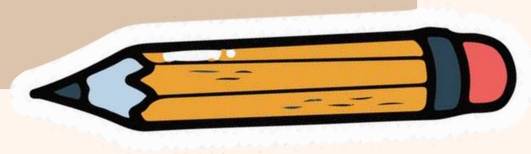
UNDERWATER CONSTRUCTION OF DIAPHRAGM WALLS AND BASEMENT

What is underwater construction?

underwater construction is industrial construction in an underwater environment. There is often but not necessarily a significant component of commercial diving involved. It is a part of the marine construction industry.

What is diaphragm wall?

Diaphragm walls is a continuous wall constructed in ground in to facilitate certain construction activities such as :a retaining wall ,as a cutoff provision to support deep excavation , as the final wall for basement or other underground structure , as a separating structure. A diaphragm walls forms a rectangular section constructed in-situ under the soil. Hence, this an underground concrete wall .These walls are constructed panel by panel each interlocked to ensure structural stability and water tightness.



Diaphragm wall

Depending on the function the following kinds of diaphragm walls are used :

Structural walls

They are used as retaining walls for the perimeter walls of deep basements and underground parking facilities ,subways, underpass etc.

Load Bearing walls

They are used in place of drilled piers in foundation of tall buildings, bridge piers etc.

Cutoff walls

In hydraulic structure diaphragm walls are used as impermeable cutoffs to prevent seepage below earth dams, weirs and levees.

Stages of construction of diaphragm walls

Cast-in-situ structural RCC diaphragm wall shall be constructed by resorting to either successive panel method or alternate panel method.

METHODS

In successive method

A panel shall be cast by the side of another completed panel, so as to form good joint and continuous leak proof diaphragm wall .

In alternate panel

Primary panels a shall be cast first leaving suitable gaps in between. Secondary panels shall then be cast, resulting in a continuous diaphragm wall.

