can be operated by a handle on the cistern (as a conventional siphon flush mechanism).

One 'disadvantage' of the flap flush system compared with the siphon style is that when the seal on the flap becomes worn, water will continually flow down into the pan - this does not happen when any parts of the siphon type become worn, the flush action just becomes harder to achieve.

5.4 Siphon flushing cistern



Siphon flushing tank



Siphon flushing cistern has a ceramic or plastic siphon, as shown in above picture, next to the flush pipe. The lever is connected to the valve in the siphon, which is lifted up when the lever is moved up, and water enters the siphon by suction created by it. The whole cistern is flushed through the flush pipe into the WC, washing off the soil in the pan.

5.5 Replacing a flap valve

When a siphon cistern fails to flush satisfactory, one reason may be a damaged flap valve preventing enough water being lifted into the down pipe to start the siphon - this can occur suddenly but more often the problem with flush gradually get worse. Before thinking about replacing a flap valve, it is worth checking the water level within the cistern, a low water level can give similar symptoms - the water level should be about 12mm (½ inch) below the overflow outlet.

Replacement flap valves for most siphons are available from hardware stores, but they do vary in shape and size. As a last resort a new, oversized flap valve can be cut to size.

Having confirmed that the likely cause of the problem is a worn cistern flap valve, and obtained a suitable replacement flap valve, the procedure depends upon whether the lavatory suit has a high/low cistern or a close couple arrangement.

STEPS to be followed (High/low cistern) :-

- Turn off the water supply to the cistern and flush it empty (if the cistern is fed direct from a tank [i.e. where there is not shut-off valve in the pipe], it may be possible to tie up the ball-valve arm to temporarily shut off the water to the cistern rather than drain the whole tank).
- Within the cistern, locate the lifting link between the vertical rod and the handle/chain rocker - disconnect the link but leave it attached to the top of the vertical rod.
- Working under the cistern, unscrew the fitting to the down pipe, there is no need to fully remove the down pipe.
- Under the cistern, undo the very large siphon securing nut; as the nut is turned, the siphon will need to be held within the cistern to avoid it rotating.
- Once the siphon is released, lift it out of the cistern making sure that it clears the ball valve mechanism as in some cisterns there is little space. In some cisterns, removing the float from the end of the arm may make removal of the siphon easier.
- With the siphon on a table/bench:
  - Remove the lifting link from the vertical rod and any washer fitted over the top of the rod.
  - Allow the perforated disc to drop out of the bottom of the siphon reservoir.
  - Remove any washer and weight from around the vertical rod (noting their positions).
  - Remove the old flap valve from the perforated disc.
  - Reassemble using the new flap valve and making sure that all parts are fitted in their original positions.
  - Finally, refit the perforated disc assembly in the siphon reservoir and fit any washer and the lifting link.
- Clean any hardened plumbers jointing compound which was previously used to seal the joint from the bottom of the siphon and the cistern (inside and out).
- Refit the siphon to the cistern using fairly generous quantities of plumbers jointing compound on the joint and making sure that the large rubber washer is fitted between the bottom of the siphon and

the inside of the cistern. Before fully tightening the nut under the cistern, make sure that the position of the siphon will not obstruct the vertical movement of the ball-valve arm.

- If appropriate, refit the float to the valve arm.
- Reconnect the lifting link to the cistern handle/chain rocker.
- Reconnect the down pipe to the bottom of the siphon under the cistern.
- Turn on the water supply to the cistern (or release the ball-valve arm) to allow the cistern to refill.

STEPS to be followed(Close couple cistern):-

The only real difference is that the cistern must be removed from the pan before the siphon can be removed from the cistern.

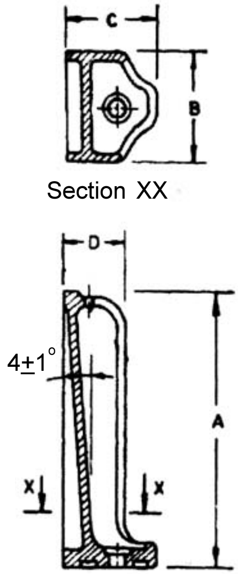
- Turn off the water supply to the cistern, if it is fed direct from a tank without a shut-off valve, the tank will need to be drained. If you have to drain a water tank, it is an appropriate time to also fit a shutoff valve in the outlet pipe from the tank so that any future work on the water system will not require the tank to be drained.
- Once the water supply is turned off/drained, flush the cistern and disconnect the supply coupling to the ball-valve.
- Disconnect the overflow from the cistern.
- Normally, the cistern is fixed to the wall and to the pan, release the fixings to the pan first and then those to the wall.
- Carefully lift off the cistern and tip it over the pan to discharge any water left in the bottom of the cistern.
- The siphon can now be removed from the cistern and the flap valve replaced as described above.
- When the siphon has been repaired and reassembled in the cistern, the cistern can be refitted to the pan making sure that the large ‘doughnut’ washer (if originally fitted) is located between the underside of the cistern and the pan around the siphon outlet.
- Make sure that the overflow and water input line up with the cistern fittings and secure the cistern to the wall and pan (do not over tighten the fixings to the pan).
- Reconnect the overflow and water supply pipes to the cistern fittings.

  Turn on the water supply to the cistern to allow the cistern to fill up.

6.0 Urinals

6.1 A **urinal** is any specialized toilet or container designed for urinating, generally by men and boys. Public urinals are normally designed for use while standing upright. There are 2 different types of urinals, namely stall type and bowl type.

6.2 Stall type:- Stall type urinals are used for offices, factories, public buildings, cinema halls etc. The system comprises of simple compartments of raising side walls, the front wall is glazed and slanted by $4 \pm 1°$ from vertical plane. Urine is passed against this wall. Bottom drain is provided along the front wall. Urine is drained through the bottom drain to the soil pipe through trap. Usually centre line spacing of the units is kept as 60 cm.

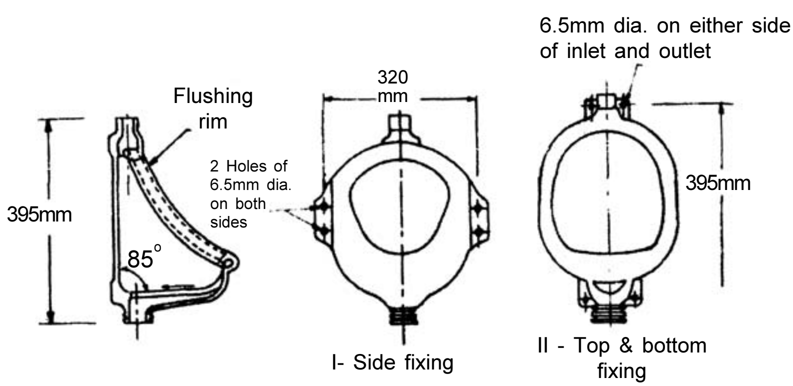


Salient dimensions

	Type-I	Type-II
A =	1140mm	1500mm
B =	460mm	500mm
C =	400mm	400mm
D =	255mm	190mm

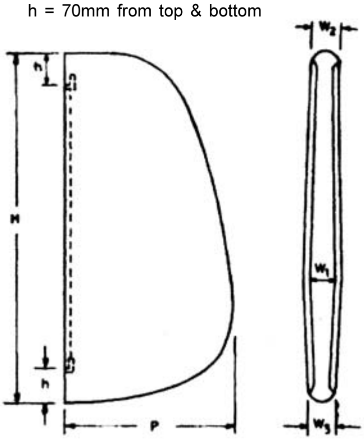
Stall type Urinal

6.3 Bowl Type:- These type of urinals are generally used in private building, offices. These are more convenient to use and better in appearance than stall type urinals. They are made up of glazed earthenware or vitreous china clay. Outlet horn is provided at the bottom of the pan. The urinal bowl is connected to the drain pipe through floor trap. The usual centre to centre spacing between the units is kept about 60 cm and a partition plate is provided between two bowls. The bowls may be with flushing rims or without them. The flushing rim has 12 holes provided in the rim and on flushing water ejects from the holes and falls along the walls of the bowl, cleaning the bowl efficiently. Where the bowl is without rim, the water is ejected from the top spreader of 12.5 mm diameter with slots of spreader downward, and falls along the rear face of the bowl and clears the bowl though this is not as efficient but meets the requirement. Depending on whether the bowl is to be fixed on wall or in a corner, wall hung or angle back bowls urinals are used.



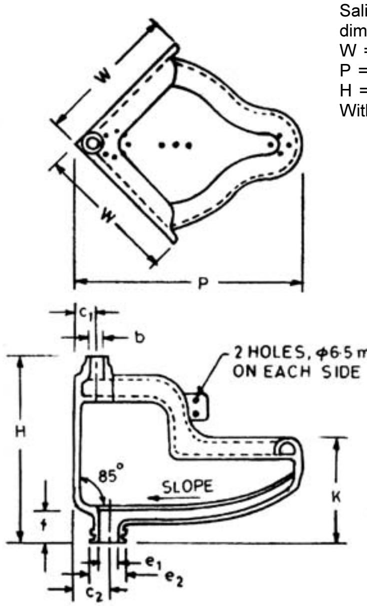
Wall hung bowl urinal

Salient dimensions
H = 675mm or 825mm
P = 325mm or 450mm
h = 70mm from top & bottom



Partition plate

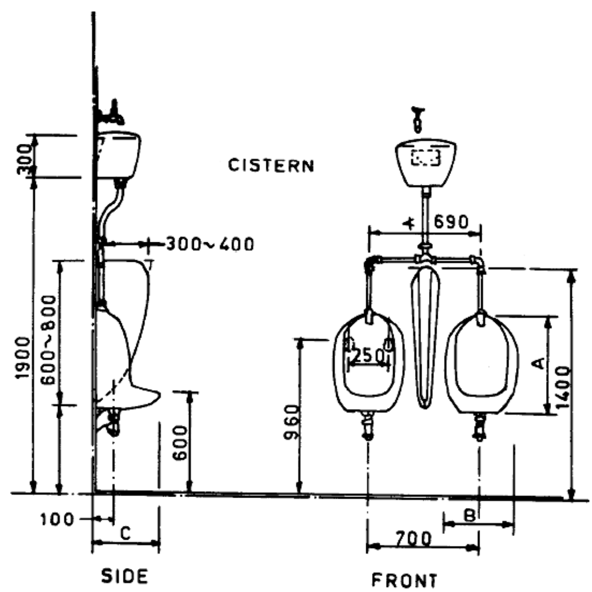
Salient dimensions
W = 345mm
P = 420mm
H = 270mm
With flush RIM



Bowl pattern urinal - Angle back

6.4 Installation of the bowl type urinals

1. Urinals shall be fixed in position by using wooden plugs and screws. It shall be at a height of 60 cm from the standing level to the top of the urinal, unless otherwise specific requirement for the school children.
2. The bowls are either side fixing or top and bottom fixing as shown in figure above. Accordingly marking for the plug holes should be done.
3. The size of wooden plug shall be 50 x 50 mm at the base tapering to 38 x 38 mm at the top and length of 50 mm these shall be fixed in wall in cement mortar 1:3 (1 cement : 3 fine sand). After the plug is fixed in the wall, the mortar shall be cured till it is set.



Typical layout for urinals as shown in IS:2064

4. Each urinal shall be connected to 32 mm diameter waste pipe, which shall be discharged into the channel or a floor trap. In some public urinals both traps are also provided before the connection to channel or trap. The connection between the urinal and flush or waste pipe shall be made by means of putty or white lead mixed with chopped jute fiber.
5. The height of the bottom of the cistern to the end of the spreader or inlet socket is generally not less than 0.9 meter to allow a water head of 0.9 meter for flushing the urinal.

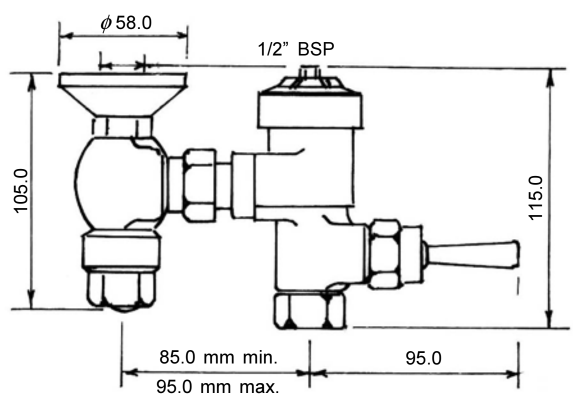
6.5 Installation of the Stall type Urinals

Installation procedure for stall type urinal is similar to bowl type urinal. Only difference is that there are clamps provided by the manufacturers. These clamps are fixed on the wall at keeping the distance of 60 cm from the foot rest to the top of dip of urinal. Then stall type of the urinal is hanged on these clamps and waste pipe is connected to stall type urinal.

6.6 Flushing:-

Most public urinals incorporate a flushing system to rinse urine from the bowl of the device to prevent foul odors. The flush can be triggered by one of several methods:

6.6.1 Manual handles:- Each urinal is equipped with a button or short lever to activate the flush, to which water is supplied through a cistern or directly through flush valve with users expected to operate it as they leave. Such a directly-controlled system is the most efficient provided that uses remember to use it.



6.6.2 Timed flush:- Instead, the traditional system is a timed flush that operates automatically at regular intervals. Groups of up to ten or so urinals will be connected to a single overhead cistern, which contains the timing mechanism. A constant drip-feed of water slowly fills the cistern, until a tripping point is reached, the valve opens, and all the urinals in the group are flushed. Electronic controllers performing the same function are also used.

This system does not require any action from its users, but it is wasteful of water where the toilets are used irregularly. To help reduce water usage when use of urinals are closed, an electric water valve is connected to the light switch. When the building is in active use during the day and the light is on, the timed flush operates normally. At night or on holidays when the building is closed, the light is turned off and the flushing action stops.

6.6.3 Automatic flush

Battery-powered hands-free automatic sensor operated flush system.

Automatic flush facilities can be retrofitted to existing systems. The handle-operated valves of a manual system can be replaced with a suitably-designed self-contained electronic valve, often battery-powered to avoid the need to add cables. Timed-flush installations may add a device that regulates the water flow to the cistern according to the overall activity detected in the room. This does not provide true per-fixture automatic flushing, but is simple and cheap to add because only one device is required for the whole system.

To prevent false-triggering of the automatic flush, most infra-red detectors require that a presence be detected for at least five seconds, such as when a person is standing in front of it. This prevents a whole line of automatic flush units from triggering in series if someone just walks past them.

The automatic flush mechanism also typically waits for the presence to go out of sensor range before flushing. This reduces water usage, compared to a sensor that would trigger a continuous flushing action all the while a presence is being detected.

6.7 Plastic waste pipes and connector

Plastic waste pipe is available in 4 basic sizes (external diameter) for different plumbing uses:

- 21.5mm - for overflows such as water tank, cisterns etc
- 32mm - for hand basin waste pipe
- 40mm - for sink and bath waste pipe
- 110mm - for soil pipe and main drains

6.7.1 Types of plastics

The most widely used are:

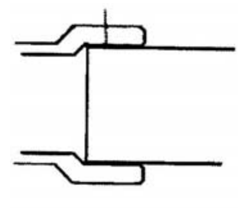
- **Acrylonitrile Butadiene Styrene (ABS)** - A tough material suitable for both hot and cold waste water. It normally incorporates a UV stabiliser which means it is suitable for both indoor and outdoor use. Suitable for all methods of joining.
- **Modified Unplasticised Polyvinyl Chloride (MUPVC)** - A tough material suitable for both hot and cold waste water. Suitable for both indoor and outdoor use. Suitable for all methods of joining.
- **Polypropylene (PP)** - A very tough but flexible material having a sort of waxy feel suitable for both hot and cold waste water. Often the cheapest but usually it does not incorporate a UV stabiliser so should

not be used outdoors; exposure to sunlight can cause it to become brittle over time. Not suitable for joining using solvent.

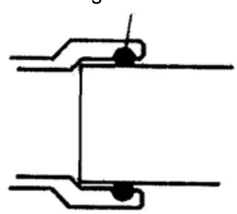
6.7.2 Methods of joining

Three different methods of joining and sealing pipes are available:

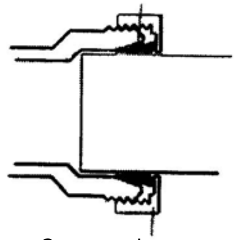
a) **Solvent:** Pipes and connectors of some types of plastic can be bonded together using a special solvent cement. These plastics tend to be the more expensive available but are easy to use. The major drawback of this type of waste pipes/connectors is that you only have one chance to make the connection, once connected there is no chance to adjust the angle or length without taking a hacksaw to the joint and remaking it with new pipe and connectors. If a joint is likely to be broken in the future for any reason, solvent type joints should not be used.



b) **'O' ring:** These connectors can be used of all types of pipes of the appropriate diameter. To make a connection, the pipe is just pushed into the connector through the 'O' ring thus making the seal. Once the connection is made, the angle of the pipe/ connector can be adjusted by gripping the pipe and connector (one in each hand) and twisting the pipe. If necessary to shorten lengths, the pipe can be pulled out, cut and re-inserted. To ease pushing the pipe into the connector, the end of the pipe should be lightly chamfered before insertion so that the pipe can easily start to enter the seal.



c) **Compression:** Compression waste pipe connectors are often used to terminate waste pipes into the outlet of the waste trap under basins, baths and sinks. However, inline connectors are also available using compression joints, these are the most expensive type available and their use is generally not warranted unless a particular bend or joint is likely to need to be broken on a regular basis. The compression screw and seal are removed from the connector and slid onto the pipe, the pipe is then inserted (requiring no effective effort) into the connection, the seal is then pushed along the pipe into the mouth of the connector and the screw is wound onto the connector making the seal compress between the pipe and the connector. To adjust or



remove the pipe, the screw cover is undone thus releasing the seal, the pipe can then be adjusted or removed with no effective effort.

d) 110mm diameter soil pipe and main domestic drainpipe:

The main soil waste pipe is 110mm diameter, two types of plastic are used - one for the external down pipe and the other for below ground installation. The joints for soil pipes are normally large ‘O’ rings or similar circular, push fit seals. As with the smaller ‘O’ ring connectors, the pipe going into the joint should be chamfered to ease it pass the seal ring.

7.0 Quality checks on vitreous china fixtures:

7.1 General

i) All appliances should bear at suitable location a) the name of manufacturer or brand name b) the batch and lot no. c) ISI mark

ii) The vitreous china ware is made from a mixture of clays and finely ground minerals such as quartz and feldspar and fired at high temperatures. Such a material even without glazing should not have water absorption, >0.5% by dry weight of the appliance.

The appliance is then coated with impervious, non crazing vitreous glaze giving white or colour finish. The glaze should form a high gloss and be of such thickness and capacity to give uniform colour and finish.

iii) The fixtures may have certain unglazed surfaces but they should not be visible after installation in the normal manner.

iv) Thickness of the appliance/fixture at any location should not be less than 6 mm.

v) The appliance should be visually examined for a) polishing marks b) bubbles and specks c) waves in finish d) warpage e) crazing etc. from a distance of 60 cm. and practically no such defects should be visible to naked eye. There are however some isolated spots and permissible limits given in IS:2556 Pt.1, which may be referred to.

vi) The glazed appliance should not have any adverse noticeable effect on treatment with chemicals as under,

Chemical	Strength (%)	Time (Hrs)	Temperature
Acetic acid	10	16	100 deg C
Citric acid	10	16	100 deg C
Detergent	(*)	48	60 deg C
Hcl	(**)	48	25-35 deg C
NaOH	5	0.5	60 deg C
Sodium stearate	0.15	48	60 deg C
Sulphuric acid	3	16	100 deg C

(*) Contains aqueous solution containing 0.04% by volume of a condensate product of nonylphenol with 8-10 molecules of ethylene oxide.

(**) Equal volume of water with HCl having specific gravity of 1.18.

vii) The dimensional tolerances on various parts of appliance, if not laid down in the IS code specifically are as under:

a) For dimensions $\geq$ 75 mm, $\pm$2% of dimension or $\pm$ 2mm whichever is more

b) For dimensions $\leq$ 75 mm, $\pm$5% of dimension or $\pm$ 2 mm whichever is more

c) Height of flush outlet of P-Trap or horiz. Outlet $\pm$ 5 mm

d) All angles $\pm$ 3 deg.

7.2 For water closets and pans:-

i) Smudge test :- The inside of the pan or bowl of WC is smudged with quartz powder passing through 1.18 mm sieve from bottom to below the rim and flushed. No smudge should be traceable after flushing.

ii) The WC/ pan on blocking at bottom should hold not less than 10 litres of water.

ii) Toilet paper test:- About 6 pieces of normal toilet paper or a sheet of polyethylene sheet of 0.05 mm thickness and 150x115 mm are tossed into the pan/WC and on flushing on 4 occasions at least 3 times it should be washed down.

7.3 Bowl urinals:-

i) The design of urinal bowl shall be such that after proper installation, there should be no water left over in the bowl bottom after flushing.

ii) To check the cleanability of urinal bowl, the whole of interior flushing surface below the spreader is smudged with 0.1% solution of an organic dye and on flushing, no colour be left on urinal bowl.

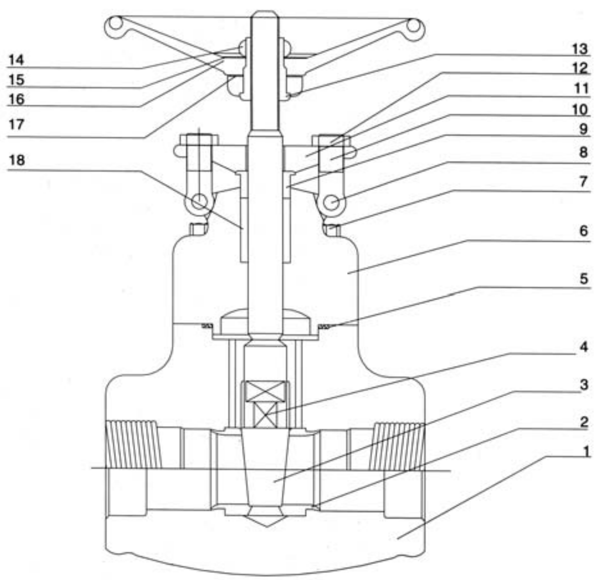
8.0 Different types of valves

8.1 Sluice valves or Gate valves:- These types of valves are provided to stop and regulate the flow of water in course of ordinary and emergency operation. Sluice valves are not intended to be used for continuous throttling, as erosion of the seats and body cavitation may occur. The control is by means of a gate in the form of a wedge or disc between the ends of the body of valve, which are placed in the pipe line. The gate is actuated by a stem whose axis is at right angle to the body ends. The water pressure is always in one direction i.e. it acts on one side of the gate and there is no change in the direction of flow.

For domestic water supply systems, gate valves are available with screwed ends as well as flanged end. These valves are manufactured in nominal diameter 15,20, 25, 32, 40, 50, 65, 80,and 100 mm, The gate valves are manufactured as class I or Class II. Class I are for pressures 1.0 MPa (10 bars) and painted in blue colour, whereas class II are suitable upto 1.6 MPa (16 bars) and painted in red colour. For water works Gate valves are heavy duty and are available up to 1200 mm diameter.

The spacing of the valve varies principally with the terrain traversed by the line. In urban areas the main function of this valve is to section out the line. These are normally placed at 150 to 200 m apart.

The gate valves are also used as scour valves. In pressure conduits, small gate off-take known as blow-off or scour valves are provided at low points above line valves situated in the line on a slope such that each section of the line between the valves can be emptied and drained completely.



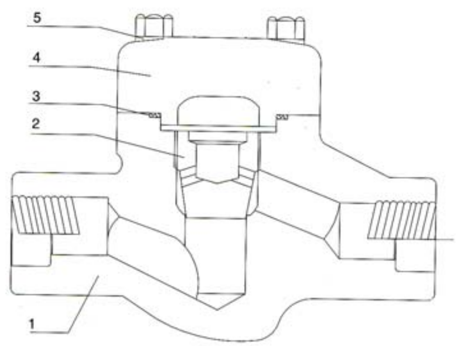
NO	Part Name
1	Body
2	Seat
3	Wedge
4	Stem
5	Gasket
6	Bonnet
7	Bolt
8	Pin
9	Gland
10	Gland eyebolt
11	Gland flange
12	Hex nut
13	Stem nut
14	Locking nut
15	Name plate
16	Hand wheel
17	Lubricating gasket
18	Packing

8.2 Check valves:- Check valves, also called non-return valves or reflux valves, automatically prevent reversal of flow in a pipeline. They are particularly useful in pumping mains when positioned near pumping stations to prevent backflow, when pumps shut down. When pump fails to stop ,water will not flow back to the pump.

The flow is controlled by means of a disc raising and falling on to a seat with water pressure (Lift check valve), the return may sometimes be added by a spring (Spring loaded check valve). The flow may also be controlled by means of a flap swinging up and down with pressure on valve seat.

For domestic water supply systems, check valves are available with screwed ends as well as flanged end. Screwed end valves are manufactured in nominal diameter 8,10,15,20, 25, 32, 40, 50, 65, 80,and 100 mm, where as flanged end valves are not made in smaller diameters of 8 and 10 mm. Depending on the water pressure the valves have to experience, gate valves are manufactured as Class I or Class II. Class I are for pressures 1.0 MPa (10 bars) and painted in blue colour, whereas class II are suitable up to 1.6 MPa (16 bars) and painted in red colour.

Typical cross section of disc type check valve and its component list is given below:-



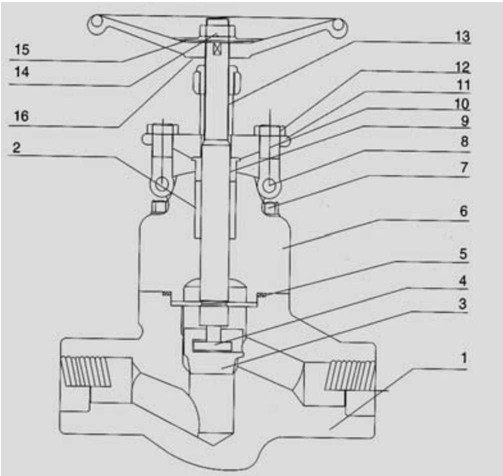
No	Part name
1	Valve Body
2	Disc
3	Gasket
4	Bonnet
5	Bolt

The Check valves are of two types,

a) Swing type: This type is used when the axis of the body end ports horizontal or vertical. Swing type can also be used in vertical direction when direction of flow is in vertical direction.

b) Lift type :- These could be either with disc or ball check and are used with the axis of the body end ports horizontal or vertical or in applications where the axis of the body end ports are at right angles.

8.3 Globe valves:- These are spherical in shape and are screw down stop valves. In straight Globe valve the body ends are in line with each other and the disc is lifted from or lowered on to the body seat by a stem whose axis is at right angles to the body ends. The pressure acts on the underside of the valve disc and there is a change of direction of flow inside the body of valve. The functioning is different from that of gate valves. For domestic water supply systems, globe valves are available with screwed ends as well as flanged end. Screwed end valves are manufactured in nominal diameter 8,10,15,20, 25, 32, 40, 50, 65, 80,and 100 mm, whereas flanged end valves are not made in smaller diameters of 8 and 10 mm. Depending on the water pressure the valves have to experience, gate valves are manufactured as class I or Class II. Class I are for pressures 1.0 MPa (10 bars) and painted in blue colour, whereas class II are suitable upto 1.6 MPa (16 bars) and painted in red colour. Typical cross section of globe valve and its component list is given below:-

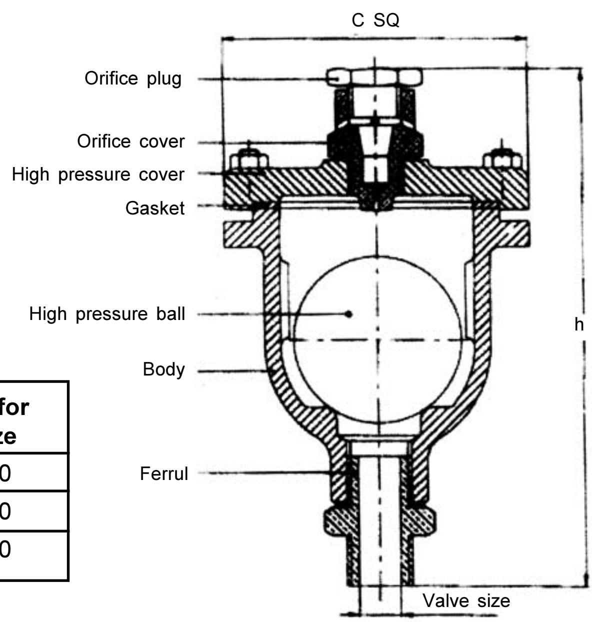


No	Part name	No	Part name
1	Valve Body	9	Gland
2	Graphite Packing	10	Gland eyebolt
3	Disc	11	Gland flange
4	Stem	12	Hex Nut
5	Gasket	13	Stem Nut
6	Bonnet	14	Locking nut
7	Bolt	15	Name plate
8	Pin	16	Hand wheel

8.4 Air valves:- Air Relief valves are of primarily 3 types i) Single air valves (Small and large orifices) ii) Double relief valves, and iii) Dynamic relief valves.

i) Single air valves (small orifice) are fitted at peaks to release the air automatically when a pipeline is being filled and large orifice valves are fixed to permit air to enter the pipeline when it is being emptied. The Relief valves are generally smaller than the pipes to which they are fitted to, and are fixed on a ferrule placed on the body of pipe. For a pipe of 100 mm dia. relief valves of 15 mm, 25 mm or 40 mm can be fixed, through a ferrule of proper size, depending on the pressure head in the pipe line.

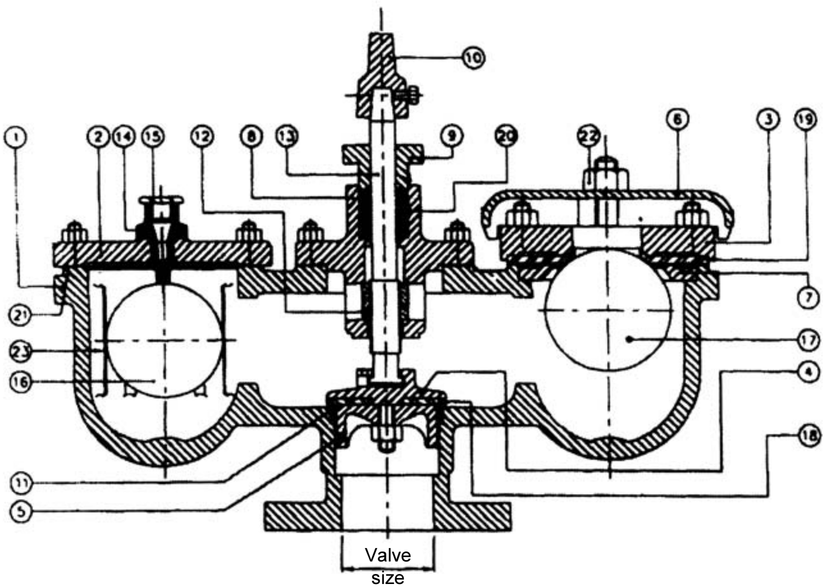
Valve size	B (min)	C SQ (min)	Suitable for main size
15	196	118	Upto 100
25	255	158	Upto 100
40	290	158	Upto 100



Single air valve

ii) Double relief valves are a combination of two single relief valves of small orifice and large orifice. The size of valves suitable for different diametre of pipes is as under,

Valve Size (mm diameter)	Suitable for Pipes Dia. mm
40	Upto 100
50	125-200
80	225-350
100	400-500
150	600-900
200	1000-1200

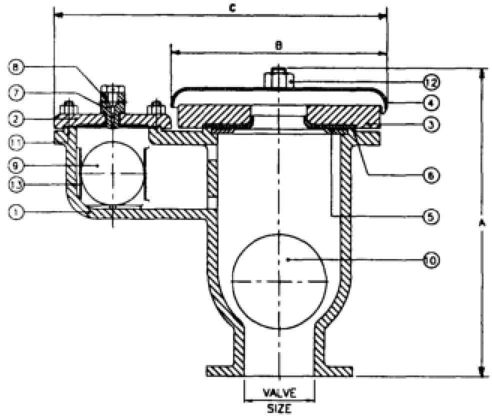


Legend

1) Body
2) High pressure cover
3) Low pressure cover
4) Valve
5) Valve holder
6) Cowl
7) Joint support ring
8) Valve cover
9) Gland
10) Cap
11) Seat ring
12) Nut for spindle
13) Spindle
14) H. P. cover
15) H. P. office plug
16) Ball for H.P. chamber (float)
17) Ball for H.P. chamber (float)
18) Valve disc
19) L.P. seat ring
20) Packings
21) Gasket
22) Bolts and nuts
23) Guide bush

Double relief valve (I.S.- 14845)

iii) Dynamic relief valves are similar to double relief valves but are used for very high water head in pipe lines. The suitability of the dynamic relief valves is also same as for double relief valves. The schematic diagram of a dynamic relief valve is given below:



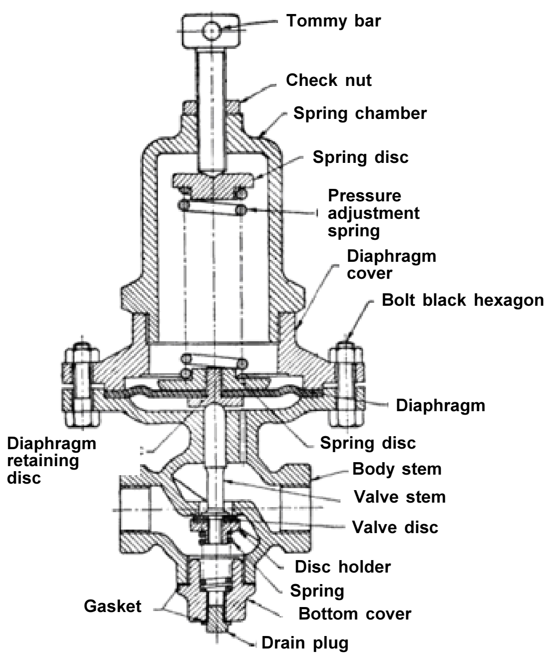
Legend

1) Body
2) High pressure cover
3) Low pressure cover
4) Cowl
5) Joint support ring
6) L.P. Seat ring
7) H. P. office
8) H. P. office plug
9) Ball for H.P. chamber (float)
10) Ball for L.P. chamber (float)
11) Gasket
12) Bolts and nuts
13) Guide bush

Dynamic relief valve (I.S.- 14845)

8.5 Pressure reducing valves: These are used to automatically maintain a reduced pressure within reasonable limits in the downstream side of the pipe line. This type of valve is always in movement and requires scheduled maintenance on regular basis.

These valves have screwed female ends. The pressure adjustment is done by a diaphragm loaded with spring by turning the tommy bar. The diaphragm and valve disc are made of synthetic rubber, where as the body is of leaded tin bronze. These are available in nominal sizes 15 mm, 20mm, 25 mm, 32 mm, 40 mm, and 50 mm. These valves are capable of reducing the pressure on out flow side by as less as to 10%



Pressure reducing valve

i.e. to 1/10th. These are installed on the municipal pipes to control the flow of water to various consumers as also in multistoried buildings, where the storage is on terrace floors.

8.6 Ball (or float) valves

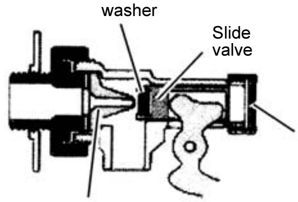
'Ball' floating on the water inside the tank/cistern moves an arm attached to the valve which controls the input of water - as the ball/arm falls, the valve is opened to allow water into the tank, then as the water level rises, so does the ball and arm closing off the valve. The point at which the valve is closed (thus setting the level of the water) can be adjusted by the arm attached to the float, the method of adjustment depends on the type. The two basic set-ups are:

- The most common arrangement is where there is a solid brass rod between the valve and ball; in this case, the rod needs to be physically bent. To do this, firmly grip the rod in both hands, hold the hand next to the valve still (so as not to put any pressure onto the valve) and use the other hand to bend the rod a small amount, up to increase the water level or down to lower it.
- On other systems there is a hinge in the arm between the valve and the ball with a lock nut and adjustment screw - to adjust just loosen off the lock nut and adjust the hinge to bend the hinge.

