

FIG. 6.15: CLASSES OF BEDDING FOR PROJECTING CONDUITS

TABLE 6.7
VALUES OF 'N' FOR DIFFERENT PIPE BEDDINGS

Type of Bedding	Value of 'N'
'A' - Reinforced concrete cradle	0.42 to 0.51
'A' - Plain concrete cradle	0.51 to 0.64
'B'	0.71
'C'	0.84
'D'	1.31

The value of 'z' in case of circular pipes is given in Table 6.8.

TABLE 6.8
VALUES OF 'z' FOR DIFFERENT PIPE BEDDINGS

Fraction of conduit on which lateral pressure acts 'm'	Value of 'z' for	
	'A' Class Beddings	Other Beddings
0.0	0.150	0.000
0.3	0.743	0.217
0.5	0.856	0.423
0.7	0.811	0.594
0.9	0.678	0.655
1.0	0.638	0.638

b) Negative Projecting Conduits

The load factor for negative projecting conduits may also be determined by the equations (6.15) and (6.16) with a value of k of 0.15, provided the side fills are well compacted.

c) Imperfect Trench Conditions

The equations for positive projecting conditions will hold good for those conditions as well.

6.5.5 Conduits Under Simultaneous Internal Pressure and External Loading

Simultaneous action of internal pressure and external load gives a lower supporting strength of a pipe than what it would be if the external load acted alone.

If the bursting strength and the three edge strength of a pipe are known, the relation between the internal pressure and external loads which will cause failure may be computed by means of the formula

$$t = \frac{T(1-s^2)}{S} \quad (6.17)$$

Where

- t = internal pressure in kg/cm² at failure when external load is simultaneously acting
- T = bursting strength of a pipe in kg/cm² when no external load is simultaneously acting
- s = three-edge bearing Load at failure in kg/linear metre when there is simultaneous action of internal pressure and
- S = Three edge bearing load at failure in kg/linear metre when there is no internal pressure simultaneously acting.

6.6 RELATIONSHIP BETWEEN THE DIFFERENT ELEMENTS IN STRUCTURAL DESIGN

The basic design relationships between the different design elements are as follows for rigid pipes

$$\text{Safe working strength} = \frac{\text{Ultimate three edge bearing strength}}{\text{Factor of safety}}$$

$$\text{Safe field supporting strength} = \text{Safe working strength} \times \text{Load factor}$$

Appendix 6.1 gives the details of three edge bearing Tests.

6.7 RECOMMENDATIONS

The factor of safety recommended for concrete pipes for sewers is '1.5' which is considerably less as compared to that for most engineering structures which have a factor of safety of atleast 2.5. As the margin of safety against the ultimate failure is low, it becomes imperative to guarantee that the loads imposed on sewer pipes are not greater than the design loads for the given installation conditions. In order to achieve this objective the following procedures are recommended.

1. Width of the trench specified for a particular job should be minimum in consonance with the requirements of adequate working space to allow access to all parts and joints of pipes.
2. Specification should lay proper emphasis on the limit of the width of trench to be adopted in the field which should not exceed that adopted in the design calculations. Any deviations from this requirement during the construction should be investigated for their possible effect on the load coming on the pipe and steps should be taken to improve the safe supporting strength of pipe for this condition of loading by adopting suitable bedding or such other methods when necessary.
3. The Field Engineer should keep in touch with the Design Engineer through out the duration of the Project and any deviation from the design assumptions due to the exigencies of work, should be immediately investigated and corrective measures taken in time.

4. All pipes used on the work should be tested as per the IS specifications and test certificates of the manufacturers should be furnished for every consignment brought to the site.
5. Whenever shoring is used, the pulling out of planks on completion of work, should be carried out in stages and this should be properly supervised to ensure that the space occupied by the planks is properly backfilled.
6. Proper backfilling methods both as regards to selection of materials, methods of placing and proper compaction should be in general agreement with the design assumptions.

6.8 ILLUSTRATIVE EXAMPLES

Illustrative examples for structural design of Buried Conduits are given in Appendix 6.2.

CONSTRUCTION OF SEWERS

CHAPTER 7

CONSTRUCTION OF SEWERS**7.1 CONSTRUCTION METHODS**

The design and the construction of sewers are so interdependent, the knowledge of one is an essential pre-requisite to the competent performance of the other. The ingenuity of the designer and supervising engineer is continually called for, to reduce the construction cost and to achieve a quality workmanship. Barring unforeseen conditions it shall be the responsibility of the supervising engineer and the contractor to complete the work as shown on the plans at minimum cost and with minimum disturbance of adjacent facilities and structures.

7.1.1 Trench**7.1.1.1 DIMENSIONS**

The width of trench at and below the top of a sewer should be the minimum necessary for its proper installation with the due consideration to its bedding. The width of a sewer trench depends on the type of shoring (single stage or two stage), working space required in the lower part of the trench and the type of ground below the surface. The width of the trench at different levels from the top of the sewer to the ground surface is primarily related to its effect upon the adjoining services and nearby structures. In undeveloped areas or open country, excavation with side slope shall be permissible from the top of the sewer to the ground surface instead of vertical excavation with proper shoring. In developed areas, however, it is essential to restrict the trench width so as to protect the existing facilities and properties and to reduce the cost of restoring the surface. Increase in width over the minimum required would unduly increase the load on the pipe.