In Successive Method

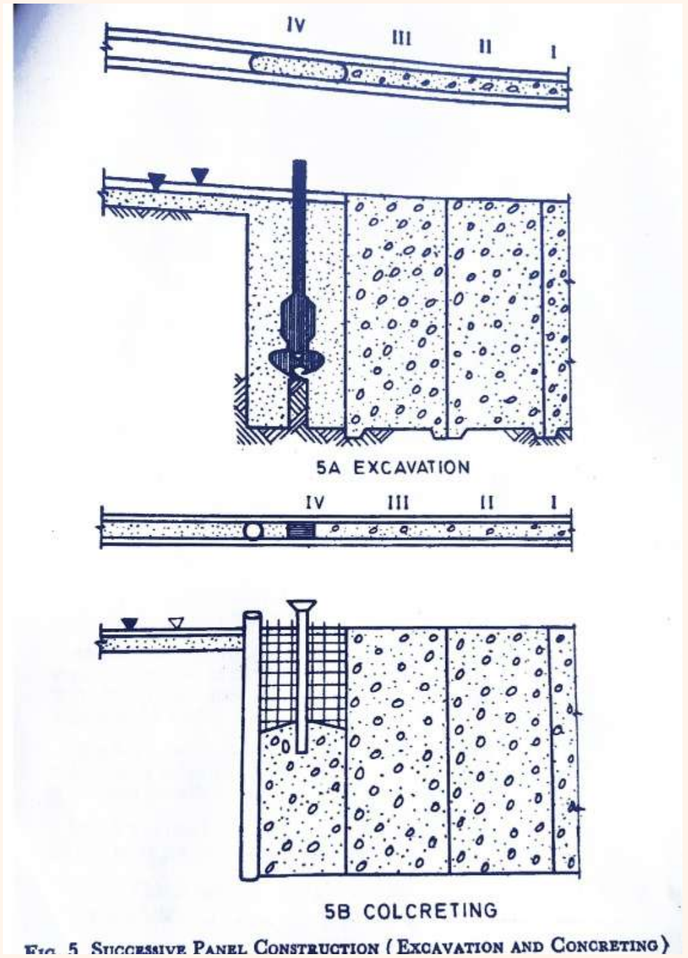