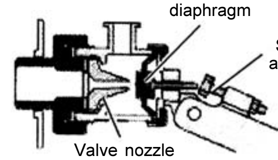
The two common types of valve mechanism are the slide (or piston) valve and the diaphragm valve.

a) The slide valve

As the float arm moves up and down with the water level in the cistern/tank, the cam on the end of the arm inside the slide valve body slides the piston towards or away from the feed hole through the middle of the valve nozzle. When the level of the water is at the correct level, the valve washer is forced against the nozzle hole and the water supply is shut off. As the water in the cistern/tank drops, the slide valve is moved back and allow



Slide valve



Diaphragm valve

water to enter the tank to fill it up. Modern slide valves may be made from plastic. The valve washer may need replacement sometimes.

b) **The diaphragm valve**
The diaphragm valve operates with an arm from the float as for the slide valve but in this case a screw adjuster on the top of the arm pushes against a 'plunger' which pushes the diaphragm against the supply valve nozzle.

One advantage of the diaphragm valve is that the only moving part which is in contact with the water is the diaphragm itself, and that this reduces problems in hard water areas where deposit build-up and corrosion can occur.

8.6.1 Slide valve washer replacement

A leaking **slide valve** will cause water to continually drip into the tank and will, over a period of time, raise the water level to the overflow. So, if water drips out of the overflow from a lavatory cistern or water tank after a period of time, the first thing to check/replace is the washer in the ball valve.

NOTE: Please read through these notes before starting to replace a washer in a slide valve, one problem which may be encountered is a seized end-cap on a brass slider (see here below) which will prevent completing the change of washer. It may be worth buying a replacement nylon slider before starting the work so that if the problem is encountered, the complete slider can simply be replaced.

Before you start you will need to turn off the water supply to the tank/ cistern - there should be no need to drain the tank however pressure from the floating ball may make it hard to remove (and then replace) the float arm, so some water may need to be drained to take the pressure off the float arm.

8.6.2 Dismantling a slide valve

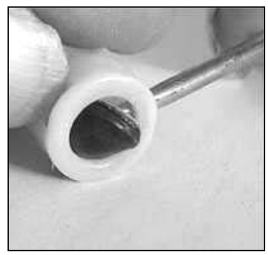
i) Start by removing the end cap from the body of the valve.
ii) Remove the split pin on which the float arm pivots and remove the float arm from the valve body. The open ends of the pin will need to be squeezed together with a pair of pliers so that the pin can be withdrawn through the holes in the valve body.
iii) Remove the slide valve from the end of the valve body. It may be necessary to use a small screwdriver through the hole underneath (where the float arm originally located) to move the

slider back so that it can be griped with the fingertips and withdrawn.

Two types of sliders are commonly used, brass with a screw end cap or nylon (as shown here). Whether the slider is brass or nylon depends largely on the age of the ball valve - they are interchangeable and not specific to particular uses.

- With a brass slider, the end cap needs to be unscrewed, the old washer replaced and the end cap re-secured. A major problem is that most slide valves have been operating for many years before the washer needs attention and the end cap is usually seized solid with the body of the slider. It may be possible to loosen the end cap by gripping it with a pair of pliers and inserting a screwdriver into the body.

  If the end cap and slider body will not part, the easiest thing is to fit a new replacement nylon slider.



- With a nylon there are normally slots around the end with the washer.

  To remove the old washer, a small screwdriver is used through one of the slots to force the washer out.

  With the old washer removed, the new washer is simply forced into the locating groove.

8.6.3 Reassembling a slide valve:

Reassembling a slide valve is just the reverse of dismantling one, points to watch are:

- When fitting the slider into the end of the valve, make sure that the washer end goes in first and that the slot in the slider lines up with the slot in the body of the valve where the end of the float arm goes.
- After the float arm has been located into the slider and the split pin fitted, slightly open up the split pin so that it cannot be removed without use of tools.
- When fitting the end cap, there is no need for it to be tightened other than a small 'nip up' - if it does come loose and drop off, water entering the valve will flow around the slider and out of the end rather than being directed down through the hole in the bottom of the valve body.

8.7 Lavatory cisterns - common problems

Below are a number of common problems encounters with cisterns and lavatories.

i) Cistern does not flush when handle/chain is operated

ii) Cistern fills very slowly

iii) Water comes out of the cistern overflow outlet

iv) Flush does not clean pan

i) Cistern does not flush when handle/chain is operated:

- If a syphon type of cistern has never flushed properly, the likelihood is that the water level is too low - it should be about 12mm (half inch) below the overflow outlet. To correct this, raise the height of the float, the method depends upon the type of valve/ball fitted:
    - On some set-ups there is a hinge in the arm between the valve and the ball with a lock nut/screw - loosen off the nut/screw and adjust the hinge.
    - Other systems have an adjustable screw at the valve end of the arm (normally with a lock nut), release the lock nut and adjust the screw as necessary to raise the float.
    - The final arrangement is where there is a solid brass rod between the valve and ball without any adjustment; in this case, the rod needs to be physically bent. To do this, firmly grip the rod in both hands, hold the hand next to the valve still (so as not to put any pressure onto the valve) and use the other hand to bend the rod up a small amount to increase the water level.
- If a linkage has become detached within the cistern, this should be fairly obvious as the handle/chain will loose its normal 'feel' - i.e. the handle or chain won't return to its normal position. Most linkages which have come loose can just be refitted and tightened after removing the top of the cistern.
- If the cistern is a direct action type syphon type, the flexible diaphragm on top of the perforated disc may have become torn. If this has occurred, the syphon needs to be removed from the cistern the disc assembly dismantled and a new diaphragm fitted - although diaphragms vary in shape and size, replacements are usually readily available at hardware stores.

ii) Cistern fills very slowly - normally a cistern should fill within 2 minutes.

This is a problem associated with the ball valve which fills the cistern with water, possible causes include:

- If the problem has gradually worsened:
    - Low water pressure in the feed pipe - either a valve has not been turned fully on or there is an obstruction in the pipe.

- The valve itself may have become clogged by scale or muck in the water supply.

iii) Water comes out of the cistern overflow outlet:

This is a problem which can be normally be traced to the ball valve or float which control the water entering the cistern, possible causes include:

- A worn valve washer not completely shutting off the water supply, most types of washers can be replaced.
- Incorrectly set water level, the problem will probably have existed since the valve was fitted or last adjusted. The water should be about 12mm (half inch) below the level of the overflow, if it is very near the overflow outlet, the water level can be reduced in a manner similar to adjusting for low cistern water levels as described above but remember that to lower the water level, the float needs to be lowered - flush the cistern after adjusting the float so that the water will fill be the new level.
- The wrong type of valve nozzle is fitted to the valve if fed direct from the mains. The problem will always have existed since the valve was fitted.

  If a tank type valve nozzle is fitted instead of a direct mains nozzle (the latter has a smaller hole), the valve may not be completely closing off the water supply.
- The ball float is restricted in its movement (possibly catching on the side of the cistern or the syphon assembly) thus not closing off the valve properly - ball floats with brass arms can normally be adjusted sideways to clear everything, ones with plastic arms may need reassembly.
- The ball float is damaged (i.e. leaking) so that it is not riding as high in the water as previous - replacement floats can normally be easily fitted although replacements for non-spherical floats may be harder to find.

iv) Flush does not clean pan:

Assuming that it's not a particularly dirty pan, the problem is probably one of the following:

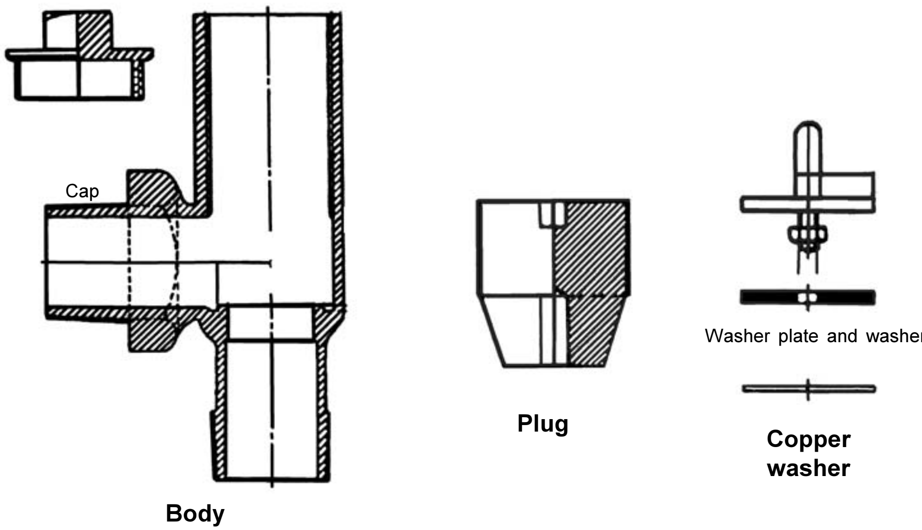
- First of all, check if the cistern is a 'half and full flush' type. If it is, check to see if everybody using it knows how to correctly use it, i.e. hold down the handle for a full flush.
- Check the water level in the cistern, it should be about 12mm (half inch) below the overflow pipe. The higher it is, the more water will be flushed down the pan and the more chance there is to clean it. Adjust the float as described above.

- Check that the down pipe meets the pan squarely and that it is not obstructed. Check with a spirit level that the rim of the pan is level side to side and back to front.

  The water in a flushing pan should run equally from around the rim.

9.0 Ferrule:

Ferrule is an appliance to draw off water with a vertical inlet for screwing on to a main and a horizontal out let. A washer plate carrying a



replaceable washer which shuts against water pressure on a seating at right angles to the axis of threaded plug which operates it. This is used to tap the water main for a connection to the consumer or for fixing the air relief valve. The nominal sizes of the ferrules is 8 mm, 10 mm, 15mm, 20mm, 25mm, 32mm, 40mm, 50mm and are manufactured in leaded tin bronze. The salient dimensions are as given in I.S. 2692.

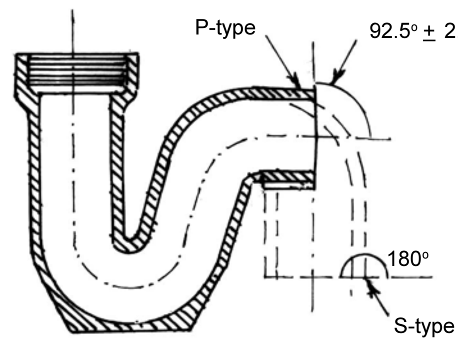
10.0 Traps:

The fittings which are placed at the end of soil pipes or sullage pipes to prevent the passage of foul gases from the pipes to the outside are called traps. Between every fixture and the waste line is a **trap** - a curved section of pipe that traps water within it. All types of traps maintain water seal between the pipe and the outside which does not permit foul gases to escape from the pipes. The trapped water forms an airtight seal that prevents sewer gas from entering the home. The efficiency of trap largely depends upon the depth of water seal. The water depth of water seal most commonly adopted in most trap is 50 mm. At the bottom of their curve, some traps have a **clean-out plug** that provides access to the trap, making it easier to clear out any clogs.

10.1 There are three main types of traps i.e. P type, Q type and S type. Out of these Q type is not seen very common.

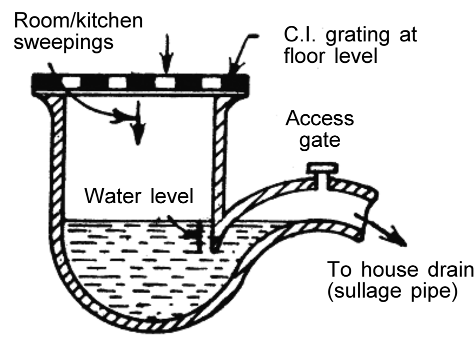
a) **P-traps:** Designed for waste lines that come out of a wall, P-traps are shaped like the letter "P" lying face down. They're located under sinks, tubs, and showers.

b) **S-traps:** Designed for waste lines that come out of the floor, S-traps can sometimes allow sewer gas into the home. So installing S-traps in new homes are not recommended.



10.2 Types of traps based on their use:-

a) **Floor trap:-** The traps which are used for admitting waste water from floors of the rooms, kitchens, baths etc. in to sullage pipe are called floor traps. Mostly these traps are P type. These are provided with cast iron/ galvanized /stainless steel gratings at the top to prevent the entry of solid and large sticky matters, into the drain pipe to avoid frequent blockage. These traps are also called as Nahani Trap.

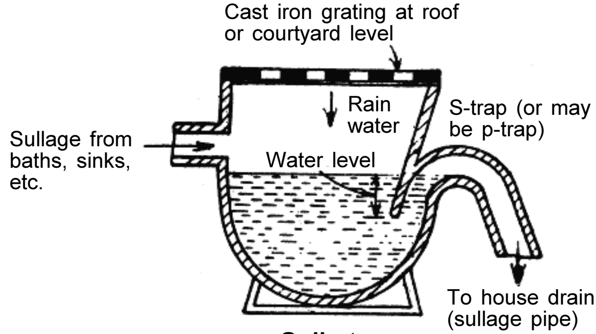


b) **Gully traps:-** This is provided at junction in the drainage system. There are two entry locations for these types of traps. Waste from bathrooms, kitchen etc. enter through horizontal inlet. Water from floor cleaning or from rain water system enters from top grating screen. These traps provide wider entry to flow, smooth surface, easy cleaning arrangements and deep water seal. The water seal is usually 50.00 mm to 75mm deep. The top is covered by cast iron/galvanized

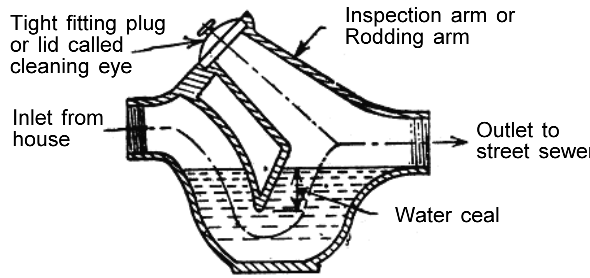
/stainless steel gratings to exclude the entry of coarser materials to avoid blockage.

c) **Intercepting traps:-** The trap which is often provided at the junction of a house sewer at the junction of house sewer and a municipal sewer. This intercepts the foul gas from the municipal sewer, from entering into the house drainage system.

e) **Cockroach repellent trap:-** These traps are provided in kitchen and bathrooms in place of grating to restrict cockroaches to enter to house from drain.



Gully trap



Intercepting trap

Cockroach repellent trap

11.0 Cleaning materials and other safety instructions

11.1 Metal fixtures like taps etc.

Acids are a necessary ingredients of cleaning materials for removing lime, however please pay attention to the following points when cleaning taps, mixers and showers:

- Only use cleaning material which is explicitly provided for this type of application, normally detergents used in the kitchen are suitable for cleaning the metallic fixtures.
- Never use cleaning material, which contain hydrochloric, formic or acetic acid, as they can cause considerable damage.
- Phosphoric acid is also restricted as it can cause damage.
- Never mix any cleaning material with another.
- Never use cleaning material or appliances with an abrasive effect, such as unsuitable cleaning powders, sponge pads or micro fiber cloths.

Follow the cleaning material manufacturer's instructions. In addition pay attention to the following points :

- Clean the fixtures as and when required.
- The cleaning dosage and time the cleaner needs to take effect should be adjusted according to the product and cleaner should not be left longer than necessary.
- Regular cleaning can prevent calcification.
- When using spray cleaners, spray first onto a soft cloth or sponge never directly onto the sanitary tap ware, as drops could enter openings and gaps and cause damage.
- After cleaning, rinse thoroughly with clean water to remove any cleaner residue.
- Residues of liquid soaps, shampoos and shower foams can also cause damage, so rinse with clean water after using. If the surface is already damaged, the effect of cleaning material will cause further damage.

11.2 Vitreous China ware:-

- All the vitreous China ware should be cleaned with recommended agents periodically, preferably not later than alternate day.
- Mild acids and detergents (Nonylphenol) can be used for cleaning as given in Table in para 7.1 above but the fixtures should be thoroughly cleaned with clean water and wiped with a cotton mop, thereafter leaving no trace of acids or detergents for a longer period.

11.3 Valves and washers:-

- Replace the rubber flapper in the tank every two to three years. If black coloring comes off on hand when touched the flapper, its time to replace it.
- Replace all washers periodically to avoid the problem of dripping taps, mixers.

11.4 Traps:-

- All floor traps, bottle traps should be opened and cleaned periodically.

Chapter 4

WATER SUPPLY AND DISTRIBUTION

1.0 General: A water supply system includes large utilities with piped transmission, treatment and distribution systems, piped and non-piped community supplies, as well as hand pumps and individual domestic supplies. This covers the whole system from the source to the point of supply to the consumer.

1.1 Source of water supply:-

The origin of all sources of water is rain fall. Water can be collected as surface water or ground water.

a) **Surface water:-** The rain water can be collected as it flows over surface either in natural lakes and ponds or artificial lakes and ponds or flowing water as in rivers, natural courses and irrigation canals or from sea water.

   i) Natural water in lakes and ponds :- These water would be more uniform in quality than water flowing in streams. Long storage permits sedimentation of suspended matter, bleaching of color and the removal of bacteria. If the catchments are protected and unerodible, the stored water may not require any treatment other than disinfection.

   ii) Artificial water in impounding reservoir:- Impounding reservoir formed by hydraulic structures constructed across river, are subject, more or less to the same conditions as natural lakes and impounds.

   iii) Flowing water as in rivers, other natural courses and irrigation canals:- Water from rivers, streams and canals are generally more variable in quality and less satisfactory than those from lakes and impounding reservoirs. Watersheds could carry suspended impurities from eroded catchments, organic debris and mineral salts.

b) **Ground water:-** Rain water percolating into the ground and reaching impermeable layers (aquifers) in the zone of saturation constitutes groundwater source. Generally ground waters are clear and colorless but are harder than the surface waters of the region in which they occur.

1.2 Water requirement/demand:- The first step is to assess the demand of water of the area, based on the population, type of requirements, viz. domestic, commercial, public usage, fire fighting demand and level of service to be rendered, whether round the clock or for few fixed hours in a day. The requirement/demand of water is fluctuating every hour of the day, any specific day of a season and these will be different from daily average per capita requirement and may vary from area to area depending upon the habits and cultural values of a community.

a) **Seasonal fluctuation:-** In summer the water requirement is generally higher than in winter season. In summer more water is used in bathing, cooling, lawn sprinkling and sometimes washing of house floors and streets. The demand in festival or marriage season is also more than normal periods. Normally the water demand in summer is higher by about 15-20% than in winter.

b) **Daily and hourly fluctuation :-** Normally, more water demand is on Saturdays, Sundays and holidays due to more comfortable bathing, washing etc. compared to other days. Similarly, on these days the peak demand is also in different hours as people observe late rising time, late eating time etc. Normal peak demand hours in a residential area may be 0600-1000 hrs in the morning and 1700-2000 hrs. in the evening and minimum flow between 1200-1600 hrs. and at night between 2300-0500 hrs. However on holidays and rest days, the peak demand may be pushed ahead by an hour or even 2 hrs. These hours will be significantly different in industrial areas where people work in night shifts also. The annual total requirement of water or the average daily requirement of any settlement can however be taken as a standard. The daily and hourly fluctuations may however differ considerably in different settlements and should be measured in each settlement separately. This however is not available in most areas, and some thumb rules have been developed over time. **Maximum daily demand** is considered 150-180% of average daily demand and **Maximum hourly demand or peak hour demand** is considered 150% of average hourly demand. The average daily demand and peak hour water demand based on the population in a particular area can be assessed by considering the various types of users. (Guidelines given in **APPENDIX-1**).

c) **Fire demand:-** As per the I.S. code 9668 an arrangement of 1800 liters per minute for 2 hours i.e. 2,20,000 liters should be made for every 50000 population or part thereof, of a town/colony having population of up to 3 lakhs nos. and additional 1800 l/minute for every 50000 above this. For smaller townships of less than 1 lakh nos. the demand should be doubled. This demand should be equitably distributed every 1 km. Thus, for a small township of, say 50,000 persons, a minimum requirement of 4,40,000 liters has to be catered to. This requirement need not necessarily be through water pipe line but could be met from a static tank within 1 km. of the habitation. This could be from natural sources also, such as ponds, lakes etc. Normally, no extra provision is made in the distribution system for fire requirement but a separate static tank of required capacity is created and if a ground reservoir is otherwise required for proper water distribution, additional capacity is created in under ground water storage.

d) Future demand :- The water supply systems need significant capital investment and are not easily expendable at a later date; as such future demand forecast has to be made initially at the time of design of the system. Normally, the codal life of pipeline, pump houses, valves etc is considered as 30 years and the future requirements up to 30 years should be taken into consideration, initially itself. The overhead or under ground storage can be added at a later date when need arises, but the arrangements of infiltration wells, galleries, and pipelines have to be made for future 30 years.

2.0 Water supply: Normal water supply system will have 3 stages, namely,

a) Transmission
b) Treatment and
c) Distribution

The different stages involve carrying the water in channels or pipes apart from pumping, regulating and treatment etc.

a) Transmission of water: Conventionally the system of carrying the water from the water source to near the habitations/ places of consumption is called transmission system. The raw water in major projects feed more than one settlements and also meet the agricultural requirement of farmers and generally carried in canals and open channels. But the schemes which are exclusively for potable water for consumption by the urban population is normally carried through pipes. While water transmitted through open channel is invariably always be flowing under gravity, the water transmitted by pipes could be either under gravity, where adequate slope and gradient are available, or could be pumped. There are obvious advantages if water can be transmitted in pipes under gravity, some of them are listed below,

i) High reliability as pumps can fail
ii) Wear and tear in pipes is minimized
iii) System is economical
iv) No attendance is required like in pumped supply.

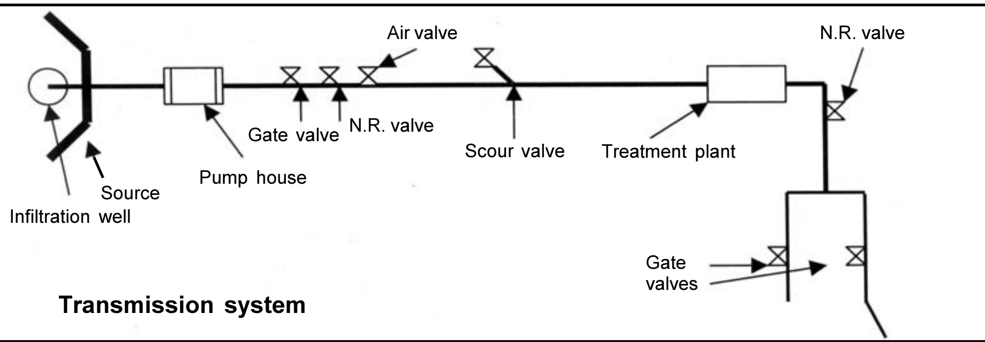
The arrangements required, however in both the systems i.e.

transmission flow under gravity or pumping is practically same except for pumps.

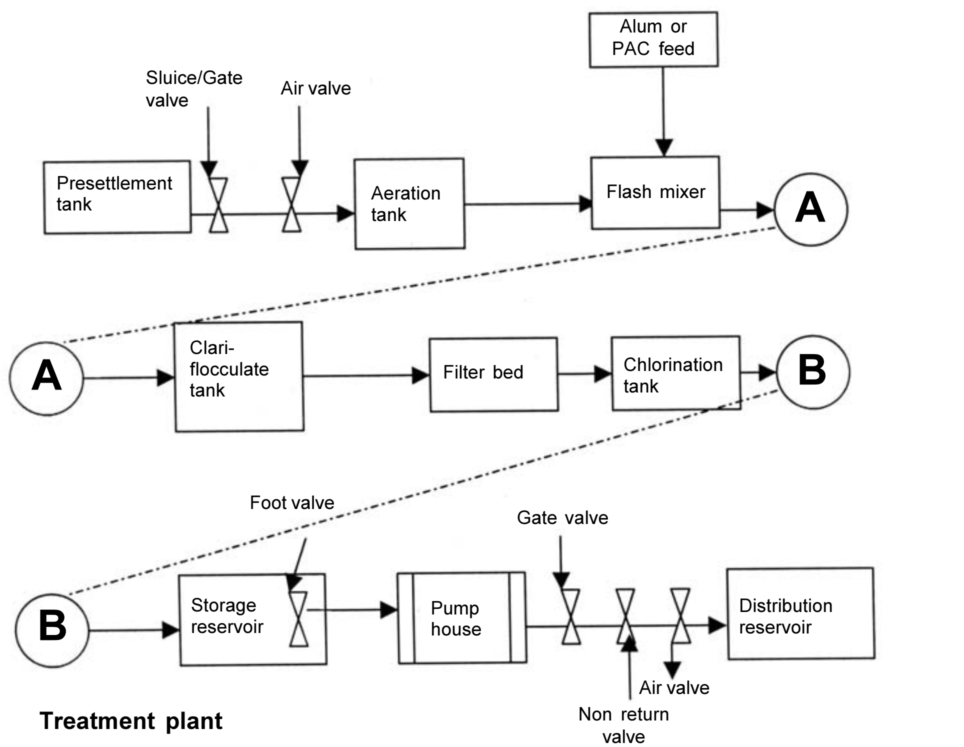
Such a system will include carrying raw water and also treated water. The various elements of a transmission system are as under:

i) Infiltration well or gallery
ii) Foot valve with draw in pipe line
iii) Pump house with pump and valves etc
iv) Pipe line and valves

A typical transmission system of water supply will go through the sequences as under:



Transmission system



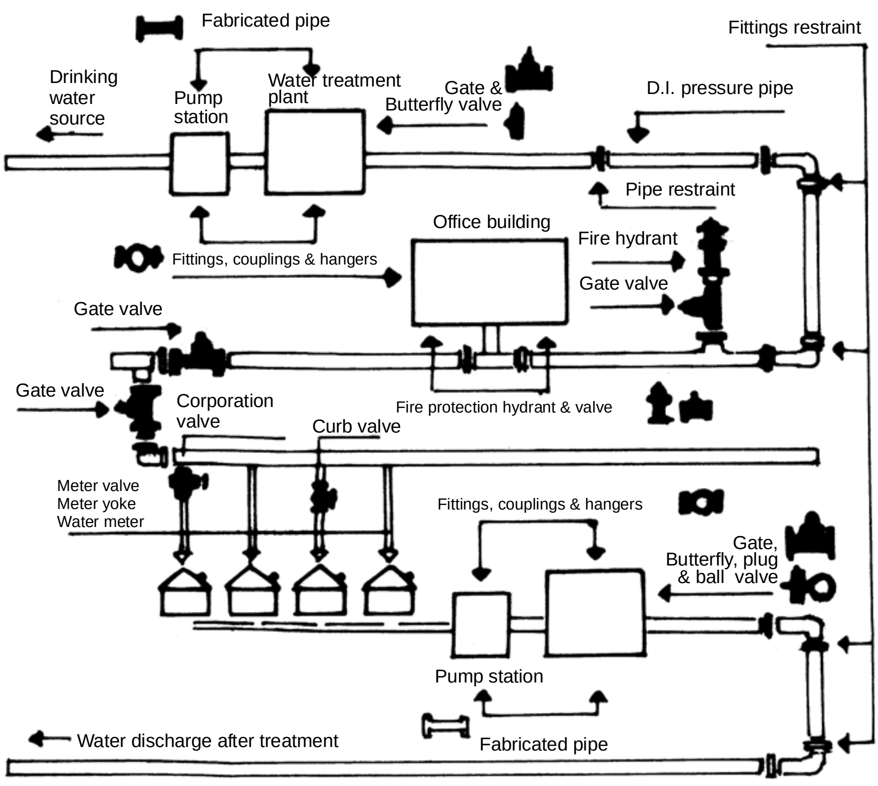
Treatment plant

b) Treatment plant:- The impurities, solids, organic or inorganic etc. are removed at the water treatment plant. It has several elements like, screens, pre-settlement tank, aeration tank, flocculation tank, chlorination tank etc. Various operations required for water treatment from surface source are shown in figure.

The operations involved for treatment of water from under ground sources will be different and may only involve chlorination. Similarly, surface water also from some sources may not require all the stages as given above, depending on the quality of water.

The treatment plant or process is sometimes not viewed as separate process but is taken as a part of transmission system only.

c) Distribution system: The treated water from the reservoir ready for human consumption may be further carried before it reaches near the town or city and the system to be put in place beyond transmission, for reaching it to the consumer is called distribution system. This will require a network of pipe lines, pumping, valves to control, maintain



TYPICAL WATER SUPPLY-TRANSMISSION AND DISTRIBUTION SYSTEM

and operate the supply, water storage tanks and reservoirs. All small or bigger water supply installations such as for colonies, production units etc. have a separate distribution system and will be dealt a little more in detail.

3.0 Water distribution system: The water distribution system should be designed economically since it involves more than half the cost of water works. Distribution system should not be designed for residual pressure more than 22 m. Fire hydrants should be located at required points in the distribution system in consultation with the agency in charge of the fire service. A good water supply distribution system should have

i) Proper geometrical configuration and material of pipes to obtain adequate pressure at all points at peak demand.

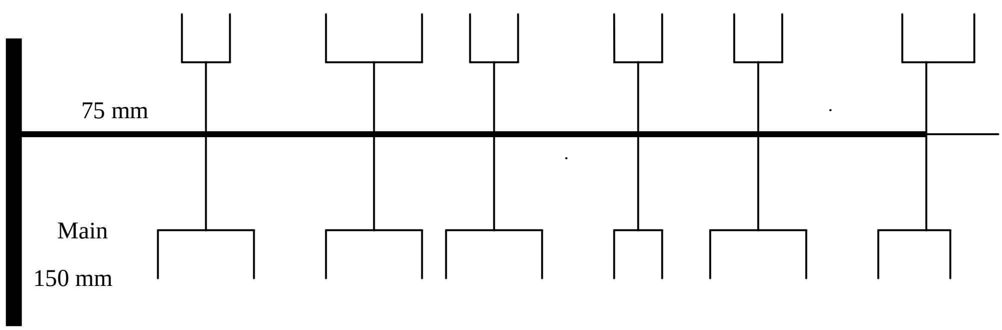
ii) Storage reservoirs and booster pumps.

iii) Location of valves for operation and maintenance.

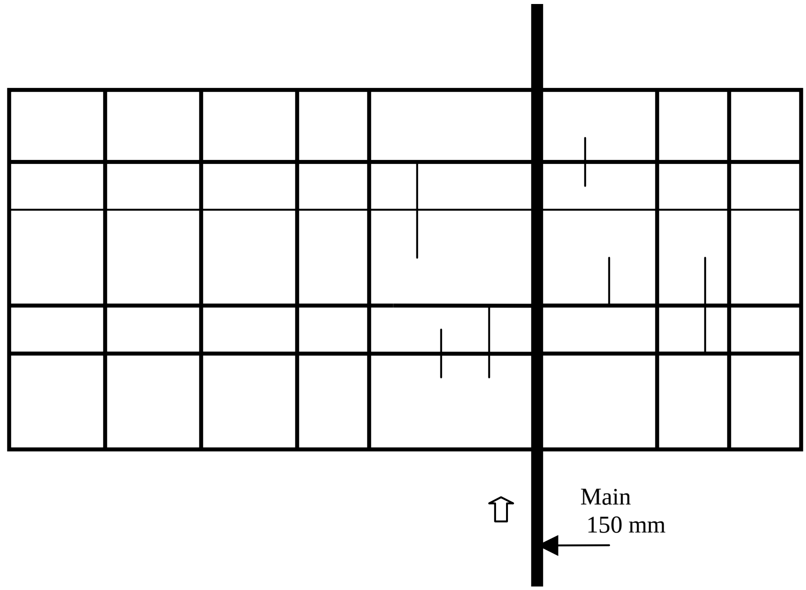
3.1 Pipes layouts and geometrical configuration:

3.1.1 Layout of pipes:- The water distribution system is mainly of four types, based on the configuration of network adopted. Following systems are adopted:

1) **Dead end or tree water distribution system:-** Water is supplied through main pipe passing through centre of the area. Sub main pipes are taken right angle to main pipe and branch pipe lines are taken right angle to sub main. This system though simple but has a drawback. In case of failure in pipeline, the area ahead of the affected point will not get water supply. Further the pressure at the farther end will be comparatively lower than the geographically, earlier served areas.

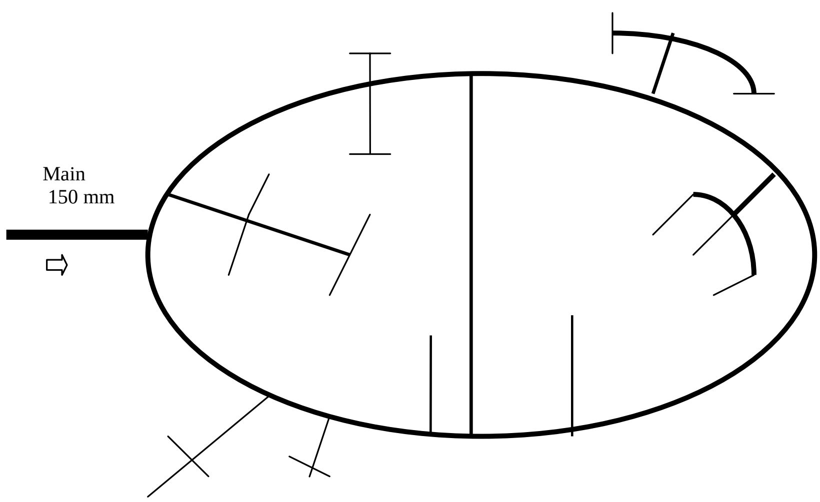


2) **Grid Iron water distribution system:-** In grid iron system, the main pipeline, sub main pipe line and branches are interconnected to each other. A grid network is laid around the main pipe line. The length of pipe line and valves required is more in numbers than the dead end

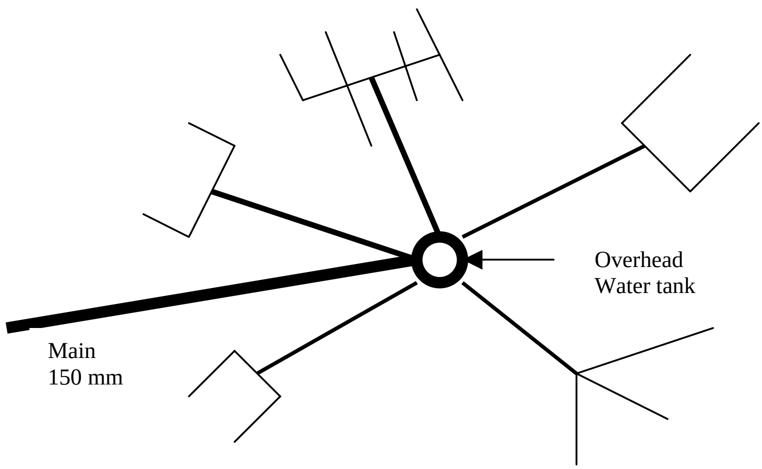


system but water pressure in the grid can be maintained reasonably equitable and any blockage of any section of pipe line does not affect the supply in rest of the area, as supply to any point is fed from more than one side.

3) **Ring water distribution system:-** Here the area is enclosed by the main pipeline either in rectangular shape or circular shape. The small areas are further enclosed by sub main pipeline. In case of failure very small area will be affected. The area ahead of affected area will get supply through other point. This also has the same disadvantage as Grid iron system that the no. of valves required to be provided is large and as such expensive.



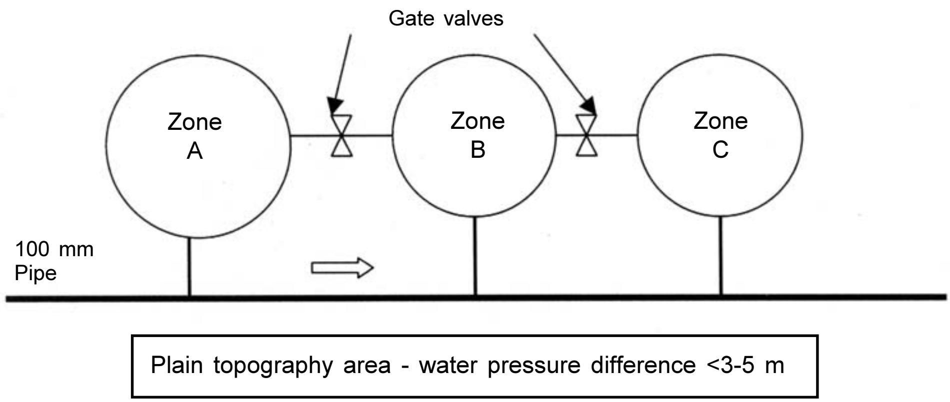
4) **Radial water distribution system:-** Water is supplied through main pipe passing through centre of the area. Further distribution is done through sub main pipes and radial branch pipes. This is suitable for areas divided on radial roads.