7.1.1.2 EXCAVATION

Excavation for sewer trenches for laying sewers shall be in straight lines and to the correct depths and gradients required for the pipes as specified in the drawings. The material excavated from the trench shall not be deposited very close to the trench to prevent the weight of the materials from causing the sides of the trench to slip or fall. The sides of the trench shall, however, be supported by shoring where necessary to ensure proper and speedy excavation. In case, the width of the road or lane where the work of excavation is to be carried out is so narrow as to warrant the stacking of materials near the trench, the same shall be taken away to a place to be decided by the Engineer-in-Charge. This excavated material shall be brought back to the site of work for filling the trench.

In case the presence of water is likely to create unstable soil conditions, a wellpoint system shall be employed to drain the immediate area of the sewer trench prior to excavation operation. A well point system consists of a series of perforated pipes driven or jetted into the water bearing strata on either side of a sewer trench and connected with a header pipe leading to a pump.

In the event of excavation being made deeper than necessary, the same shall be filled and stabilised.

7.1.1.3 SHORING

The shoring shall be adequate to prevent caving in of the trench walls of subsidence of areas adjacent to the trench. In narrow trenches of limited depth, a simple form of shoring shall consist of a pair of 40 to 50mm thick and 30cm wide planks set vertically at intervals and firmly strutted. For wider and deeper trenches a system of wall plates (wales) and struts of heavy timber section is commonly used. Continuous sheeting shall be provided outside the wall plates to maintain the stability

of the trench walls. The number and the size of the wall plates shall be fixed considering the depth of trench and type of soil. The cross struts shall be fixed in a manner to maintain pressure against the wall plates which in turn shall be kept pressed against the timber sheeting by means of timber wedges or dog spikes.

In non-cohesive soils combined with considerable ground water, it may be necessary to use continuous interlocking steel sheet piling to prevent excessive soil movements due to ground water percolation. Such sheet piling shall extend at least 1.5m below the bottom of the trench unless the lower part of the trench is in fine material. In case of deep trenches, if conditions demand, excavation and shoring may be done in stages.

7.1.1.4 UNDERGROUND SERVICES

All pipes, ducts, cables, mains and other services exposed due to the excavation shall be effectively supported.

7.1.1.5 DEWATERING

Trenches for sewer construction shall be dewatered for the placement of concrete and laying of pipe sewer or construction of concrete or brick sewer and kept dewatered until the concrete foundations, pipe joints or brick work or concrete have cured. The pumped out water from the trenches shall be disposed off in existing storm water drainage arrangement nearby. In the absence of any such arrangement the pumped water may be drained through completed portion of sewer to a permanent place of disposal. Where a trench is to be retained dry for a sufficient period of time to facilitate the placement of forms for sewer construction an underdrain shall be laid of granular material leading to a sump for further disposal. Precautions are to be taken to arrest floating of sewers laid, arising out of induced buoyancy during rainy season. Reference may be made to 6.3.2.4 for more details in this regard.

7.1.1.6 FOUNDATION AND BEDDING

Where a sewer has to be laid in a soft under ground strata or in a reclaimed land, the trench shall be excavated deeper than what is ordinarily required. The trench bottom shall be stabilised by the addition of coarse gravel or rock, in case of very bad soil the trench bottom shall be filled in with cement concrete of appropriate grade.

In the areas subject to subsidence, the pipe sewer should be laid on suitable supports or concrete cradle supported on piles.

In the case of cast-in-situ sewers, an R.C.C. section with both transverse and longitudinal steel reinforcement shall be provided when intermittent variations in soil bearing capacity are encountered. In case of long stretches of very soft trench bottom, soil stabilization shall be done either by rubble, concrete or wooden crib. For details regarding bedding types and materials reference may be made to 6.5.3.

7.1.2 Tunnelling

Tunnels are employed in sewer systems when it becomes economical, considering the nature of soil to be excavated and surface conditions with reference to the depth at which the sewer is to be laid. Generally in soft soils the minimum depth is about 10m. In rocks, however, tunnels may be adopted at lesser depths. In busy and high activity zones crowded condition of the surface, expensive pavements or presence of other service facilities near the surface sometimes make it advantageous to tunnel at shallower depths. Each situation has to be analysed in detail before any decision to tunnel is taken.

7.1.2.1 SHAFTS

Shafts are essential in tunnelling to gain access to the depth at which tunnelling is to be done to remove the excavated material. The size of shaft depends on the type and size of machinery employed for tunnelling irrespective of the size of the sewer.

7.1.2.2 METHODS OF TUNNELLING

The tunnelling methods adopted for sewer construction can be classified generally as auger or boring, jacking and mining.

a) *Auger or Boring*

In this method, rigid steel or concrete pipes are pushed into ground to reasonable distances and the earth removed by mechanical means from the shaft or pit location. Presence of boulders is a serious deterrent for adoption of this method, in which case it may be more economical to first install an oversize lining by conventional tunnelling or jacking and fill the space between the pipe and lining with sand, cement or concrete.

b) *Jacking*

In this procedure, the leading pipe is provided with a cutter or edge to protect the pipe while jacking. Soil is gradually excavated and removed through the pipe as successive lengths of pipes are added between the leading pipe and the jacks and pushed forward taking care to limit the jacking upto the point of excavation. This method usually results in minimum disturbance of the natural soils adjacent to the pipe. Jacking operation should continue without interruption as otherwise soil friction may increase, making the operation more difficult.

