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IS : 9556 - 1980

Indian Standard
CODE OF PRACTICE FOR
DESIGN AND CONSTRUCTION OF
DIAPHRAGM WALLS

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CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF DIAPHRAGM WALLS

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Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF DIAPHRAGM WALLS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 26 May 1980, after the draft finalized by the Foundation Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Diaphragm walls are subjected to large horizontal forces due to earth pressures thereby causing heavy overturning movement at the foundation. The design of such structures involves special problems and this standard has been prepared with a view to providing guidance to a designer. Cast-in-place diaphragm walls are used in the field of hydraulic, civil, maritime and industrial engineering as positive impervious cutoffs for dams; as earth retaining structures for basements, subways, wells, and bridge foundations; as quay walls; and as foundations for structures. Diaphragm walls are also used as impervious cutoffs in excavations of basins, dry docks and locks, and are usually integrated with the main structure. Diaphragm walls of 1 m thickness have successfully been built in soft clays of density about 1.5 t/m³ and 65 m depth in this country.

0.3 In the formulation of this standard, considerable assistance has been given by Central Building Research Institute, Roorkee; and Bombay Port Trust.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the design and construction of diaphragm walls.

*Rules for rounding off numerical values (revised).

2. TERMINOLOGY

2.1 Anchorage — Anchorage is a structure used to carry the lateral thrust of a wall. Ties to a series of concrete blocks or a continuous RCC beam, vertical or battered piles inclined rock or soil anchors, are generally used for this purpose.

2.2 Angle of Wall Friction — When the surface of the diaphragm wall is smooth, the earth pressures acts normal to the wall surface. In case of a rough surface, due to the influence of friction the earth pressure, deviates from the normal. Angle between the direction of earth pressure and the normal to the wall surface is termed as angle of wall friction.

2.3 Bentonite — A clay formed by alteration of volcanic ash and rich in montmorillonite clay mineral. Bentonite has exchangeable ions on the surface of particles. It swells in the presence of water and its suspensions are thixotropic.

2.4 Diaphragm Wall — A wall constructed *in situ* by special trenching methods to act as cut off wall or serve as a structural member. The standard widths are 100-200 mm for cut-off wall 450 to 1 200 mm for structural member.

2.5 Earth Pressure — Pressure exerted by earth or backfill material on any structure such as a diaphragm walls.

2.5.1 Active Earth Pressure — The minimum value of earth pressure generated when diaphragm wall moves away from the soil mass.

2.5.2 Passive Earth Pressure — The maximum value of earth pressure generated when the diaphragm wall moves towards the soil mass.

2.6 Guide Wall — Walls of shallow depth built on both sides of the centre line of a diaphragm wall to guide the grabbing equipment for trench making in order to prevent collapse of trench panels and contain bentonite slurry.

2.7 Panel — Unit trench/wall excavated or cast at a time.

2.7.1 Primary Panel — Panels made along the main axis of the wall in the first series and leaving suitable gaps for other (secondary) panels. Primary panels are usually cast with two stop and pipes for interlocking with the secondary panels.

2.7.2 Secondary Panel — Panels made along the main axis of the wall in the second series and interlocked with the panels to form an effective and reasonably leak proof joint resulting in a continuous diaphragm wall.

2.8 Tie Rod — Tie rod is a structural steel bar used to transfer the earth pressure on the wall to the anchorage.

2.9 Wale — This is a horizontal member fixed to the wall. Its function is to transfer the horizontal thrust of the wall to the tie rods/struts.

2.10 Trenching — Excavation for a panel carried out *in-situ*. Use of drilling mud may be necessary to prevent collapse of sides.

3. NECESSARY INFORMATION

3.1 The following information is generally necessary for the design and construction of diaphragm walls:

- a) The site plan and detailed drawings of the structure, showing different views, elevations and sections along with the necessary details of nearby structures on all the sides together with foundation details.
- b) Detailed subsoil investigations for the site under consideration as laid down in IS : 1892-1979* and IS : 4651 (Part I)-1974† with particular reference to bouldery formation, natural or artificial rock bunds, etc.
- c) Physical, physico-chemical and engineering properties of the subsoil.
- d) The ground water table, its probable fluctuations and subterranean flow conditions of ground water if any.
- e) Estimation of the acid radicals of the soluble salts in the water extracts of soil and in the ground water as well as determining of pH values.
- f) The details of the estimated loads during construction as well as in permanent position.
- g) In case of hydraulic structures or walls near river banks, reservoirs or sea front, etc, the maximum and minimum water levels, velocity of currents, their scour action, wave heights and wave action, etc.
- h) The size, weight, capacity and working principle of the trenching and concreting machinery intended to be used.
- j) For preparing the grout, plastic concrete, RCC or any other impermeable sheet panels the quality and amount of local materials available economically at or near the site of construction.
- k) The complete details of auxiliary construction machines like lifting cranes, tower cranes, etc, available at the site of construction.

*Code of practice for subsurface investigations for foundations (*first revision*).

†Code of practice for planning and design of ports and harbours: Part I Site investigation (*first revision*).

- m) When used as walls or part of the structures, specifications for exposed faces.
- n) Existing underground services.

4. MATERIALS

4.1 Cement — The cement shall be ordinary portland cement or rapid hardening portland cement conforming to IS:269-1976* and blast furnace slag cement conforming to IS:455-1976† or pozzolana cement conforming to IS:1489-1967‡.

4.2 Aggregate — All the aggregates shall conform to IS:383-1970§. Well graded coarse aggregate of 20 mm size shall be normally used in reinforced concrete diaphragm walls. For plain concrete, plastic concrete or grout walls, a smaller size of aggregate may be used.