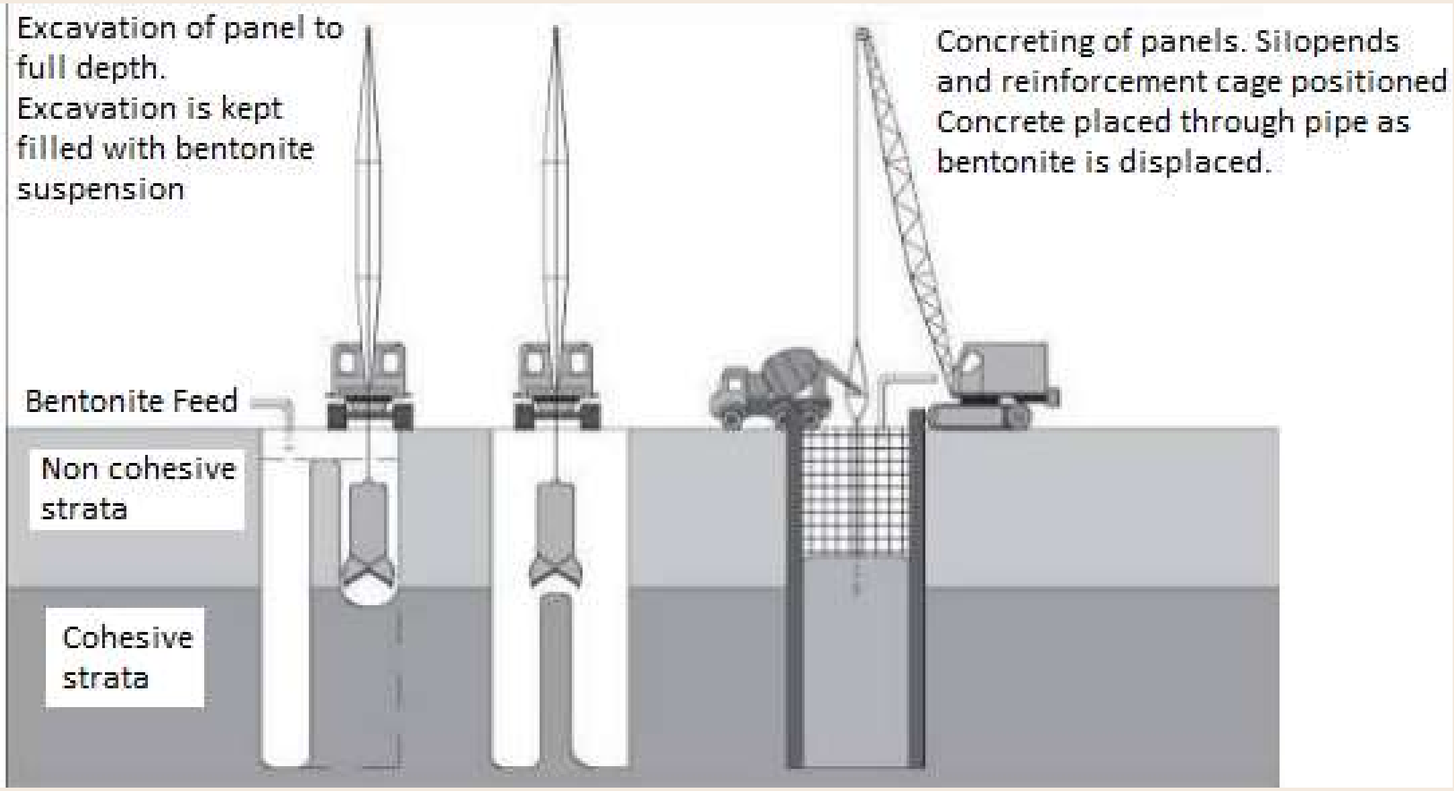
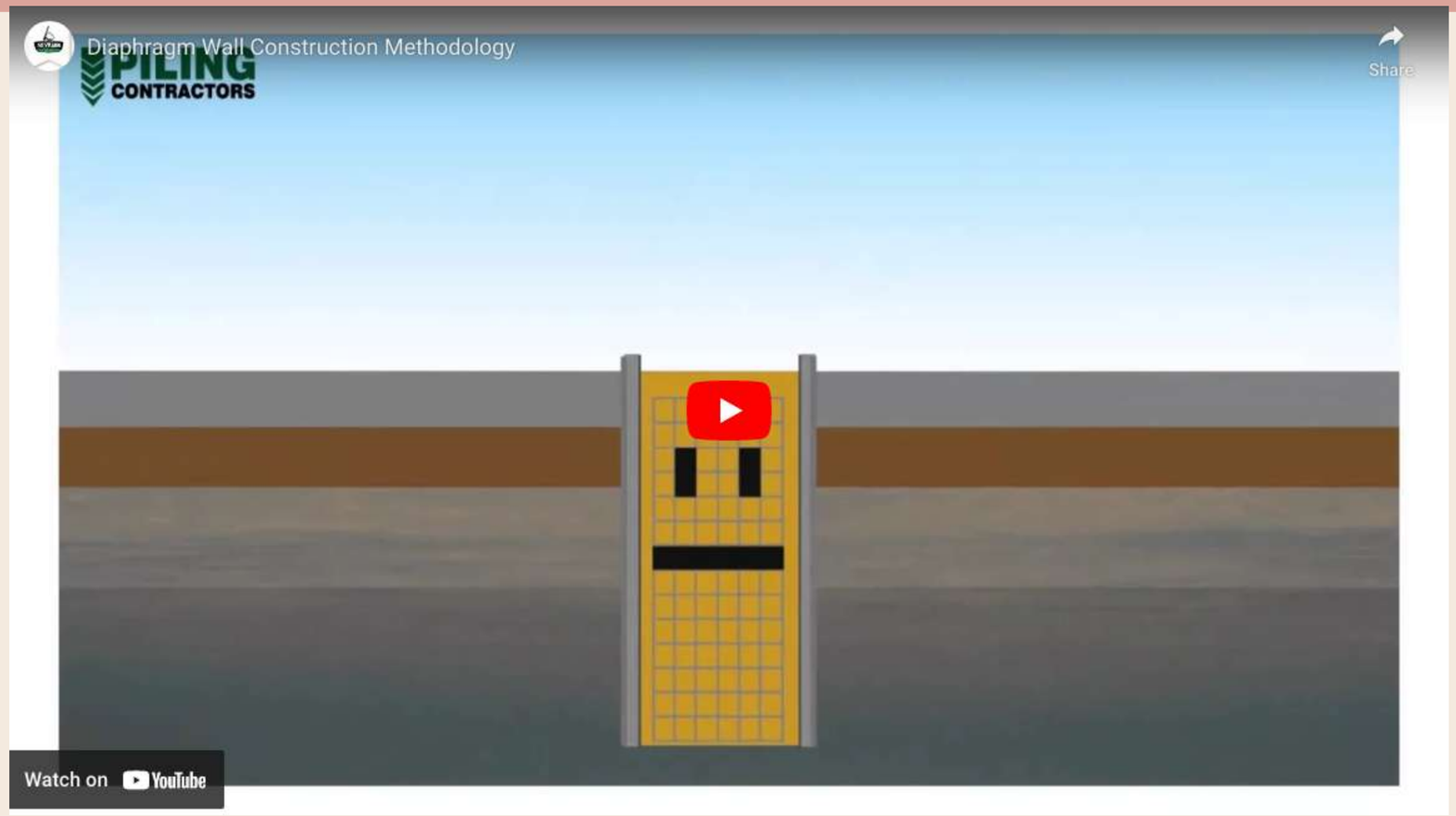