Jacking of permanent tunnel lining is generally adopted for sewers of sizes varying from 750 to 2750 mm, depending upon the conditions of soil and the location of the line. The pipes selected should be able to withstand the loads exerted by the jacking procedure. The most common pipes used for this are reinforced concrete or steel.

c) *Mining*

Tunnels larger than 1.5 m are normally built with the use of tunnel shields, boring machines or by open face mining depending on the type of material met with. Rock tunnels normally are excavated open-face with conventional mining methods or with boring tools.

Tunnel shields are used as a safety precaution in mining operations in very soft clay or in running sand especially in built up areas. In this method, a primary lining of adequate strength to support the surrounding earth is installed to provide progressive backstop for the jacks which advance the shield. As the excavation continues the lining may be installed either against the earth, filling the annular space by grouting with pea gravel or the lining may be expanded against the earth as the shield advances; the latter eliminating need for any grouting.

Boring machines of different types have been developed for tunnel excavation in clay and rock. They are usually provided with cutters mounted on a rotating head which is moved forward as boring operations continue. Earth excavated is usually carried by a conveyor system. Some machines are also equipped with shields. Though the machines are useful in fairly long runs through similar material, difficulties are encountered when the material to be excavated varies.

Open face mining without shields are adopted in particular instances where the conditions permit such operation as in rock. Segmental support of timber or steel is used for the sides and the top of the tunnel.

7.1.3 Laying of Pipe Sewers

In laying sewers, the centre of each manhole shall be marked by a peg. Two wooden posts 100mm x 100mm x 1800mm high shall be fixed on either side at nearly equal distance from the peg and sufficiently clear of all intended excavation. The sight rail when fixed on these posts shall cross the centre of manhole. The sight rails made from 250 mm wide x 40 mm thick wooden planks and screwed with the top edge against the level marks shall be fixed at distances more than 30m apart along the sewer alignment. The centre line of the sewer shall be marked on the sight rail. These vertical posts and the sight rails shall be perfectly square and planed smooth on all sides and edges. The sight rails shall be painted half white and half black alternately on both the sides and the tee heads and cross pieces of the boning rods shall be painted black. When the sewers converging to a manhole come in at various levels there shall be a rail fixed for every different level.

The boning rods with cross section 75mm x 50mm of various lengths shall be prepared from wood. Each length shall be a certain number of metres and shall have a fixed tee head and fixed intermediate cross pieces, each about 300mm long. The top edge of the cross pieces shall be fixed at a distance below the top edge equal to, the outside dia. of the pipe, the thickness of the concrete bedding or the bottom of excavation, as the case may be. The boning staff shall be marked on both sides to indicate its full length.

The posts and the sight rails shall in no case be removed until the trench is excavated, the pipes are laid, jointed and the filling is started.

When large sewer lines are to be laid or where sloped trench walls result in top-of-trench widths too great for practical use of sight rails or where soils are unstable, stakes set in the trench bottom itself on the sewer line, as rough grade for the sewer is completed, would serve the purpose.

7.1.3.1 STONWARE PIPES

The stoneware pipes shall be laid with sockets facing up the gradient, on desired bedding. Special bedding, hunching or encasing may be provided where conditions so demand (as discussed in 6.5). All the pipes shall be laid perfectly true, both to line and gradient. (IS:4127-1983). At the close of each day's work or at such other times when pipe is not being laid, the end of the pipe should be protected by a close fitting stopper.

7.1.3.2 R.C.C. PIPES

The R.C.C. pipes shall be laid in position over proper bedding, the type of which may be determined in advance, the abutting faces of the pipes being coated by means of a brush with bitumen in liquid condition. The wedge shaped groove in the end of the pipe shall be filled with sufficient quantity of either special bituminous compound or sufficient quantity of cement mortar of 1:3. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the plastic ring by appliances so as to compress roughly the plastic ring or cement mortar into the grooves, care being taken to see that concentricity of the pipes and the levels are not disturbed during the operation. Spigot and socket R.C.C. pipes shall be laid in manner similar to stoneware spigot and socket pipes. The structural requirements as discussed in Chapter 6 and IS:783-1967 may be followed.

7.1.3.3 CAST-IN-SITU CONCRETE SECTIONS

For sewer sizes beyond 2m internal dia cast-in-situ concrete sections shall generally be used, the choice depending upon the relative costs worked out for the specific project. The concrete shall be cast in suitable number of lifts usually two or three. The lifts are generally designated as the invert, the side wall and the arch.

7.1.3.4 CONSTRUCTION OF BRICK SEWERS

Sewers larger than 2m are generally constructed in brick work. The brick work shall be in cement mortar of 1:3 and plastered smooth with cement plaster of 1:2, 20mm thick both from inside and outside. A change in the alignment of brick sewer shall be on a suitable curve conforming to the surface alignment of road. Construction shall conform to IS:2212-1962 in general.