Various pipe network layouts and their advantages & disadvantages are given in table below,

Layout	Advantages	Disadvantages
Dead end or Tree System	▪ Discharge & pressure can be] worked out accurately ▪ Cutoff valves are less ▪ Laying of water pipes is simple	▪ During repairs, large portion of distribution area is affected ▪ At dead ends there is no free circulation of water
Grid iron System	▪ In case of repairs, small portion of distribution will be affected ▪ Free circulation of water ▪ Plenty of water is available for the fire fighting purpose	▪ Costlier ▪ Larger lengths of pipes ▪ More number of valves
Radial System	▪ Quick service ▪ Calculations are simple	▪ Suitable for radial streets
Ring System	▪ In case of repairs, small portion of distribution will be affected ▪ Free circulation of water ▪ Plenty of water is available for fire fighting purpose.	▪ Costlier ▪ Larger lengths of pipes ▪ More number of valves

3.1.2 Zoning: To equalize the supply of water in the whole area, distribution system is divided in zones. The water pressure in the same zone or area should not be different more than 3-5 meters. In plain topography the zones should be fed through the same pipe with inter connection between them, with sluice gate valve, normally kept closed. This will be operated only



in emergency. If however the topography is with ups and downs, and elevation difference exceeds 15m, separate feeding would be required. The interconnection shall be provided between zones, for emergency use.

3.2 Choice of proper pipe materials:-

a) Water pipes are manufactured of metal, concrete, asbestos cement, and plastic. They are available in diameters ranging from 10mm to few meters. The cost of transmission and distribution system constitutes a major portion of the water supply project cost. It is important to select the right size and material for an optimum design of network. The various types of pipes used are:

Metallic pipes:

i) Unlined metallic pipes like CI, DI, MS, GI

ii) Metallic pipes of ductile iron lined with cement mortar or epoxy lining

Non metallic pipes:

i) Reinforced concrete, prestressed concrete, asbestos cement

ii) Plastic pipes, PVC, polyethylene, glass reinforced plastic etc.

b) Selection of pipe material is based on the following considerations:

- The initial carrying capacity of the pipe and its reduction with use.
- The strength of the pipe as measured by its ability to resist internal pressures and external loads.
- The life and durability of pipes as determined by the resistance of cast iron and steel pipe to corrosion, of concrete and AC pipe to erosion and disintegration and plastic pipe to cracking and disintegration.
- The ease or difficulty of transportation, handling and laying and joining under different conditions of topography, geology and other prevailing conditions.

- The safety, economy and availability of manufactured sizes of pipes and specials.
- The availability of skilled personnel in construction and commissioning of pipelines.
- The ease or difficulty of operation and maintenance.

c) The table below gives some of the functional properties of different types of pipes,

Type	Diameters (mm)	Weight	Effect with age, head loss	Test pressure	Jointing	Others
(1)	(2)	(3)	(4)	(5)	(6)	(7)
C.I.	80-1500	Heavy	No, maxm. Head loss	10-25	Caulking, not weldable	Brittle and careful handling
M.S.	No limit	< C.I.	Yes, but given coating minm. Head loss	No limit	Weldable	Highly suited for Dynamic loading
D.I.	80-1000	30% light than C.I.	No, and given lining minm. Head loss	35	Caulking & Suitable for rubber gasket	Strong, suitable for laying over ground
A.C	80-600	Light	No, Minm. Head loss	5-25 kg/cm^2	AC coupling and rubber rings	Easily break, only for under ground use
R.C.C	150-1800	Heavy	No, Minm. Head loss	2-6 Kg/cm^2	Caulk Spigot & socket, Collar, Flush, Bandage	Requires conc. bedding Used for under ground
P.S.C.	410-1800	Heavy, lighter than RCC	No, Minm. Head loss	6-20 Kg/cm^2	Spigot & socket with rubber gasket	For under ground use
P.V.C	20-315	1/5th of M.S.	Affected by sun light, Minm head loss	2-10 Kg/cm^2	Spigot & socket with Solvent cement	For under ground use. Require bedding in soft soils
H.D.P.E	15-150	Very light	No, Minm. Head loss.	-	Special fittings	Can withstand heavy traffic
M.D.P.E	20-110	Very light	No, Minm. loss	-	- do-	-do- Suitable for domestic connections
G.R.P.	350-2400	Lighter than M.S. and PSC	No. Minm. head loss	3-15 Kg/cm^2	GRP specials	Cheap and non-corroding

4.0 Design of water supply system

4.1 Diameter of pipes:

The diameter of pipes is selected on the consideration of the quantity of flow, minimum velocity of flow required on the requirement of self-cleansing, and need to keep the pressure of water at all points at a reasonably same level without exceeding the permissible pressure the pipe can withstand, at the peak hour.

The average velocity in a pipe line should normally be not less than 0.6 m/sec and not more than 1.5 m/sec. (Velocity in Delivery mains can be up to 2.5 m/sec.) and the hydraulic gradient in the pipes should be between 1 and 4 per 1000. Knowing the flow (discharge) required the limits of hydraulic gradient and the losses of head caused on the way, the size of the pipes can be worked out, using one of the several formulae available. Hazen William's formula is commonly used by the water supply Engineers.

Modified Hazen William formula is commonly used to work out the velocity and head loss in the pipe lines, which is as under:

$$V = 143.534\ C\ R^{0.6575}\ S^{0.5525}$$

$$h = [L(Q/C)^{1.81}]/994.62\ D^{4.81}$$

V= velocity of flow in m/sec

C= Pipe roughness coefficient

R= Hydraulic radius in meters

S= Friction slope(Hydraulic gradient)

D= Internal diameter of pipe

h= Friction head loss

L= Length of pipe in meters

Q= Flow in m^3/se

This equation appears difficult and complicated for practical use, but can be easily worked out knowing the various parameters. The above equation can be plotted in the form of nomogram to find the value of velocity and head loss and the nomogram is given as **APPENDIX-2.**

The value of roughness coefficient is given in **Table 1**, **APPENDIX-2**. The pipeline transitions and fittings like valves, bends etc. result in pressure head loss which is = k $V^2/2g$. The value of k is given in **Table 2, APPENDIX-2.** The head loss can also be equated to additional length of pipe, which is given in **Table 3**, **APPENDIX-2.**

4.2 Location of service reservoirs/tanks:

The location of service reservoir is important for regulation of pressure in the system as well as for coping the fluctuations in demand. The ideal location is the central point. It is preferred if a tail end reservoir is also provided which could be filled either by gravity from the central reservoir or directly pumped during lean demand hours. This helps in maintaining equal pressure at even the tail end areas.

4.2.1 Storage reservoirs:

The distribution system could be either direct or through service reservoirs. In direct system the service connection is directly given from the main and no reservoir or boosting is required. This system is suitable for buildings up to 3-storeys and where the municipal supplies are very reliable, which is normally not the case. The system of collecting water in an under ground tank and then pumping them through an overhead tank or directly pumping to consumers is mostly adopted. Direct pumping from ground tank to consumer has also several limitations.

a) Pumping will be required for prolonged hours,

b) Any break down in pumps will disrupt supply,

c) Pressure in tail end shall be lower.

This therefore is adopted when supply is not required through out the day and limited to about 4-6 hrs only.

4.2.2 Most of the efficient distribution systems are designed on under ground reservoirs and overhead reservoirs, unless the source supply is reliable and is available for as many hours as required. The water from the municipality or other source is generally rationed and supply is available only for a few hours in a day, then it is received in an under ground tank and pumped into over head tank from where it is distributed under gravity flow to the consumers. The service reservoirs have following advantages:

a) Provide a reserve to meet fluctuating demands and supply even during some break down of equipment etc.

b) The size of the main pipe can be reduced, from the requirement of peak hour demand.

4.2.3 Capacity: The minimum service storage capacity depends on the hours of pumping, rate of pumping and variation in demand during the day. General principle is that total storage capacity of a system, both under ground and over head should be equal to maximum total demand on any day. However, when the main supply is reliable and available for maximum part of 24 hrs., the under ground reservoir is not required and only over head reservoir needs to be created. In most of the distribution systems, however, data regarding consumption patterns is not available and the systems are designed on some assumed scales. The details of water requirement are given in **APPENDIX-1**.

a) Under ground tank: The capacity of the under ground tank, where ever required, to collect and distribute should be conservatively equal to maximum daily requirement without considering the “Fire demand”. If the supply is received from source two times a day in equal quantity, the under ground tank could be for capacity reduced by the over head capacity. The under ground capacity creation is generally much cheaper than over head and in case of "fire requirement" the same has to be met from the sump after boosting only. It is therefore the practice to keep the under ground tank capacity equal to maxm. daily demand.

b) **Over head tanks:** The over head reservoir/tank should be able to serve the peak hour demand as well as demand during rest of the day, taking maximum 16 hours of pumping, with provision of Diesel stand by pumps. The working out of tankage capacity is based on the assumption, that simultaneous pumping is done at the peak hours when, maximum consumption is taking place. If however standby arrangements are not available and there are some specified hours of shut-down period of electricity, the same can also be accounted and the storage capacity will be more. An example of working the storage capacity under different scenario is given in **APPENDIX-3**.

The Railway rules (Para 536 of IRWM) provide as under,

"The storage capacity should be higher of the following,

a) With efficient stand by pump:-
   i) 1/4th the maximum water consumption in 24 Hours
   ii) 1/3rd the normal water consumption in 24 Hours
b) Without stand by pump,
   i) 1/3rd the maximum water consumption in 24 Hours
   ii) 1/2 the normal consumption in 24 Hours

Here the normal consumption is the average daily consumption; maximum in 24 hours is the maximum daily demand, which is about 1.3 times the average daily demand.

The details of various types of water tanks are given at **APPENDIX-4.**

4.2.4 Capacity of pumping:-

As per Railway Rules (I.R.W.M. Para 527), the pumping system should be capable of supplying:-

a) In 12 hours or less, the normal quantity required in 24 hours;
b) In 16 hours or less, the present maximum quantity required in 24 hours;
c) In about 20 hours, the estimated maximum future requirements in 24 hours.

For small pumping system two full capacity pumps or two pumps of 50 % capacity and one standby pump may be provided. In medium and large pumping stations at least two standby pumps may be provided.

Here, the normal quantity required in 24 hours means the average daily demand, the present maximum in 24 hrs. means the maximum daily demand and estimated maximum future requirement means the maximum daily demand in the design period of 30 years of the system.

Pump Horse Power = [Q_L (H+h)] / 4560

Where

Q_L = Quantity of water in liters per minute

H = Vertical height in meters from suction-level to highest point of discharge

h = Head lost in friction in meters.

4.2.5 Valves:-

There are several requirements to be met in any pipeline supply where water runs under pressure. These are met with by placing various types of valves on the pipe line. The different valves and their functions are given below:

a) **Sluice valves:** The main pipeline is divided into several segments, the spacing depending mainly on the terrain and the nature of the layout. Sectioning requirement which is achieved by placing main line valves to stop and regulate the flow of water either during ordinary operations or in emergency. The principle considerations in location of the valves are accessibility and proximity to special points such as branches, stream crossings etc. Normal spacing is about 500 m and is achieved by placing sluice valves of gate type or butterfly type.

   These valves are usually placed at major summits of pressure conduits. Summits identify the sections of the line that can be drained by gravity, and pressure is least at these points permitting cheaper valves and easier operation. Gravity conduits are provided with valves at points strategic for the operation of supply points, at the two ends of sag pipes and wherever it is convenient to drain the given section.

   Sluice valves are not intended to be used for continuous throttling, as erosion of the seats and body cavitations may occur. It is sometimes advisable to install small diameter by pass valves around large diameter line valves to equalize pressure across the gate and thus facilitate opening as well as allow small flows, whenever required.

b) **Scour valves:** The main pipeline may carry sediments from the source and are required to be cleaned periodically and scour valves or blow off valves are required to be placed at all the low points. In case of plain terrain, the valves are provided at convenient locations i.e. where some natural drainage channel is available where the pipeline can be emptied and cleaned. Fire hydrants are normally placed at the location of blow offs or scour valves and should be installed at every 100m in built up areas. These are also gate type valves.

c) **Air valves:** When a pipeline is being filled, air could be trapped specially at the peak points which results in reduction in the carrying capacity of the pipe, besides they can corrode the pipes and affect the working of different valves also. Air valves are provided to release the trapped air when a pipeline is being filled and also permit air to enter the pipeline when it is being emptied. These are normally provided on both sides of the main line valves at the peak point, the downstream side of other valves and at changes in gradient to steeper slopes.

d) **Non-return valves:** Near the pumping mains the flow of water is normally reversed when the pumps are shut down. Check valves or non-return valves are required to be placed near the pumping stations to prevent back flow of the water.

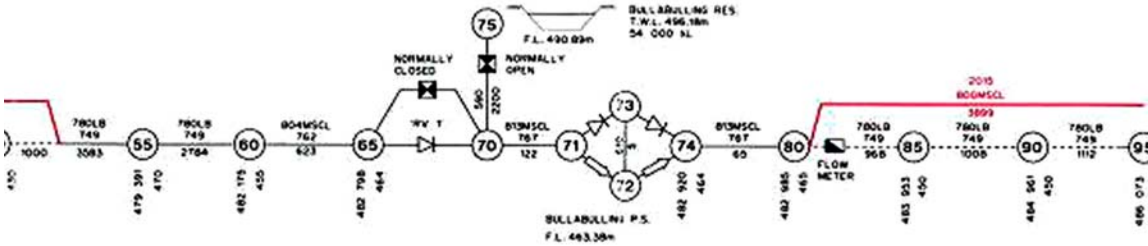
e) **Pressure reducing valves :** In order to maintain almost constant pressure throughout in the pipeline, pressure reducing valves and pressure sustaining valves or globe valves are provided on the downstream and upstream side of the main pipe line.

4.2.6 It is desirable to have various types of valves close together especially in built up areas. Where there is more than one pipeline, they should be interconnected at each side of main valves so that only shortest possible length of one pipe line needs to be put out of commission at a time when required. This interconnection will also result in minimum loss effect.

4.2.7 If the velocity of water flowing in a pipe is suddenly diminished, the pressure upstream increases suddenly and manifests as a series of shock something like hammer blows which sometimes be as great to burst the pipe or damage the other equipment. The same could also happen with the sudden stoppage of valve. In larger mains the pressure may be reduced at very slow rate and additionally pressure relief or surge valves are used to control the same. This phenomenon normally takes place in large diameter mains. However, the importance of regulating the valves slowly cannot be overemphasized even in cases of small diameter main pipelines.

4.2.8 Size of valves to be used for distribution system:-

Sluice valve For pipe size up to 300mm For pipe size greater than 300mm	 Same as pipe size 2/3rd of pipe size but minimum 300mm
Scour valves For all size of pipes	 d/2 + 25 mm where d is diameter of main pipe
Air valve For all size of pipes	 1/4 to 1/6 of the diameter of pipe



2002 survey of the G&AWS.
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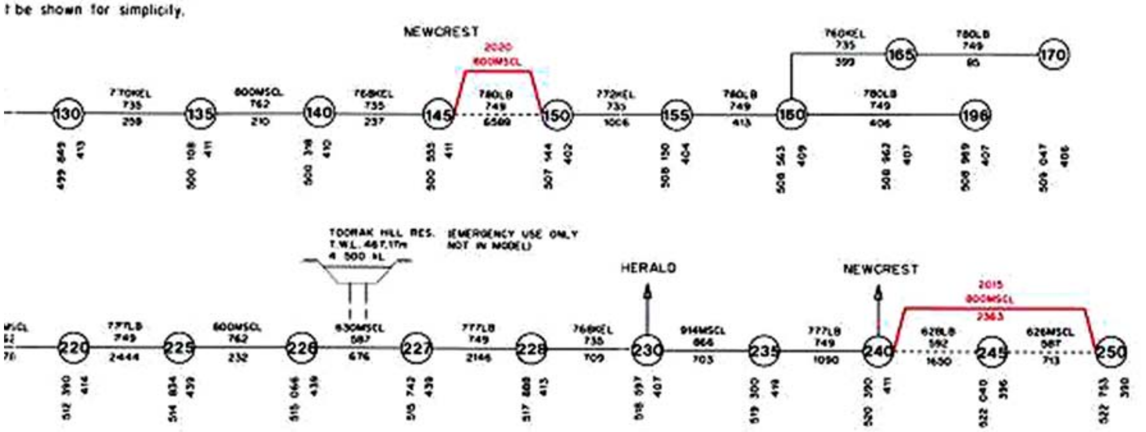
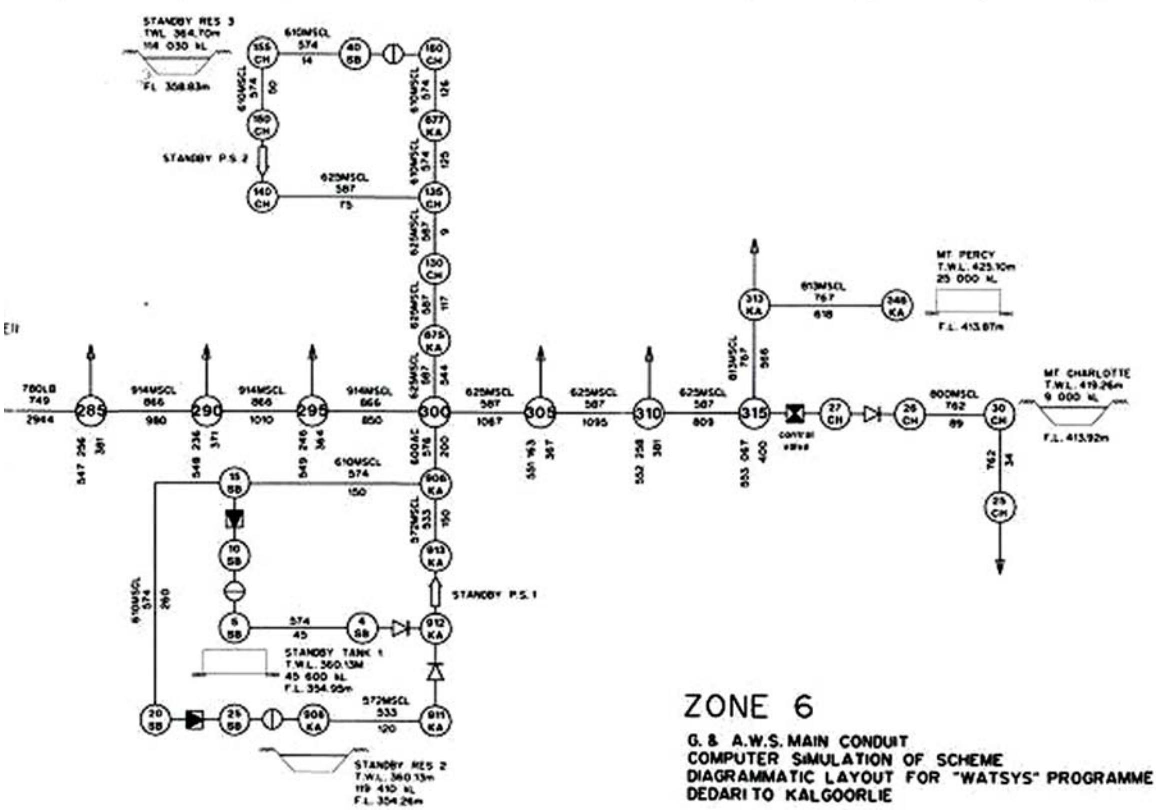
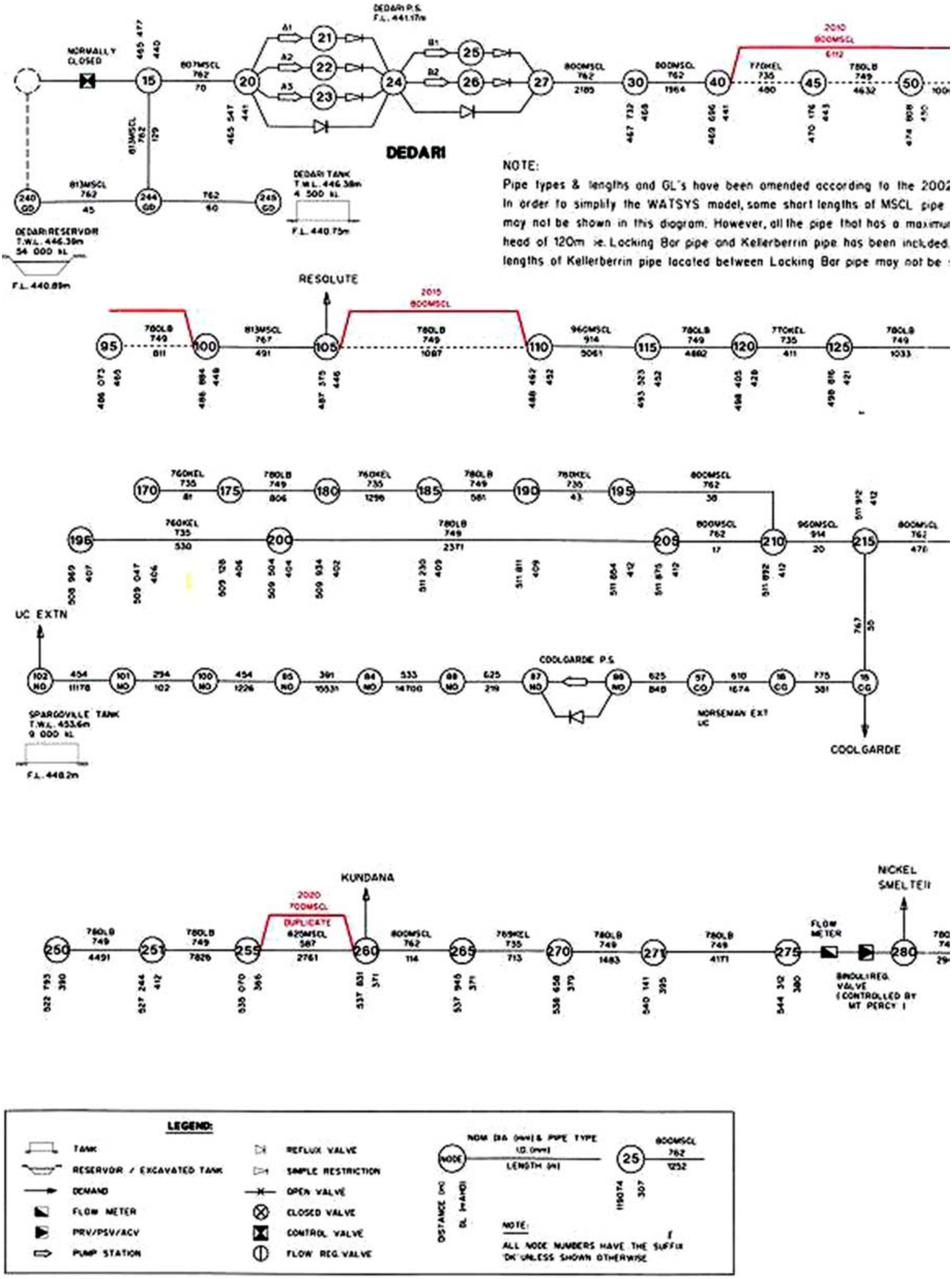




ZONE 6

G. & A.W.S. MAIN CONDUIT
COMPUTER SIMULATION OF SCHEME
DIAGRAMMATIC LAYOUT FOR "WATSYS" PROGRAMME
DEDARI TO KALGOORLIE



Typical Water Supply Plan

4.3 Water pressure in water distribution system :-

Water pressure is limited to a maximum of 80 psi (56.25 m of water head) in order to remove water hammer, unnecessary use of water, splashing, excessive discharge of pressure relief valves, and to protect appliance valves and mechanism from pressure that exceeds their design limits.

Where static water pressure exceeds 80 psi (56.25 m of water head), an approved pressure regulators, preceded by an adequate strainer, is required to control the pressure of all outlets in the building in order to reduce the static pressure so as not to exceed 80 psi (56.25 m of water head). This regulator must be installed in an accessible location, above ground or in a vault equipped with drain capabilities.

Although static pressure down stream of a pressure reducing valve (PRV) may be 80 psi (56.25 m of water head), during a flow condition there will be a considerable pressure drop. As noted earlier in this chapter, globe valves (PRVs are globe valves) are normally unsuitable as “control” valves because of their excessive flow resistance. By design, PRVs are modulating valves, which have a high level of flow resistance and consequent pressure drop even when fully open. Therefore pipe sizing downstream of the PRV must be based on worst-case pressure loss during a maximum demand water flow.

4.4 Solved example:- The solved example explaining the principle of working out the pressures requirement at different points of a water supply system a) Dead end system and b) Closed Grid system are given in **APPENDIX-5.**

4.5 Water supply plan:-

Diagrammatic layout of the water distribution system and the pipe plan for the colony should be maintained up to date by the JE/SE(Works) responsible for the colony maintenance. A typical diagrammatic plan is shown on previous page.

4.6 Water distribution to a residential/commercial building:-

Generally water distribution system is down take supply system. In this system the supply from the street main is drawn either into Ground level storage tank from where the supply is pumped to an overhead tank and then distributed by gravity **or** to the overhead tank directly from the street mains and then distributed by gravity. There are four basic methods of distribution of water to multistoried buildings.

i) Direct supply from mains to ablutionary taps and kitchen with WCs and urinals supplied by overhead tanks.

ii) Direct pumping system.

iii) Hydro-Pneumatic system.

iv) Overhead tanks for distribution.

i) Direct supply system:- This system is adopted when adequate pressure is available round the clock at the topmost floor. Generally this system can not be adopted above two to three floors in most of the cities.

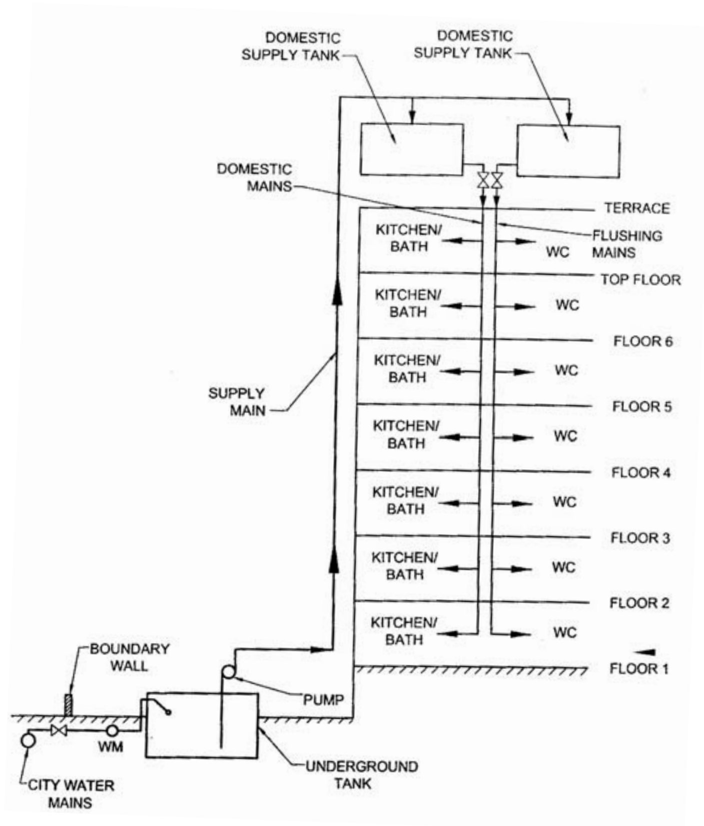
ii) Direct pumping system:- In this system water is directly pumped into the distribution system without going through overhead tank except for flushing purpose. Normally smaller pumps are installed for use during low consumption period and large pumps are installed for use when demand is high. Constant and reliable power supply is necessary for this type of system.

iii) Hydro-pneumatic system:- Hydro-pneumatic system is a variation of direct pumping system. An air tight pressure vessel is installed on the line to regulate the operation of the pumps. As pump operates, the incoming water in the vessel, compresses the air on top. As water is drawn into the system, pressure falls into the vessel starting the pump at preset pressure. The air in the pressure tank slowly reduces the volume due to dissolution in water and leakages from pipe lines. An air compressor is also necessary to feed air into the vessel so as to maintain the required air-water ratio. The system shall have reliable power supply to avoid breakdown in the water supply.

There is an alternate option of providing variable speed drive pumping system where a pump with a large variation in its pressure-discharge and speed is used with the help of electronic device. With this arrangement the same pump is able to deliver water as required at different times of day. The system consumes energy in proportion to the work done and save considerable amount of power as compared to the fixed speed pumps used conventionally.

Hydro-pneumatic system generally eliminates the need for an overhead tank and may supply water at much higher pressure than available from overhead tanks particularly on the upper floors, resulting in even distribution of water at all floors.

iv) Overhead tanks for distribution:- This is most common of the distribution systems adopted by various types of buildings. The system comprises pumping water to one or more overhead tanks placed at the top most location of the hydraulic zone. Water collected in the overhead tank is distributed to the various parts of the building by a set of pipes located generally on the terrace. Typical overhead distribution system is shown in figure.



4.6.1 Hot water distribution:-

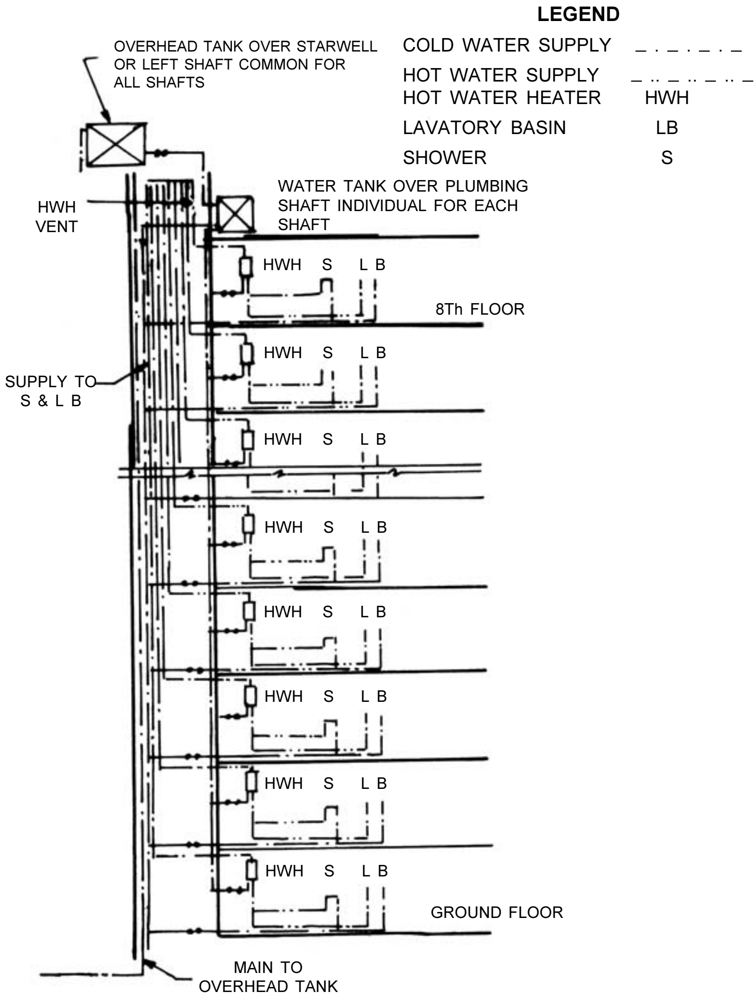
Care should be taken in installing the piping to prevent air locks in the piping and negative pressure in the hot water heater. Cold water feed pipe should not be cross connected with any other source of water supply under pressure.

Each pressure type hot water heater or cylinder is to be provided with vent pipe of not less than 20.00 mm diameter. The vent pipe should be raised above the water line of the cold water tank by 150.00 mm plus 10.00 mm for every 300.00 mm height of the water line above the bottom of the heater. Typical overhead distribution with hot water is shown in figure on next page.

4.6.2 General requirement for piping work:-

a) The consumer pipe within the premises is to be laid underground with a suitable cover to safeguard against damage from traffic and extremes of weather.

b) To control the branch pipe to each separately occupied part of a building supplied by a common service pipe, a stop tap should be fixed to minimize the interruption of the supply during repairs. All such



stop valves are to be fixed in accessible positions and properly protected. To supply water for drinking or for culinary purposes, direct taps are to be provided on the branch pipes connected directly to the consumer pipes. In the case of multistoried buildings, down take taps should be supplied from over head tanks.

c) Pumps are not to be allowed on the service pipe, as they cause a drop in pressure on the suction side, thereby affecting the supply to the adjoining population. In cases where pumping is required, a properly protected storage tank of adequate capacity is to be provided to feed the pump.

d) No direct boosting (booster pumps) is allowed from the service pipes.

e) Consumer pipes are to be designed and constructed to avoid air-locks. Draining taps should be provided at the lowest points from which the piping is raised continuously to draw-off taps.

f) A backflow prevention device is to be arranged or connected at or as near as practicable to each point of delivery and use of water. All backflow prevention devices are to be installed so that they are accessible for examination, repair or replacement. Such devices should be tested periodically by the authority to ensure that the device is functioning efficiently and no backflow is occurring at any time.

4.6.3 Prohibited connections:-

a) A service pipe is not to be connected into any distribution pipe, such connection may permit backflow of water from a cistern into the service pipe, in certain circumstances, with consequent danger of contamination and depletion of storage capacity. It might also result in pipes and fittings being subjected to a pressure higher than that for which they are designed, and in flooding from overflowing cistern.

b) No pipe for conveyance or in connection with water supplied by the authority shall communicate with any other receptacle used or capable of being used for conveyance other than water supplied by the authority.

c) Where storage tanks are provided, no person should connect or be permitted to connect any service pipe with any distribution pipe.

d) No service or supply pipe should be connected directly to any water-closet or a urinal. All such supplies are to be made from flushing cisterns, which are supplied from storage tanks.

e) No service or supply pipe is to be connected directly to any hot water system or to any other apparatus used for heating other than through a feed cistern thereof.

4.6.4 Water meters:- Generally water meters are provided at the entrance of the individual / colony/ society property. The water charges are equally distributed to the consumers. To encourage saving of water following procedures are adopted for new construction:-

1. Water meters are provided to individual flat/ house owner and water charges are charged on actual consumption of the user.
2. Prepaid card facility is available for water meters, which will deliver water equal to the amount of prepaid card feed to the water meter.

Meter boxes shall be constructed in such a manner that rats cannot enter a building by following the service pipes from the box into the building. Strainer plates on drain inlet shall be designed and installed so that no opening is exceeding 12.7 mm. In or on buildings where openings have been made in walls, floors or, ceilings for the passage of pipes, such openings shall be closed and protected by the installation of approved metal collars securely fastened to the adjoining structure.

4.7 Preventive maintenance of pipe lines: The main function in the management of preventive maintenance is assessment, detection, and prevention of wastage of water from pipelines and maintaining the capacity of pipelines.

4.7.1 Waste assessment and detection: The corrosion, fracture, faulty joints, ferrule connections, service pipes and fittings lead mainly to wastage of water. Faulty washers in valves, abandoned service pipes, leakage from water tanks are other source of wastage of water. Sometimes the wastage from the later could be as high as 30-40%.

a) **Assessment of waste :** In residential areas where water supply is for 24 hours, the difference between the minimum night flow (least consumption is expected between 0.0 hours and 03.00 hours) and accountable flow can give a fair assessment of leakages. Wastage above 20% of average daily flow needs early action for rectification.

   In intermittent supplies, only leakage related to water mains is assessed. Waste in mains in a zone/ area are assessed by closing all the taps in the house service connections and measuring the flow in the mains. The extent of flow is direct measure of leakage. Above 10% of the average daily needs corrective action to be taken.

b) **Survey procedure**

   Survey of water waste requires planning and knowledge of the area supply system thoroughly. One of the requirements is to know the location of pipes and valves. If it is not available it has to be constructed.