FIG. 5. SUCCESSIVE PANEL CONSTRUCTION (EXCAVATION AND CONCRETING)

In Alternate panel Method



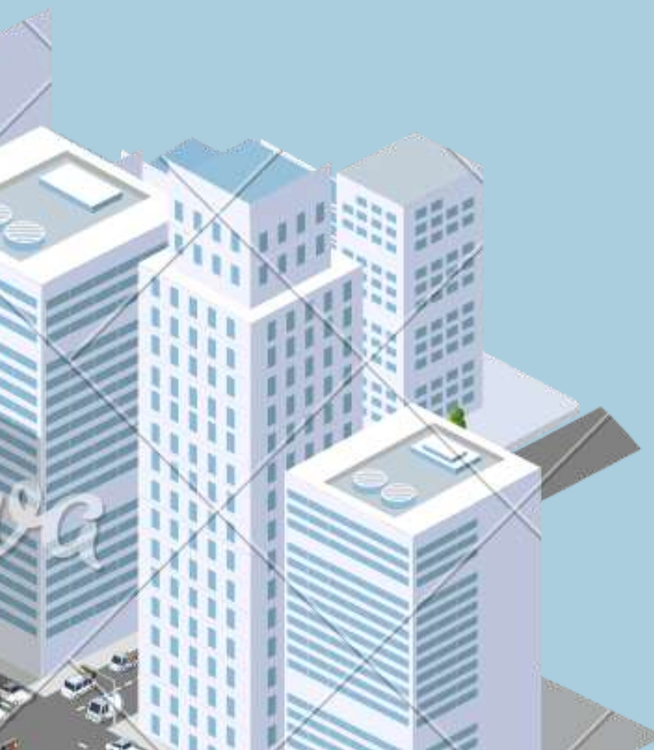


https://youtu.be/wUIQyiHfex0

For design & construction of diaphragm wall IS:9556-1980 shall prevail

For design &construction of diaphragm wall for under seepage control IS:14344-1996 shall used