4.3 Sand — Well graded sand consisting of 50 percent coarse sand shall be used (see IS : 2116-1965||).

4.4 Water — Clean water free from deleterious impurities, as specified in IS:456-1978¶ shall be used in concrete mixing. Water used for preparation of bentonite slurry shall be free from salinity and other deleterious impurities.

4.5 Admixtures — If required, chemical admixtures in concrete may be used as specified in IS : 456-1978¶.

4.6 Reinforcement — Mild steel bars conforming to IS : 432 (Part I)-1966**, deformed bars conforming to IS : 1139-1966††, cold worked bars conforming to IS : 1786-1979‡‡ and structural steel section conforming to IS : 226-1975§§ shall be used.

4.6.1 All reinforcement bars and other structural steel sections used shall be clean and free from loose mill scales, dust, rust, oils, grease, paint or other coatings which may reduce the bond with concrete.

*Specification for ordinary and low heat portland cement (*third revision*).

†Specification for portland slag cement (*third revision*).

‡Specification for portland-pozzolana cement (*second revision*).

§Specification for coarse and fine aggregates from natural sources for concrete (*second revision*).

||Specification for sand for masonry mortars.

¶Code of practice for plain and reinforced concrete (*third revision*).

**Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part I Mild steel and medium tensile steel bars (*second revision*).

††Specification for hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcements (*revised*).

‡‡Specification for cold-worked steel high strength deformed bars for concrete reinforcement (*second revision*).

§§Specification for structural steel standard quality (*fifth revision*).

4.6.2 The joints between main reinforcement bars, the links and other steel sections shall be properly welded with respect to design considerations and handling requirements. Welding shall be done according to relevant Indian Standard while using mild steel bars in concrete construction.

4.7 Concrete — The water-cement ratio of concrete used shall not be greater than 0.6. The slump of the concrete used shall be 150 mm to 200 mm for ensuring easy flow through tremie pipe used in concreting. The concrete mix shall be suitably designed for the required slump and 10 percent extra cement added for under water work.

4.8 Bentonite — Sodium based bentonite shall be used in preparing bentonite slurry. The concentration of bentonite slurry used shall conform to requirements given in 6 and 8. For saline and chemically contaminated ground water condition, the slurry may be suitably processed with chemicals.

4.9 In case of grout walls, the cement, clay and chemical grouts used shall be designed and tested according to requirement of the structure.

4.10 Retarding agents and expansive additives may be added in the cement clay grout if required.

5. EQUIPMENT AND ACCESSORIES

5.1 Trenching Equipment — Depending upon the type of soil encountered at the site and the depth, and length and thickness of diaphragm wall to be constructed, suitable trenching equipment shall be chosen. The general trenching equipment shall include rotary boring rigs, percussion boring rigs, trenching bucket type shovels, mechanical grabs, hydraulic grabs, grabs with Kelly bars, grabs controlled by suspended wire ropes of a crane, direct mud circulation boring rigs, reverse mud circulation rigs and submersible mortar drills for trenching equipments. For gravelly soils, boulder deposits and rock formations, specially designed chiselling equipments shall be considered. When required methods using combination of above processes may be chosen.

5.2 Slurry Preparation and Testing Equipment — Tanks of suitable sizes and slurry pumps of suitable capacity should be used for storage, mixing and circulation of bentonite slurry at a site. A separate water pump may be used for water supply to slurry tank. Equipment for sampling the slurry from deep trenches and testing its concentrations, viscosity, pH value and hardness of ground water in which the bentonite slurry and concrete are prepared, should also be used. The testing of slurry after contamination with soil or cement indicates the need of disposal or reuse as the case may be. Vibrating screens, hydrocyclones, and centrifuges for cleaning the bentonite slurry for reuse may be employed.

5.3 Concreting Equipment — Concrete mixers, tremie pipes of suitable length and size and concrete pouring devices (manual or mechanical) should be used according to the need of the work. The lifting arrangement for tremie pipes should be capable of doing the work with desired speed.

5.4. Lifting Devices — Cranes of suitable capacity and boom length should be used in the case of precast wall panels for lowering them in the trenches. The same may be used for stacking the panels at site or during casting the panels in the casting shed. The reinforcement cages of large depths and lengths of wall panels may be lifted by crane, derrick or any other suitable auxiliary rig. If the loads of the panel and reinforcement cage are small, this work may also be done by winch and pulley arrangement provided on the diaphragm walling ring. Cranes or rigs with winches of adequate capacity may be used for operating the trenching grabs as necessary.

5.5 General Guidelines — Choice of rotary, percussion, grabbing equipment, and equipment for direct or reverse mud circulation, etc, shall be made to suit the soil conditions. Vibrations and noise produced during construction should not have any damaging effect on the people and existing structures. Consideration shall be given in selection of equipment when they are required to work on a site with restricted space or head room.

6. SPECIFICATIONS OF BENTONITE SLURRY

6.1 Following tests are normally carried out on freshly prepared bentonite slurry to be used in diaphragm walling:

<i>Type of Test</i>	<i>Method of Test</i>	<i>Permissible Value at 20°C</i>
Density	Mud balance or hydrometer	1.04 to 1.10 g/ml
pH value	pH indicator paper strips	9.5 to 12
Viscosity	Marsh cone method	30 to 90 seconds
10-minute gel strength	Shearometer or vane shear apparatus	1.4 to 10 N/m ² (14 to 100 dyn/cm ²)

6.2 The relationship between concentration C of bentonite slurry expressed as percentage by mass and the density γ_s is given below:

$$\gamma_s = 1.0 + 0.006C.$$

NOTE — The above relation is valid for Indian bentonites and represents an average sample. There may be some variations of bentonites. Laboratory calibration may be prepared for the bentonite samples actually used.