7.1.3.5 CAST IRON PIPES

The pipes shall be laid in position with the socket ends of all pipes facing up gradient. Any deviations either in plan or in elevation of less than 1 1/4 degree shall be effected by laying the straight pipes round the flat curve of such radius that the minimum thickness of lead in a lead joint at the face of the socket, shall not be reduced below 6mm. The spigot shall be carefully pushed into the socket with one or more laps of spun yarn wound round it. Each joint shall be tested before running the lead, by passing completely round it a wooden gauge notched out to the correct depth of lead and the notch being held close up against the face of socket. IS: 3114-1985 should be followed in setting out the sewers.

7.1.4 Jointing of Sewers

Joints of pipe sewers may generally be any of the following types:

- i) Spigot and socket joint (rigid and semi flexible)
- ii) Collar Joint (rigid and semi flexible)
- iii) Cast Iron detachable joint (semi flexible)
- iv) Coupling joint (semi flexible)

Cement joints are rigid and even a slight settlement of pipes can cause cracks and hence leakage. To avoid this problem it is recommended that semi flexible joints should be used.

7.1.4.1 STONEWARE PIPES

All the pipe joints shall be caulked with tarred gasket in one length for each joint and sufficiently long to entirely surround the spigot end of the pipe. The gasket shall be caulked lightly home but not so as to occupy more than a quarter of the socket depth. The socket shall then be filled with a mixture of one part of cement and one part of clean fine sand mixed with just sufficient quantity of water to have a consistency of semi-dry condition and a fillet shall be formed round the joint with a trowel forming an angle of 45 degrees with the barrel of the pipe (IS:4127 - 1983). Rubber gaskets may also be used for jointing.

7.1.4.2 CONCRETE PIPES

Concrete spigot and socket pipes are laid and jointed as described above for glazed stoneware spigot and socket pipes with yarn or rubber gasket and cement.

Asbestos cement pipes are jointed by coupling joints or C.I. detachable joints.

Large size concrete sewers have 'ogee' joints in which the pipe has mortise at one end and a tenon to suit at the other end and are jointed with cement or asphalt. A concrete collar sufficiently wide to cover and overlap the joint is fixed on it.

The collars shall be placed symmetrically over the end of two pipes and the annular space between the inside of the collar and the outside of the pipe shall be filled with hemp yarn soaked in tar or cement slurry tamped with just sufficient quantity of water to have a consistency of semi dry condition, well packed and thoroughly rammed with caulking tools and then filled with cement mortar (1:2) prop. The joints shall be finished off with a fillet sloping at 45 degrees to the surface of the pipe. The finished joints shall be protected and cured for atleast 24 hours. Any plastic solution or cement mortar that may have squeezed in shall be removed to leave the inside of the pipe perfectly clean.

For more details of jointing procedure reference may be made to IS:783-1985.

7.1.4.3 C.I. PIPES

For C.I. pipes several types of joints such as rubber gasket known as Tylon joint, mechanical joint known as screw gland joint and conventional joint known as lead joint are used.

For details CPHEEO's Manual on Water Supply & Treatment and relevant Indian Standards may be referred to.

7.1.5 Hydraulic Testing of Pipe Sewers

7.1.5.1 WATER TEST

Each section of sewer shall be tested for water tightness preferably between manholes. To prevent change in alignment and disturbance after the pipes have been laid, it is desirable to backfill the pipes upto the top keeping atleast 90cm length of the pipe open at the joints. However, this may not be feasible in the case of pipes of shorter length, such as stoneware and FCC pipes. With concrete encasement or concrete crade, partial covering of the pipe is not necessary.

In case of concrete and stoneware pipes with cement mortar joints, pipes shall be tested three days after the cement mortar joints have been made. It is necessary that the pipelines are filled with water for about a week before commencing the application of pressure to allow for the absorption by pipe wall.

The sewers are tested by plugging the upper end with a provision for an air outlet pipe with stop cock. The water is filled through a funnel connected at the lower end provided with a plug. After the air has been expelled through the air outlet, the stop cock is closed and water level in the funnel is raised to 2.5m above the invert at the upper end. Water level in the funnel is noted after 30 minutes and the quantity of water required to restore the original water level in the funnel is determined. The pipe line under pressure is then inspected while the funnel is still in position. There shall not be any leaks in the pipe or the joints (small sweating on the pipe surface is permitted). Any sewer or part there of that does not meet the test shall be emptied and repaired or relaid as required and tested again.

The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 litres/mm dia. of pipes per kilometre length per day.

For non-pressure pipes it is better to observe the leakage for a period of 24 hours if feasible.

Exfiltration test for detection of leakage shall be carried out at a time when the ground-water table is low.

For concrete, R.C.C. and Asbestos cement pipes of more than 600mm dia. the quantity of water inflow can be increased by 10% for each additional 100mm of pipe dia.

For brick sewers, regardless of their dia. the permissible leakage of water shall not exceed 10 cubic meters for 24 hours per km. length of sewer.

7.1.5.2 AIR TESTING

Air testing becomes necessary particularly in large dia. pipes when the required quantity of water is not available for testing.

It is done by subjecting the stretch of pipe to an air pressure of 100mm of water by means of a hand pump. If the pressure is maintained at 75mm the joints shall be assumed to be water tight. In case the drop is more than 25mm the leaking joints shall be traced and suitably treated to ensure water tightness. The exact point of leakage can be detected by applying soap solution to all the joints in the line and looking for air bubbles.