1. **Preparatory work:**

   i) Subdividing the area into sub-areas of distribution network from field inspection and plans.

   ii) Location, testing and repairing of valves, fittings, taps and meters.

   iii) Correct alignment of pipelines. This can be done using ‘Electronic Pipeline Locator’

   iv) Testing for isolation of areas and sub-areas from others by feeding water through a single feeder pipe with closure of all boundary valves except the feed valve.

2. **Assessment:**

   The steps involved are,

   - Estimation of total daily consumption of the sub-area by calculation or by flow gauging for the day.

- ‘Flow test’ for measurement of waste by isolating sub-areas by means of an integrating type water meter, and
- ‘step test’ to localize leakage in various parts of sub-area by internal valves.

i) In smaller distribution systems of 150-200 connections, the sub-area could be the total area itself and further sub-division may not be practical and if practical, it be divided in smaller sub-areas. The daily consumption can be obtained from the data available or actual spot measurement by an integrating meter installed in the pipe feeding a group of houses after isolating the sub-area from the rest and feeding it through a single entry controlled by valve.

ii) The rate of flow in the sub-area is measured by an integrating meter temporarily installed or Deacons water meter permanently installed in the system.

iii) The 2 steps will give an estimate of leakage/wastage and next step is to localize the leakage. It is done by ‘Step test’. Flow is noted in the pipe system of sub-area after every stepwise reduction in the size of the area by closing the internal valves in each step. It should be ensured that all the spindles of valves, taps, bib cocks etc are water tight and there is no scope for any flow except by leakage. Then the detection of leakage has to be done by a) Visual examination of moist surface and/or b) Traversing the sub-area at nighty sounding rod or electronic leak detector.

4.7.2 Locating the leakage: Sounding rods alone or along with the ‘electronic leak detectors’ are traversed over the surface above the center line of the pipe alignment for noise generated by possible leaks in the main pipes.

4.7.3 Instruments for monitoring leakage: A Water supply maintaining Engineer must have following instruments in his reach,

i) Sounding rod: It is a 1.2 meter long, 12 mm diameter hollow steel rod, flat or pointed at one end and fixed with a cup shape brass cap of 50 mm diameter on the other. The rod is touched with the narrow end on the ground and taken over the center line alignment of pipe line and the noises of the water leaking is picked up by human ear, thus locating the leakage location.

ii) Integrating type water meter: Normal integrating turbine type meter when connected between two hydrants connected with a temporary pressure hose, serving as a bypass before feeding into the sub-area, measures the flow. Normally 25 mm or 80 mm diameters are used.

iii) Electronic pipe line locator: This is useful in exactly locating the under ground metallic pipes and it works on the principle of electromagnetic induction and wireless signals.

iv) Pressure gauge: Spring type pressure gauge with recorder is used to measure pressures at the inlet and various points of the pipe length. Recorder permits continuous record of pressure with time.

4.7.4 Cleaning of pipes: The carrying capacity of pipes gets reduced during service, especially of C.I. and M.S. steel pipes, by growth of slimes, incrustations or deposits. It is necessary to clean/ flush and swab the pipes periodically.

a) Flushing: The flushing can remove loose deposits of small size and not the slimy layers or hard incrustations. It also disentangles, microscopic biological growth, which grow bigger with time. Water at high velocity around 1.2 m/sec is induced in a section of pipe between two hydrants or scour valves and water made to flow in one direction only, ensuring that the dirty water does not enter the cleaned section. The period of flushing is determined by the quality of water coming out, normally it takes about twice the quantity of water the pipe can hold. Normally the fire hydrants are provided at every 100 m and pipes from 100-300 m can be cleaned in one operation.

b) Swabbing: This is used for removing semi-hard deposits and incrustations not deeply bedded. A swab made of polyurethane foam of equal or slightly larger diameter (25 mm larger for 75 or 100 mm diameter pipes and 50 mm larger for larger diameter pipes) than the pipe diameter and 30-60 cm long is sent inside the pipe and allowed to move in the pipe under pressure of water flow. It is collected at other end through the hydrant or scour valve. Procedure for swabbing 100mm pipe is as under:

Step 1 - The length to be cleaned is isolated by means of valves.

Step 2 - The swab is dipped in bleaching powder solution of strength 50ml/liter of chlorine prior to insertion. In case of vertical hydrants, it is inserted at one of the hydrants and exit from another hydrant 100-300 m away. In case of duck-foot bend in the hydrant, the insertion has to be done by opening one of the valves and exit also from another valve at a distance.

Step 3 - After insertion the valve is closed or valve body is covered.

Step 4 - The water is allowed in by opening a valve near the hydrant and keeping the exit valve open, while the valve on the other side of pipe closed. This ensures that water flows in one direction only.

Step 5 - The swab will move little slowly but shall come out of the open end. In case the swab gets stuck in between, the water can be passed in the opposite direction to dislodge it.

c) **Frequency of cleaning:** Nothing has been laid down anywhere regarding the frequency. It is however recommended that flushing of all pipes should be done once every year and swabbing every third year. The flushing can be dispensed with in the year when swabbing is done.

APPENDIX-1

Water demand

i) Average daily requirement/demand of quantity of water:- The average daily demand of water is obtained by taking the annual requirement of water and dividing by 365 days. The quantity assumed for design of water supply system, in the absence of specific data is taken as under,

Sr.No	Type of use	As per National bldg code(lpd)	As per IRWM (lpd)	Remarks
1.	House hold, w/s thro. a) Stand post b) House connection c) With flushing	 40 100 150	 - 155 200	5, Occupants per house-hold
2.	Office staff	45	45	
3.	Workshop staff	30	30	
4.	Apron washing/sq.m	-	10	
5.	Platform washing/sq. m	-	5	
6.	Passengers on railway station a) Wayside b) Terminals	 25 45	 - 25*	* no. of passengers boarding+ 50% detraining
7.	Carriage washing on washing line/carriage a) Washing line b) On P.F.	 - -	 3600,2600(MG) 500	Water drawn from separate source.
8.	Carriage watering a) Full watering b) Wayside topping up	 - -	 2000/coach 1500/coach	
9.	Garden Lawn per hectare		22,500	
10.	Hospital a) < 100 beds b) >100 beds	 340 450	 - 450	

ii) Maximum daily demand:- The maximum daily demand is normally taken varying between 50% to 80% more than average daily demand, depending mainly on the extremeness of weather in the locality during summer and winter. The areas where the winter and summer are extreme like in North India, the maximum daily demand may be 180% of the average daily demand but in moderate climates areas it may be 150% of the daily average like in most of rest of the country.

a) The overhead reservoir capacity is decided based on maximum daily demand.

iii) Maximum hourly demand :- . Further the maximum hourly demand is taken as 150% of maximum daily demand. This also may vary depending on the nature of constitution of population. Where the population has similar habits e.g. same working hours in the day time, the demand in peak hours is likely to be higher compared to the areas where people have distributed working hours e.g. in workshop or production units where the work is in three shifts.

a) The main pipeline from the tank/reservoir of distribution system is to be designed for maximum hourly demand of the system.

b) The pumping delivery main is also to be designed for maximum hourly demand.

c) The service pipes from mains should also be designed to carry maximum hourly requirement.

Peak hour factor:- The peak hour factor is obtained by multiplying the maxm. daily factor and maxm. hourly factor i.e. peak hour factor is 1.8x1.5=2.7. However, taking into account the future demand, normally the system is designed for a peak hour factor of 3.0.

APPENDIX-2

Tables and Nomogram

a) Modified Hazen William formula

$V = 143.534\ C\ R^{0.6575}\ S^{0.5525}$

$h = [L(Q/C)^{1.81}]/994.62\ D^{4.81}$

V= velocity of flow in m/sec

C= Pipe roughness coefficient

R= Hydraulic radius in meters (=D/4 for circular pipes)

S= Friction slope

D= Internal diameter of pipe

h= Friction head loss

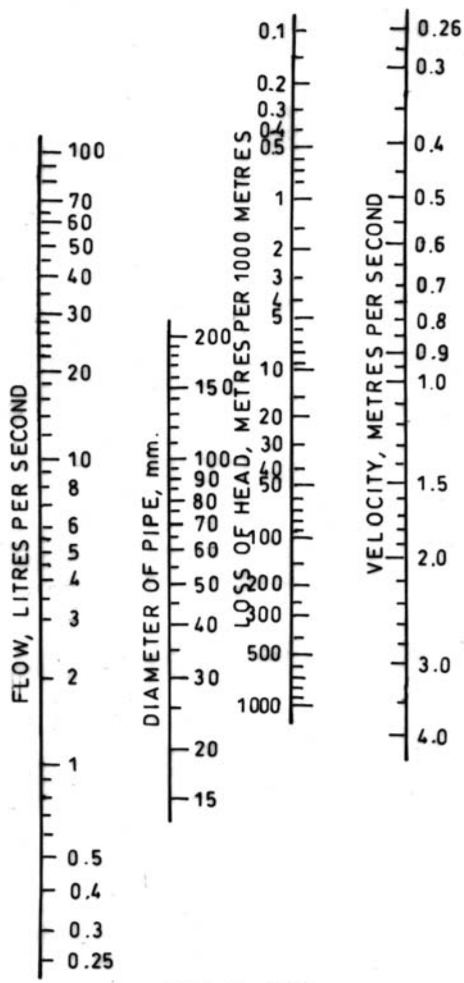
L= Length of pipe in meters

Q= Flow in m^3/sec

The above equation can be plotted to directly read the relationship i.e. value of head loss, velocity of flow, discharge and diameter of pipe, and the graph is given.

The value of Roughness coefficient is given in Table-1.

The pipeline transitions and fittings like valves, bends etc. result in pressure head loss which is = k $V^2/2g$ The value of k is given in Table-2. The head loss can also be seen as additional length of pipe, which is given in Table-3.



For C=100

Examples of the use of nomogram are given below:

Example 1

Find the total friction loss in 25 mm diameter G.I. Pipe discharging 0.25 l/s in a total length of 300 m.

Procedure

Q =O.25 l/s

Pipe diameter = 25 mm

Frictional loss from nomogram = 30m / 1000m

Total friction loss in 300m length = (30m / 1000m)/1000 = 9m

Example 2

Find suitable diameter pipe to carry 15 liter per second from service line to overhead tank. Total length of service main = 200 m

Residual pressure available at the take off point on supply line is 15m.

Procedure

Available head = 15 m

Deduct residual head = 2m

Deduct 10 percent for losses in bends and specials = 1.3 m

Friction head available for, loss in pipe, of 200m = 15-2-1.3 = 11.7m

Friction head available for loss in pipe of 1000 m =

$$1000 \text{ m } \frac{11.7 \text{ x } 1000}{2000} = 58.5 \text{ m/ } 1000 \text{ m}$$

From the nomogram for a discharge of 15 l/s and friction loss of 58.5m/ 1000m diameter of nearest commercial size of pipe is 100 mm diameter.

TABLE-1

S. no.	Pipe material	Diameter (mm)		Velocity m/sec		C, for new pipe	C, for 30 yrs. old pipes
		From	To	From	To		
1	RCC	100	2000	0.3	1.8	1.0	1.0
2	AC	100	600	0.3	2.0	1.0	1.0
3	HDPE & PVC	20	100	0.3	1.8	1.0	1.0
4	CI/DI Non-corrosive water	100	1000	0.3	1.8	1.0	0.85
5	CI/DI corrosive water	100	1000	0.3	1.8	1.0	0.53
6	Metal pipes with lining of epoxy/ cement mortar- Corrosive water	100	2000	0.3	2.1	1.0	1.0
7	SGSW	100	600	0.3	2.1	1.0	1.0
8	GI with non-corrosive water	15	100	0.3	1.5	0.87	0.74

Note : The range of values are to be used in ratio of areas of pipes/ fittings. More the diameter, more the loss.

TABLE - 2

Whenever the flow meets an obstruction caused by any change of direction, a valve, a contraction in pipe diameter, holes etc. water head loss is caused and is given by, K $V^2/2g$ and the coefficient K is different for different fittings,

Value of K, for head loss

Type of fitting	Value of K
Sudden contracton	0.3 – 0.5
Entrance shape well rounded	0.5
Elbow 90 degree	0.5 – 1.0
-do- 45 degree	0.4 – 0.75
-do - 22 degree	0.25 – 0.50
Tee 90 degree	1.5
Straight run	0.3
Coupling	0.3
Gate valve (Open)	0.3 – 0.4
With reducer and increaser	0.5
Globe valve	10.0
Angle	5.0
Swing check valve	2.5
Venturi meter	0.3
orifice	1.0

Note : The range of values are to be used in ratio of areas of pipes/fittings. More the diameter, more the loss.

TABLE-3

Equivalent length of pipe for different size of fittings (For K=1)

It is convenient to work out the total value of K due to all fittings and straight lengths of pipes and convert it to equivalent length of pipe and then calculate the various parameters required like, discharge, velocity and head etc. by adding it to the actual length of pipe.

Diameter (mm)	Equivalent length (m)	Diameter (mm)	Equivalent length(m)
15	0.3	65	2.4
20	0.6	80	3.0
25	0.75	90	3.6
32	0.9	100	4.2
40	1.2	125	5.1
50	2.1	150	6.0

APPENDIX-3

Design of water distribution

Storage capacity of reservoir:-

Problem : A colony has 480 houses. The peak demand is for 6 hrs. a day between 0700-1000 hrs and 1700-2000 hrs. There is no demand between 2300-0300 hrs. To maintain 24 hrs. supply of water, calculate the capacity of over head reservoir under following cases:

Case a) Power is not available for 4 hrs. everyday between 06-10 hrs.

Case b) Power is available round the clock as stand by Diesel pump is available.

i) If pumping is done for 14 hours

ii) If pumping is done for 8 hours

Solution :

Population of colony = 5X 480 = 2400 nos.
Normal Demand (consumption) = 200X2400 = 480000 lts
Peak hour factor (assume) = 2.0 (between 0700-1000 & 1700-2000 hrs)
Assume proportional consumption in other than peak hours.
Hourly average demand = 480000/24 = 20000 lts/hr(20 kl)
Peak hour demand = 20000X2.0 = 40000 lts/hr (40 kl/hr)
Demand in other hrs. = 480000-6X40000 = 240000 lts
= 240000/(24-4) =17100 (17.1 kls/hr)
i) Rate of pumping (14 Hrs) = 480000/14 = 34.25 kls/hr
ii) Rate of pumping (8 Hrs) = 480000/8 = 60 kls/hr

Case a) Pumping can't be done between 0600-1000 hrs.

Given data			**pumping 14hrs- 34.25 kl/hr**		**pumping 8hrs@ 60 kl/hr**	
			14 hrs. pumping		8 hours pumping	
Period in hrs	Hourly demand	Cumulative demand	Cumulative pumping	Cumulative deficit/surplus	Cum. pumping	Cum. deficit/ surplus
03-06	17.1	51.3	0	(-)51.3	0	(-)51.3
06-07	17.1	68.4	0	(-) 68.4	0	(-)68.4
07-10	40	188.4	0	(-)188.4	0	(-)188.4
10-12	17.1	222.6	68.5	(-) 154.1	120	(-)102.6
12-14	17.1	256.8	177	(-) 79.8	240	(-) 16.8
14-16	17.1	291	242	(-) 49.0	240	(-)51
16-17	17.1	308.1	242	(-) 66.1	300	(-)8.1
17-20	40	428.1	344.75	(-) 73.65	480	(+) 51.9
20-22	17.1	462.3	413.25	(-) 51	480	(+) 17.7
22-23	17.1	480	447	(-) 32.5	480	0
23-00	0	480	480.	(+) 0	480	0
00-03	0	480	480	(+) 0	480	0

i) Pumping for 14 hrs	ii) Pumping for 8 hrs
Maximum deficit = 188.4 kl	Maximum deficit = 188.4 kl
Maximum surplus = 0	Maximum surplus = 51.9 kl
TOTAL = 188.4 kl	TOTAL = 240.3 kl
(38%)	(50%)

Case b) Power is available or stand by Diesel pump is available round the clock.

Given data			Pumping 14hrs- 34.25 kl/hr		Pumping 8hrs@ 60 kl/hr	
			14 Hrs. pumping		8 hours pumping	
Period in hrs	Hourly demand	Cumulative demand	Cumulative pumping	Cumulative deficit/surplus	Cum. pumping	Cum. deficit/ surplus
03-06	17.1	51.3	0	(-)51.3	0	(-)51.3
06-07	17.1	68.4	34.25	(-) 34.2	60.0	(-)8.4
07-10	40	188.4	137.0	(-)51.1	240.0	(+)51.2
10-12	17.1	222.6	205.50	(-) 17.1	240.0	(+)17.4
12-14	17.1	256.8	274.0	(+) 17.2	240	(-) 16.8
14-16	17.1	291	274.0	(+) 17.1	240	(-)51
16-17	17.1	308.1	274.0	(-) 34.1	300.0	(-)8.1
17-20	40	428.1	376.7	(-) 73.65	480.0	(+) 51.9
20-22	17.1	462.3	445.5	(-) 17.1	480.0	(+) 17.7
22-23	17.1	480	480.0	(-) 0	480.0	0
23-00	0	480	480.	(+) 0	480.0	0
00-03	0	480	480	(+) 0	480.0	0

i) Pumping for 14 hrs	ii) Pumping for 8 hrs
Maximum deficit = 73.65 Kls	Maximum deficit = 51.3 kls
Maximum surplus =17.20 kls	Maximum surplus = 51.9 kls
TOTAL TANK CAP. REQD.= 90.85kls	TOTAL TANK CAP. REQD. = 103.2 kls
(18.5 %)	(23%)

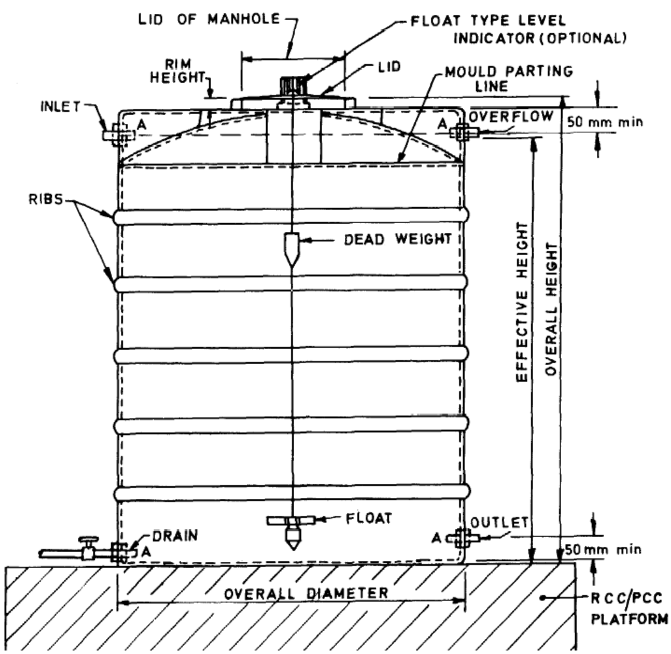
From the above it will be noted that service reservoir capacity in different cases is different and it can be optimized by suitably choosing the rate and timings of pumping. The requirement varies between 18% to 50% of total daily water consumption under different conditions of pumping.

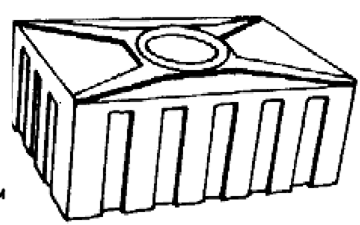
APPENDIX-4

Water tanks

1. R.C.C./P.S.C. tanks:- Reinforced concrete tanks could be rectangular/square or circular in shape. Small size tanks are generally rectangular or square in shape but larger tanks are invariably circular in plan. A circular tank with conical shape at the bottom is known as Intz tank. Intz tanks are very efficient tanks and are normally adopted for overhead water tanks of large capacity. Nowadays prestressed concrete tank is becoming popular due to these being cheaper than R.C.C tanks. RCC or PSC tanks can be installed over head on staging or can be placed at ground depending on specific requirement. These can be made in any size and shape, but are generally circular or rectangular in plan. This is a very satisfactory type of water tank overhead or on ground or even underground but needs best quality control to ensure durability and water tightness for life long.

2. Polyethylene moulded tanks:-





For capacities up to 200 liters loft tanks made of colourless polyethylene and for higher capacities cylindrical ribbed polyethylene tanks are used. The tanks are manufactured of different sizes but the range of size as per IS:12701-1996, are as below,

S. No.	Capacity (Liters)	Diameter range (mm) or length (Loft) tanks	width (mm) for (Loft)	Height range (mm)	Wall thick (mm)	Weight (kg)
1	150 (Loft)	620-820	620-820	285-485	2.75	6.6
2	200(Loft)	930-1130	620-820	285-485	2.75	7.7
3	300(Loft)	995-1200	620-820	285-485	2.75	11.0
4	400(Loft)	1150-1350	855-1150	335-535	2.75	13.0
5	500(Loft)	1150-1500	900-1250	335-535	2.75	15.0
6	200	650-850		490-690	3.0	7.8
7	300	650-850		700-900	3.0	9.0
8	400	700- 980		700-950	3.5	15.0
9	500	800-1140		625-1025	4.0	18.0
10	700	900-1140		800-1100	4.4	23.0
11	1000	1000-1200		1050-1350	4.5	33.0
12	1500	1080-1450		1150-1590	4.5	47.0
13	1700	1300-1500		1260-1650	4.5	54.0
14	2000	1365-1500		1400-1700	5.4	64.0
15	2500	1380-1610		1400-1810	7.7	81.0
16	3000	1410-1800		1640-2150	8.1	96.0
17	4000	1450-1920		1750-2400	10.4	147.0
18	5000	1800-2110		1800-2100	10.7	180.0
19	6000	1800-2200		20652800	10.7	205.0
20	7500	1890-2250		2100-2930	10.7	239.0
21	10000	1900-2680		2400-3740	11.5	319.0
22	15000	2100-2680		3100-4000	11.5	408.0
23	20000	2100-3150		3190-5000	13.2	566.0

The weight given in the table is without the lid. Normally the cylindrical tanks used for exterior are black in colour due to addition of carbon black to the polyethylene about 2-3% by weight. These tanks are for use of storing water at normal temperature only, at higher temperatures the tank can get distorted. Following precautions are necessary for installation of Polyethylene tanks.

i) The base of the tank should be fully supported on whole bottom area on a firm surface. In case of a grillage, the same should be provided with a steel sheet of adequate thickness so that it does not yield at any point and should be given coating of anti-corrosive paint.

ii) The pipeline, valve and any other fitting should be so aligned that there is no distortion in the tank at the location of fitting.

iii) The check nuts of the threaded connections should be placed after placing rubber gaskets and never over tightened. Never put sealing compound or putty in contact with tank. PTFE unsintered tape may be used wrapped around the threads as a sealant.

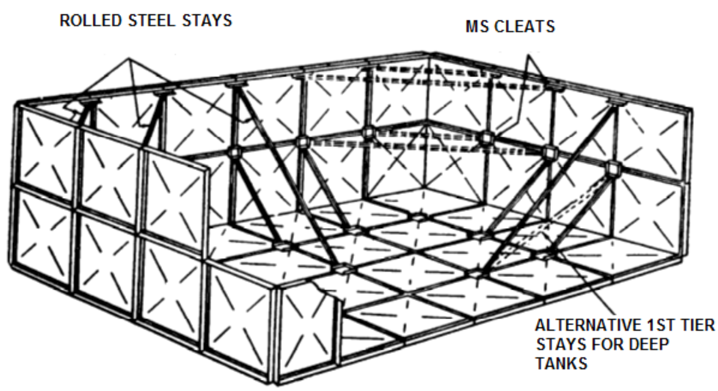
iv) Holes in tank should not be scored or scratched but always drilled or cut using high speed drill or saw.

The Pre-truded tanks similar to Polyethylene tanks are also available in FRP (Fiber Reinforced Plastic). Since the FRP is not affected by UV rays (sunlight), these have longer life.

3. Pressed steel panel tanks: -

a) Sectional panel tank or pressed steel panel tank consists of 4' x 4' or 1.25 meter x 1.25 meter M.S. panel manufactured from 4.5mm to 6.0mm thickness according to requirement.

b) All tanks are internally braced with angle stays to endure the rigidity of the tank when filled with water. For tanks of height up to 2.5 m horizontal members can be used for bracing in width and length.



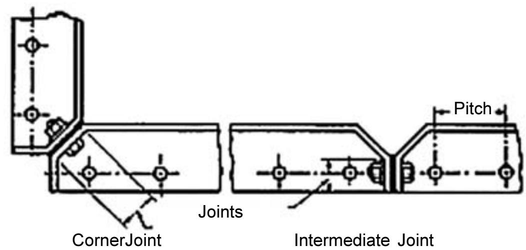
X-SECTION OF A M.S. PRESSED STEEL TANK

c) The internal surface should be coated with a layer of black bituminous paint and externally with red oxide. The seams of the tanks are sealed with Either (Ethylene Vinyl Acetate plus Natural Rubber) sealant tape or non-toxic and odourless jointing compound.

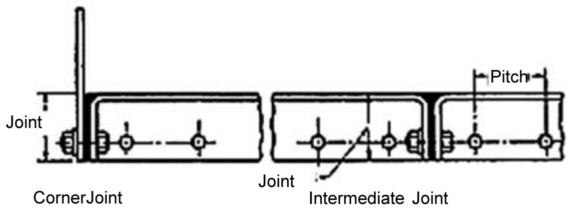
d) The top panel is supported by top panel support, which is made of hot-dipped galvanised material. The tank cover shall be constructed from 1.4mm to 3.0mm of thickness hot-dipped galvanised material according to the requirement.

e) Internal & external ladder shall be made of hot-dipped galvanised material. The internal ladder can be avoided for tanks of height less than 2.5 m. Level indicator shall be made of Aluminum c/w P.V.C ball float.

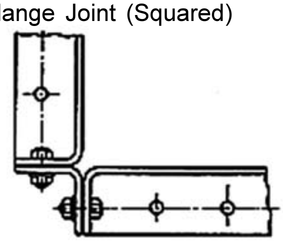
f) The sectional panels are pressed to double flanges at the angles of 45 degree and 90 degree to the face of the plate on four sides.



Flange Joint (Partly Squared)



Flange Joint (Squared)



Corner Details

g) The minimum thickness of plates to be adopted is as under,

Depth	**Location of plates in different water tanks**	**Nominal thickness (mm)**	**Bolts dia. @80mm c/c**
1.25 m	Bottom and sides (Cubic tank only)	3.5	12 or 8 mm @ 55 mm c/c
2.5 m	Bottom and first tier plate	6.0	14
	Top tier side plates	5.0	14
3.75 m	Bottom and first tier side plates	6.0	14
	Second tier side plates	6.0	14
	Top tier side plates	5.0	14
5.0 m	Bottom and first tier side plates	8.0	14
	Second and third tier side plates	6.0	14
	Top tier side plates	5.0	14

4. FRP panel tanks: - These are similar to MS pressed panel tanks except that the panels are made from fiber reinforced plastic by SMC process, as against Mild Steel. These do not corrode and prefabricated panels can be assembled at site. These are not affected by ultra violet light and do not easily get embrittled as in case of Polyethylene or other polymer tanks. These are lighter than MS tanks. The modular size of a unit is 1.0x1.0 m and half size panel 1.0x0.5 m are also manufactured. The normal life expectancy is about 15 years.

The properties of the FRP(Fiber Reinforced Plastic) panels is given below:

S.No.	Item	Unit	Property
1.	Specific gravity		1.8
2.	Tensile strength	MPa	105
3.	Bending strength	Kg/cm^2	1900
4.	Elastic Modulous	MPa	13000
5.	Compressive strength	Kg/cm^2	1700
6.	Barcol Hardness	-	54
7.	Water absorption	%	< 0.01
8.	Liquification turbidity	Degree	< 0.1
9.	Liquification Chromacity	Degree	< 1
10.	Thermal expansion, α	/deg.C	$2x10^{-5}$
11.	Thermal conductivity	Kcal/mh.C	0.23
12.	Fiber content	%	31.4
13.	Toxicity	-	Nil

5. Comparative properties of different type of water tanks are given in table below:

S. No.	FRP panel water tanks	PVC/Polyethylene water tanks	Steel water tanks	Concrete water tanks
(1)	(2)	(3)	(4)	(5)
1	The hot pressing method for panels eliminates styrene and makes it an ideal product for storing drinking water.	It is one piece construction and eliminates any problem of accumulation of dust etc. if kept properly covered.	Corrosion can cause dangerous toxins in drinking water	Rough surface collects dirt and bacteria. Manhole gaps and corridors encourage breeding of insects and accumulation of dust.
2	No metal components need to be in contact with water. Reinforcement, bolts and nuts for assembly are on the outside.	Fragile material that could easily be broken by normal work related activity	Residual chlorides can cause chlorine gas when water pours into tank through inlet, this may degrade both metal and water quality.	Very durable if constructed properly.

(1)	(2)	(3)	(4)	(5)
3	Exclusive base panel design ensures complete free flow drainage; this eliminates residual contaminated water with cleaning.	Bottom slope will not allow complete drainage of hose pressure water with chemicals used for cleaning resulting in contamination of incoming water.	Bottom slope will not allow complete drainage of hose pressure water with chemicals used for cleaning resulting in contamination of incoming water.	Flat bottom will not allow complete drainage of hose pressure water with chemicals resulting in contamination of incoming water
4	Modular panel with low thermal coefficient and flexible rubber sealant ensures a leak free design.	UV degrades the material and is then easily broken. Exposure to weather variations such as cold, heat and UV rays on a thinly walled tank, which has continuously changing water levels, causes embrittlement resulting in cracking and a short life.	Weak points at welded joints lead to leakage problems with welded tanks. Bolted steel tanks are susceptible to high expansion and contraction due to thermal properties, which can over a time affect sealant causing leakage	Poorly sealed and maintained tanks will absorb water, which will corrode the steel reinforce-ment inside concrete causing cracks due to expansion and leakage. Water absorption in poorly or untreated concrete is high causing corrosion to the internal steel reinforcement that in turn causes expansion cracks
5	Panel is lightweight and easy to handle. Uniform quality end product. Can be assembled at site quickly.	Due to the extreme lightness of the tank a normal light storm could break the connecting pipes and blow the tank away when it is empty. When used on a roof concrete block are placed in the tank to minimise the risk of being blown away by the wind when empty.	Can be assembled at site and suitable for quick construction.	Needs to be constructed at site and quality control, if not excercised pose problems of leakage and damage to tank.
6	Non-insulated panels have 240 times less thermal conductivity than metal, ensuring stable temperatures	Water temperature will be above ambient temperatures in summer and below ambient in winter.	Water temperature will be above ambient temperatures in summer and below ambient in winter.	Acceptable thermal properties in temperature weather conditions

APPENDIX-5

Balancing a network/grid for water head and discharge

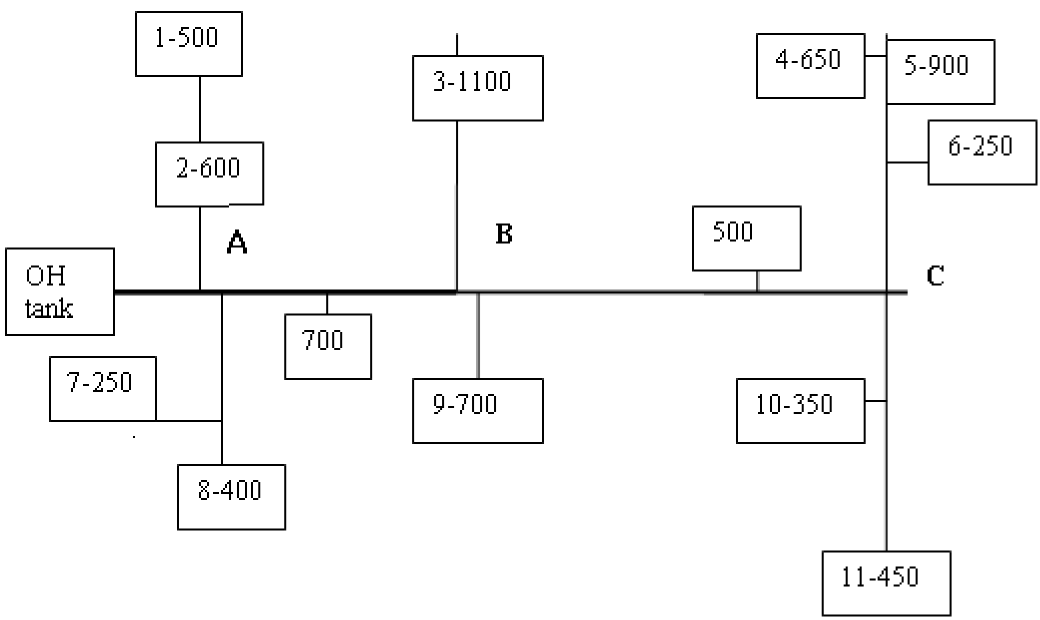
In any closed grid layout of pipes, the following conditions should be satisfied,

i) Quantity of water entering a junction or a node must be equal to the water leaving it, this is necessary for continuity to be maintained.

ii) The algebraic sum of pressure drops around a closed loop has to be zero, to maintain continuity of pressure.

Example problem: Analysis to find pressure and head loss at different points.

1. Dead end system:- A dead end system can be designed using the Hazen Williams nomogram and diameter required of main pipe line worked out as shown hereunder:



Site information available:-

a) A main pipe line ABC from over head tank, is to be laid serving the 11 no. of population pockets 1 to 11 with no. of users in each pocket, as shown above. Additionally, there are some scattered users on pipe AB 700 nos. and on pipe BC another 500 nos. Further site data is as below,

b) Length AB =700m, Length BC= 550 m.

c) RL of OH Tank = 185.5m, RL of A = 168.0m, RL of B = 154.0m and RL of C= 146.0m

d) Average daily demand is 200 liters/person/day.

e) The height of buildings is maximum 4-storeys and a minimum pressure of 3 m head should be available on the top floor of every building.

Solution:-

i) Water demand:-The main pipeline is to be designed for maximum hourly demand of the system. The maximum daily demand is normally taken varying between 50% to 80% more than average daily demand, depending mainly on the extremeness of weather in the locality during summer and winter. The areas where the winter and summer are extreme like in North India the maximum daily demand may be 180% of the average but in moderate climates areas it may be 150% of the daily average like in most of rest of the country. Further the maximum hourly demand is taken as 150% of maximum daily demand. This also may vary depending on the nature of constitution of population. Where the population has similar habits e.g. same working hours in the day time, the demand in peak hours is likely to be higher compared to the areas where people have distributed working hours e.g. in workshop or production units where the work is in three shifts. In the instant case, we take the maximum daily demand as 150% of average daily demand and also peak hour demand as 150% of maximum daily demand. Peak hour demand / person = 200x1.5x1.5/ 24 = 450/24 = 18.75 liters/ hour or 450/(60x60) = 0.005 lit/sec/person.

ii) Population and demand:- The calculation of the area and population served by the two segments of pipe viz. AB and BC and water demand are as under,

Pipe	**Population served (Numbers)**			**Maximum demand(l/hour)**
	Previous	**Local**	**Total**	
BC	(Pocket-4,5,6,10,11) 650+900+250+350+450 = 2600	500	3100	18.75x3100=58125 or 16.16l/sec
AB	3100 + (Pocket-1,2,3,7,8,9) i.e.500+600+1100+250+400+ 700= 6650	700	7350	18.75x7350=137812 or 38.30 l/sec

iii) Minimum water head:- The height of the buildings in the settlements is 4- storey i.e. 3x4 = 12 m. To have sufficient water head of minimum 3 m in top floor of the buildings the minimum head should be 12+3 = 15 m at ground level at all points.

iv) **Length of pipes:-** AB= 700m and BC= 550m. The lengths of pipe beyond the main line feeding the population is ignored being small compared to length of mains. Similarly, the loss of head due to fixtures, such as bends, tees and valves etc is ignored for simplicity, which however can be worked out as equivalent length of pipe as per **APPENDIX 2** (Table - 3) and added to the length AB and BC. Similarly, if the pipe length of feeder lines reaching the consumer is significant, they can also be accounted for.

v) **Design of pipe line:-** Assume, velocity in pipe BC as 0.9m/sec. Therefore assumed area of pipe BC (16.16 l/sec)/0.9 m/sec = 179.6 cm^2 or provide Appx. 15 cm dia. pipe. For pipe line AB the assumed area of pipe line based on 0.9 m/sec velocity is (38.30 L/sec)/0.9 m/sec = 425 cm^2 or provide approximately 20 cm. diameter.

a) **Loss of head: -** From Hazen William Nomogram, for a pipe of 15 cm dia. and velocity 16.16x 1000/(15x15xπ/4) = 0.91 m/sec the head loss is read as 10 m/1000 m of length. i.e 5.5 m over 550m and similarly for 20 cm dia pipe the velocity is 38.30x1000/(20X20x π/4) = 121cm/sec or 1.21 m/sec and the head loss is 14 m /1000m. or 9.8 m over 700m.