6.3 Tests to determine density, viscosity, shear strength and pH value shall be carried out until a consistent working pattern is established, taking into account the mixing process, blending of freshly mixed bentonite slurry with previously used slurry and any process which may be employed to remove impurities from previously used bentonite slurry.

6.4 When results show consistent behaviour the tests for shear strength and pH value may be discontinued and tests required to determine density and viscosity need be carried out.

6.5 The frequency of testing shall be on panel to panel basis where bentonite slurry becomes heavily contaminated with fine sand during its first use, and may be on a daily basis where contamination may be slight. In cases where a mechanical process is employed to remove contaminating solids from the slurry, the frequency of slurry testing shall depend on equipment employed.

6.6 Prior to placing of concrete in any panel a bentonite slurry sample shall be taken (that is, about 0.2 m from the trench bottom) and the same shall be tested for density. The sampling shall be done carefully by an appropriate method. The density thus determined shall not be greater than 1.25 g/ml to ensure satisfactory placing of concrete. If the slurry is found to have higher density, the same shall be thinned by feeding in fresh bentonite till the required density is achieved.

6.7 Suitable slurry pumps, submersible pumps or air lift shall be used in replacing the contaminated slurry at the bottom of trench by fresh bentonite slurry.

7. BENTONITE SLURRY AND ADDITIVES

7.1 Sodium bentonite powder shall be mixed thoroughly with potable water to form a fully dispersed lump-free homogeneous slurry. Suitable slurry tanks shall be used for this operation. The use of a slurry pump with special nozzle (see Fig. 1) is suggested for preparing bentonite slurry. Use of paddle stirrer or other mechanical devices such as colloidal grout mixer, (see Fig. 2), may also be made for proper mixing of slurry. The temperature of water used and of the slurry used shall not be less than 5°C.

7.2 Where saline or chemically contaminated ground water is present, special additives as listed below may be used to render bentonite slurry fit for use. These additives are used in very small amount of 0.1 to 0.5 percent by mass of the slurry.

7.2.1 Ferrochrome lignosulphonate in combination with soda ash or bichromate of soda, may be used for effective bentonite hydration, if hardness of sea water exceeds 200 ppm.

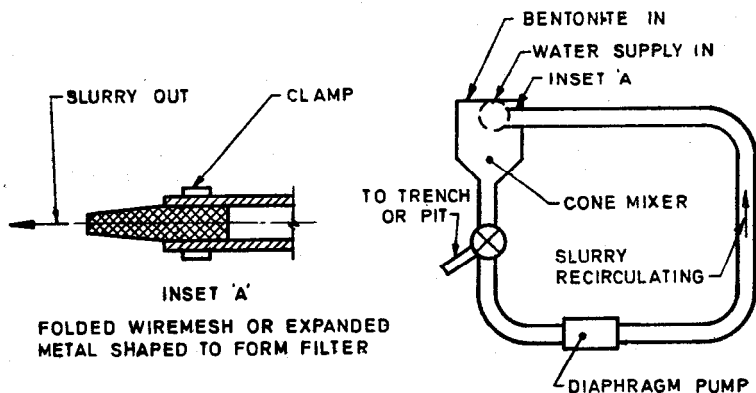


FIG. 1 SPECIAL NOZZLE AND SLURRY MIXING PLANT

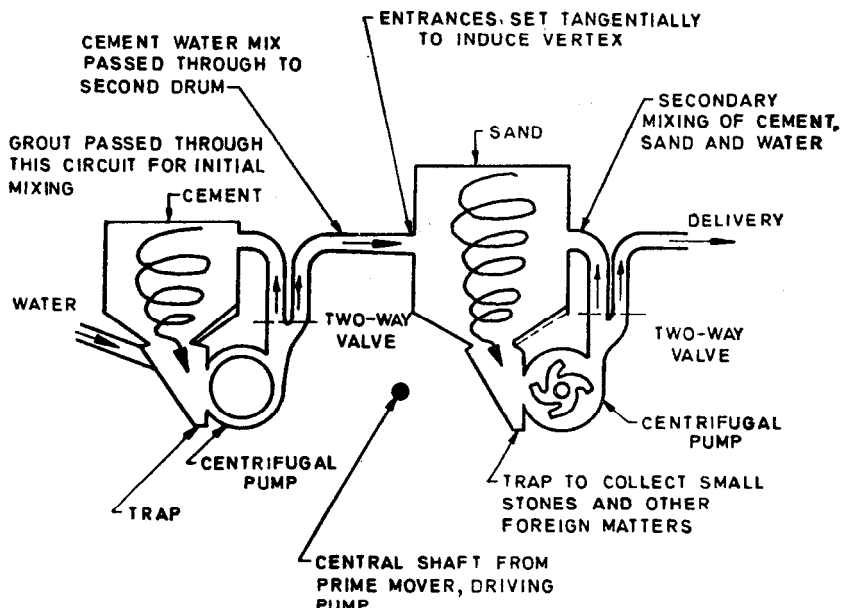


FIG. 2 FLOW DIAGRAM OF CONCRETE DOUBLE DRUM COLLOIDAL GROUT MIXER

7.2.2 Sodium carboxymethylcellulose (S.C.M.C.) is yet another additive sometimes used. It protects slurry against effects of electrolytes, accelerates filter cake formation, and reduces fluid loss by increasing the viscosity of slurry.

7.2.3 Cement contamination may be counteracted by phosphates. The calcium gets removed and clay solids dispersed. Phosphates decrease pH value thereby lowering viscosity and yield value of slurry.

7.2.4 Carboxymethylcellulose, gums or presheared asbestoes may be used to increase viscosity and reduce filter loss.

7.2.5 To remove fine silty solids and clay solids from the slurry, flocculants may be used. Vinyl acetate maleic anhydride co-polymer or polyacrylamides may be used. Guar gum can flocculate clays, carbonates, etc.