7.1.6 Check for Obstruction

As soon as a stretch of sewer is laid and tested, a double disc or solid or closed cylinder, 75mm less in dimension than the internal dimension of the sewer shall be run through the stretch of the sewer to ensure that it is free from any obstruction.

7.1.7 Construction of Manholes

The manholes shall be constructed simultaneously with the sewers. The manholes shall normally be of brick-work in cement mortar 1:3 and plastered both inside and outside with 20mm thick cement plaster in cement mortar 1:3. The foundation of manholes shall be 15cm thick cement concrete of appropriate grade and thickness may be increased to 30cm when subsoil water is encountered, the projection of concrete being 10cm on all sides of the external face of brick work. The floor of the manholes shall be in cement concrete of appropriate grade. Salt glazed or concrete half channel pipes of the required size and curve shall be laid and embedded in cement concrete base to the same line and fall as the sewer. Both sides of the channel pipes shall be benched up in concrete and rendered smooth in 20mm thick cement mortar and formed to a slope of 1 in 10 to the channel. Bricks on edge shall be cut to a proper form and laid around the upper half of all the pipes entering or leaving the manhole, to form an arch. All round the pipe there shall be a joint of cement mortar 12mm thick between the pipe and the bricks. The ends of the pipes shall be built in and neatly finished off with cement mortar. The masonry shaft or the manhole shall be provided on the top with a heavy air tight cast iron frame and cover conforming to IS:1726 or any other approved type of frame and cover. Where the depth of the manhole exceeds 90cm below the surface of the ground, steps of cast iron or of any other approved material shall be built into the brick work. The distance between the two consecutive steps shall not be more than 40cm. The top of manhole shall be flush with the finished road level (S:4111 Part I - 1967 Manholes).

The entire height of the manhole shall be tested for water-tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water. A drop in water level not more than 50mm per 24 hours shall be permitted. In case of high subsoil water it should be ensured that there is no leakage of ground water into the manhole by observing the manhole for 24 hours after emptying it.

7.1.8 Sewer Connections

These shall be laid in the same manner as the sewer. In case the connection is at a level higher than 60cm, a vertical drop arrangement comprising of 90 degrees bend or a double tee junction encased in 1/2 brick thick brick work shall be provided. The drop arrangement shall be in brick work in cement mortar 1:3, plastered with 20mm thick cement plaster from outside in cement mortar 1:3. The lowest bend may preferably be of cast iron and the entire vertical pipe line encased in concrete. The top end of the drop arrangement in the manhole, when a tee is used, shall be plugged with brick work with a conspicuous mark there on so that in case a serious sewer choke occurs in the incoming line, this end can be made use off for roding purposes.

7.1.9 Backfilling of the Trenches

Backfilling of the sewer trench is a very important consideration in sewer construction. The method of backfilling to be used varies with the width of the trench, the character of the material excavated, the method of excavation and the degree of compaction required. In developed streets, a high degree of compaction is required to minimise the load while in less important streets, a more moderate specification for back fill may be justified. In open country it may be sufficient to mound the trench and after natural settlement return to regrade the areas.

No trench shall be filled in unless the sewer stretches have been tested and approved for water tightness of joints. However, partial filling may be done keeping the joints open to avoid disturbance. The refilling shall proceed around and above the pipes. Soft material screened free from stones or hard substances shall first be used and hand pressed under and around the pipes to half their height. Similar soft material shall then be put upto a height of 30cm above the top of the pipe and this will be moistened with water and well rammed. The remainder of the trench can be filled with hard material, in stages, each not exceeding 60cm. At each stage the filling shall be well rammed, consolidated and completely saturated with water and then only further filling shall be continued. Before and during the backfilling of a trench, precautions shall be taken against the floatation of the pipe line due to the entry of large quantities of water into the trench causing an uplift of the empty or the partly filled pipe line. Reference may be made to 6.3.2.4 for more details in this regard. Upon completion of the backfill, the surface shall be restored fully to the level that existed prior to the construction of the sewer.

7.1.10 Removal of Sheet piling

Sheet piling driven below the spring line of a sewer shall be withdrawn a little at a time as the back-filling progresses. Some of the backfilled earth is forced into the void created by withdrawing the sheet piling by means of a water jet. To avoid any damage to buildings, cables, gas mains, water mains, sewers etc., near the excavation or to avoid disturbance to the sewer already laid portions of the sheet piling may be left in the trenches.

CHAPTER 8

MAINTENANCE OF SEWERAGE SYSTEMS

8.1 INTRODUCTION

Quality maintenance of sewerage system consists of the optimum use of labour, equipment and materials to keep the system in good condition, so that it can accomplish efficiently its intended purpose of collection and transportation of wastewater to the treatment plant.

8.2 TYPES OF MAINTENANCE

There are two types of maintenance of a sewerage system - preventive and emergency. It is necessary that preventive or routine maintenance are carried out to prevent any breakdown of the system and to avoid emergency operations to deal with clogged sewer lines or overflowing manholes or backing up of sewage into a house or structural failure of the system. Preventive maintenance is more economical and provides for a reliability in operations of the sewer facilities. Emergency repairs, which would be very rare if proper maintenance is carried out will also have to be provided for. Proper inspection and preventive maintenance is a necessity.