Pipe	Diameter	Head loss			Reduced levels/head			
		Per 1000m	Length	On length.	Ground	Cum loss (m)	R.L. Hydraulic	Head available (m)
BC	15 cm	10m	550 m	5.5 m	C-146 B-154	15.3 5.5	170.2 180.0	24.2 26.0
AB	20 cm	14 m	700 m	9.8 m Tank-185.5	A-168	0.0	185.5	17.5

b) The head available at point A=17.5 m, at B=21.7 m and at C= 23.7 m which is more than 15 m required as such the assumption is correct and diameters of AB=200 mm and BC=150 mm is correct. Since, the pressure available is more than 15 m, small losses which are not accounted in approximations will also be cared for.

2) Closed grid pipe line analysis:- The dead end pipeline can be designed by using the method described above, however, networks having supply as well as discharges in more than one direction are not amenable to solution using direct method as given above. There are several methods based on 'hit and trial' developed, most commonly used is called 'Hardy Cross Method'.

Hardy cross method:- In a closed network or grid, following two principles of continuity must be observed:

i) 'Total algebraic sum of loss of head should be zero' for maintaining continuity at each junction.

ii) The quantity of water entering a junction, must be equal to the quantity of water leaving the junction.

Application of this method is done using following simplifications:

a) The whole grid/ network with several loops is reduced to a grid of few loops, such that each pipe in the network is included in one of the loops of a simpler grid.

b) The minor losses may either be neglected or equated to equivalent length of pipe.

Flow discharge is assumed in the network, and head loss in each pipe is determined using pipe flow formula. Corrections are made in the flow discharge in each pipe till the heads balanced for the principle of continuity. If Q_a is the assumed flow in a pipe and actual flow is Q, then correction in the flow is:

$\Delta = Q - Q_a$

and Head loss = k Q_a, where k, is constant depending upon the pipe diameter, material, roughness etc.

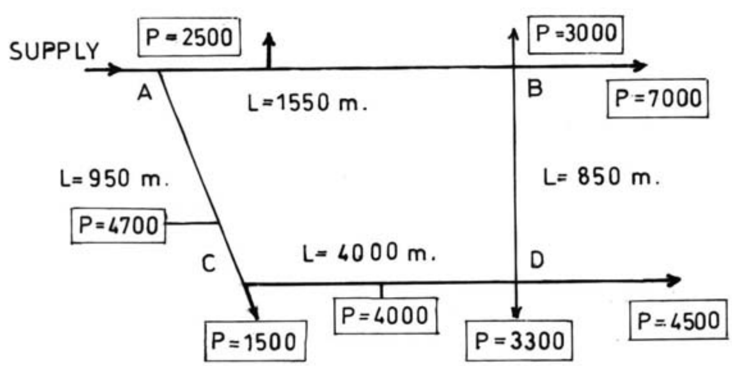
or the equation can be expressed after neglecting smaller terms as,

$$\Delta = \frac{-\Sigma (k\, Q_a^{x})}{\Sigma (x.k\, Q_a^{\,x-1})} \quad \text{or also} = \frac{-\Sigma \text{ head loss}}{x.\ \Sigma\ (\text{Head loss}/Q_a)}$$

The Σ head loss is the algebraic sum of head losses in the various pipes of the closed loop. Commonly, +ve sign is given to losses in clockwise direction and –ve, for counterclockwise direction. x the constant depending on pipe and as per Hazen Williams (**APPENDIX-2**) is taken as 1.85. The minor losses are normally neglected, though they can be worked out and equated to equivalent length of pipe. In case of multiple loops, the system is divided into two or more loops, including all the pipes in the circuit of one loop.

Design of a pipe line in a grid system:-

The following grid is to be designed to supply 200 l/day average demand at all the points



Solution :-

i) Average daily demand is 200 l/Day

ii) Assume the maximum hourly demand as 1.8x1.5=2.7 times the daily average demand i.e. 200x2.7/24= 22.5 l/hour or 22.5/3600= 0.00625 l/sec

iii) The various flow discharges for which pipes are to be designed are,

At B, along line AB = 7000x0.00625 = 43.75 l/sec

At B, along line DB =3000x0.00625 = 18.78 l/sec

At D, along pipe BD = 3300x0.00625 = 20.62 l/sec

At D, along pipe CD = 4500x 0.00625 = 28.12 l/sec

At point C in line = 1500x 0.00625 = 9.37 l/sec

Local Supply in line CD = 4000x0.00625 = 25 l/sec

Local supply in line AB = 2500x0.00625 = 15.62 l/sec

Local supply in line AC = 4700x0.00625 = 29.37 l/sec

TOTAL SUPPLY REQUIRED = 190.6 l/sec i.e. total input reqd at

A = 190.6 l/sec

iv) The flow discharge in pipes have to be now assumed, keeping in view the directions and the continuity i.e. the input should be equal to the draw off at each junction. The assumed values are shown in figure below:

A; 190.6=Supply AB+ Supply AC= 102+88.6 (Assumed)

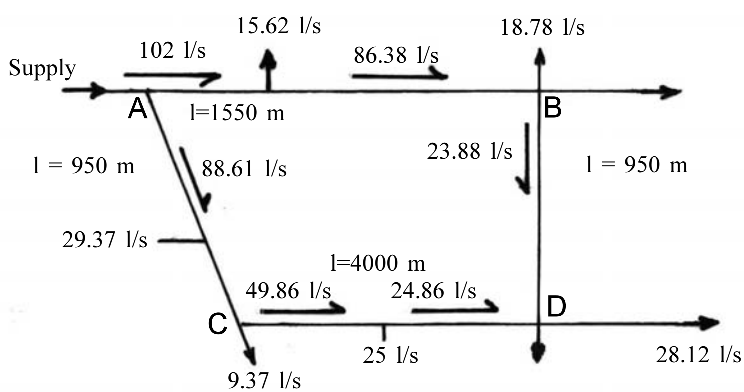
Beyond local supply on AB; 102-15.62=86.38

B; 86.32-18.78-43.75= Supply BD= 23.88

C; 88.6-29.37-9.37=supply in CD= 49.86

Beyond local supply on CD= 49.86-25=24.86

D; 24.86+23.88=20.62+28.12 (Balance)



Assume the diameter of pipes based on velocity of 1.0 m/sec (approximately)

Route	Pipe	Q_a, l/s	Length m	Dia. (mm)	Head loss/1000m	Head loss(m)	Head loss/Q_a
ABD	AB	102	1550	300	14.26	22.10	216.67
	AC	23.88	950	200	5.0	4.25	177.97
				Total	26.35	394.64	
ACD	AC	88.6	950	280	15.0	14.25	160.83
	CD	49.86	1100	250	8.3	9.13	183.11
				Total	23.38	343.94	
				G.Total		738.58	

Then correction $\Delta = (26.35\text{-}23.38)/\ (1.85\text{x}\ 738.58) = 2.17$ L/sec.

The correction is very small as such assumptions are correct. If the correction is large, the next iteration be done using Qa= Qa+ Δ, and so on till proper match or correction value is small.

Chapter 5

HOUSE BUILDING DRAINAGE

1.0 Principles for drainage:

a) **Discharge flow:** All dwelling units must be provided with minimum following fittings:

i) One bath room provided with a tap and a floor trap,

ii) One water closet with flushing system with an extra tap, and

iii) One tap with a floor trap or a sink in the kitchen or wash place.

The requirements of fixtures for other than residences is given in **APPENDIX-1**. The various fixtures do not discharge simultaneously and the maximum flow in a building drain or a stack depends on the probable maximum number of simultaneous discharging fixtures. For the calculation of this peak flow, certain loading factors or drainage fixture unit (dfu) have been assigned to fixtures, considering their probability and frequency of use. The size of trap diameters, and dfu's for different fixture units is given in table-1 of **APPENDIX-2**.

For calculating the total peak flow in liters/min from the total dfu's, the graph in **APPENDIX-2**,can be used.

Maximum discharge flow: The above assessment gives an average flow however for design of pipelines etc. the maximum discharge, three times the average flow is taken. As a thumb rule, a flow of 3 liters/ minute, per 10 persons is assumed from a building.

b) **Air vent:** The drainage system whether in a building or of an area is generally designed as flowing under gravity. However, when the waste is flowing through pipes, it creates a suction effect trailing the flow, simultaneously an increase in air pressure ahead of the flow. The standard fixture like water closet, traps have a water seal of about 50mm, and any suction or increased air pressure in the vertical or horizontal pipe carrying the flow, if cause break in this trap will totally destabilize the system and the sewer gas, foul smell may enter through the fixtures into the building. It is therefore of importance that proper means of allowing air into the pipe should be there to ensure least disturbance to the air pressure inside the pipe. It also requires that pipes are sized suitably and adequate arrangements are made to avoid disruption and maintain balance of air pressure, so as not to allow drop of pressure more than 25 mm of water head (half of 50 mm head in the traps).

c) **Velocity of flow:** The velocity of waste water flow in vertical pipes normally is 3-4 m/sec. and in horizontal pipes is about 0.6m/sec. even in pipes laid at a slope of 1 in 500. The flow in vertical pipes is independent of the height from which the waste water is dropping, as it flows in a circular motion hugging the wall of the pipe and not drop directly downward under gravity as would be expected. So, air has to rush in to replace the suction pressure created behind the flow from the top vacant pipe. However, the rush of flow of air is affected by the friction in the pipe and can still break the seal unless adequate size of pipes and vent pipes are provided. Due to a very considerable difference in velocities in vertical and horizontal pipes, the flow at transition from vertical to horizontal pipe needs careful consideration. This situation is normally met when the discharge from a multi-storey building reaches the ground and has to run along the ground. Unless proper transition is provided, the solids will tend to collect at the junction and water will jump and flow at a faster speed, causing choking of the drainage. The drain pipes are not to flow full for danger of breaking the trap seal and are designed to run half full under maximum peak flow condition, with a self cleansing velocity of 0.75 m/sec. It may however not always possible to provide the self cleansing velocity in the pipes due to site constraints and the velocity should however not be less than 0.6 m/sec. and not more than 2.4 m/sec. The Table-5 in **APPENDIX-2** gives the discharge values, with reference to different gradients for various diameters of pipes.

d) Other factors: Efficient and economical plumbing can be achieved by keeping following in view:

i) Placing of fixtures around an easily accessible shaft,

ii) Pipes should be laid in straight lines, both in horizontal and vertical planes,

iii) Avoid abrupt changes of direction in pipes, no bends and junctions are permitted in the sewers except at manholes and inspection chambers,

iv) Pipes should be adequately supported

v) Avoid accumulation of rain water or any back flow from sewers in low elevation areas of building,

vi) Sewer drains should be laid at a slope to achieve self cleansing velocity of 0.6- 0.75 m/sec. and generally should not flow more than half full. If the pipe flows more than half, the instability in flow could destroy the seal of the traps.

vii) Sewer pipes should be at least 900 mm below the road and minimum 600 mm below the fields and gardens,

viii) Pipes should not be laid near foundations of building or near large trees.

2.0 Drain appurtenances:

2.1 Traps:- A trap may be an integral part of the appliance, as in case of European W.C. or attached to its outlet. The fittings which are placed at the end of soil pipes or waste water pipes to prevent the passage of foul gases from the pipes to the outside are called traps. Between every fixture and the waste pipe is a trap - a curved section of pipe that traps water within it. All types of traps maintain water seal between the pipe and the outside which does not permit foul gases to escape from the pipes. The trapped water forms an airtight seal that prevents sewer gas from entering the home. The efficiency of trap largely depends upon the depth of water seal. The water depth of water seal most commonly adopted in most traps is 50 mm. At the bottom of their curve, some traps have a **clean-out plug** that provides access to the trap, making it easier to clear out any clogs.

2.1.1 There are three main types of traps:

P-traps: Designed for waste lines that come out of a wall, P-traps are shaped like the letter "P" lying face down. They're located under sinks, tubs, and showers.

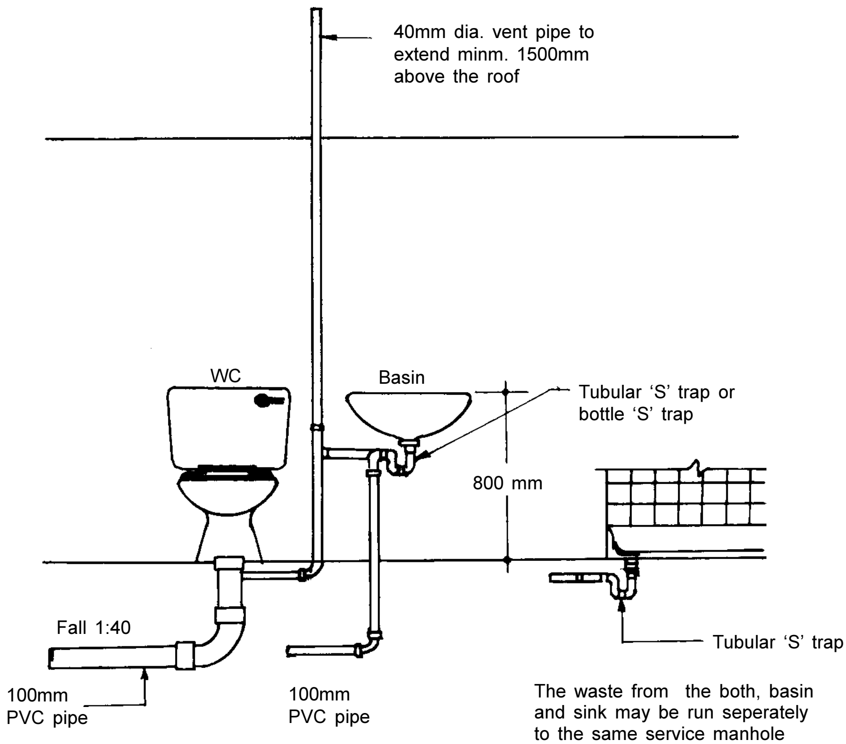
S-traps: Designed for waste lines that come out of the floor, S-traps can sometimes allow sewer gas into the home. So generally S-traps are not installed in new construction.

Integral traps: Toilets have built-in "integral" traps, which work just like P-traps.

P-trap S-trap Integral trap

2.1.2 Floor drains:-

All toilets/ bathrooms should be provided with floor drains to facilitate cleaning. They are connected to traps of a size to serve efficiently the purpose. The trap is to be accessible from the floor drain or by a separate cleanout within the drain. Special design of floor traps are available in market, which can be cleaned by taking off the cover/jall from the floor drain. (Fig. on pg. 130)



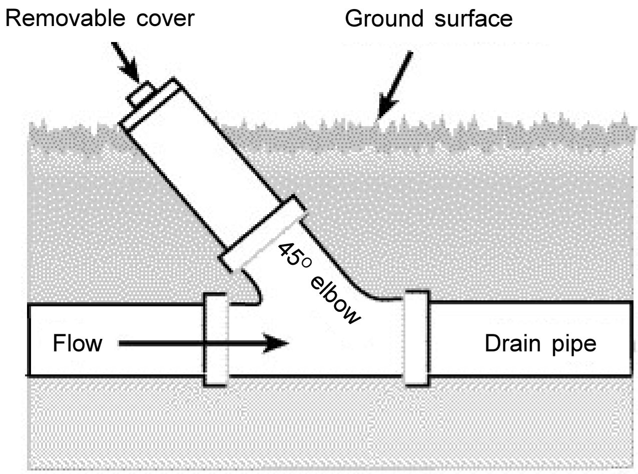
Sketch showing location of traps

2.2 Gully traps:- The traps which are provided at the junction in the drainage system. (Fig. on pg. 131)

There are two entry locations for these traps. Water from bathrooms, kitchen etc. enter through horizontal inlet. Water from floor cleaning or from rain water system enter through top grating screen. (Fig. on pg. 131)

2.3 Intercepting traps:- The trap which is often provided at the junction of a house sewer and a municipal sewer intercepts the foul gas from the municipal sewer from entering house drainage system.

2.4 Clean outs:- The various appurtenances like traps, stacks and branch pipes should be provided with clean outs for inspection and easy clearing any blockages etc. The clean out is also be placed inside the building near the connection between the building drain and the building sewer or installed outside the building at the lower end of the building drain and extended to drain. Additionally, cleanouts are provided in the sewer system in place of manholes, except for major junctions. Clean out is a pipe that leads from the sewage system to the surface of the ground. Cleanouts provide access so that the sewer can be cleaned. Clean outs shall be placed at all upstream ends, intersection of sewer lines, major changes in direction, at high points and at intervals of 60-100 m in straight reaches and long flat sections.



The clean out is also placed inside the building near the connection between the building drain and the building sewer or installed outside the building at the lower end of the building drain and extended to drain.

Each cleanouts fitting for cast-iron pipe consists of a cast-iron pipe and a plug.

Each clean out for galvanized, wrought iron, galvanized steel, PVC (Polyvinyl Chloride), UPVC or Stainless steel clean outs and plugs shall have raised heads or countersunk rectangular slots of sizes shown below:

Size of pipe mm	Size of cleanout mm	Threads (Per 25.4 mm)
40	40	11.5
50	40	11.5
65	65	8
75	65	8
100 and larger	75	8

The recommended locations of clean outs are as under:

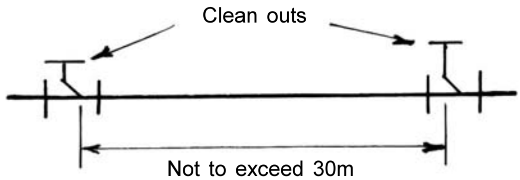
i) At every 30m interval of horizontal drainage line.

ii) Inside the building at a point of exit, 'Y' junction branch or trap

iii) At every change of direction greater than 45 degree.

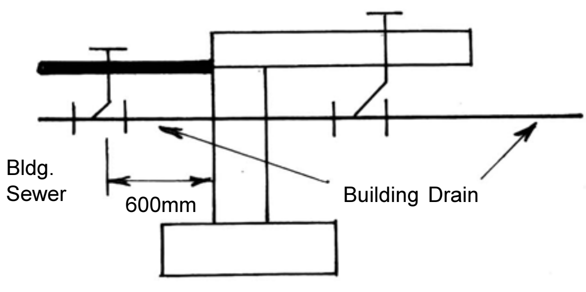
iv) At the horizontal header, receiving vertical stacks.

Each cleanouts shall be installed so that it opens to allow cleaning in the direction of flow of the soil or waste or at right angles thereto and, except in the case of 'Y' branch and end of line cleanout shall be installed vertically above the flow line of the pipe. Cleanouts installed under concrete or asphalt paving shall be made accessible by yard boxes or by extending flush with paving with approved materials and shall be adequately protected.



i) Installation of cleanouts on straight runs

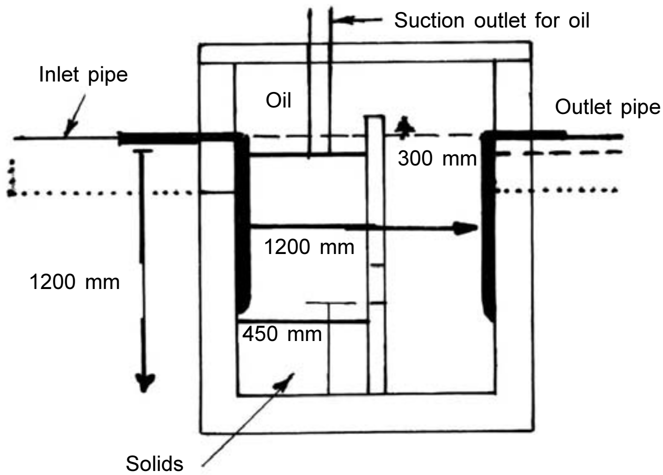
ii) Location of cleanouts for change of direction



iii) Installation of cleanouts at 600mm outside the building and inside building at first floor level

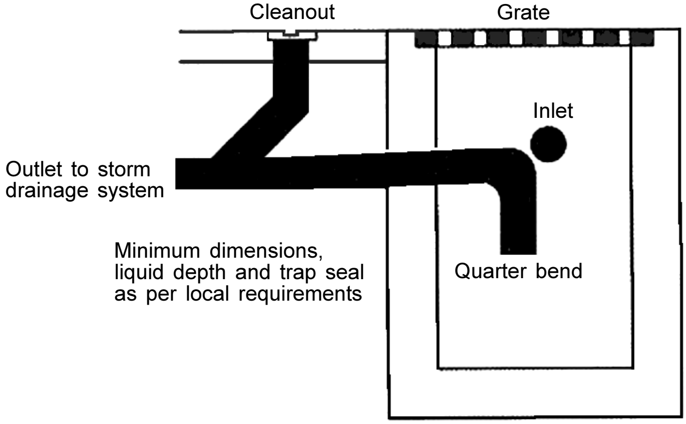
2.5 Oil interceptor:

Oil and lubricants used in loco sheds, carriage and wagon shops, workshops often get washed away with waste water and many times also carry with it cotton waste soaked in grease and lubricants. The oil and lubricants are lighter than water and float on the surface of water and the saturated cotton waste being heavy settles down on the bottom. To avoid clogging of the drainage system and not to pollute the waste water, oil interceptors are placed in the drain line. The floating oil/lubricants are decanted from the top surface and the settled waste is removed by dredging manually at periodic intervals. The principle of gravity oil/lubricant interceptor is given in sketch below. There are other types of interceptors like hydro-mechanical grease interceptors which separate the oil and grease and store separately using pumps and other equipment.



Principle of gravity oil/grease interceptor

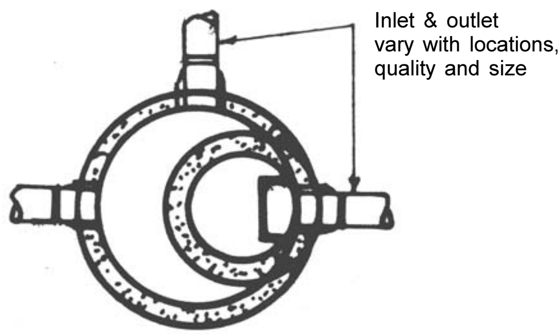
2.6 Catch basins:- Suspended solids can be removed from liquids by using catch basins. Floating solids can be prevented from entering the drainage system by installing a quarter bend inside the catch basin, which faces downwards. Figure shows a system where suspended solids can be removed from storm water or liquid waste by using sump or catch basins. These are used on curb of streets for collection of rain water.

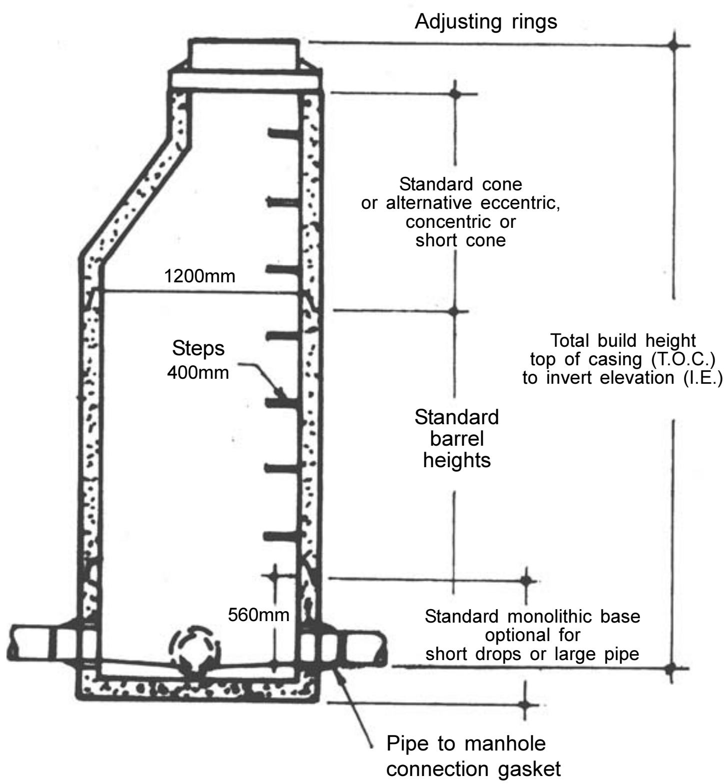


Catch basin

2.7 Man holes:- The openings which are provided in the sewer line for a man to enter through it for inspection, cleaning, repairing and maintenance are called man hole.. There are masonry RCC chambers and fitted with CI or RCC cover at top. Man hole are provided at every bend, junction, change of gradient or change of sewer diameter. According to IS 411 spacing of manholes is designed with reference to sewer diameters as given below:

Sewer Dia. In mm	Up to 300	301 to 500	501 to 900
Spacing in meters	45	75	90





The crown of the pipes, in case of different diameters of pipes meeting in a manhole, should be same level and the necessary slope given in the invert of the manhole chamber. The normal size of the circular manholes depends on the depth of the manholes and is as under,

i) For depths 0.9-1.65 m …… 900 mm diameter

ii) For depths 1.65-2.30 m ….. 1200 mm diameter

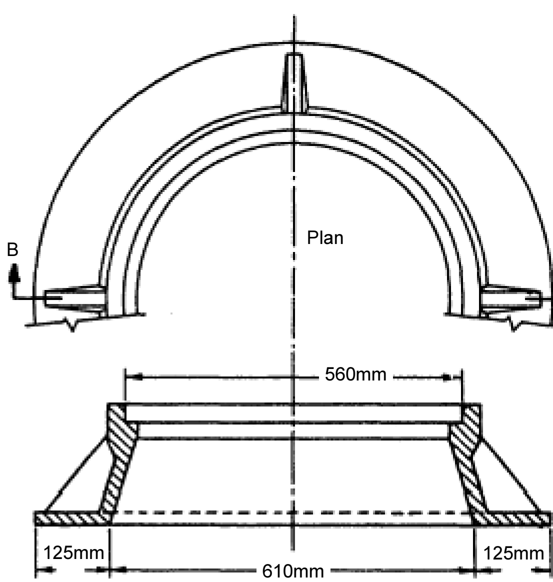
iii) For depths 2.30-9.00 m …… 1500 mm diameter

iv) For depthw 9.00-14.00 m … 1800 mm diameter

The manholes are to be provided with a cover, placed in a frame embedded in plane concrete over the masonry, in proper alignment and level. The cover should be 500 mm diameter.

2.7.1 A junction box is similar to a manhole but is installed, of necessity, at a point where two or more trunk lines converge. The walls of an inlet, manhole, or junction box maybe constructed of special concrete masonry units or of cast-in-place concrete. The bottom consists of a formed slab, sloped in the direction of the line gradient and often shaped with channels for carrying the water across the box from the inflowing pipe to the outflowing pipe.

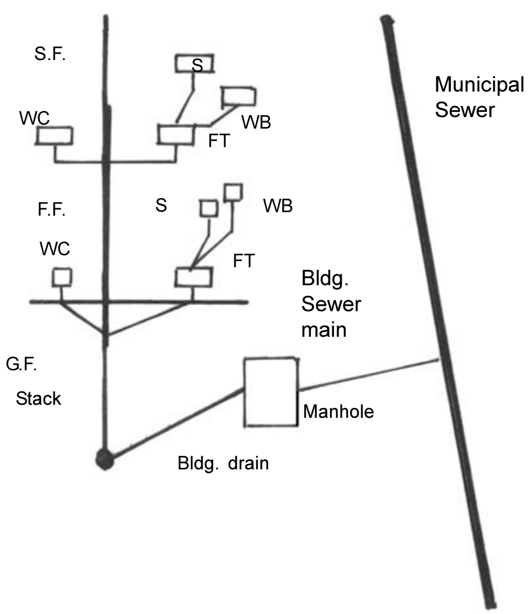
2.8 The access opening for a manhole, curb inlet, or junction box consists of the cover and a supporting metal **frame.** A frame for a circular **cover** is shown in figure below.



Section B-B

Some covers are rectangular. The frame usually rests on one or more courses of **adjusting blocks** so that the rim elevation of the cover can be varied slightly to fit the surface grade elevation by varying the vertical dimensions, or the number of courses of the adjusting blocks.

3.0 Building drainage: The term 'stack' is used for the vertical pipe line of soil or waste water piping into which the soil or waste branches carry the discharge from fixtures. Branch pipes are 'T', 'Y', 'T-Y', double 'Y' and 'V' shaped and connect the fixtures to the sewer main or stack. A waste stack carries liquid wastes that do not contain human excrement; a soil stack carries liquid wastes that carry human excreta . Most buildings do not have separate soil and waste stacks. A single stack known as the soil and waste stack, or simply the soil stack, serves to carry both soil and waste water. Soil stacks are usually made of cast-iron pipe with caulked joints. They may, however, be made of other materials like PVC, AC pipes etc. The stacks discharge to the building drains, which are horizontal pipes and lead to a manhole or an inspection chamber. The pipes which finally take the waste water from the building drain and connect to the 'municipal sewer' or any other approved point of disposal is called 'Building sewer'.



Sketch showing sewer system in 3-storied bldg.

3.1 System of plumbing for building drainage:

i) Two pipe system,

ii) One- pipe system,

iii) Single stack system, and

iv) Single stack partially ventilated system.

3.1.1 Two pipe system:- In this system of plumbing, the soil and the waste pipes are distinct and separate as shown in figure. The soil pipes are connected to the building sewer direct. Waste pipes are connected to the building sewer through a trapped gully. The gully trap forms a barrier to the passage of foul air from the sewer into waste pipe.

All traps of soil appliances are completely ventilated through a separate ventilating pipe. Likewise traps of all waste appliances are completely ventilated through a separate ventilating pipe. Thus this system of plumbing contains one soil pipe, one waste pipe and two ventilating pipes.

The two-pipe system is age-old and safe system, especially advantageous where the sullage (waste water) from waste appliances can be dealt with separately for use in gardening or other such purposes. The two pipe system is proper system to adopt where fitments are scattered with water closet, baths and basins widely separated. Due to unsightly and uneconomic web of pipes, this system is not much favored today.

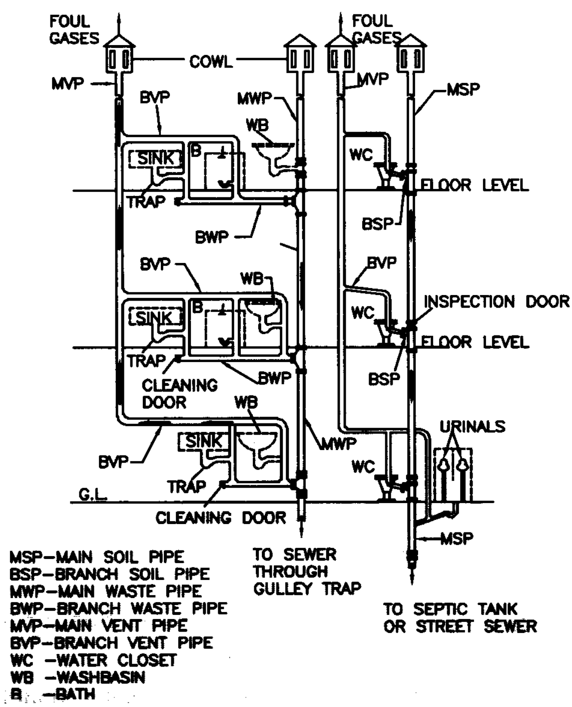
This system is best suited when,

i) The location of toilets and stacks for the WCs and waste fittings is not uniform or repetitive.

ii) In large buildings and houses with open ground and gardens, the sullage water from waste pipes can be usefully utilized.

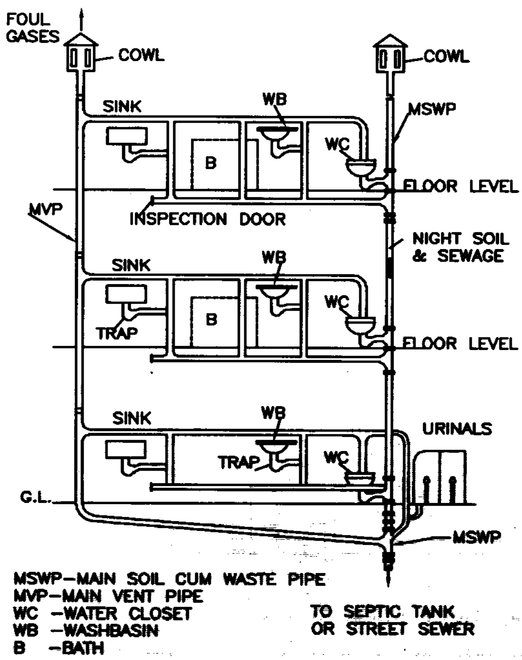
iii) In large colonies and multi-storied buildings, the sullage is treated within the premises for reuse for flushing WCs, cooling towers, gardening etc.

3.1.2 One pipe system:- In this system of plumbing, foul water from all soil appliances and waste water from shower, washbasin, sink etc. is connected to one main pipe which is connected to the building sewer. Gully traps and separate waste pipes are completely dispensed with. All the traps of soil and



Two pipe system

waste appliances must have adequate water seal, which should be maintained all the times. They are completely ventilated through a single ventilating pipe. The term one pipe system is a misnomer as there are actually two stacks, one soil-cum-waste pipe, and the other vent stack. A typical one-pipe system is illustrated in figure. Assembled soil-stack inlet hubs and threaded connections should face up and out. The system works better because of continuous flow of waste water which makes it less prone to blockage. This system also dispenses with provision of gully traps which require constant cleaning.



One pipe system

This system is suitable for buildings when,

i) The toilet layout and the shafts are repetitive. It requires less space and is economical.
ii) The system is best suitable if the main pipes run at ceiling of the lowest floor or in a service floor.

3.1.3 Single stack system:- In this system, all soil and waste fittings discharge in to a single pipe called soil-cum waste pipe. This system of plumbing is the same as one-pipe system but without separate ventilation pipe. Thus it contains only one soil-cum waste pipe and there is no separate ventilating pipe. The stack itself is made to serve the vent requirements by restricting the flow in the stake. It is also extended above the roof of the building to provide partial ventilation.

Single stack system has been found satisfactory in actual working if there is close grouping of sanitary appliances and short branches discharge soil and waste into the main stack in the direction of flow, thereby minimising the danger of loss of water seal of traps by induced siphonage. Adequate cleanouts are necessary in the stack so the plumbing and sewer line can be serviced and cleaned. Following additional safeguards as per National Building Code, should be taken for adopting this system,

i) As far as practicable the fixtures on a floor be directly connected to stack to increase flow in the downward direction.

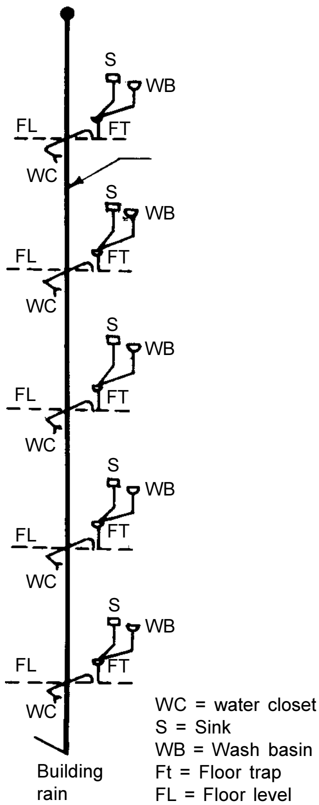
ii) The vertical distance between the waste water branch and WC branch connection should be separated by minimum 200 mm when soil pipe is above waste water branch.

iii) Depth of water seal in fixtures should be 50 mm when connected to waste pipes of 75 mm or more but should be 75mm when the diameter of branch waste pipe is less than 75 mm.

iv) Branches and stacks which receive discharge from WCs should be not less than 100 mm.

v) The lowest stack should be given large radius bend to meet the horizontal building drain, to avoid back pressure. The vertical distance between lowest connection from the invert level of drain should be minimum 750 mm, in case of more than 4 storeys and can be 450 mm for lesser height.

vi) For taller buildings, ground floor appliances are recommended to be directly connected to manhole and not to the stack.