7.2.6 Pregelatinised starch may be employed as a fluid loss control. It may also be used as a protective colloid against the effect of electrolytes.

8. STABILITY OF SLURRY FILLED TRENCHES

8.1 The bentonite slurry filled in the trench imparts stability by mainly applying hydrostatic pressure on the wall, against the impermeable thin film formed along the wall. Secondly, the slurry filled in the trench provides passive resistance against failure of the trench, and thirdly, the shearing resistance of the slurry saturated zone and the plastering effects of the filter cake formed also contribute towards trench stability. The hydrostatic pressure alone represents 65 to 80 percent of the total stabilizing forces. If the density of slurry used is such that it can provide a factor of safety of one due to hydrostatic pressure, then the factor of safety of the actual trench shall be between 1.25 to 1.50. Therefore, taking only hydrostatic pressure and considering $F=1$, the density of slurry may be calculated as indicated by the following formula. This formula should be used as a guide only:

For clays:

$$F = \frac{N_c C_u}{H (\gamma - \gamma_s)}$$

where

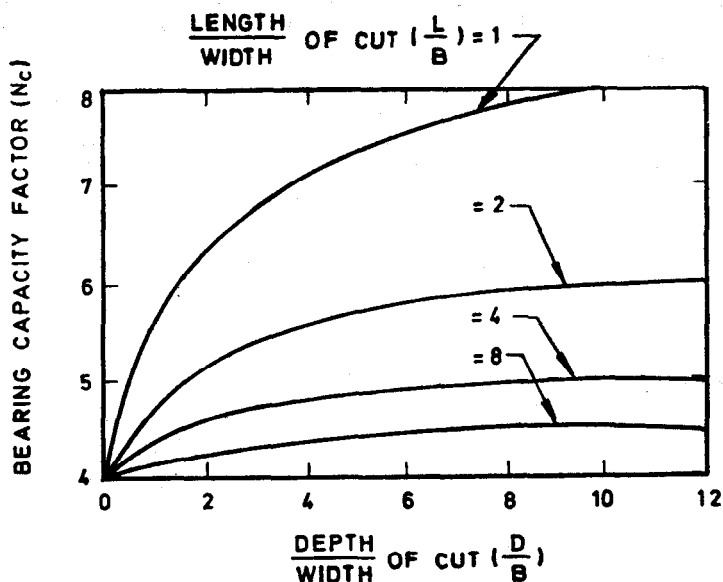
H = depth of the trench,

C_u = undrained shear strength of clayey soils,

γ = natural density of saturated soils,

γ_s = density of the slurry needed for the trench, and

N_c = bearing capacity factor which varies from 4 at the ground surface to 8 for deeper depths, depending upon D/B and L/B ratio of the trench. This factor accounts for arching action in horizontal as well as vertical directions (see Fig. 3).

FIG. 3 STABILITY FACTOR N_c FOR RECTANGULAR CUTS IN CLAY (II)

For sandy soils:

$$\gamma_s = \gamma_w + A (K_a \gamma')$$

where

$$A = \frac{1 - e^{-2n K_a \tan \phi'}}{2n K_a \tan \phi'}$$

$$K_a = \tan^2 (45^\circ - \phi'/2)$$

γ' = effective unit weight of the sandy soil

= submerged unit weight

= saturated weight — weight of water

= $\gamma_{\text{sat.}} - \gamma_w$

The value of A depends upon $n = \frac{\text{depth}}{\text{length}}$ ratio of the trench (see Fig. 4).

As a general rule, level of bentonite slurry in the trench shall be adequately higher than the water level.

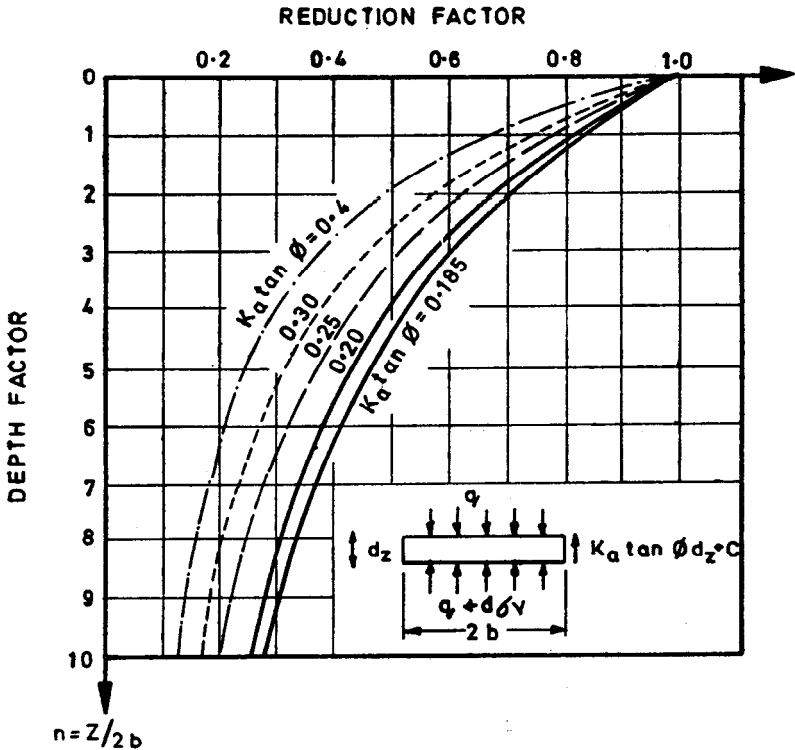


FIG. 4 REDUCTION FACTOR A FOR EARTH PRESSURE IN TRENCH OF LENGTH $2b$ ($cd = 0$)

9. GUIDE WALLS

9.1 Guide walls shall be constructed prior to main slurry trenching operation.

9.2 Guide walls shall be 100 to 250 mm thick, 1 to 2 m deep and made of lightly reinforced concrete, and shall represent the reference lines. In soft ground or fill, guide walls may be taken deeper. When ground water table is close to surface, guide walls higher than the surface level shall be constructed to maintain additional slurry head.