8.3 NECESSITY OF MAINTENANCE

Sewer maintenance functions are too often neglected and given attention only as emergency arises. Adequate budgets are seldom provided for supervision, manpower and equipment, unlike the case for maintenance of other utilities like electric cables, telephone cables, gas and water mains. Such attitude towards sewer maintenance is found even in large cities. Considering the health hazards that the public at large has to face, it will be appropriate to provide sufficient funds to take care of men, material, equipment and machinery required for efficient maintenance.

All efforts should be made to see that there is no failure in the internal drainage system of a premises. A serious health hazard results when sewage backs up through the plumbing fixtures or into the basements. The householder is confronted with the unpleasant task of cleaning the premises after the sewer line has been cleaned. Extensive property damage may also occur, particularly where expensive appliances are located in the basements.

Maintenance helps to protect the capital investment and ensures an effective and economical expenditure in operating and maintaining the sewerage facilities. It also helps to build up and maintain cordial relations with the public, whose understanding and support are essential for the success of the facility.

8.4 ORGANISATION FOR MAINTENANCE

The organisation responsible for the maintenance of the sewerage system will vary with the size and type of the sewerage system and the relative age of the system. The larger the Municipality, the larger and more complex will be its maintenance organisation. The size of the organisation will vary from a couple of employees to several hundred regular employees. The primary effort of the staff is to maintain sewers free flowing and unobstructed.

The sewer system with its components properly designed and installed is handed over to the person in charge of maintenance who assumes the responsibility to make it function satisfactorily for the benefit of the community. One should have sufficient experience in the design and construction of the system to enable him to perform his task efficiently with an understanding and appreciation of the problems that may arise during maintenance. One has not only to be a technical man but has also to deal with human relations in order to be successful in his work. Inservice training shall be imparted

to the maintenance personnel to improve upon the methods adopted based on the latest trends. Failure to develop a better understanding of human relations and also lack of development of the concept of service to the community generally results in the maintenance part becoming unpopular. The general public is also to be made aware of do's and don'ts to help in keeping the sewers free flowing and unobstructed.

8.5 PROVISIONS IN DESIGN

Maintenance really begins with the design and construction of the sewerage system. Hence due consideration shall be given to maintenance requirements at the time of designing sewerage systems.

Since sewer maintenance has to commence from manholes which are located in the streets, the size of the manholes must be designed to permit safe access and sufficient working space. The sewers shall be laid at a sufficient grade to provide self cleansing velocity. Inverted siphons and eccentric manholes should be avoided wherever possible.

8.6 HOUSE CONNECTIONS

House connections or service connections to the public or municipal sewer should preferably be approved by the Maintenance Engineer. It is necessary to see that the fittings and pipes in the houses are according to the byelaws or rules or regulations in force. If such byelaws, rules or regulations are not existing, then reference may be made to the relevant IS code of practice. House connections may be of minimum size of 150mm in dia and should preferably be connected to the Municipal or Public sewer through a manhole. When 'Y' or 'T' connections are allowed, extreme care must be taken when breaking the sewer pipe line and inserting the Y or T saddle. Similarly, the connection to the manhole must be properly done and closed. Care has to be taken that brick bats or other materials of construction are not allowed to fall and lie in the manhole. It is this extraneous material that is largely responsible for persistent clogging of the sewer lines.

It should also be ensured that the house fittings are properly trapped not only to prevent the ingress of sewer gases into the houses but also to ensure that large objects do not find their way into the sewers. Similarly, it should be ensured that any liquid or material which is likely to be injurious to the material of the sewer line or to prejudicially interfere with its contents or be a hazard to the workmen engaged in the maintenance of the sewer lines, like very hot water, acids, chemicals etc., are not allowed.

8.7 PLANNING FOR SEWER MAINTENANCE

Sewer inspections and maintenance should be planned. The whole sewerage systems should be marked on a plan and divided into sections and areas, which are placed under a maintenance gang. The maintenance gang preferably consists of a supervisor or mate with atleast 6 skilled sewer men. The area under each gang will depend on the size of the sewer, depth to which it is laid, the spacing of manholes, the condition of sewer line (whether surcharged or not) whether cleaning is being done by manual labour or by mechanical sewer machines etc. In case, house gully traps are to be maintained, special gang of one or two persons who will clean these traps regularly in a phased or planned manner is necessary.

The work of each sewer maintenance gang would consist of the following:

- a) Check manhole condition for deposition of silt, flow, new connections done, damaged walls or steps, manhole covers, clogged vertical pipes in drop manholes etc. While the cleaning of the manhole, pipes etc., will be undertaken by the gang, repairs etc. may be reported to be handled by a separate construction gang of mason and helpers. It is preferable that the repair gang comes out on the work when the sewer cleaning or maintenance gang is working, so that brick bats, debris mortar etc., which fall in the

manhole are removed there and then. This will cause a major blockage if the same is allowed to flow into the sewer line, which usually occurs when repairs are done separately. In such cases, a couple of sewer men should be deputed to clean the manhole of the debris immediately after repair work is completed

- b) Check the sewer line between two successive manholes for silting and flow conditions and remove the deposited silt and
- c) Check for any harmful and extraneous matter entering into the sewer line so that further investigation for the cause and location can be determined
- d) Check air release valves in rising or force mains, sluice gates or stoppage in the sewer lines, overflow arrangements etc.

A record of daily work done by the gang, and also a record of work done on the sewer lines should be maintained so that chronic trouble spots may be investigated and remedial action taken.