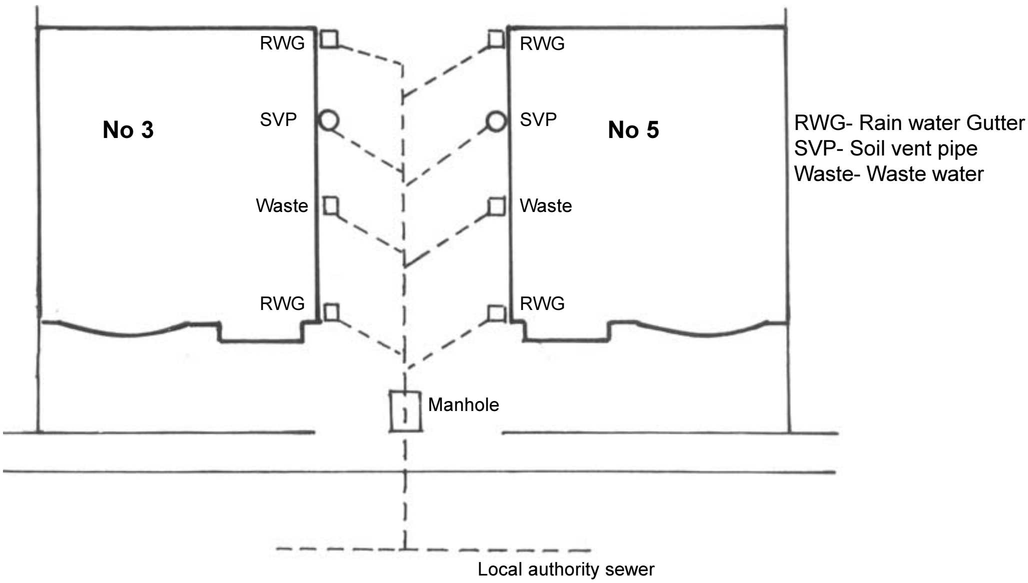
vii) For economy of sanitary pipe work, the single stack system as shown in figure is used now a days in both domestic and public buildings. It is recommended with 100 mm diameter stack up to 5-storeys. Not more than two toilet units should be discharged into the single stack at each floor.

3.1.4 Single stack partially vented system:- In this system there is one soil pipe into which all soil and waste appliances discharge and only the trap of all the soil appliances are ventilated through a single ventilating pipe. Thus it contains soil-cum-waste pipe and one ventilating pipe for the soil appliance only. Thus it is a via-media between the one pipe system and the single stack system.

Adequate cleanouts are necessary in the stack so the plumbing and sewer line can be serviced and cleaned.

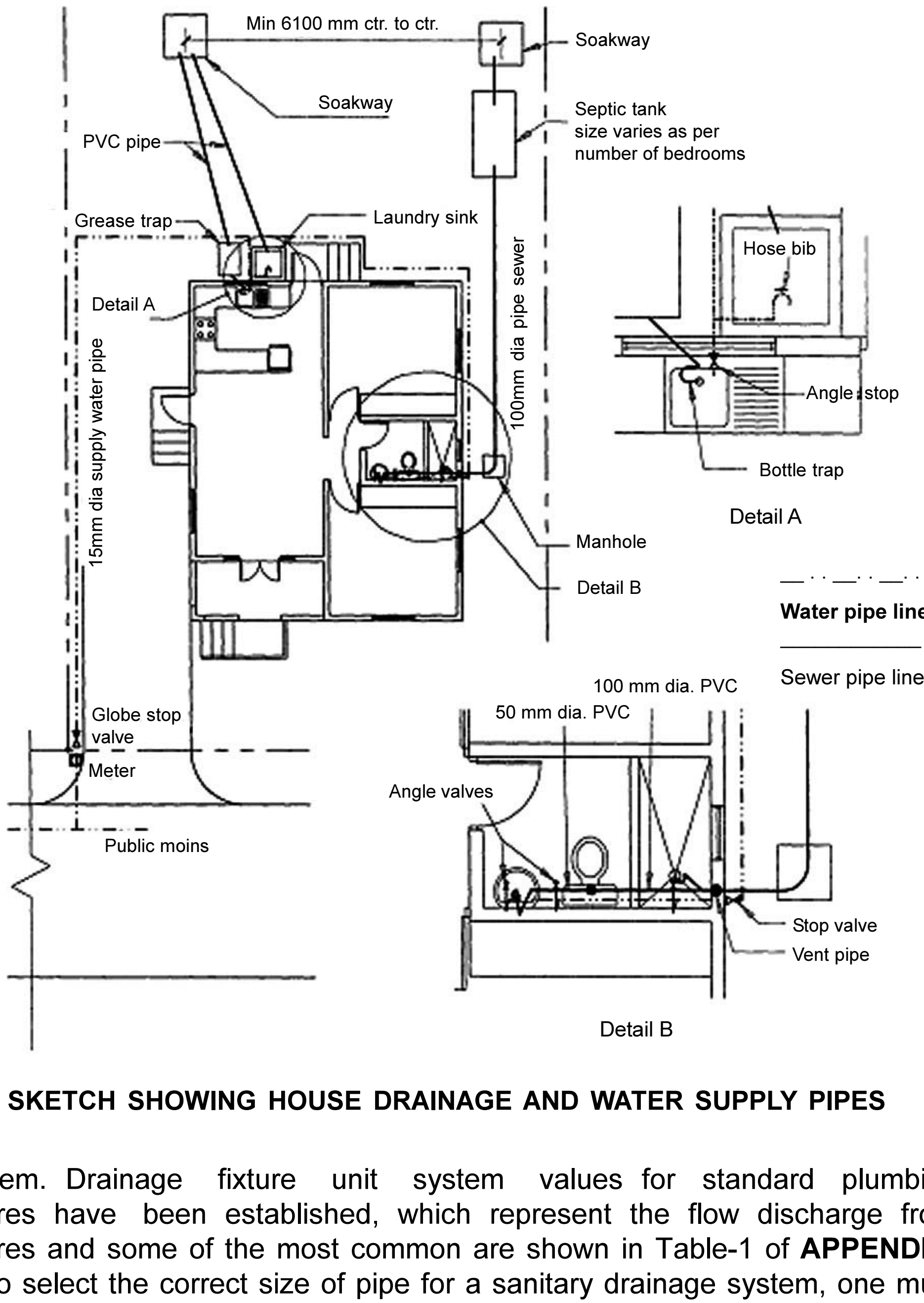
3.2 installation of the soil stack: In the actual installation of the soil stack, one of the initial considerations should be fastening the hub to floor beams of the first floor. This is accomplished by means of a pipe rest set in notches which are cut into the joist or beams, or by means of wooden cleats. This hub should be firmly placed as it is the foundation on which the stack is built up to the roof.

If the home has only one storey, with a ground-floor bathroom, it will be necessary to use a T-Y fitting instead, of a hub, as this will receive the discharge from the water closets all other fixtures on the floor. In that case, the entire support of the stack will depend on this fitting, which must be located properly to assure the proper slope of the piping.



SKETCH SHOWING DRAINAGE IN TWO BUILDING BLOCKS

3.3 Sizing stacks and branches: The vertical sewer pipe which collects the discharge from various fixtures is i.e. 'Stack' and the building drain in a sanitary system must be of sufficient size to carry off all the water and waste materials that may be discharged into it at any one time. The minimum allowable size is 75 mm for cast-iron pipe, but sound practice prescribes a 100 mm pipe, and most plumbing codes or ordinances require 100 mm pipe as a minimum. Increasing the size beyond that computed as required does not increase the efficiency of the drain. The passage of liquid and solid waste through a horizontal pipe, i.e. the building drain creates a natural scouring action, which is partially lost when the size of the drain is increased above the necessary size. The flow in too large a pipe is shallow and slow, and solids tend to settle to the bottom. The solids may accumulate to such an extent that they cause stoppages in the line. The standard method used in determining the size of a building drain is the Unit



SKETCH SHOWING HOUSE DRAINAGE AND WATER SUPPLY PIPES

System. Drainage fixture unit system values for standard plumbing fixtures have been established, which represent the flow discharge from fixtures and some of the most common are shown in Table-1 of **APPENDIX-2**. To select the correct size of pipe for a sanitary drainage system, one must first calculate the total volume of liquid waste, expressed in drainage fixture units (dfu), that the system wil be subjected to.

The Table-1 in **APPENDIX-2**, gives the recommended size of drain pipes for different fixtures and weighted units (drainage fixture unit) for connecting them to the main pipes.

Table–2 of **APPENDIX-2** gives the recommended maximum unit loading and maximum length of drainage and vent pipes for connecting to mains.

The maximum no. of fixtures units that can be connected to branches, stacks, building drains and sewers as recommended by National Building Code are given in **APPENDIX-2**, table-3 and 4. The velocity and discharge in different diameter pipes at different gradients is given in **APPENDIX-2**, table-5.

3.4 General considerations:

i) All vertical soil, waste, ventilating pipes shall be covered on top with a heavily galvanized iron wire dome or cast iron terminal guards. All C.I. pipes are to be painted periodically and shall be fixed to give a minimum clear cover of 50 mm from the wall by means of suitable clamps. A.C. cowls may be used in case of A.C. pipes are used as soil pipes.

ii) Horizontal drainage lines connecting with other horizontal lines must enter with 45^{O} fittings.

iii) All vertical drainage lines connecting with horizontal drainage lines must enter through 45^{O} 'Y' branches or other equivalent fitting of equal deviation.

iv) Where shaft is used for carrying the stacks, the same shall be big enough for allowing inspection and repairs when required. In no case it should be less than 1X1 m.

v) The rain water pipe shall in no case be connected to soil pipe and there shall not be any trap in soil pipe or between it and any drain with which it is connected.

vi) The ventilating pipe shall always be taken to appoint 1500 mm above the level of eaves or flat roof or parapet whichever is higher or top of any window within a horizontal distance of 3 m.

vii) Branch ventilating pipes should be connected to the top of branch soil pipe and branch waste pipe between 75 mm and 450 mm from crown of the trap.

viii) Clean outs provide access to horizontal and vertical pipes and stacks to allow inspection and a means to remove any obstruction that may cause chockage. The size of clean out should be same as that of pipe up to 100mm pipes. For larger diameter pipes also, 100 mm clean out is adequate. These should be provided, at point of exit, 'Y' junction branch, or a trap. They also should be provided at every change of direction greater than 45 degrees, and at the base of the stacks.

4.0 Storm water drainage:- Sanitary sewers carry waste from buildings to points of disposal; storm sewers carry surface runoff water to natural water courses or basins. In either case the utility line must have a gradient; that is, a downward slope toward the disposal point, just steep enough to ensure a gravity flow of waste and water through the pipes.

4.1 Natural drainage:- When rainwater falls on the earth's surface, some of the water is absorbed into the ground. The amount absorbed will vary, according to the physical characteristics of the surface. In sandy soil, for instance, a large amount will be absorbed; on a concrete surface, absorption will be negligible. Of the water not absorbed into the ground, some evaporates, and some absorbed through the roots and exuded onto the leaves of plants, dissipates through a process called transpiration.

The water that remains after absorption, evaporation, and transpiration is technically known as runoff.

4.2 Artificial drainage:- When artificial structures are introduced into an area, the natural drainage arrangements of the area are upset. When, for example, an area originally containing many hills and ridges is leveled off flat, the previously existing natural drainage channels are removed, and much of the effect of gravity on runoff is lost. When an area of natural soil is covered by artificial paving, a quantity of water that previously could have been absorbed will now present drainage problems.

In short, when man-made structures, such as bridges, buildings, and so forth, are erected in an area, it is usually necessary to design and construct an artificial drainage system to offset the extent to which the natural drainage system has been upset. Storm sewers are usually the primary feature of an artificial drainage system; however, there are other features, such as drainage ditches. Both storm sewers and ditches carry surface runoff. The only real difference between a drainage ditch and a storm sewer is the fact that the ditch lies on the surface and the storm sewer lies below the surface.

5.0 Storm water drainage system: Storm water drainage systems are designed to drain all the run off from the terrace tops, rain fall in the open areas and any other getting added from nearby areas after accounting for the rain fall that would be soaked up by the ground. The imperviousness factor for different types of areas are as under:

Type of area	Imperviousness factor(%)
Commercial and Industrial area	70-90
Residential heavy density	60-75
Residential low density	35-60
Parks and open spaces	10-20

It would therefore of interest that more the perviousness/ porosity of the area, lesser run off and smaller the storm water drainage system requirement. Besides by more percolation the water table of the area is recharged. In this direction it is better to provide the circulating areas, the walk ways, the walking plazas etc. with open jointed brick paving or with interlocking blocks.

5.1 Planning: Following should be considered while designing a storm drainage system:

i) The area should become self draining by gravity with respect to H.F.L.(High Flood Level) of the area or the drainage channel passing the area.

ii) Level of the main road or any such continuing feature should be determined to ensure proper drainage.

iii) The drainage should follow natural slopes.

iv) The intensity of rainfall, design frequency of storm and the time of concentration i.e. the time for the water to reach the outfall from the area needs to be worked out for proper design of the drainage system.

5.1.1 Roof drainage: The slope on the terrace of flat roofs should be minimum 1 in 100 and should be steeper up to 1 in 66, for rough finish surface. The rain water pipes of C.I. are normally used as rain water pipes.

a) The size of pipes according to flat roof area should be given below,

Dia.of pipe	Roof area in m^2 for average rain fall in mm/hour					
	50	75	100	125	150	200
50	13.4	8.9	6.6	5.3	4.4	3.3
65	24.1	16.0	12.0	9.6	8.0	6.0
75	40.8	27.0	20.4	16.3	13.6	10.2
100	85.1	57.0	42.7	34.2	28.3	21.3
125	159.71	106.73	80.5	64.3	53.5	40.0
150	249.60	166.82	125.27	100.0	83.6	62.7

The number of pipes of a chosen diameter can be worked out knowing the average intensity of rain fall and the area of flat roof. It is better to have multiple no. of pipes towards the lower edge of the roof to minimize the length of travel of water on the roof.

b) In case of sloping roofs like GI sheet or AC sheet roofings, the slope of the gutter is normally kept between 1:100 to 1:200 and the horizontal projection of roof area in sq. m for different diameter of gutters and slopes should be as below:

Φ(mm) of gutter/ slope	Maximum rainfall in mm per hour									
	50 mm		75mm		100mm		125 mm		150mm	
	1:200	1:100	1:200	1:100	1:200	1:100	1:200	1:100	1:200	1:100
75	32	45	20	30	16	22	12	18	10	15
100	65	95	44	63	32	45	26	35	22	30
125	115	160	75	110	58	80	45	65	38	54
150	175	250	115	165	90	125	70	100	60	80
175	250	360	170	240	125	180	100	145	85	120
200	350	520	250	345	185	260	145	200	120	170
250	670	945	450	630	335	465	250	375	220	315

For rainfall between the values given above, the area should be worked out in proportion to the intensity of rain fall.

5.1.2 The rain water pipes can discharge directly on the ground or collect in a surface drain and lead to a street drain, if the street drain is with in 30 m, otherwise it should be carried in an under ground rain pipe up to the road curb inlet. It shall not connect to a soil pipe, waste water pipe or ventilating pipe nor shall it discharge into a sewer. In case of special permission by the municipal authorities, the rain water pipe may discharge to the sewer duly intercepted by gully trap. In case of none of the things are available then the rain water pipe has to be carried to the nearest pond, low area etc.

5.1.3 The storm runoff or discharge has to be estimated by detailed survey of the area and assessing the design frequency and time of concentration of the storm water for a particular topography. The imperviousness factor also is to be accounted for, based on the land use pattern.

5.1.4 Storm sewer route survey:- The character of the route survey for a storm sewer depends on the circumstances. The nature of the ground may be such as to indicate, without the necessity for reconnaissance and preliminary location surveys, just where the line must go. This is likely to be the case in a development area; that is, an area that will be closely built up and in which the lines of the streets and locations of the buildings have already been determined. In these circumstances, the reconnaissance and preliminary surveys may be said to be done on paper.

On the other hand, a line - or parts of it - often must be run for considerable distances over rough, irregular country. In these circumstances the route survey consists of reconnaissance, preliminary location, and final-location surveys. If topographic maps of the area exist, they are studied to determine the general area along which the line will be run. If no such maps exist, a reconnaissance party must select one or more feasible route areas, run random traverses through these, and collect enough topographic data to make the planning of a tentative route possible.

After these data have been studied, a tentative route for the line is selected. A preliminary survey party runs this line, making any necessary adjustments required by circumstances encountered in the field, taking profile elevations, and gathering enough topographic data in the vicinity of the line to make design of the system possible. The system is then designed, and a plan and profile are made.

5.1.5 The system consists of pipe, inlets, catch basins, and other drainage structures to carry the surface runoff to a point of disposal. Storm drainage systems should be separate from sanitary sewage systems. However, storm water should never be drained into sewers intended for sanitary sewage only. This involves laying storm drain lines both inside and outside buildings and other structures. This pipe material may be the same as that used for the sewerage system. Storm sewer systems, however, may include pipe of much larger sizes than are needed for sanitary sewers. Plain or reinforced concrete pipe (rather than clay, cast iron, or asbestos cement) is generally used for the larger lines. Also, it is not so important that the joints be watertight in storm sewer systems. In fact, the mortar is sometimes omitted from a portion of the joint and washed gravel is placed next to the opening; the storm drain thus serves also as an under drain to pick up subsurface water. Storm and sewerage systems may differ in the installation of the piping. When a change of direction is necessary, long radius fittings are used and a cleanout need not be installed. This is especially true in and under buildings. But a manhole is used outside of buildings when a change of direction is necessary, or when two or more lines are connected together.

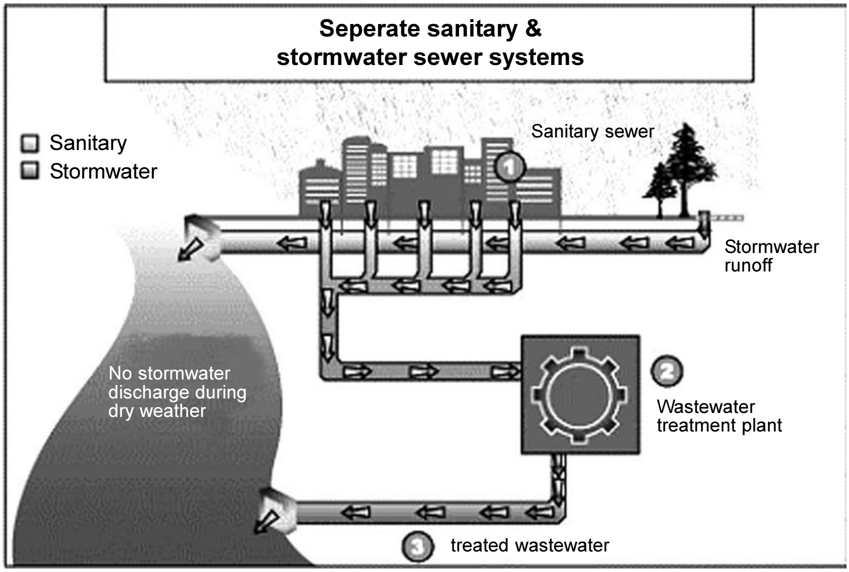
5.2 Drainage systems:-

i) Combined system:- A system in which sewage (foul water) and storm water (surface water) are conveyed by the same sewers and drains. This is not permitted in new systems in newer cities and towns however, exists in some old towns and cities.

ii) Separate system:- A system in which sewage and storm water are conveyed by the separate sewers and drains. This is adopted in all new sewerage and storm water disposal systems.

iii) Partially separate system:- A modification of the Separate system in which part of the storm water is conveyed by the sewage sewers and drains.

Whatever be the system of disposal of storm water, it primarily is the same except for connections either to the sewerage pipe or running independently.



5.2.1 Surface drains: A surface drainage system consists principally of ditches that form the drainage channels. A ditch may consist simply of a depression formed in the natural soil, or it may be a paved ditch. Where a ditch must pass under a structure (such as a highway embankment, for example), an opening called a culvert is constructed. A pipe culvert has a circular opening; a box culvert has a rectangular opening. Walls constructed at the ends of a culvert are called end walls or abutments. An end wall, running perpendicular to the line through the culvert, may have extensions called wings (or wing walls), running at an oblique angle to the line through the culvert.

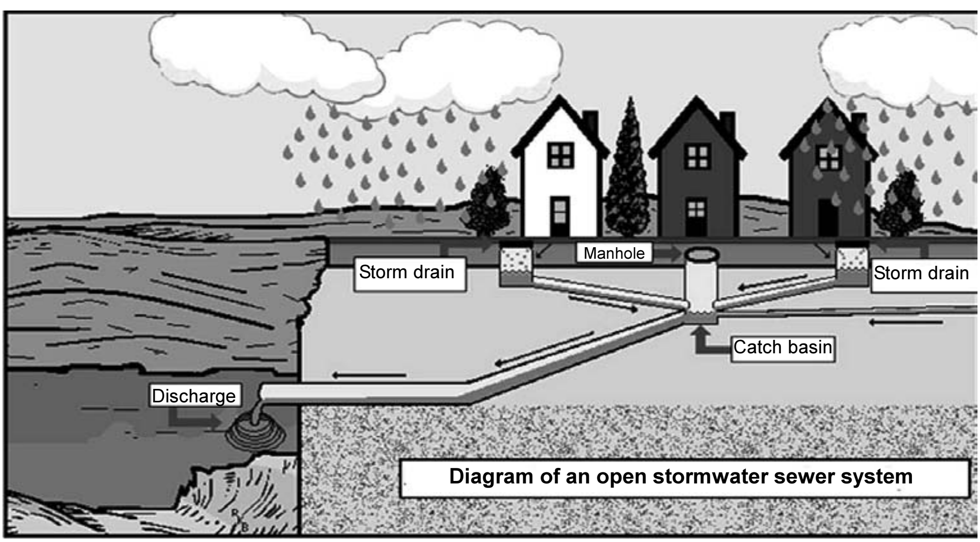
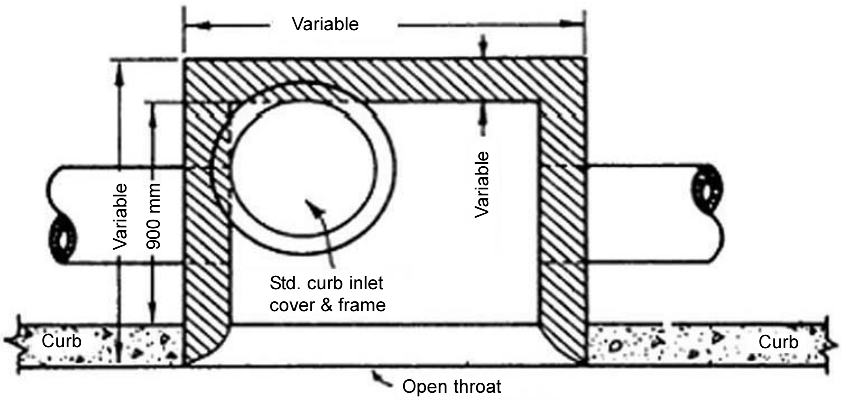
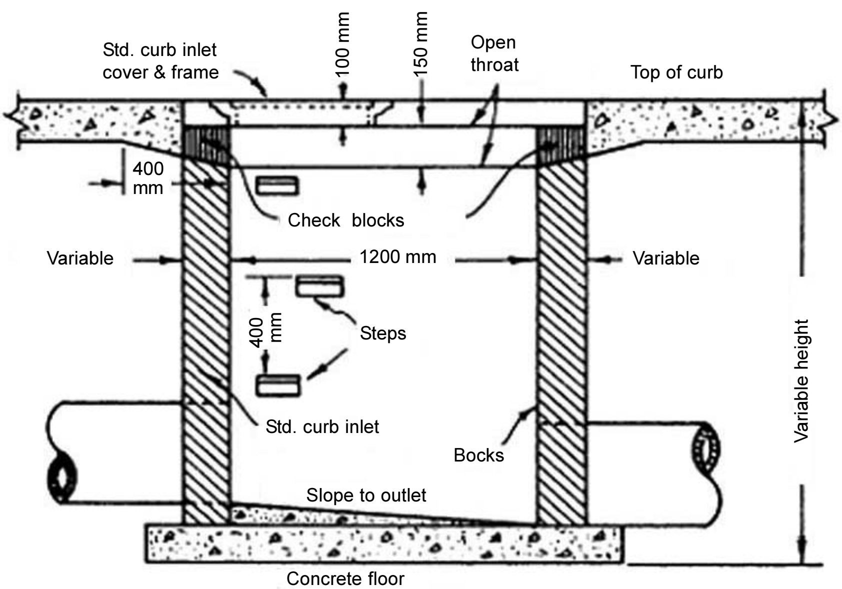


Diagram of an open stormwater sewer system

5.2.2 Storm sewers: An underground drainage system (that is, a storm sewer) consists, broadly speaking, of a buried pipeline called the trunk or main, and a series of storm water inlets, which admit surface runoff into the pipeline. An inlet consists of a surface opening that admits the surface water runoff and an inner chamber called a box (sometimes called a catch basin). A box is usually rectangular but may be cylindrical. An inlet with a surface opening in the side of a curb is called a curb or curb inlet. A working drawing of a curb inlet is shown in figure below,



Plan



Section on curb line

An inlet with a horizontal surface opening covered by a grating is called a grate (or sometimes a drop) inlet.

5.2.3 Appurtenances: Technically speaking, the term storm sewer applies to the pipeline; the inlets are called appurtenances. There are other appurtenances, the most common of which are manholes. A manhole is a box that is installed, of necessity, at a point where the trunk changes direction, gradient, or both. These are of similar design and construction as sanitary manholes. Distances between manholes are normally 100 m, but this distance may be extended to a maximum of 150 m., when specified.

6.0 Septic tanks

6.1 In the rural or undeveloped areas, where municipal sewers are not yet laid and where there are no facilities to carry the sewage to the public sewage treatment plants, septic tanks are constructed for satisfactory disposal of the sewage from the isolated buildings.

6.2 Septic tank is a plain sedimentation tank, where bio chemical reaction by anaerobic bacteria takes place. Sewage is detained in the tank in 3 zones, sedimentation, digestion and storage. The septic tank should be as far removed from nearest habitable building as economically feasible, but not closer than 6.0m, to avoid damage to the structure.

6.3 Stages of functioning

All sewage from the building is collected in a sewer chamber provided with sewer trap. The inlet of the septic tank is unglazed stone ware tee placed horizontally, so that the tee head remains vertical. The sewage falls down through this tee. The sewage comes in the first zone and solid particles be allowed to settle over a prescribed detention period. The balance sewage flows into the digestion chamber, where, due to unavailability of free oxygen the anaerobic action takes place, in the second zone. The organic part is degenerated in to liquids gases and residual mineral solids. In the third zone the solids settle at the bottom are called sludge. It should be removed periodically at an interval of 1 to 2 years and used as manure. The effluent is not to be disposed off except in the soak pit directly or through the “Up flow filter” chamber for further treatment.

6.4 Up flow filter

The effluent from the septic tank is allowed to pass through a filter media to improve its quality and before it is disposed off in the soak pit. This up flow filter is designed to take the effluent directly to the bottom of tank and then it passes upwards through a filter media of 20 mm stone chips, placed compactly above a false RCC bottom with sufficient openings. The outlet of the up flow filter chamber is connected to the soak pit.

6.5 Soak pit

The effluent discharged through the outlet of the septic tank is disposed through the soakage gallery or soak pit. For soak pit a spot is selected away from the human habitat. It is hollow rectangular pit of depth

1.2m to 1.8m with plan dimension not less than 1.0mx 1.0m. The pit need not be lined in case of hard strata but for loose strata brick lining should be done without plastering and the brick work backed by at least 75 mm of clean coarse aggregate. Loose brick bats are laid at the bottom to improve the soaking quality and the entire depth is filled with stones at locations where it is not proposed to cover the pit. Where it is close to the habitat, it should invariably be covered by means of a RCC slab. Effluent falls in the pit through an inlet pipe which should be at a depth of 0.9 meter from the top, as an anti-mosquito measure, and is allowed to be absorbed in the surrounding soil.

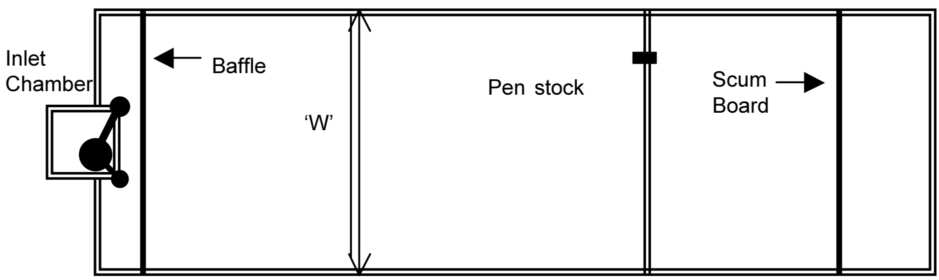
6.6 Principles of design of septic tanks

1. The capacity to be provided is to be a minimum of 100 liters per user and the minimum number for design should be 5 persons. The minimum retention period should be 24 to 36 hours.
2. The minimum inner width should be 75cm. The length should be three times the width. It is customary to divide a medium to large tank in to 3 equal chambers, however, for many septic tanks specially smaller ones, the sedimentation and digestion tank is combined as one only.
3. The liquid depth should be 1 to 2m only and the top level of the tank should be 30 cm above the liquid level thus forming an air space.
4. There will be two cross walls inside the tank with three chambers or one cross wall and two chambers as shown in figure below.
5. The inside and outside should be plastered with 1:3 cement mortar. The bottom concrete floor is given a slope 1 in 20 in bigger tanks and 1:10 for smaller tanks, towards the lintel side so that sludge will get collected there.
6. The inlet should be higher by 50mm than the outlet level.
7. The minimum nominal diameter of the pipes shall be 100 mm. At junction of pipes in man holes, when the sewage is collected at Septic tank from more than one location, direction of flow from a branch connection shall not make an angle exceeding 45 degree with the direction of flow in the main pipe.
8. The gradient of land drains, under ground drains as well as bottom of dispersion trenches, and soak ways shall not be steeper than 1:400, preferably 1:300.
9. Septic tank shall be provided with a ventilating pipe of at least 50 mm diameter. The top of the pipe should extend 2.0 m above ground when the septic tank is about 15 m away from the nearest building and should extend 2.0 m above the top of the building when the building is nearer than 15 m.
10. When the no. of users is more than 100, 2 nos. of chambers are

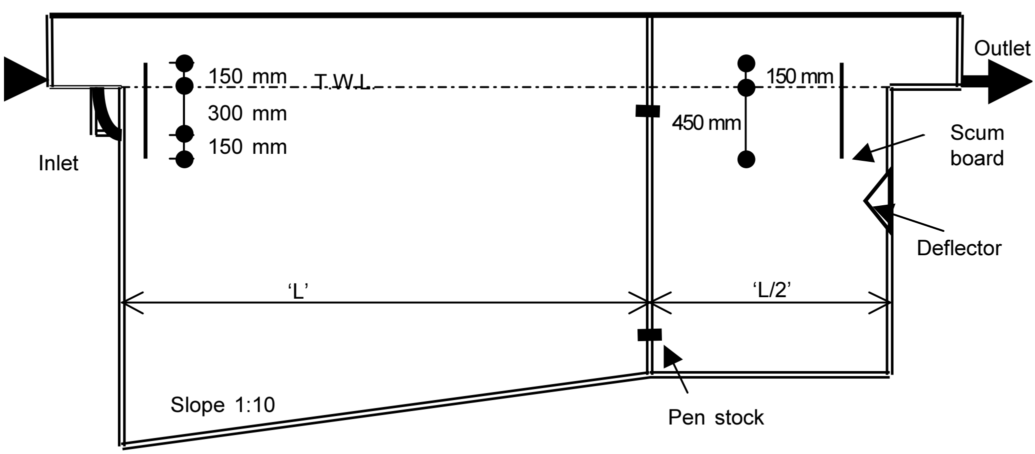
normally provided of combined capacity as required, to work in parallel, so that when one is being de-sludged the other is operative.

11. The dimensions of a septic tank for residential colony is generally as given in table below:

No. of users	Length (m)	Width (m)	Depth for desludging time	
			12 months	24 months
50	5.0	2.0	1.0 m	1.24 m
100	7.5	2.65	-do-	-do-
150	10.0	3.0	-do-	-do-
200	12.0	3.3	-do-	-do-
300	15.0	4.0	-do-	-do-



PLAN



ELEVATION

Septic tank of two compartments for more than 50 users

6.7 Maintenance of septic tanks

1. Since sludge is allowed to accumulate at the bottom of the tank, the capacity of the septic tank reduces. Therefore, septic tanks should be

cleaned every 6 to 12 months or as per the designed period for cleaning.

2. The tank should be filled with water, at the time of making it functional.
3. The effluent from the tank should be properly disposed off. Brick bats in the pit should be changed periodically.
4. Avoid the discharge of effluent in natural water bodies.

All chambers and the inlet and outlet pipe should be cleaned periodically to avoid choke-up in the system.

7.0 Maintenance and cleaning of sewers:

There are two types of maintenances namely, a) preventive and ii) emergency. Preventive maintenance works out cheaper and must be carried out periodically, where as emergency maintenance is required in case of break down in the system.

7.1 Preventive maintenance:

i) Proper and quality construction is first step towards proper maintenance.

ii) Special detergents available in market or similar generic products for cleaning of toilets, urinals should be poured and allowed to stand in the traps overnight every week and flushed in the morning. This allows maintaining the trap seal in the fixtures to the designed level.

iii) All the clean outs in traps of fixtures such as wash basins, kitchen sinks, floor traps etc. should be opened and cleaned at least once every three months. The interceptor traps, gully traps should be manually dredged and any solids removed once every six months.

iv) Check manhole condition for deposition of silt, flow, damaged walls and clean the manhole at periodic intervals.

v) Check the sewer line between two manholes and remove the deposited silt, at periodic intervals.

7.2 Maintenance essentially means removing the silt from the sewers before they get blocked and any distressed part of the sewer or appurtenance to be attended before collapse.

7.2.1 Hand excavation:- Large diameter sewers are cleared by manual digging-out of deposited material. Laborers enter the sewer and shovel sediment into skips that are transported to the surface for emptying. The method is limited in application to larger size pipe generally more than 900mm diameter.

7.2.2 Manila rope and cloth ball: For small diameter pipes up to 300 mm, this is a common method for cleaning the sewers. Bamboo strips tied together are inserted into the sewer through the manhole or even from top. When the front end of the bamboo strip reaches other manhole, a thick manila rope is tied to the rear end of the bamboo strip and pulled from downstream side. A cloth ball is attached to the rope and as the rope is pulled and pushed in the sewer, the ball sweeps the line and the grit is collected at the down stream manhole, which is manually removed. This is then carried out on next length between two manholes.

7.2.3 Sectional sewer rods : The rods may be of bamboo, hard wood or light metal about 1 m long. There is a coupling at the end of the rod by which rods can be coupled and pushed inside the sewer from one end. The front end of the first rod is fitted with a cutting edge, a brush or a rubber ring to dislodge the deposited silt or obstruction. These rods are also useful in locating the obstruction in case of caving of sewer etc. This is normally used for small dia. sewers.

7.2.4 Sewer cleaning bucket machine : A cable is threaded in the sewers by manual means using the section rods or split bamboo. The cable is attached to two powered winches on either end. One expansion sewer bucket is attached to the two ends of the cable, which is pulled by winches in both directions one by one. The buckets dredge the silt, get loaded and deposit out side the manhole. Various bucket sizes ranging between 150 mm to 900 mm are available.

7.2.5 Roding or boring machine: A flexible rod to which a cleaning tool is attached such as auger, corkscrew and sand cups, is rotated inside the sewer. The flexible rod is guided through the manhole by a bent pipe. The rod is pulled in and pulled out successively when the machine has engaged with the obstruction to dislodge it.

7.2.6 Water jetting:- It is widely used technique that relies on the ability of an applied high-pressure stream of water to dislodge deposited material from sewer inverts and wall and transport it down the sewer for subsequent removal. Jetting is a versatile and efficient procedure for removing a wide range of materials and is widely used in practice.

7.2.7 Flushing:- It is a technique in which short duration waves of liquid are introduced or created so as to scour the sediment into suspension and hence, transport to downstream. Here a flusher or flush bag is used. The bag attached to a fire hose is lowered into the sewer and allowed to fill up till it chokes the sewer. The upstream pressure built up breaks loose the obstruction.