9.3 The clearance between finished diaphragm wall and guide may be 50 mm minimum for straight panels. The clearance shall be suitably increased when the panels are curved.

9.4 The finished faces of the guide walls towards the trench shall be vertical.

9.5 Guide walls after construction should be suitably propped to maintain specified tolerance.

9.6 Mesh or cage reinforcement shall be used in guide walls.

9.7 The level of bentonite slurry in the trench shall be 1 m or more, if necessary, higher than the ground water table.

9.8 For heavy machinery, guide walls shall be constructed with suitable ground slab (on both sides of the walls).

9.9 Guide walls get support from adjoining panels and, therefore, their construction should be done continuously.

10. STAGES OF CONSTRUCTION

10.1 Cast-in-situ structural RCC diaphragm wall shall be constructed by resorting to either successive panel method or alternate panel method. In successive panel method, a panel shall be cast by the side of another completed panel, so as to form a good joint and a continuous leakproof diaphragm wall. In alternate panel method, primary panels shall be cast first, leaving suitable gaps in between. Secondary panels shall then be cast, resulting in a continuous diaphragm wall. The panel lengths vary depending on the soil strata and depth of trenching and surcharging, however lengths of 1.5 m to 6 m are usually adopted.

10.2 Successive Panels Method — In this method a panel shall be cast in continuation of previously completed panel. Use of form tubes is generally used for creating a joint between primary panels and secondary panels. However with larger width of diaphragm wall and greater depth of diaphragm wall it may not be possible to provide form tube due to handling, lowering and extraction difficulties. In such a case special tools, such as semicircular chisels are used to effect a joint between primary and secondary panel and in this case form tubes are eliminated.

NOTE — Form tubes of 1 m diameter and 30 m long have been successfully used.

10.2.1 Excavation of each trench panel (see Fig. 5A) shall be done with the help of suitable machinery. The trench panel shall be kept filled with bentonite slurry of suitable consistency and viscosity during the excavation period.

10.2.2 A stop end tube with a smooth surface, or a structural section shall be inserted in the trench at the end of the panel to support concrete and to form a suitable joint with the next panels.

10.2.3 Reinforcement cage shall then be lowered in the trench panel and suitably supported. The concrete cover for the reinforcement shall be maintained by the use of spacers. Boxes or inserts for formation of recesses or for ground anchors shall be lowered along with the case to correct position and levels.

10.2.4 Before placing concrete in the panel the trench shall be flushed properly to clean the bottom and to remove thicker suspension from the lower level. The density of the slurry shall be checked by taking a sample about 0.2 m from the bottom. If the density of the sample is found to exceed 1.25 g/ml. The flushing shall be carried out with fresh bentonite slurry, concreting in the trench panel shall be done through one or more tremie pipes with suitable funnels as shown in Fig. 5B.

10.2.5 The end tube shall be taken out gradually after initial set of concrete. This may be done carefully with the help of a suitable crane or any other lifting device. Withdrawal of end tube should not cause any cracks in concrete at the panel end.

10.2.6 Jointing between the successive panels may be achieved in any of the different ways shown in Fig. 6.

10.3 Alternate Panel Method

10.3.1 In this method primary panels shall be cast first leaving suitable gaps in between. Secondary panels shall then be cast in these gaps (*see* Fig. 7). Two stop end tubes are used at the ends of the primary panels to support concrete and to form suitable joints with the secondary panels.

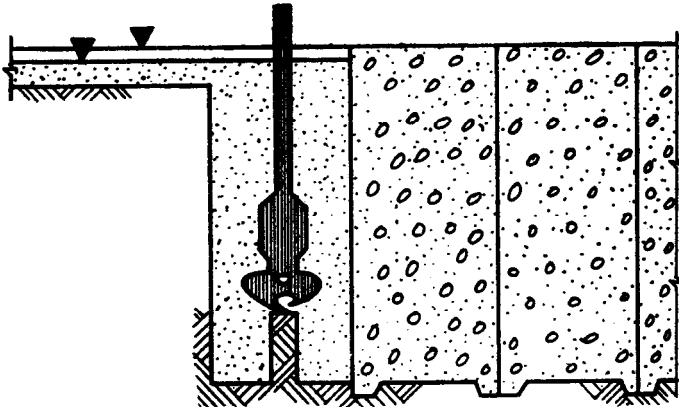
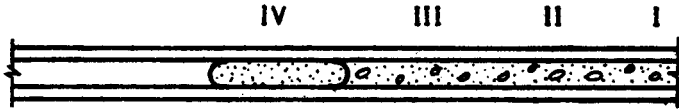
10.3.2 The excavated length of trench for secondary panel may be smaller than that of primary panel.

10.3.3 The shape of the secondary panel end should be such as to form a good joint with primary panels.

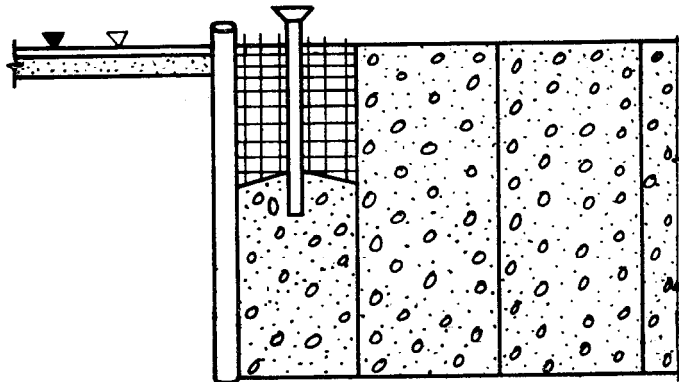
10.3.4 The other construction techniques shall be similar to those in the successive panel method.