8.8 SEWER CLEANING EQUIPMENT AND PROCEDURES

Sewer cleaning works require usual implements like pick axes, manhole guards, tripod stands, danger flags, lanterns, batteries, safety lamps, lead acetate paper, silt drums, ropes, iron hooks, hand carts, plunger rods, observation rods, shovels etc.

In addition, sewer cleaning work calls for the following special equipments and devices like a portable pump set running on either diesel or petrol engine, manila rope and cloth balls, sectional sewer rods, a sewer cleaning bucket machine, a dredger, a roding machine with flexible sewer rods and cleaning tool attachments such as augers, corkscrews, hedghogs and sand cups, scraper, and hydraulically propelled devices such as flush bags, sewer balls, wooden ball and sewer scooters, sewer jetting machine, gully emptiers and pneumatic plugs.

8.8.1 Portable Pump Set

In cases where sewers are blocked completely and sewage has accumulated in manholes, the collected sewage has to be pumped out to tackle the sewer blockage. Such pumps should be of non-clogging type preferably on four wheel trailers for the larger sizes and should be provided with a self priming unit to save time and effort. Small pneumatic pumps can be used where high lifts are required and the volume of liquid to be pumped is not large, such as when pumping out flooded basements and dewatering deep trench excavations. In case of very deep manholes, non-clog submersible pumps may be used.

8.8.2 Manila Rope and Cloth Ball

The most common way of cleaning small diameter sewers upto 300mm dia is by the use of a manila rope and cloth ball. Flexible bamboo strips tied together are inserted into the sewer line by a person on top. If necessary, another man inside the manhole helps in pushing the rod through the sewer line. When the front end of the bamboo strip reaches the next manhole, a thick manila rope is tied to the rear end of the bamboo splits. The bamboo splits are then pulled by another man in the downstream manhole and pushed through the sewer line. As the rope is pulled, the ball sweeps the sewer line and the accumulated grit is carried to the next manhole where it is removed out by means of buckets. This operation is repeated between the next manholes until the stretch of sewer line is cleaned.

8.8.3 Sectional Sewer Rods

These rods are used for cleaning small sewers. The sewer rods may be of bamboo or teakwood or light metal usually about one meter long at the end of which is a coupling which remains intact in the sewer but can be easily disjointed in the manhole. Sections of the rods are pushed down the sewer. The front or the advancing end of the sewer rod is generally fitted with a brush, a rubber ring for cleaning or a cutting edge to cut and dislodge the obstructions. These rods are also useful to locate the obstruction from either manhole in case, that particular portion of the sewer has to be exposed for attending to the problem.

8.8.4 Sewer Cleaning Bucket Machine

The bucket machine consists of two powered winches with cables in between. In cleaning a section of sewer, the winches are centred over two adjacent manholes. To get the cable from one winch to the other, it is necessary to thread the cable through the sewer line by means of sewer rods or flexible split bamboo rods. The cable from the drum of each winch is fastened to the barrel on each end of an expansion sewer bucket fitted with closing device, so that the bucket can be pulled in either direction by the machine on the appropriate end. The bucket is pulled into the loosened material in the sewer until the operator feels that it is loaded with debris. The winch is then thrown out of gear and the opposing winch is put into action. When the reverse pull is started, the bucket automatically closes and the dirt is deposited in a truck or a trailer. This operation is repeated until the line is clear. Various bucket sizes are available for sewers of 150mm to 900mm in size. The machine is also used along with other scraping instruments for loosening sludge banks of detritus or cutting roots and dislodging obstructions (Fig.8.1).

8.8.5 Dredger (Clam-shell)

It consists of a grab bucket on a wire rope which is lowered into the manhole in open condition with the help of a crane and pulley. On reaching the bottom of the manhole the segments are closed, picking up the accumulated silt. The bucket is then raised above ground level where the bucket opens and the silt is automatically dropped into a truck or a trailer. The closing of the bucket can be effected by wire ropes or by a pneumatically operated cylinder. The disadvantage in this system is that it cannot clean the corners of the catchpits of manholes. Sometimes the deposits at the corners may become so hard that the same may be required to be chiselled out.

8.8.6 Roding Machine with Flexible Sewer Rods

This consists of a machine which rotates a flexible rod to which is attached the cleaning tool such as auger, corkscrew or hedgehog and sand cups (Fig.8.2). The flexible rod consists of a series of steel rods with screw couplings. The flexible rod is guided through the manhole by a bent pipe. The machine rotates the rod with the tool attached to one end, the other being fixed to the machine. The rotating rod is thrust into the bent pipe manually with clamps with long handles holding the rod near the couplings. As the rod is thrust inside, the machine also is drawn towards the manhole. The rod is pulled in and out in quick succession when the tool is engaging the obstruction, so as to dislodge or loosen it. When the obstruction is cleared, the rod is pulled out by means of clamps keeping the rod rotating to facilitate quick and easy removal. The various tools attached to the rods are shown in Fig.8.3