There are several other hydraulically propelled devices such as sewer balls, sewer scooters etc. which are also used for cleaning the sewers.

APPENDIX-1

Requirement of fitments for drainage and sanitation in other than residences

S.No. (1)	Fixtures (2)	Visitors toilets Male (3)	Staff toilets Female (4)	Male (5)	Female (6)
Office Building					
i)	Water Closet	1 for 25	1 for15	1 for 25	1 for 15
ii)	Ablution tap in W.C.	1 each	1 each	1 each	1 each
iii)	Urinals	1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100	-	1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100	-
iv)	Wash basins	1 for 25	1 for 25	1 for 25	1 for 25
v)	Water fountain	1 for 100	1 for 100	1 for 100	1 for 100
vi)	Cleaners Sink	1 for each floor			
vii)	Executive rooms and conference hall	Suit of 1 W.C.+1 wash basin+1 shower(option)		1 suit for individual officers rooms	
Work shop / factory					
		Office/visitors		**Workers**	
i)	Water closet	1 for 25 2 for 26-35 3 for 36-65 4 for 66-100	1 for 15 2 for 16-25 3 for 26-40 4 for 41-57 5 for 58-77 6 for 78-100	1 for upto 15 2 for 16-35 3 for 36-65 4 for 66-100 Add 3% for beyond up to 200	1 for 12 2 for 13-25 3 for 26-40 4 for 41-57 5 for 58-77 6 for 78-100 Add 5 % for beyond
ii)	Ablution tap	1 for each water closet			
iii)	Urinals	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100 Add 3% for 100-200	-	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100 Add 3% for Add 3% for 100-200	-
iii)	Wash basins	1 for 25 or part thereof.			
iv)	Water fountain	1 for every 100 or part there of. Min. 1 at each floor.			
v)	Emergency shower and eye wash fountain	1 on each floor	1 on each floor	1 on each floor	1 on each floor
vi)	Cleaners sink	One on each floor			

(1)	(2)	(3)	(4)	(5)	(6)
Railway station and platforms					
i)	W.C.	A &B category Stns. 1 for 175 passengers* (Minm. 10 Nos.)		Other category stns. 1 for 112 passengers* (Minm.1-4 Nos.)	
ii)	Urinals	1 for 670 passengers* (Minm.10 nos.)		1 for450 passengers* (Minm. 1-4 Nos.)	
iii)	Water taps	1 for 25 Passengers*		1 for 25 passengers*	
iv)	Bath/showers	1 for 120 passengers* only at Junction and terminals		1 for 80 passengers* only at Junction and terminals	

(*) The no. of passengers is the average no. at any time during peak including the inward and outward passengers (excluding mela traffic)

APPENDIX-2

Table-1

The recommended size of drain pipes for different fixtures and weighted units (drainage fixture unit) for connecting them to the main pipes,

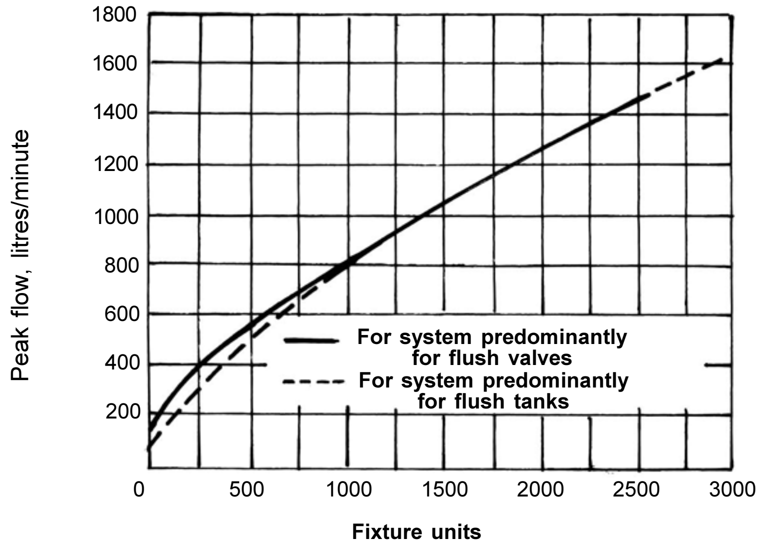
Plumbing fixtures/ appliances	Minimum trap size & trap arm (mm)and dfu's			
	Dia. mm	Weighted units equivalent (dfu)		
		Resident bldg.	Public bldg.	Assembly bldg.
Group-W.C.(tank), Wash				
basin, shower	80	6.0	6.0	8.0
Bath tub/shower	40	2.0	2.0	-
Urinal	40	1.0	2.0	2.0
Washing machine	50	3.0	3.0	3.0
Dish washer	40	2.0	2.0	2.0
Water fountain/cooler	25	0.5	0.5	0.5
Floor drain(emergency)	50	0	0	0
Floor drain (trap)	50	2.0	2.0	2.0
Wash basin	32	1.0	2.0	2.0
Kitchen sink	40	2.0	2.0	-
Water closet (tank)	80	3.0	4.0	6.0
Water closet (Valve)	80	4.0	8.0	8.0

For any fixtures not covered under above, the dfu should be adopted based on the fixture drain on trap size, as under,

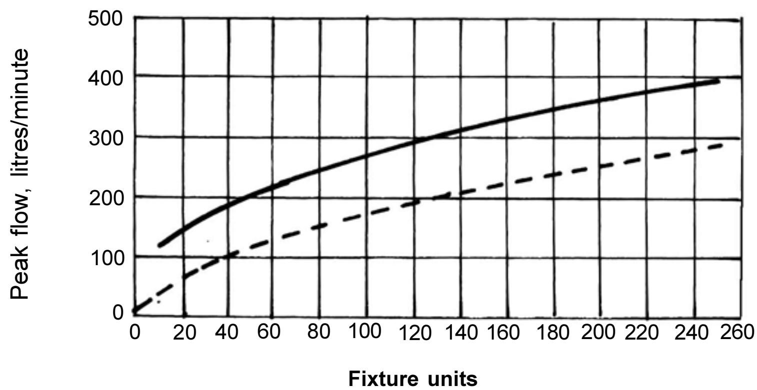
Fixture drain on trap size (mm)	Drain fixture units (dfu)
32 and less	1
40	2
50	3
60	4
80	5
100	6

The total no. of fixtures and corresponding dfus can be worked out, loaded on any branch or stack as also the sewers and correspondingly discharge in liters/minute can be assessed using the graph given below:

Graph for assessing the flow in litre/min.



Estimate curves



Enlarged graph for DFU'S 0-250

Table-2

The recommended maximum unit loading and maximum length of drainage and vent pipes for connecting to mains

Dia. (mm)	32	40	50	65	75	100	125	150	200	250	300
Maximum length(m)											
Vert.	14	20	26	45	65	91	119	155	229		
Horiz.	No limitation										
Vert. stack											
Total for one branch		2	6	9	20	90	200	350	600	1000	1500
Total for stack		8	24	42	72	500	1100	1900	3600	5600	8400
Vent pipe length,(m)											
Vert or horiz.	14	18	37	55	65	91	119	155	229		
Maxm. Units	1	8	24	48	84	256	600	1380	3600		

Table-3

Maximum number of fixtures-units that can be connected to branches and stacks

Diameter of pipe (mm)	**Maximum no. of fixtures units that can be connected**			
	Horiz. Fixture Branch(*)	One stack of 3-storey in height or 3 intervals	More than 3- storey height	
			Total for Stack	Total at 1 storey or Branch interval
30	1	2	2	1
40	3	4	8	2
50	6	10	24	6
65	12	20	42	9
75	20	30	60	16
100	160	240	500	90
125	360	540	1100	200
150	620	960	1900	350
200	1400	2200	3600	600
250	2500	3800	5600	1000
300	3900	6000	8400	1500
375	7000	-	-	-

(*) Does not include branches of the building sewer

Table-4

Maximum number of fixtures units that can be connected to building drains and sewers

Diameter of pipe (mm)	Maximum no. of fixtures that can be connected to any portion of (*) building drains or building sewer for gradient			
	1 in 200	1 in 100	1 in 50	1 in 25
100	-	180	216	250
150	-	700	840	1000
200	1400	1600	1920	2300
250	2500	2900	3300	4200
300	3900	4600	5600	6700
375	7000	8300	10000	12000

(*) Includes branches of the building sewer also.

Table-5

Different diameter of pipes giving velocity and corresponding discharge at minimum and maximum gradients.

Diameter (mm)	Maxm. gradient for velocity 0.75 m/sec	Discharge at minm. gradient (m^3/min.)	Maxm. gradient for velocity 2.4m/sec	Discharge at maxm. gradient (m^3/min.)
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	2.40
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

APPENDIX-3

Design of drainage system

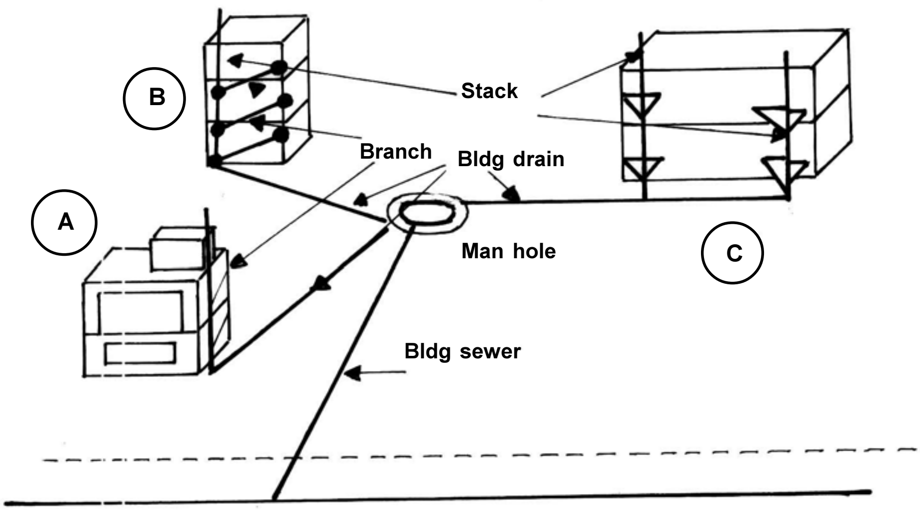
Problem:- There are 3 buildings v.i.z. A, B, and C with fixtures as shown below. Find out the diameters of pipes required to be used for

a) Horizontal Branches

b) Stacks

c) Building drains

d) Building sewer



Municipal main sewer

SOLUTION:- For smaller size of infrastructure like in present case, the design can be done using the tables given in **APPENDIX-2**, as below,

Building	Fixture	Quantity (Nos)			DFU*			
		Per branch	Per Stack		Per Fixture	Per Branch	Per Stack	
A, 2-No.	W.C.(Tank)	2	4		3	6	12	
residences,	W.B.	3	6		1	3	6	
Branches-2	Shower	2	4		2	4	8	
Stack -1	Kitchen sink	1	2		2	2	4	
	Water Fountain	1	2		0.5	0.5	1	
	Sub-Total					15.5	31	
B, 3-No.	W.C.(Valve)	2	6		4	8	24	
residences,	W.B.	2	6		1	2	6	
Branches-3	Shower	2	6		2	4	12	
Stack -1	Kitchen sink	1	3		2	2	6	
	Washing M/C	3	9		3	9	27	
	Sub-Total				25	75		
			/stack	total			/stack	total
C, 4-No.	W.C.(Tank)	-	2	4	3		6	12
residences,	W.B.	-	2	4	1		2	4
Branches-0	Shower	-	4	8	2		8	16
Stack -2	Kitchen sink	-	2	4	2		4	8
	Dish washer	-	2	4	2		4	8
	Sub-Total						24	48
	TOTAL						154	

Building A

Load on branches bldg. A = 15.5 DFU (Provide 75mm dia pipe as per table 3 of Appx.2)

Load on stacks bldg. A = 31 DFU (Provide 75mm dia pipe as per table 3 of Appx.2)

Load on bldg. drain on bldg. A = 31 DFU (Provide 100mm dia pipe as per table 4 of Appx.2)

Building B

Load on branches bldg. B = 25 DFU (Provide 100mm dia pipe as per table 3 of Appx.2)

Load on stacks bldg. B = 75 DFU (Provide 100mm dia pipe as per table 3 of Appx.2)

Load on bldg drain bldg. B = 75 DFU (Provide 100mm dia pipe as per table 4 of Appx.2)

Building C

Load on stacks	=	24 DFU (Provide 75mm dia pipe as per table 3 of Appx.2)
Load on building drain bldg C	=	48 DFU (Provide 100mm dia pipe as per table 4 of Appx.2)

Building sewer:-

Total load on building sewer (Man hole to municipal sewer)	=	154 DFU

As per table 4 of **APPENDIX-2**, 100mm diameter of pipe at a gradient of 1:100 is adequate. Maximum length of pipes horizontal and vertical is to be restricted as per Table-2.

However, when much bigger infrastructure is to be designed, use of formulae for water flow in pipes and channels may be resorted to. In that case the first step is to work out the amount of discharge in liters/sec from the Table 1 and the graph given there under in **APPENDIX-2**.

Chapter 6

SUBSURFACE WATER SOURCES

1.0 Ground water:- Most rainwater is absorbed by the ground and fills the tiny spaces between soil particles. However, excess water runs over the top of the soil until it reaches a river, stream, or reservoir. Runoff water brings pollutants it encounters along the way to the reservoir.

As water seeps into the ground, it settles in the pores and cracks of underground rocks and into the spaces between grains of sand and pieces of gravel. In time, the water trickles down into a layer of rock or other material that is watertight. This watertight zone collects the groundwater, creating a saturated zone known as an aquifer. Aquifers are usually made from gravel, sandstone, limestone, or basalt (volcanic rock). This water can be tapped for irrigation and drinking purpose as well. Most rural areas, and some cities depend on groundwater as their source for water.

Well water typically contains more minerals in solution than surface water and may require treatment to soften the water by removing minerals such as arsenic, iron and manganese.

1.1 Capacity of aquifers:- The different soil formations have different capacities for yielding water. Any aquifer holds water in the pores of which some is always retained and some only is released and is determined by specific yield. Specific yield is the difference between the porosity of the soil less the water retained by pores and is expressed in %. The specific yield of some of the normally occuring aquifers is given below:

Type of soil formation	Porosity(%)	Specific yield(%)
Clay	45-55	1-10
Sand	35-40	10-30
Gravel	30-40	15-30
Sand and Gravel	20-35	15-25
Sandstone	10-20	5-15
Shale	1-10	0.5-5
Lime stone	1-10	0.5-5

It will be noted that though clay has large porosity but yields only little water, whereas sand and gravels yield ample quantity.

1.2 Safe yield of a well: The maximum safe yield of a well is that yield which is dependable and continuous output during a long drought. The well yield may be found from the soil properties in the different water bearing strata, when the well is dug or bored. Trial bores are also done to ascertain the safe yield of any prospective well.

Determining the safe yield of a well involves a test to see the balance between the maximum amount of water that can be pumped out of the well and the amount of water that recharges back into the well from the surrounding ground water source. The test requires the continuous pumping of the well for an extended period of time.

1.3 Location of nearby wells:-

If the nearby well is within the radius of circle of influence, it may cause a reduction in the yield. When wells are made very close to each other, their circle of influence, which are formed during pumping, over lap each other. The radius of circle of influence of a well depends upon the rate of pumping. More the rate of pumping, larger will be the radius of influence circle. Therefore well should be spaced quite distance apart so that they may not affect the yield of each other.

Distance between the proposed and old well, if any, should not be less than 150 m so that yield from the new source does not affect the yield of the old source.

2.0 Development of ground water sources:- The wells may be shallow or deep. Open wells can be economically constructed up to 20 m deep if the water table of ground water with sufficient yield is available. Normally, hand pumps are placed in open wells these days for ease of drawing water. Tube well or bore well can be constructed below 20 m deep up to 500 m or even deeper.

The bottom of the well should be at level sufficiently below the lowest probable summer water table.

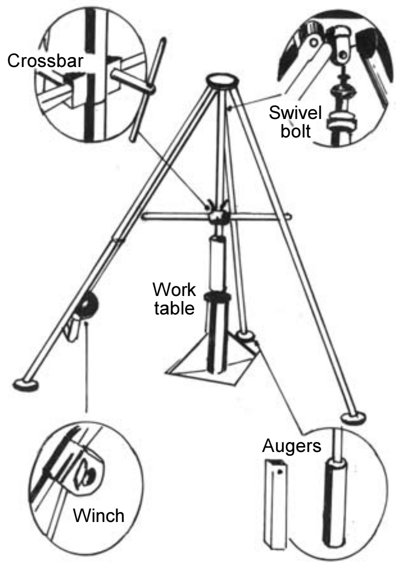
The Central ground water board/public health engineering department or rural water supply department of the State Govt. have survey records of the water table in most of the region and should be consulted, for any proposal of development of ground water resource.

2.1 Open wells: Open wells up to a depth of 20 m can be dug manually and lined or they can be made by sinking circular R.C.C. rings.

2.1.1 Ring wells: Concrete ring well is a method that requires either a steel casing ring mould for casting the concrete rings on site or for pre-cast rings to be transported from factory to construction site. The rings, measuring 0.9m in diameter and 0.5m in height are stacked upon each other in an excavated well hole, or they can be used for sinking wells or a combination of both procedures. By digging soil out from under the bottom of the casing, the whole structure will be allowed to settle. When the top of the well casing has reached the surface of the surrounding soil, another section is added to the top. Thereafter digging is repeated until another section can be added on to the well at ground level, and so on until a satisfactory depth has been reached.

2.2 Drilling or boring : When ample water is not available at depths of around 10 m, normally bore wells or drilled wells are adopted and either hand operated pumps or power operated pumps are installed. There are several methods of boring the earth strata to reach the aquifers. Some of the commonly used are given below:

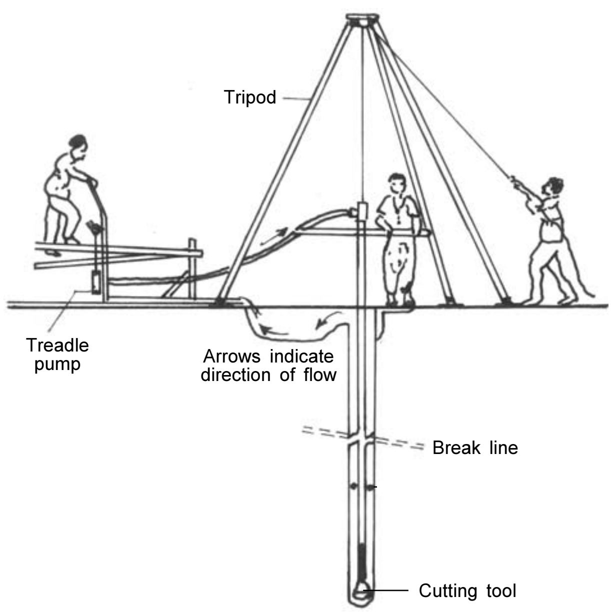
a) Auguring: Auguring cuts earth away by the rotation of a cylindrical tool with one or more cutting edges. The excavated earth feeds upwards inside the tool body, which needs lifting to the surface for emptying at intervals.



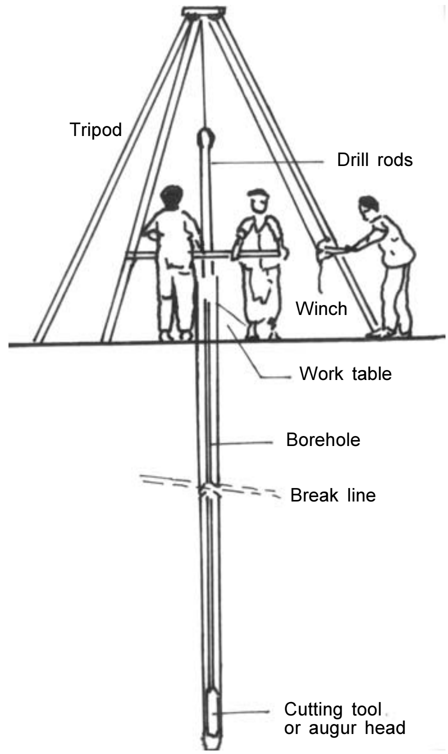
A rig with an augur attached to the end, can sink a well hole up to 170mm in diameter and about 115m deep in about two days in ground which is predominantly soft.

The crossbar is friction-bolted to a stem, at a height suitable for pushing round by hand. Helpers can sit on it if auguring needs extra weight. Additional stem sections are added as auguring proceeds.

Several shapes and sizes of auger-bit are available, including a “hole-saw” which is designed to penetrate soft rock. Thin layers of rock have been penetrated; however, the method is primarily suitable for soils, soft or hard.



b) Wash boring: A water jet is forced through a pipe at the bottom of the bore, which is advanced with the help of a cutting tool duly hammered up and down by means of a pulley. The water jet loosens the bottom of the bore simultaneously brings the excavated material with it to the surface.



c) **Hand boring:** Tube wells 25mm and upwards in diameter (the larger ones are able to accommodate a “down-the-hole” pump) are sunk to depths of 60m or more. A boring pipe, usually a galvanised mild steel tube fitted with a case-hardened open socket at its base, moves vertically under the action of a bamboo tied to the pipe by manila rope. The boring pipe rests initially in a shallow pit filled with a water/ cow-dung mixture, which acts as a drilling mud and helps to stabilise the walls of the bored hole during drilling. Using a bamboo lever, two men raise and drop the pipe successively.

For the duration of each upstroke, another man seals the open top of the pipe with his hand, creating a partial vacuum inside it, so that the water within the pipe rises with it. He removes his hand for the down stroke, during which the pipe drops faster than the water inside it. As this hand-on / hand-off cycle repeats, water starts to gush from the top of the pipe and the whole assembly begins to work as an elementary force pump.

Soil, fluidized by repeated strokes of the case-hardened socket, is entrained into the upward flow of the water and the boring pipe sinks further into the ground with each stroke. Boring rates of 20m per hour have been achieved in soft soils.

d) **Mechanical rigs:** There are several types of powered rigs and augurs which are used to bore through hard strata as well as deeper wells. Some of these are:

- Cable tool or percussion rigs - for alluvium and boulders
- Rotary rigs - for semi consolidated formations
- Reverse circulation rigs - large diameters in conglomerate consolidated formations
- Air Rotary rigs - for lime stones
- Rotary cum percussion rigs - consolidated formations

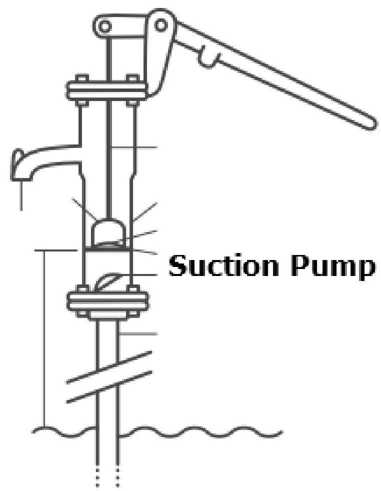
- Jetting drill - for small dia. in unconsolidated formations
- Down the hole hammer - Hard rocks
- Calyx rigs - hard strata, used for deepening existing wells

2.3 Minimum distance between well and point of pollution:-

The table shows that the well should not be closer than the distances shown from various possible hazardous sources.

Contamination sources	Recommended distances meters
Building sewer	15
Septic tank	15
Disposal field	30
Seepage pit	30
Cess pool	45

3.0 Pumps:- Pumps are either hand driven or power driven.



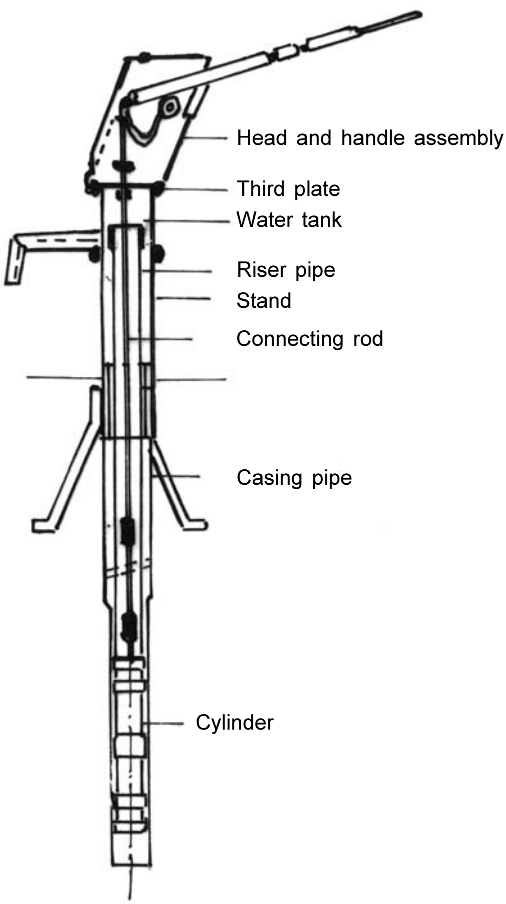
3.1 Hand pumps: The simplest hand pump, often referred to as a pitcher pump or suction pump, is satisfactory for use on wells or cisterns in which the water never needs to be lifted up to about 7m. If these pumps are maintained in good condition, they are easily primed and will hold their prime from one use to the next. However, if the valves leak, the pump will need to be primed each time it is used.

3.2 Water from deep wells is lifted with a similar plunger type pump in which the cylinder, including the plunger and valves, is supported on the discharge pipe deep enough in the well to be submerged in water at all times. These are also called **'Lift pumps'**. The pump handle is connected to the plunger by means of a long rod. While this type of pump is self-priming due to the cylinder being submerged in the water, it must nevertheless be maintained in good condition to work effectively.

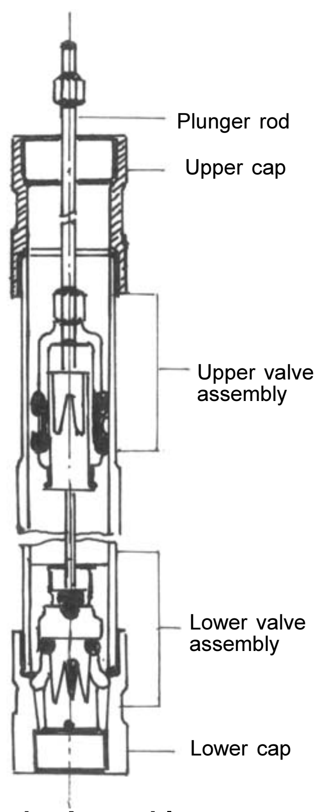
Lift pumps are used primarily as a manually powered means of bringing water to the surface from a borehole, rainwater tank or well. The main types of traditional hand pumps are the India Mark II, the India Mark III, and Extra deep-well pumps. These pumps normally cannot pump from very deep, however, hand pumps have been developed that can also pump from up to 100 m deep.

Water from deep wells is lifted with a similar plunger type pump in which the cylinder, including the plunger and valves, is supported on the discharge pipe deep enough in the well to be submerged in water at all times. The pump handle is connected to the plunger by means of a long rod. While this type of pump is self-priming due to the cylinder being submerged in the water, it must nevertheless be maintained in good condition to work effectively.

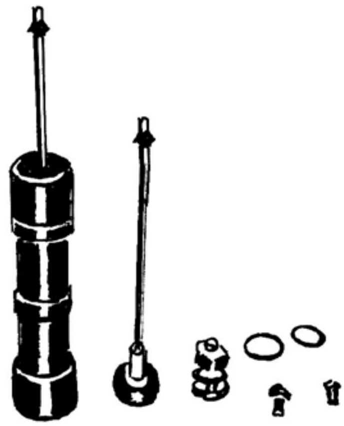
Occasionally it is necessary to use a hand pump to force water above the level of the pump. Models are available that are designed with a packing around the lift rod and a pipe connection at the point of discharge enabling them to force water to a tank higher than the pump. An even more sophisticated model is equipped with a small "differential" cylinder that causes the pump to discharge on both the "up" and "down" strokes.



Hand Pump



Cylinder Assembly



Cylinder with single piece plunger and check valve

3.3 Selection of hand pump:- Hand pumps should be selected only from standard makes depending upon the diameter of bore, and the depth of the bore. Details of some standard hand pumps manufactured in India and also exported to many countries abroad is given below:

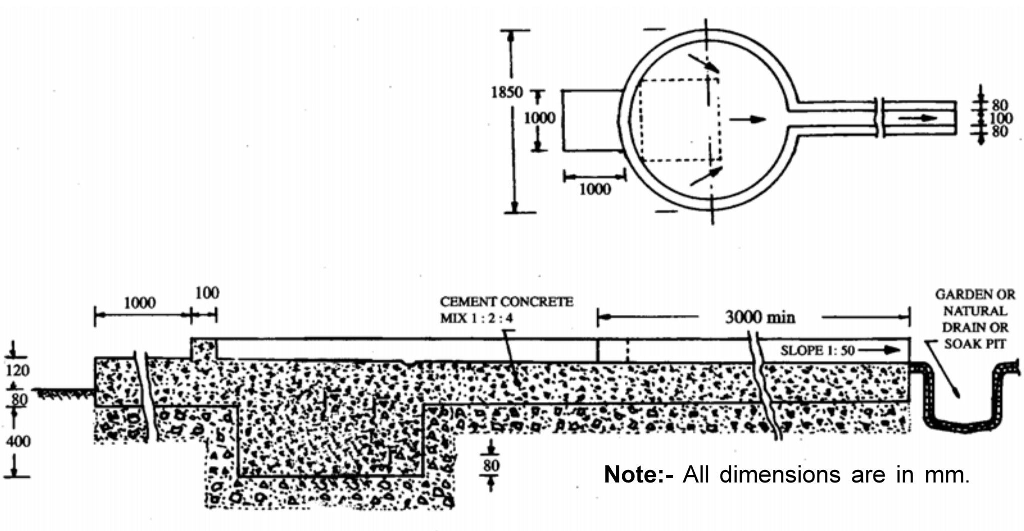
Sr. No.	Characteristics	India mark II pump	India mark III (65mm)	India mark III (50mm)	Extra deep well pump
1	Minimum Bore well diameter (mm)	100	125	100	100
2	Application range a. Static water level(m) b. Optimum installation depth (m)	 15-40 21-40	 15-25 21-30	 15-50 21-60	 40-90 50-90
3	Stroke length(mm)	125	125	125	100
4	Discharge per 40 stroke (liters/minute)	15	15	10	12
5	Riser Main a. Size (mm) b. Material	 32 Galvanised steel	 65 Galvanised steel	 50 Galvanised steel/PVC	 32 Galvanised steel
6	Connecting Rod a. Size (mm) b. Material	 12 Steel zinc plated	 12 Steel zinc plated	 12 Steel zinc plated	 12 Steel zinc plated

3.4 Causes and remedies for hand pumps

Trouble	Cause	Remedy
1) Pump handle works easily but no flow of water	Water level gone down below the cylinder assembly.	Add more pipes and rods.
	Worn out cylinder rubber cup washer	Overhaul the cylinder and replace the nitrile rubber cup washer.
	Connecting rod joint disconnected	Pull out the pump and join the connecting rod wherever necessary
	Valve seat worn out	Replace valve seats
	Pump cylinder cracked	Replace cylinder assembly
2) Delayed flow or small flow	Damaged rising main	Replace the damaged pipe or disconnect the affected rising main
	Leakage in cylinder check valve or upper valve	Overhaul cylinder. Replace rubber seats
	Nitrile rubber washers worn out	Overhaul the cylinder and replace Nitrile rubber cup washers
3) Folding of chain during return stroke	Improper commissioning	Adjust the length of last connecting rod by cutting and taping suitably.
	Nitrile rubber cup washers getting jammed inside the cylinder	Overhaul the cylinder and replace Nitrile rubber cup washers.
4) Noise during operation	Stand assembly flange not leveled properly	Level the flange
	Bent connecting rod	Change the defective rod
	Off-set of hexagonal coupler weld	Change the defective rod
5) Shaky handle	Loose handle axle nuts	Tighten handle axle nuts
	Worn out ball bearings	Replace ball bearings
	Spacer damaged or short in length	Replace spacer
	Bearings loose in the bearing housing	Replace the handle assembly

4.0 Platform for hand pump:- The platform is integral and vital part of the well hand pump. In addition to providing a sound foundation to a pump, it serves to protect the water source from pollution that is caused by contaminated water flowing back into the bore well. The platform helps to prevent formation of muddy pools of stagnant water around the pump. It is very important that platform be constructed before the hand pump is installed.

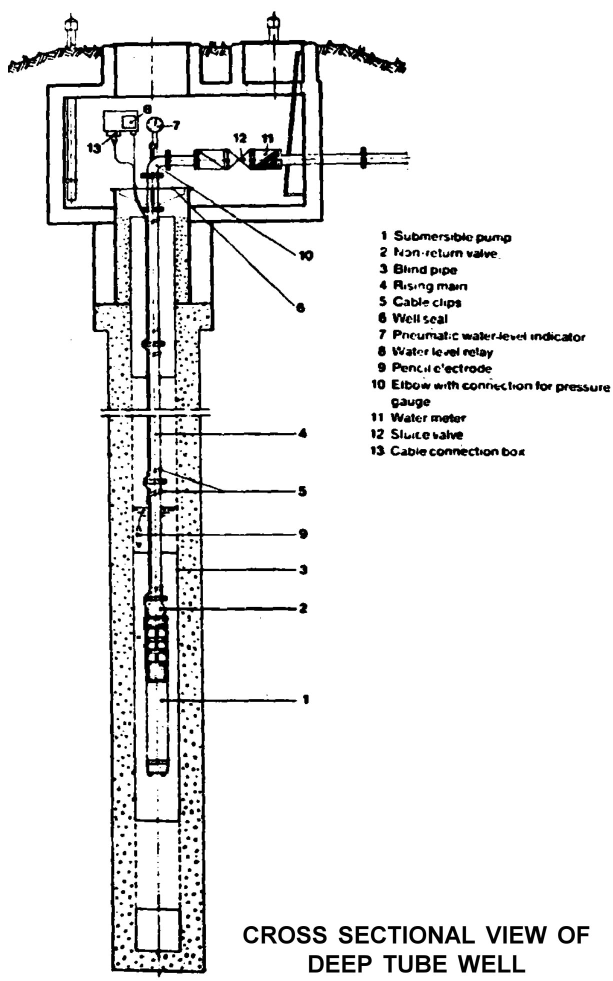
The recommended design and construction of platform common to all types of pump is shown below:-



Platform for Hand Pump

5.0 Deep tube well:-

Deep tube wells are usually designed to give a discharge of 100 to 200 cubic meter per hour and extends to the depth of 70 meter or more. These include wells which are drilled by rotary percussion or rotary cum percussion rigs. Its annual output is approximately 15 times that of an average shallow tube well. The device used for lifting water from the tube-well can be submersible pump or turbine pump but normally submersible pumps are only used.



CROSS SECTIONAL VIEW OF DEEP TUBE WELL

5.1 Steps to be followed in sinking deep tube well:

a. Trial boring:-

i) During sinking of pipes, samples of strata are examined for yield and samples of water taken for analysis.

ii) From the results obtained, the areas of strainer necessary for the quantity of water required and the strata in which the strainer should be located are decided upon.

b. Samples of water for analysis:- For a large water supply, water should be drawn from as great depth as possible to eliminate the danger of bacteriological contamination which can be expected in water drawn from the upper strata. Water drawn from deep ground is likely to be bacteriologically pure.

c. The bore is developed by over-pumping (that is, pumping at above the design-rate) before the well enters service can improve the efficiency of the packing by drawing further fine particles into it. Where the surrounding ground has many fine particles, the flow of water can be accelerated by back-flushing at a higher rate. This over-pumping and back-flushing is known as developing the tube well.

d. Tube-well installation:- Initially the casing pipes are sunk to required depth. Strainers and plain pipes of tube well proper are then lowered to correct depths. It is common to maintain the water level in the well at least 7.5m above the top of the submersible pump. This depth of water over the pump provides a reasonable level of safety for dry conditions and provides for full cooling of the pump's electrical motor.