10.4 Direct Circulation Method

10.4.1 This method is used with rotary or percussion type rigs where drilling fluid (bentonite slurry) is pumped through the drilling rods. It can be used for successive panel or alternate panel construction. The stages of construction are shown in Fig. 8. Simple trenching rigs for excavation may be used. Special cutters (for cutting and jointing) and elliptical concreting tremie pipes for backfilling the trench panel may be used.



5A EXCAVATION



5B COLCRETING

FIG. 5 SUCCESSIVE PANEL CONSTRUCTION (EXCAVATION AND CONCRETING)

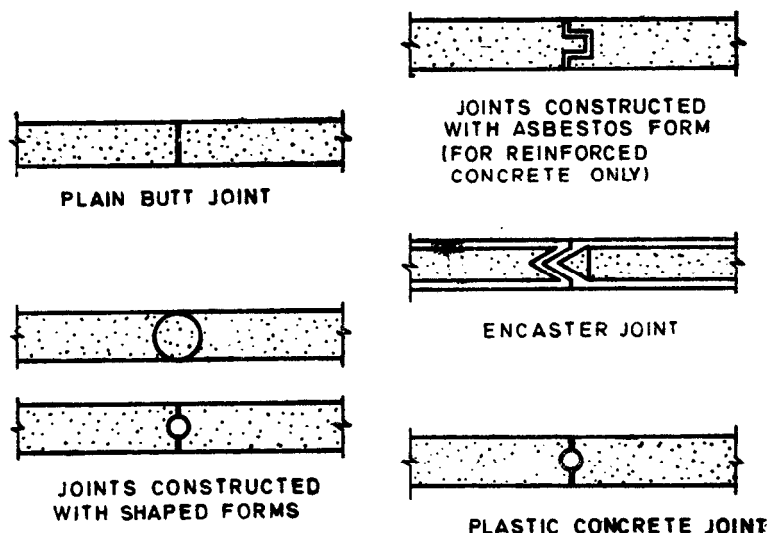


FIG. 6 DIFFERENT TYPE OF JOINTS

10.4.2 The trench panel may be excavated in the ground by making overlapping bore holes with bentonite slurry-jet in combination with percussion and to and fro rotary motion of jetting pipe having a suitable cutter at the tip.

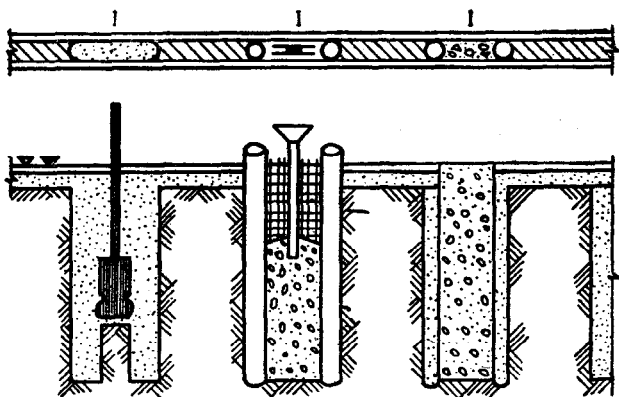
10.4.3 A special semicircular cutter shall be used for providing appropriate shape at each panel end to form a suitable joint.

10.4.4 The elliptical or oblong tremie pipe shall be used for concrete having aggregate of 20 mm and smaller. This shall be used for walls of 20 to 30 cm thickness. For walls of greater thickness, a circular tremie pipe may be used.

10.4.5 The operations of filling bentonite slurry in the trench and lowering of reinforcement cage into the trench panel shall be similar to method described under successive panel method.

10.4.6 For thicker walls, that is, 40 cm and more, suitable modified semicircular jointing cutter may be used.

10.4.7 This method is suitable for shallow depths and bringing up lighter cuttings.



7A



7B

I = Primary panels
II = Secondary panels

NOTE — Due to space left by stop end tubes primary and secondary panels are of different sizes and panel end shape.