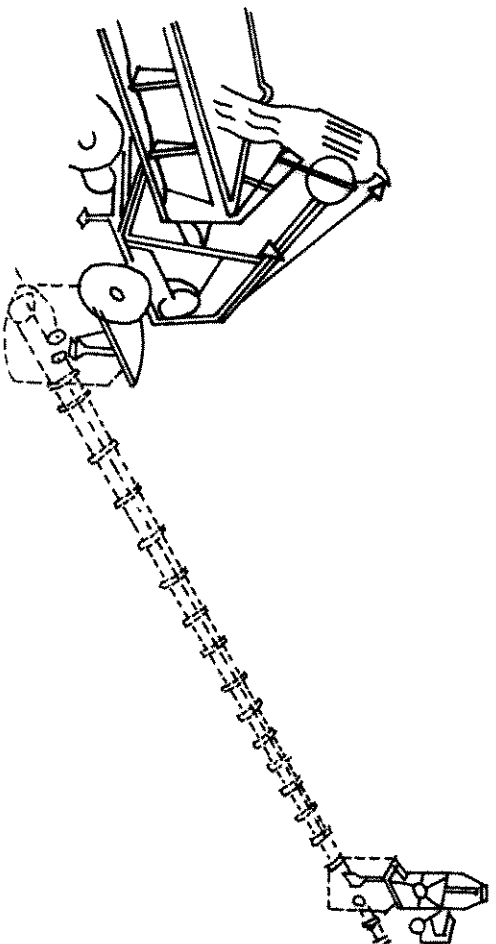


FIG. 8.1 : SEWER CLEANING BUCKET MACHINE

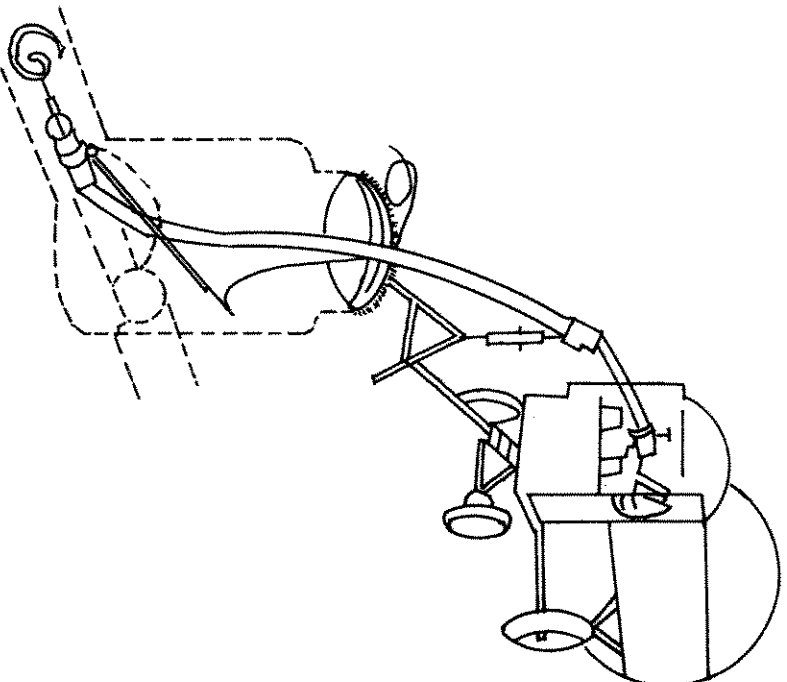


FIG. 8.2 : RODDING MACHINE WITH FLEXIBLE SEWER RODS FOR
SEWER CLEANING

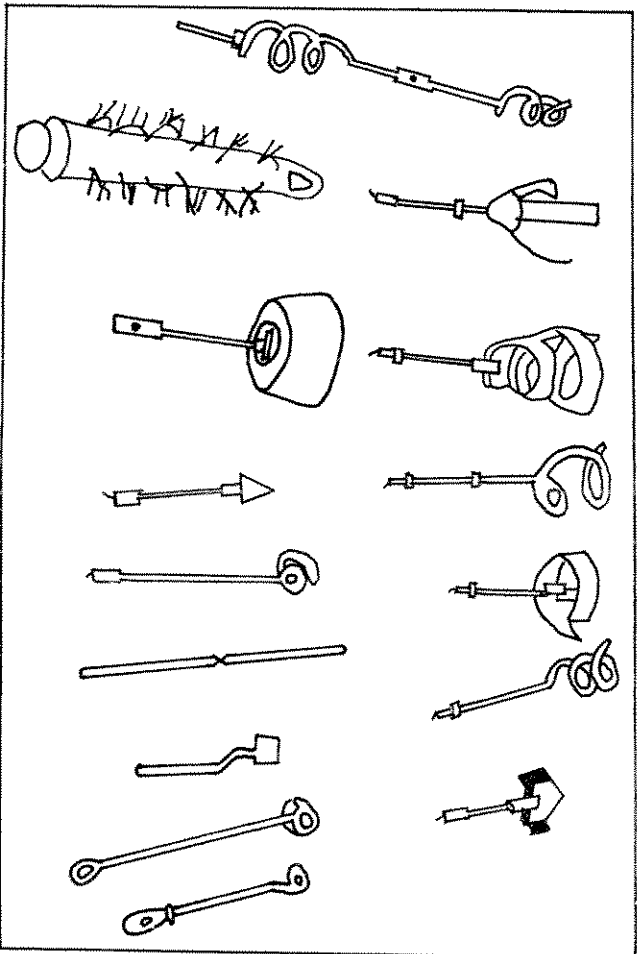


FIG. 8.3 : TOOLS FOR SEWER CLEANING