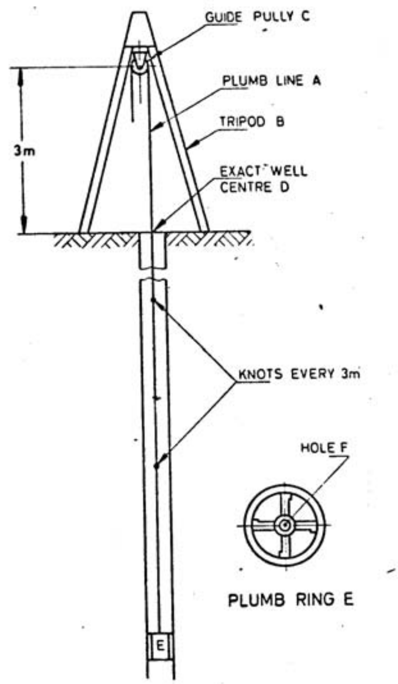
e. In suitable cases where the strata is having finer particles, pebbles or gravel is let down between the casing pipes and the bore well as shrouding during casing pipe extraction. This is essential when the strainers are located in fine sand.

The total area of the openings in the screen of strainer should be such that the velocity of inflowing water is sufficiently low to avoid disturbance to the smaller particles of the water bearing stratum.

f. Checking verticality of tube wells:-

The verticality of the tube is tested using plumb or plunger whose diameter is 6.00 mm smaller than the diameter of casing well. The plumb can be made up of piece of steel sheet or a short piece of pipe. Two disks made out of 3mm thick steel plate, with diameter slightly less than the pipe diameter, are connected together by a rod of 25mm diameter and 3 meter long tightened with the help of nuts at the ends. Some holes are punched in plates to facilitate immersion in water. A knob is fixed on the top nut to which a thin steel wire is attached. The disk is suspended into the pipe by wire passing over a pulley on a tripod.

The hole F from which the plumb line has to pass shall be in the exact centre of the ring. Knots or marks shall be made at every 3 m on the plumb line to indicate the depth to which the ring has been lowered in the well. The guide pulley is to be fixed on a tripod of a frame as shown in figure. The plumbing shall be suspended from the guide pulley which should be at least 3 m above the top of the well. The vertical centre of the pulley shall be so located that the plumb line A comes exactly at the centre of the well.



For the tube well encased with pipes up to 350mm diameter, the verticality of the tube well shall be measured in terms of clear cylindrical space available after construction of tube well.

When the disk is lowered into the pipe, the wire is exactly in the centre of pipe. When disks are further lowered down and if the well pipe is not truly vertical, the wire will deviate from the centre and that shall be indicated at the top of pipe.

Absolute vertically is ideal and is a requirement for installation of submersible pumps but a deviation of 100 mm per 30 meters of boring is generally acceptable where submersible pumps are not to be installed.

g. Grout the bore hole with cement mortar slurry for top 3-4m to avoid any percolation of dirty water into the bore.

h. Make a hand pump platform around the bore, to provide a sound foundation to the hand pump as well as to ensure no pounding of water around the pump and provide healthy environment.

5.2 Testing of tube well:-

a) Measurement of tube well depth:-

The depth of tube well can be measured by two methods :-

i) **Measurement with the help of cables or rods: -** When the formation of tube well bottom portion is consolidated, the depth of tube well is measured by means of cables or rods. The bottom of tube well is cleaned and then the depth is measured by either twisted metallic cable strained by plumb-bob or by means of rigid rod. Three distinct measurements are taken and average of the three readings is taken as depth of the tube well.

If the depth of tube well does not exceed 100 m, then the accuracy of measurement is $\pm$ 0.5 %. If the depth exceeds 100m then the accuracy can be decided by the Railway engineers in consultation with the drilling contractors.

ii) Measurement by means of casing:- When the formation of tube well bottom portion is unconsolidated and casing is used for tube well, the depth of tube well is measured by means of casing. In this case the depth of tube well is deemed to be equal to the length of pipes inserted after deduction the screwed ends. Each pipe should be measured to an accuracy of $\pm$ 0.1% the accuracy of measurement of depth of tube well is $\pm$ 0.3 %.

b) Measurement of water level of the tube well:-

The water level of the tube well can be measured either by

i) Direct measurement,

ii) Electric measurement or

iii) Air pressure line method.

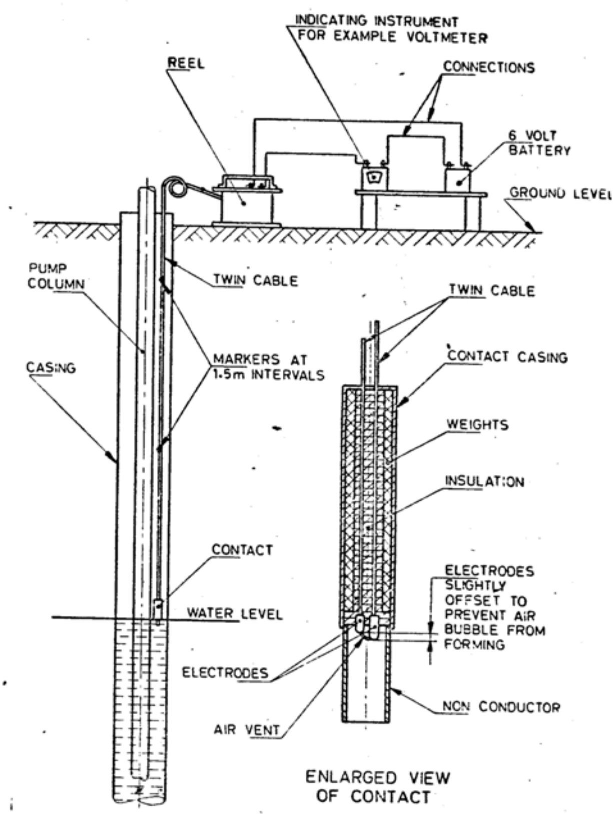
i) Direct measurement:- The water level of tube well can be measured directly by a steel tape or cable with suitable sinker attached at the end. The steel tape or cable is wound round a rotating drum fixed at the top of well. The steel tape or cable is then released by rotating the drum and the length of tape or cable is measured. Averages of three results are taken. Any measurement which deviated from the average by more than $\pm$0.3 % shall be discarded and new measurement to be taken.

ii) Electric measurement method:-

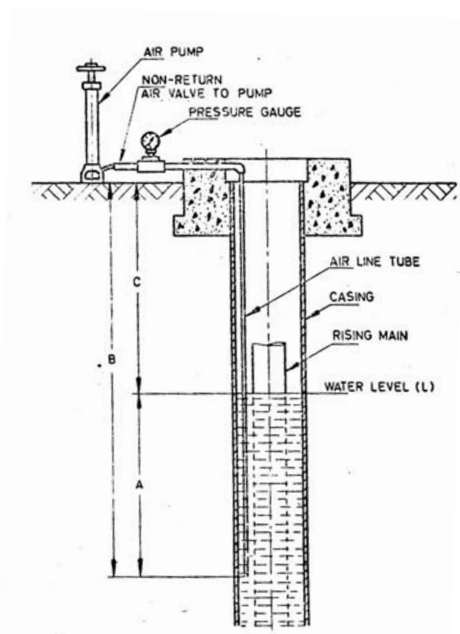
The water level can be measured by lowering either single pole or double pole contact switch. In the simplest case, a switch has two pieces of metal called contacts that touch to make a circuit, and separate to break the circuit. The contact material is chosen for its resistance to corrosion, because most metals form insulating oxides that would prevent the switch from working. As soon as the contact touches the water electric circuit complets and the indicating instruments operated. The water level can be obtained by measuring the length of cable inside the well.

Single pole contact with single cable can be used only at the places where the casing is provided from the top of the bore to below the water surface to be measured. All all other cases, double pole contact with two cables must be used.

iii) Air pressure line method:- Level measurement by hydrostatic pressure is based on the principle that the hydrostatic pressure difference between the top and bottom of a column of liquid is related to the density of the liquid and the height of the column. For open tanks and sumps, it is only necessary to measure the gauge pressure at the lowest monitored level. Air pressure lines are commonly used to measure water levels in deep wells due to their low cost and lack of maintenance. The air line consists of a hollow tube that extends from the surface to a depth below the lowest pumped water level. The pressure gauge is calibrated and graduated in meters of water. The procedure to measure water levels with an air line can be seen in figure.



The water level in an unpressurized air line will be the same as the water level in the well. Air pressure is applied to the top of the air line and is measured with a pressure gauge. The air pressure increases until all of the water is evacuated from the air line at which time the air pressure stabilizes. The maximum air pressure in the air line is a measure of the height of water above the end of the air line. The difference of readings B and A will be the required depth of water.



5.3 Testing of yield and drawdown of the tube well:

The drawing off of water through a tube well, results in a lowering of water level. This drawdown creates a hydraulic gradient in the water bearing material with the result that underground flow into the tube well takes place. The rate of inflow depends upon the hydraulic gradient permeability and saturated thickness of water bearing material and of tube well construction.

After the well has been completely constructed and cleaned out and the depth of the well accurately measured, this test should be carried out.

This test is conducted by installing a test pump in the tube well temporarily and pumping out water. At each rate of discharge, pumping is carried out at least for 30 minutes. If the water level and discharge are found to be fluctuating, development is carried out for some more hours, until the discharge becomes steady and sand content is within tolerable limits. The specific capacity of the well at various pumping rates is computed based on drawdown test data.

Since the yield is influenced by number of factors such as geological formation, rainfall, neighboring tube wells etc, the pumping rate shall in general not exceed 60 percent of the yield determined by test. It is recommended, however that geological advice should be obtained on the percentage to be adopted for each location.

6.0 Power driven pumps:- Power driven pumps are extensively used for water and sewage carrying purpose. The selection of pump is governed by following factors:-

1) Whether pump is submersible or above the surface of water?

2) How much suction head and delivery head required?

3) How much discharge is required?

4) Power supply available single phase/ three phase?

5) Space or other site condition constraints

6) Pipe line size.

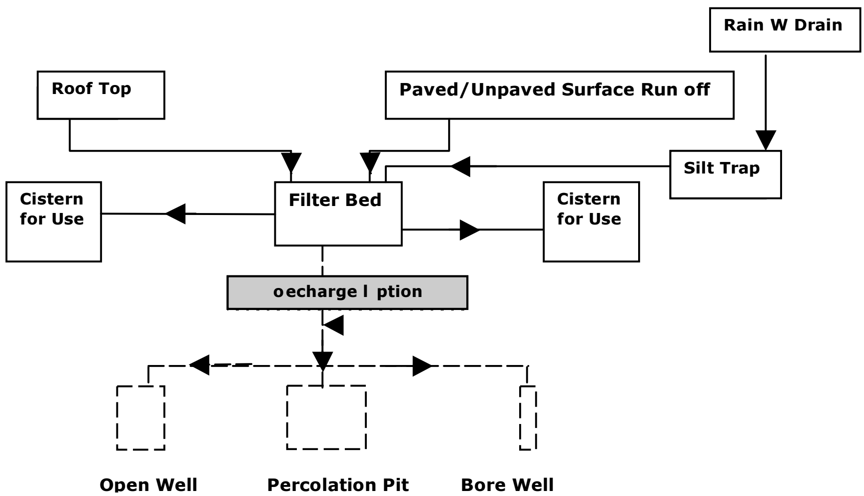
The pumps are classified on the principle on which they work or the type of end use they are required to perform. Engineers prefer to classify the pumps as per their end use and details are given in **APPENDIX-1.**

7.0 Rain water harvesting:- Rain water harvesting is the process of direct collection of rainwater, which can be stored for direct use or can be discharged into the ground water. This happens naturally in open rural areas at some low places or ponds, but in congested areas certain systems have to be developed for capture and storage of water. The concept can easily be adopted in single storey houses, row houses and additional efforts are required in multistoried buildings in congested areas where some additional plumbing is required. The first rain water however contains impurities as also the bird droppings and other debris from the roof are washed down in the first rain and as such the same should not be collected. The rain water harvesting is done by either of two methods,

i) By directly collecting and storing for consumption after necessary treatment

ii) By recharging the water table and pumping it as per requirement.

The concept is explained in the flow chart below.



Schematic flowchart for rain water harvesting

7.1 The locations where rain water harvesting is suitable for direct storage and consumption are:

a. Existing water system inadequate.

b. Where the rain fall (Minm. 500- 600 mm annually) is spread over a span of more than 80-90 days, otherwise storage requirements become very large to feed the year round. In such cases, recharging the ground water is generally more economical.

c. Where the size of the dwelling unit compound is big enough to give adequate run off.

d. In coastal areas, the water runs off to the sea and ground water is saline, further rainfall is also wide spread.

In aria of Rajasthan and Saurashtra, this is the best or the only system for a reliable water supply, even if the storage requirements may be large. In coastal areas like Saurashtra, the soil has become saline due to history of drawing out sub-soil water and recharging the ground water is not useful.

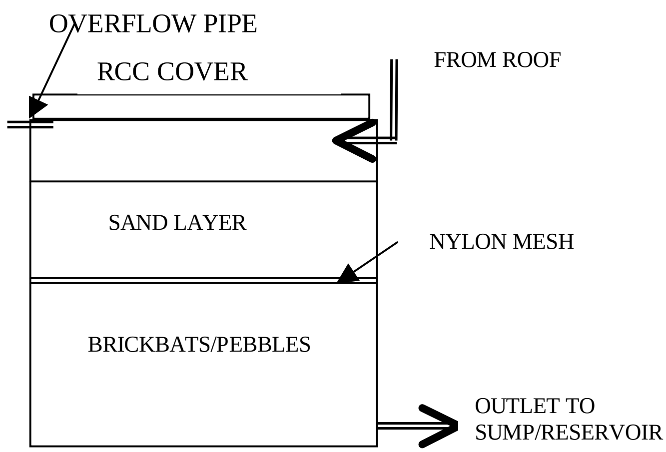
7.2 Method-direct collection and storing:- Rain water from roof tops can be flown down in PVC pipes into a filter unit which can be made of simple 3-stage filtration unit consisting of sand, brick koba and broken fired clay brick bats or even 2-stages consisting of sand and brick bats or pebbles. If it is intended to use the collected water for drinking purpose without any chemical treatment, a 100 mm thick layer of lumps of charcoal is placed above the sand layer. The filter tank can also be made in a 200 lt. barrel filled with sand, big lumps of charcoal and topped with pebbles or small stones and then a nylon mesh is tied at the surface of it all. From filter unit the water is led to a sump or reservoir. The sump can be replaced by old abandoned wells or small dug wells of about 600 mm diameter and about 5 meter deep, depending on soil type. Such small sumps or wells can be used for single dwelling units and bigger sumps can be made for multiple units. Another method of collection of rain water is to obstruct the flow of water out of the house compound by creating a small raised bund at the gate and a perforated concrete slab is placed here over a 600 mm deep pit across full width of gate and a pipe connected from this to a sump or a dug well or an abandoned well.

The rain water thus collected is good enough for toilet, washing and bathing, gardening etc. which is about 70% of the total requirement of a household. The rain water is softer compared to surface water and forms good lather with soap and its requirement for washing and cleaning uses is reduced considerably compared to tap water. However, for drinking purposes, the water needs to be chemically treated or boiled to remove any bacteriological impurities. It is also observed that roofs painted with oil mixed bitumen compounds impart some undesirable qualities like odour and colour to water and it is not advisable to use such water for drinking purpose.

a) **Quantity of rain water:-** The roughness of the roofs material and features like efficiency of collection system governs the net quantity of rain water that can be harvested. Ideally, if annual rainfall is 1000mm over an area of 100 sqm, 100 cum (1 lakh liters) of water can be collected. But considering the various factors normally 80% of this is taken as the quantity harvestable for roofs and 20%-30% for unpaved compound area. If the roof area is 30 sqm and 70 sqm is the compound unpaved area, out of above, then the total harvestable qty. of water would be (30x0.8x1.0)+(70x0.3x1.0) = 45 cum (45,000 liters). In case of treated enclosed areas, the runoff can be worked out as per table below:

S.No.	Type of treatment	% Harvestable
1.	Bentonite 20% mixed	51-87
2.	Cement 8% mixed with soil, a layer of 12.5 mm thick	23-41
3.	Mud-plaster 12.5 mm thick	38-67
4.	Lime concrete 50 mm thick	48-74
5.	Well Compacted and dressed earth	35-57
6.	Mud with wheat husk(bhusa) and Jantha emulsion (Type of bitumen)	49-79
7.	Sodium carbonate @1Kg/10sqm spray over 12.5 mm thick compacted Tank silt layer	63-92

b) **Filter chamber:-** For a single unit household, with approximate roof catchments of about 30 sqm, a filter chamber of 750x750x750 mm is adequate. The bottom half height is filled with brick bats or pebble stones and a layer of 300 mm thick coarse river sand is filled over it, a fine nylon mesh is placed in between the two layers to avoid fouling of the brick bat layer. The chamber is provided with a RCC cover. The inlet pipe carrying the rain water from the roof is fed at the top and the outlet pipe discharges at the bottom. An overflow pipe should also be provided and connected to a dug well or a open well or any other structure for recharging the ground water with surplus water. For bigger units bigger chambers or multiple chambers are required.



Filter chamber (750 x 750 x 750 mm)

c) **Sump/reservoir:-** The sump or storage is normally created under ground for big installations where pumping will be required for drawing out water and on surface for small installations where the drawing out will be by means of a tap or valve at low levels. The tank/reservoir must have facility for periodic cleaning, overflow pipe and inner surface non-reactive with water. These can be made in wood, brick masonry, concrete, earthen ware or ferro-cement. Ferro-cement tanks have become quite popular in India.

The capacity of tank is decided on factors like, i) distribution of rainfall over the year ii) requirement of water etc. If the distribution of rainfall is evenly spread round the year minimum storage is required but if it is limited to only a few months of the year, maximum storage is required for water to be available during the dry season. The working example of storage capacity required is given in **APPENDIX-2.**

At most of the way side stations in arid districts of India in Madhya Pradesh, Saurashtra and Rajasthan, open wells had been serving the villages for domestic use, however due to overdrawing of water or due to avoidance of manual labour, such wells gave way to hand pumps and the wells were abandoned and have been used for dumping debris etc. Such abandoned wells are a good sump for water harvesting, after dredging and cleaning.

APPENDIX-1

Power driven pumps

1.0 General:

Apart from deep tube wells and hand pumps, water from many bore wells, mainly for agriculture purpose and for lifting water from sumps and reservoirs are pumped using other type of pumps, namely centrifugal pumps etc. There are a number of pumps in the market from which to select for a particular application. They all have characteristics which influence their suitability for a specific water supply as well as the volume and pressure required.

Centrifugal pumps are simple (only one moving part), durable, and relatively inexpensive for a given capacity. However, they are suitable only for low lifts and are prone to losing their prime unless the suction pipe is equipped with a good foot valve (check valve). Neither will they discharge against a very high head (pressure).

There are several designs of centrifugal pumps that further influence one's choice. The impeller may be an open type with a relatively large clearance between it and the casing or it may be a closed type with very close clearances. The open type will tolerate sand or silt in the water much better than the closed-impeller type.

A centrifugal pump may have an integral electric motor or petrol-powered engine which the manufacturer will have matched correctly, or it may have a belt drive. In the latter case, great care must be taken to drive the pump at a suitable speed and with a motor or engine of adequate power.

As with the propeller fans, centrifugal pumps have volume, pressure and power requirement characteristics that vary with speed as follows:

i) Volume changes directly with the speed.

ii) Maximum pressure changes directly as the square of the change in speed.

iii) Power required changes directly as the cube of the change in speed.

This means that if a pump was designed to run at 2,000 rpm and be operated by a 1 kW motor, and the motor pulley is exchanged for one that is 1.5 times the original diameter, the pump will then turn at 3,000 rpm. The corresponding changes in volume, maximum pressure and power required will be:

- Volume = 1 1/2 times as much
- Maximum pressure $(1\ 1/2)^2$ = 2.25 times as great
- Power $(1\ 1/2)^3$ = 3.375 times as great

Consequently, the motor will be badly overloaded and may be damaged.

Jet pumps are centrifugal pumps for a shallow that may have a jet (ejector) built into the pump housing. This will improve both the lifting and discharge efficiency. These pumps are suitable for lifts of up to about 8 m.

A deep-well jet pump will have the ejector installed below the low-water level in the well. Two pipes of different dimensions connect it to the pump which may be located at the top of the well or even some distance to one side. The smaller of the two pipes carries water to the ejector, while the larger one delivers water to the pump housing where most is discharged but some is returned to the ejector. These deep-well jet pumps are suitable for wells in which the water level drops to 30m. The correct ejector for maximum efficiency is chosen on the basis of the lowest expected water level in the well.

The selection of the pump depends upon the site condition. Various make pumps are available in the market like CRI pumps, Kirloskar Brothers Limited, KSB Pumps etc. Various aspects are to be considered for selecting the pumps, such as: - suction head, delivery head, flow rate, power capacity, diameter of suction pipe line, diameter of delivery pipe line, material to be pumped or any other specific obligation/requirement etc. Following type of pumps are generally available in market and user can select the pump depending upon his requirement. The details given below are from the product catalogue of CRI Pumps. Users may go through other manufacturers catalogue also. Details of some of the pumps are given below:-

The models and various features may change as regular changes are taking place as per research and design. Readers may contact dealers for any changes in specifications.

1.1 Bore well compressor pump:-These pumps are suitable for domestic, small building, industrial application etc. These pumps are suitable for a low yield bore well. They can function satisfactorily even if water contains sand and silt. The delivery head, power range in kW, flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Type of pump (CRI Pumps INDIA)	Suction head (m)	Delivery head (m)	Flow rate liters per second & (m^3/hr)	Nominal size outlet pipe (mm)	Power range kW
1	MC	91.5	Very low delivery head	2.2 (7.9)	25 & 32	0.37-1.1
2	S&D	122		14.4 (52)	25, 32, 40 & 50	0.37-7.5

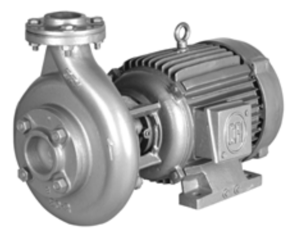
1.2 Centrifugal jet pump:- These pumps are suitable for shallow wells, house supply, small colonies, pressure boosting, car washing etc. These pumps are self priming type and no priming is required for these kinds of pumps. The suction lift, delivery head, power range in kW, flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Type of pump (CRI Pumps INDIA)	Suction lift (m)	Delivery head (m)	Flow rate liters per second & (m^3/hr)	Nominal size of suction & outlet pipe (mm)	Power range kW
1	CJS	8	50	0.9(3.3)	25X 25	0.37-0.75
2	JM	8 (3.5 m in case of high speed)	45	1.2 (4.3)	25X 25	0.75-1.5

1.3 Deep well submersible pump:- These pumps are available from 80.00 mm diameter to 200.00 mm diameter. These pumps are fitted in submerged condition so no suction lift is available for these kind of pumps. These pumps are suitable for carrying water for domestic, boosting purpose, fire fighting, rural water supply and many other applications. The delivery head, power range in kW, flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Outer diameter of pump (mm)	Delivery head (m)	Flow rate liters per second & (m^3/hr)	Nominal size of outlet pipe Inches	Power range kW
1	80.0	93	1.5(5.4)	25& 32	0.37-1.1
2	100.0	7.0 to 395.0	0.2-5.0 (0.72 -18)	32, 40,50 65	0.37-2.2
3	125.0	24.0 to 50.0	4.5-10 (16.2 -36)	65 ,& 75	3.7-5.5
4	150.0	9.0 to 503.0	0.3-22 (16.2 -36)	40,50, 65, 75 & 100	1.1-1.5
5	175.0	12.0 to 90.0	5-29 (18-104.4)	100	3.7-15
6	200.0	9.0 to 277.0	5-50 (18-180)	75,100, 125,150	3.7-55

1.4 Centrifugal mono block pump:-These pumps are suitable for domestic, gardens, industrial application etc. These pumps can be fitted to a level of around 7 meters above the lowest water level. The suction lift, delivery head, power range in kW ,flow rate and other details for selection of suitable pump for specific application is given below:-



Sr No	Type of pump (CRI Pumps INDIA)	Suction lift (m)	Delivery head (m)	Flow rate liters per second & (m^3/hr)	Nominal size of suction & outlet pipe (mm)	Power range kW
1	ACM	7	52.5	17.8(64)	25x25, 32x25, 40x32, 40x40, 50x40, 50x50, 65x50, 80x65 & 80x80	0.37-2.2
2	CH,CS&DM	7	82	39(140.4)	50x40, 50x50, 65x50,70x65, 100x80,100x100, 125x125 & 150x150	2.2-15
3	NR & ENR	8	50	0.9(3.3)	25X 25	0.19-0.75

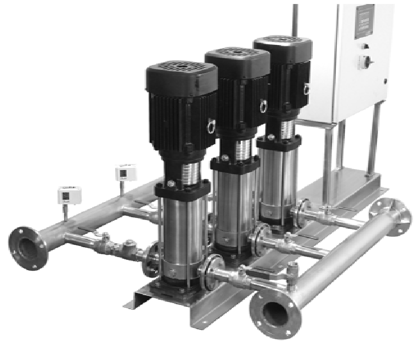
1.5 Open well submersible pump:-

These pumps can be fitted in open well or any other reservoir. As space constrain is not there compare to deep well submersible pump, they can be manufactured from 250 mm outer diameter to 400 mm outer diameter. These pumps give higher discharge than deep well submersible pumps.

These pumps are suitable for public water supply, rural water supply, irrigation and many other applications. These pumps are fitted in submerged condition so no suction lift is available for these kind of pumps. The delivery head, power range in kW, flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Type of pump (CRI Pumps INDIA)	Delivery head (m)	Flow rate liters per second & (m^3/hr)	Nominal size of suction and outlet pipe (mm)	Power range kW
1	CSM	76	64(230.4)	25& 32	2.2-15
2	CV& CVH	300	34 (122.4)	32, 40,50, 65	2.2-30
3	CSS	34	13.6 (49)	65 ,& 75	0.37-2.2
4	CVS	99	2.0 (7.0)	40,50,65,75 &100	0.55-2.2

1.6 Pumps used for hydro pneumatic pumps



Hydro pneumatic system provides even flow at any outlet of pipeline. This system need not to operate manually, it works automatically which is controlled by VFD (variable frequency drive) panel and pressure switch unit. It can sense pipeline pressure and works as per setting.

In line pumps with hydro pneumatic system**-** These pumps are suitable for pressure boosting to a colony or a building in a water distribution system. The delivery head, power range in kW ,flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Type of pump (CRI Pumps INDIA)	Suction lift (m)	Delivery head (m)	Flow rate Liter per second & (m^3/hr)	Nominal size of suction & outlet pipe (mm)	Power range kW
1	MHS	7	50	2.5(9)	25x25, 32x25	0.225-1.1

1.7 Dewatering, sewage, drainage pump:-These pumps are suitable for dewatering, handling, effluent water, water mixed with air or gas & mud. The total head, power range in kW, flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Maximum size of solids which can be passed (mm)	Total head (m)	Flow rate liters per second & (m^3/hr)	Nominal size of suction & outlet pipe (mm)	Power range kW
1	120	40	1166.7(4200)	32,40,50,75, 100, 150,200, 250,300, 350,400,550, 600, 700	0.75-75

1.8 Surface sewage pump:- These pumps are suitable for pumping sewage water, storm water, effluent, dewatering muddy water from construction site etc. The total head, power range in kW, flow rate and other details for selection of suitable pump for specific application is given below:-

Sr No	Maximum size of solids which can be passed (mm)	Total head (m)	Flow rate liters per second & (m^3/hr)	Nominal size of suction and outlet pipe (mm)	Power range kW
1	50	46	178 (640)	25X25 to 200X200	0.75-75

2.0 The comparison of various pumps according to their application is given in following table:-

a) Pumps for extracting water from deep well

Borewell compressor pump	Centrifugal jet pump	Deepwell submersible pump
In this type of pump, compressed air is used to create pressure for water flow	In this type of pump, pressurised water through jet assembly is used to create pressure for water flow	In this type of pump, centrifugal force is created by rotating impeller to create pressure for water flow. (Centrifugal pump)
Priming is not required	Priming is required	Priming is not required
Used when water yield is very less	Used when water yield is very less	Extensively used for all types of borewell.
Can be used maximum up to 150 m depth	Can be used maximum up to 60 m depth	Can be used maximum up to 400 m depth
Can be used in sandy and silty bore wells	Can not be used in sandy and silty bore wells	Can be used in sandy and silty bore wells, but special care is to be taken to install strainers.
Skilled operator is required for operation and maintenance	Skilled operator is required for operation and maintenance	No special skill is required for operation and maintenance

b) Pumps for extracting water from open source

Centrifugal monoblock pump	Openwell submersible pump
These are centrifugal pumps	These are centrifugal pumps
Priming is required	Priming is not required
Skilled operator is required for operation and maintenance	No special skill is required for operation and maintenance
Maximum suction head up to 10 m at sea level is available (it reduces 1m for every 1000 feet height elevation)	No suction head available, should be installed in water itself.
Max. Total head up to 100m	Max. head Up to 300m
Max. discharge available up to 39 lps(140 m^3/hr)	Max. discharge available up to 52 lps (187m^3/hr)
Pump house is required	Pump house is not required

c) Inline Pumps

(1) Inline pumps	(2) Pressure booster pumps
These are centrifugal pumps	These are centrifugal pumps
Suitable for high water flow and pressure requirement generally above 5 bar pressure	Suitable for low water flow and normal pressure requirement generally below 5 bar pressure
Used for multistoried buildings and other industrial use.	Used for domestic water supply having lesser water demand and generally up to 3 storied apartment.

(1)	(2)
Installed vertically	Installed horizontally
Temperature withstanding capacity - 20 °C to 120 °C	Temperature withstanding capacity 85 °C

d) Dewatering pumps

These pumps are non clog type.

Surface sewage	**Submersible sewage**	**Submersible drainage**
These are centrifugal pumps	These are centrifugal pumps	These are centrifugal pumps
Installed above sewage level	Installed in sewage itself	Installed in sewage itself
Solid handling capacity up to 16 mm	Solid handling capacity up to 120 mm	Solid handling capacity up to 33 mm
Priming is not required	Priming is not required	Priming is not required
Maximum suction head up to 6 m	-	-
Total head 46 m	Delivery head 40	Delivery head 40
Max. Discharge 22 lps (80 m^3/hr)	Max. Discharge 300 Lps (1100 m^3/hr)	Max. Discharge 1300 lps (4800 m^3/hr)

Note:- i) Priming is the process of removing entrapped air from suction pipeline by pouring water for smooth functioning of the pump.

ii) The location of the pump should be such that the pump is easily accessible for regular inspection and it should be relatively free from dust, fumes and moisture. The pumps should be installed in a covered area, protected against the weather and it should not be installed in a tilted position. Do not wrap the pump with air tight materials such as polythene sheet, rubber sheet, canvas cloth, etc, as condensation will form in tightly wrapped motor and winding will burnout.

3.0 Important Instructions

- The suction lift should be as short as possible.
- Install the pump according to manufacturer's recommended head range.
- Muddy water will damage the pump (sewage/special purpose pumps are designed to take care of this).
- Pump must not be operated dry.
- Install water level monitor to protect from dry running.
- Reduce number of bends, elbows, 'T' bends and valves as much as possible.
- Use appropriate size, good quality cable and starter / protection device.
- The weight of the pipes should not be applied to the pump.

- Use ISI marked low friction good quality pipes.
- Pipe diameter must never be smaller than the pump connections.

  The pump should be run for few minutes once in 2 days to prevent from seizing.

APPENDIX-2

Design example (Rain water harvesting)

Problem: A rural house has a sloping roof of 120 sqm (horizontal projected area). The maximum rainfall is 25mm/hr. The 10 year rainfall data is as under:

Year	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5	Yr. 6	Yr. 7	Yr. 8	Yr. 9	Yr. 10
mm	490	500	560	480	540	480	520	580	500	510

The monthly distribution is as under:

Mon.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
RF %	0	0	0	5	5	10	30	30	15	5	0	0

Solution

This is a case where the rainfall is concentrated over a 6 month period of the year and the annual rainfall area will be suitable to work out the storage capacity of tank.

i) Total availability of rain harvestable water

The maximum annual rainfall is 580 mm only once in 10 years as such is unlikely to repeat earlier than 10 yrs. Most frequent occurring rain is 500mm or more. So we can design for 500 mm rain fall per year. The rain water harvestable= 120x0.8x500=48000 liters.

ii) **Storage tank capacity:-** Considering 5 members in a household, the daily requirement if taken as 25 l/day/person i.e. 125 liters per day or 3750 liters/month.

Month	**Monthly rainfall%**	**Monthly RF mm**	**Harvested water**	**Cum har-vested**	**Consump-tion/month**	**Consum. Cum.**	**Difference**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8= (5-7)**
Jan	0	0	0	0	3750	3750	-3750
Feb	0	0	0	0	3750	7500	-7500
Mar	0	0	0	0	3750	11250	-11250
Apr	5	25	2400	2400	3750	15000	-12600
May	5	25	2400	4800	3750	18750	-13950
June	10	50	4800	9600	3750	22500	-12900
July	30	150	14400	24000	3750	26250	-2250
Aug	30	150	14400	38400	3750	30000	+8400
Sept	15	75	7200	45200	3750	33750	+11450
Oct	5	25	2400	47600	3750	37500	+11100
Nov	0	0	0	47600	3750	41250	+6350
Dec	0	0	0	47600	3750	45000	+2600

The maximum deficit is in month of May	= 13950 liters
The maximum surplus is in month of Sept.	= 11450 liters
Maximum surplus + deficit	= 25400 liters (say 25000 liters)

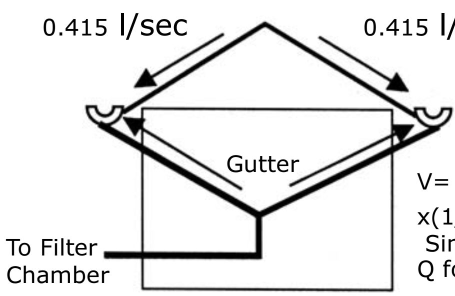
Therefore the tank capacity required is 25000 liters (25 Cum).

If however, the rainfall is concentrated during 2-3 months it is customary to provide storage for full annual requirement or harvestable water during the year.

The height of the tank should be decided so as to be accommodated below the gutter height minus the depth of filter chamber to permit drawal of water by manual means. If however, this is not feasible, the storage tank has to be constructed atleast partly under ground.

iii) Size of gutter:-

Refer to table in para 5.1.1(a) of chapter 5, the diameter of gutter (75mm) for rainfall of intensity 25mm/hour (slope 1:200) is adequate for areas up to 64 sqm (32 sqm for 50mm/hour rainfall) and as the roof area is being served by two gutters on either, it is recommended to provide minimum 75mm dia. pipe which is adequate. This can also be worked out from first principle as under:



$$Q = \frac{25 \times 120 \times 1000}{1000 \times 3600 \times 2} = 0.415 \text{ l/sec}$$

$$V = 1/0.025 \times (R)^{2/3} \times (1/S)^{1/2} = 1/.025 \times (.019)^{2/3} \times (1/200)^{1/2} = 0.2 \text{ m/sec}$$

Since R= 0.075/4=0.019 and slope, S=1:200

Q for 75 mm Φ half pipe $= \frac{1}{2} \times \pi \times .075 \times .075/4 \times V$

$= \frac{1}{2} \times \pi \times 0.075 \times 0.075 \times 0.2$

$= 0.00176 \text{ m}^3\text{/sec} = 1.76 \text{ l/s}$

This is more than 0.415 l/sec reqd.

iv) Size of down take pipe:- The table under para 5.1.1(b) of chapter 5 gives the diameter of down take pipes in case of flat roofs, the same can be used for even sloped roofs though the time of concentration of water at the down take pipe in case of slope roof is comparatively lesser than flat roofs and about 10% extra size of down-take pipes in case of slope roofs may be considered.

For 60 sqm area with a rainfall of 25 mm/Hr. (Half of that for 50 mm/ Hr.) is 75 mm diameter. So provide 75 mm dia at two ends to collect from the two gutters. The pipe taking the collected water to the filter chamber is receiving water from both sides of roof i.e. from 120 sqm and from the same table minimum 100mm diameter pipe needs to be provided.

v) **Filter chamber:-** The plan area of a filter chamber for 30 sqm roof area is 750x750 mm for 25 mm/hr. and in this case the area is 120 sqm i.e. 4 times and as such provide corresponding area i.e. 1000x2250 mm plan size keeping the depth same.