FIG. 7 CONSTRUCTION OF PANELS

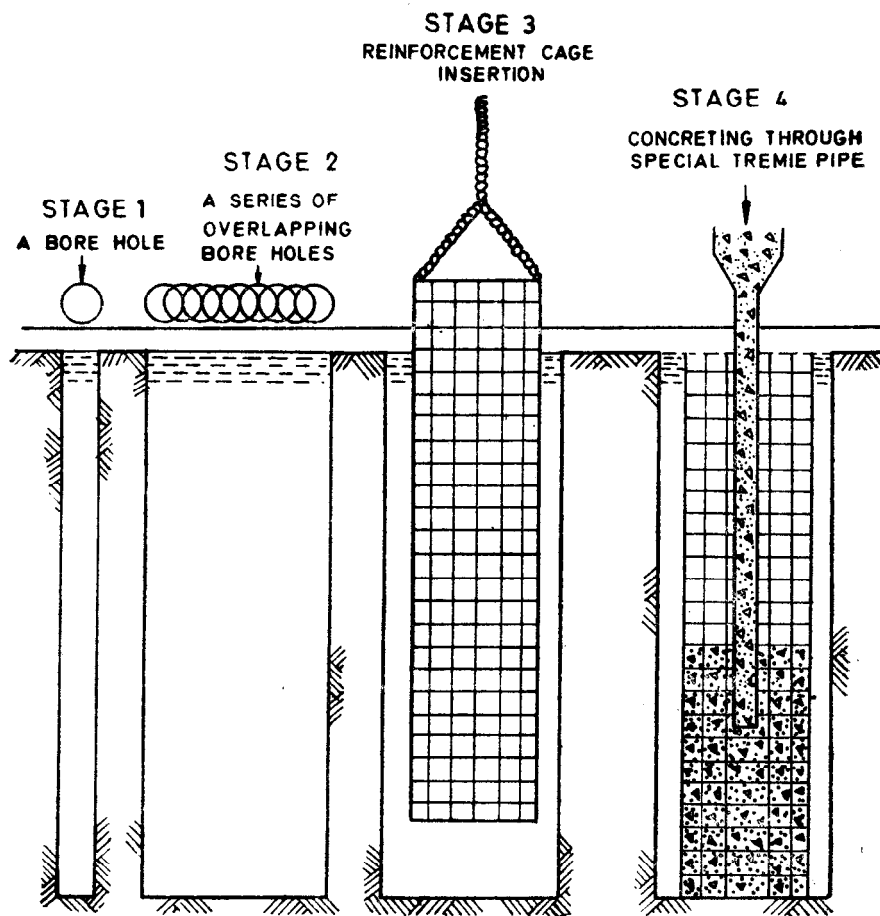


FIG. 8 STAGES OF DIAPHRAGM WALL CONSTRUCTION BY DIRECT CIRCULATION METHOD

10.5 Reverse Circulation Method

10.5.1 The reverse circulation method within percussion shall be used to make trench panel in the ground as shown in Fig. 9. Forward and backward movement of the rig from one end of the panel to the other end shall increase the depth of the panel in a zig-zag manner.

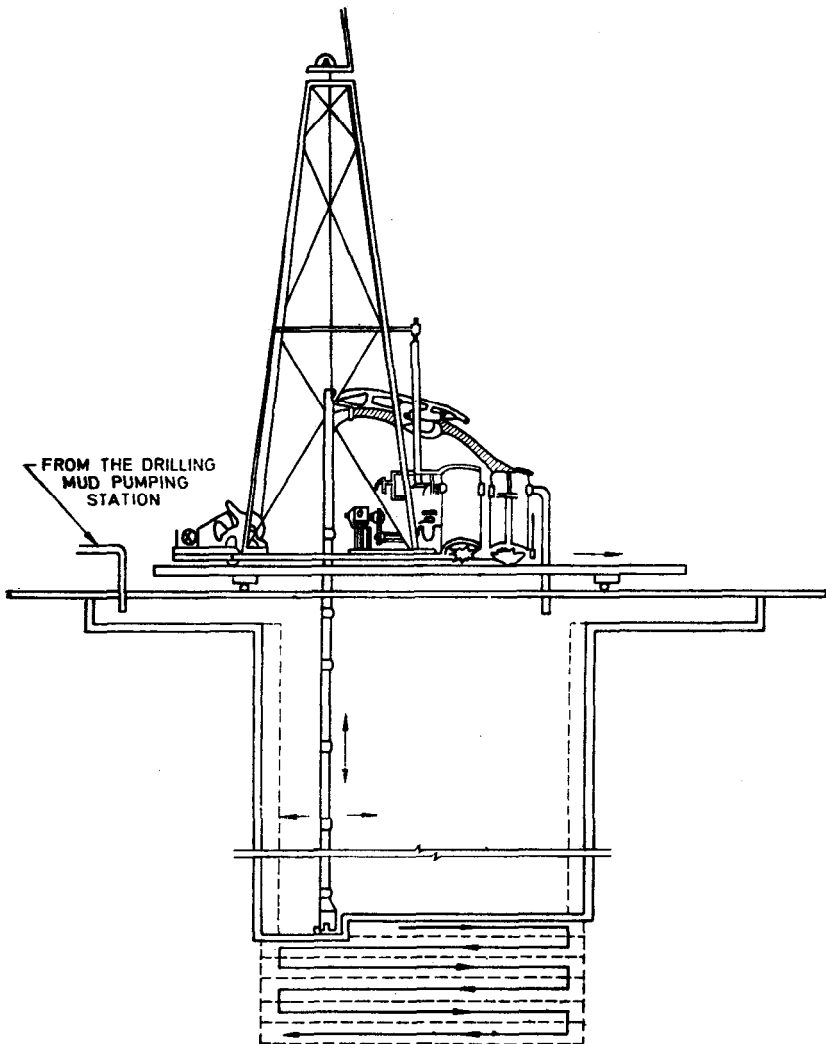


FIG. 9 TRENCH EXCAVATION BY REVERSE CIRCULATION METHOD

10.5.2 High capacity pumps shall be used to suck the loosened soil in the slurry filled trench. Separators or sedimentation tanks shall be used to retain the soil cuttings and to pass the slurry for circulation and reuse.

10.5.3 This method is suitable for greater depths and to bring up heavier cuttings.

10.6 Wall of Precast RCC Panels

10.6.1 The trench panel shall be made in the ground using normal machines or grabs. The trench shall be kept filled up with self-setting bentonite slurry. Specially designed precast RCC panels with provision for suitable jointing shall be lowered in the trench with the help of crane. The panels shall be supported in the trench by using special supports.

Inside face of panels before lowering them into the trench shall be treated with a special compound.

10.6.2 The self-setting bentonite slurry shall be slow setting and should develop adequate strength and impermeability.

10.6.3 Precast panels used in the process shall provide an aesthetically pleasing surface of wall on excavation of soil. The quality of concrete in PRECAST RCC panels is better than that achieved by tremie concrete method.

10.7 Grout Cut-Off Walls

10.7.1 Where structural strength is not required the self setting bentonite slurry may be used to provide an impermeable cut-off wall.

10.7.2 Suitably designed clay concrete or sand bentonite cement mix may be used for diaphragm walls which are primarily meant as impermeable cut-offs.

11. TOLERANCES

11.1 Guide Walls — The finished faces of the guide walls towards the trench shall be vertical. There shall be no ridges or abrupt changes on the face of the guide wall. Variations from a straight line or a specified profile shall not exceed 25 mm in 3 m.

11.2 Diaphragm Wall

11.2.1 Verticality — The face of the wall and ends of the panel to be exposed shall be vertical within a tolerance of 1 : 80.

11.3 The effective trimmed final wall levels shall normally be taken as 250 mm below the top of guide wall when concrete is cast to the top of trench. If water table is high and if required cut-off is low and water table is also at depth, concreting can be stopped at lower level. For trimmed final wall levels below this level, the vertical tolerance in profile of concrete cast shall be between 150-500 mm above the specified wall levels.

11.4 Where recesses are formed by inserts in walls, these shall be positioned within a vertical and horizontal tolerance of 150 mm.

11.5 In positioning of reinforcement, longitudinal tolerance of cage head at top of the guide wall measured along the trench shall be 75 mm and vertical tolerance at cage head in relation to top of guide wall shall be 50 mm.

12. DESIGN CONSIDERATIONS

12.1 Following considerations shall apply to RCC walls used for retaining the sides of basement excavation.

12.1.1 The earth pressures acting on the diaphragm wall shall be calculated in accordance with IS:4651 (Part III)-1974*.

12.1.2 The effect of excavation in stages and the strutting or anchoring at the various levels shall be taken into account in arriving at the stresses in the wall.

12.1.3 In designing, a panel may be treated as a unit unless the adjacent panels are so constructed or connected as to ensure continuity and adequate shear transfer between panels.

12.1.4 Struts or anchors, preferably prestressed, shall be used to increase the stability of the wall and to control deflections.

12.1.5 In diaphragm walls constructed close to an existing structure the soil retained by the wall is subject to surcharge load. In such cases smaller length of panels may be adopted. However, in soils with low shear strength reduction in panel length is recommended.

12.1.6 The design should take into account the effect of inserts and recesses on the strength of the wall.

12.2 Considerations given in 12.2.1 to 12.2.5 shall apply to the design of the RCC work.

*Code of practice for planning and design of ports and harbours: Part III Loading (first revision).

12.2.1 All RCC work shall be designed in accordance with the provisions of IS : 456-1978*.

12.2.2 Permissible Stresses in Concrete — Permissible stresses in concrete shall be in accordance with IS : 456-1978*.

12.2.3 Permissible Stresses in Reinforcement — Permissible stresses in reinforcement shall be in accordance with IS : 456-1978*.

12.2.4 Minimum clear cover for main reinforcement shall be 75 mm.

12.2.5 Minimum clear distance between bars shall be 100 mm.

13. RECORDS

13.1 Following records shall be maintained in a manner approved by the engineer-in-charge:

- a) Name of work
- b) Panel No. and reference drawing No.
- c) Date of commencement and completion of excavation
- d) Date of concreting of panel
- e) Length of panel
- f) Thickness of panel
- g) Top of guide wall level
- h) The depth of guide wall
- j) Top level of wall as cast, in relation to top of guide wall at the edges and at the centre
- k) Depth of panel from base to top of guide wall
- m) Strata encountered
- n) Volume of concrete used, slump, water-to-cement ratio
- p) Cubes taken and their results
- q) Details of reinforcement (cage type)
- r) Details of any obstructions encountered and time spent in overcoming them

*Code of practice for plain and reinforced concrete (*third revision*).

(Continued from page 2)

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AMENDMENT NO. 1 JULY 1984

TO

IS : 9556-1980 CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF DIAPHRAGM WALLS

(Page 4, clause **2.4**, lines 2 and 3) — Substitute ' machines ' for ' methods ' and ' 800 ' for ' 200 '.

(Page 4, clause **2.6**, line 2) — Substitute ' or boring tool ' for ' equipment '.

(Page 6, clause **4.3**, line 1) — Delete the words ' consisting of 50 percent coarse sand '.

(Page 7, clause **4.6.2**) — Add the following clause after **4.6.2**:

‘4.6.3 Reinforcement in each panel should form a cage and the vertical ends of the cage should match with the type of joints of the panel. For ease of handling and good workmanship, the cage should be made rigid. Clear distance between reinforcement bars should not be less than 100 mm for easy flow of concrete.’

(Page 7, clause **4.7**) — Add the following new matter at the end:
‘ for method other than tremie ’.

(Page 7, clause **5.1**, lines 6, 7 and 8) — Substitute ' with kelly bars ' for ' grabs with Kelly bars ' add the word ' winch ' after ' crane ' and substitute ' motor ' for ' mortar ' respectively.

(Page 8, clause **5.4**, line 8) — Substitute ' rig ' for ' ring '.

(Page 9, clause **7.1**, line 1) — Add the word ' based ' after ' sodium '.

(Page 9, clause **7.1**) — Add the following clause after clause **7.1**:

‘7.1.1 For proper stabilisation of the trench walls by bentonite slurry, it is essential to allow adequate gelation period for bentonite slurry. For this purpose after slurry is mixed thoroughly it should not be used for a period of minimum 12 h.’

(Page 12, clause **8.1**, last two lines) — Substitute ' minimum 1.5 m ' for ' adequately '.

(Page 13, clause **9.2**) — Add the following new matter at the end:

‘ The top of the ground level shall be minimum 1·5 m above high water table. ’

(Page 15, clause **10.2.3**) — Add the following clause after **10.2.3**:

‘ **10.2.3.1** Circular cover blocks are considered essential to the reinforcement, so that they roll along the trench without damage and maintain adequate cover. ’

(Page 21, clause **10.7.2**, line 1) — Add ‘ (plastic concrete) ’ after ‘ clay concrete. ’