CONSTRUCTION OF DIAPHRAGM WALL



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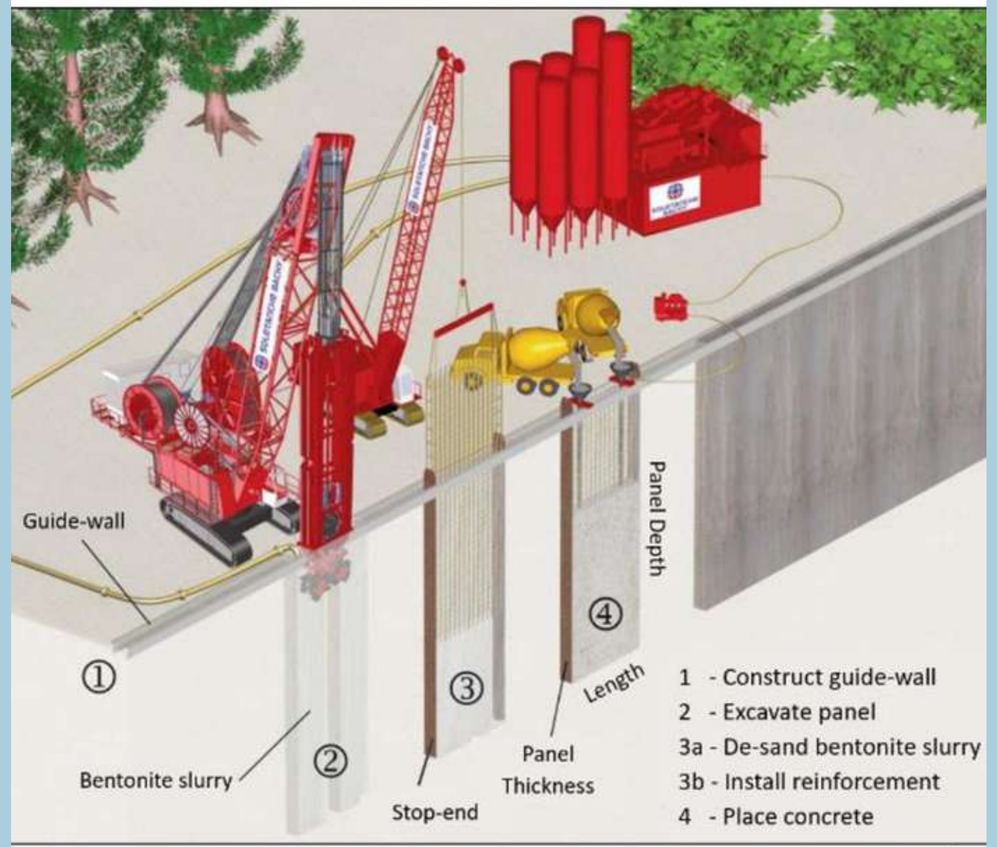
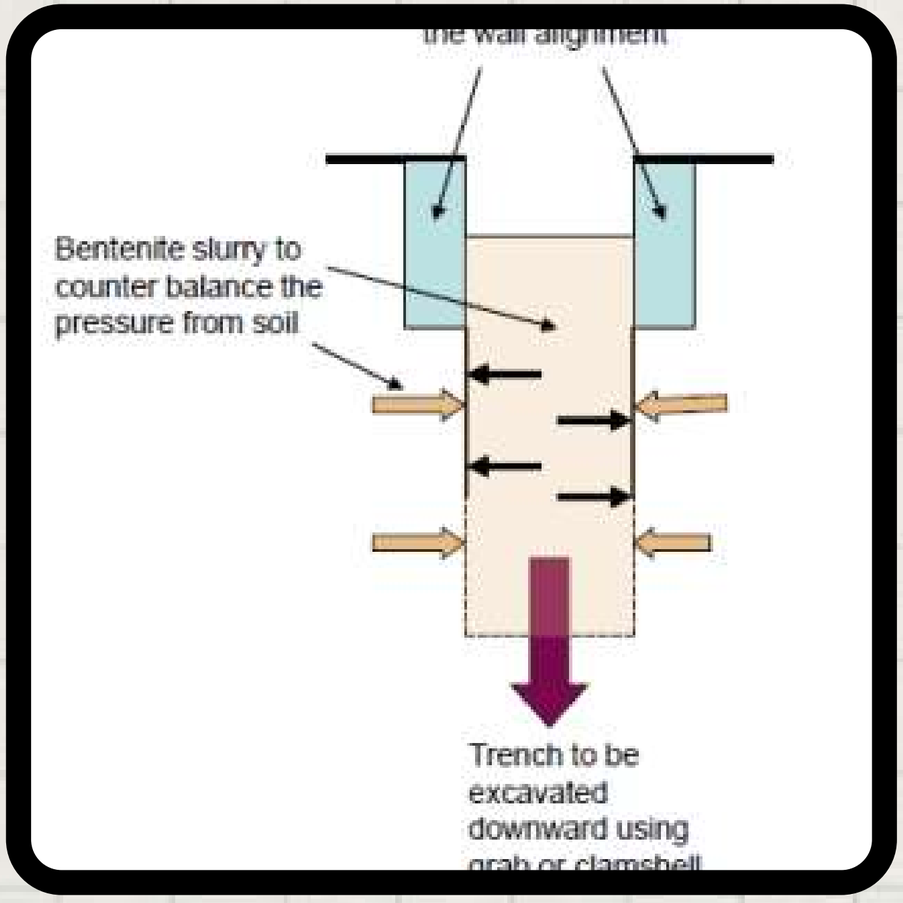


3- Illustration of diaphragm wall construction stages (Image source: Soletanche Bachy [2])

GUIDE WALL



Guide wall is two parallel concrete beams constructed along the side of the wall as a guide to the clamshell which is used for the excavation of the diaphragm wall trenches.

TRENCH EXCAVATION

In normal soil condition excavation is done using a clamshell or grab suspended by cables to a crane. The grab can easily cut through soft ground. In case of encountering boulders, a gravity hammer(chisel) will be used to break the rock and then the spoil out using the grab.

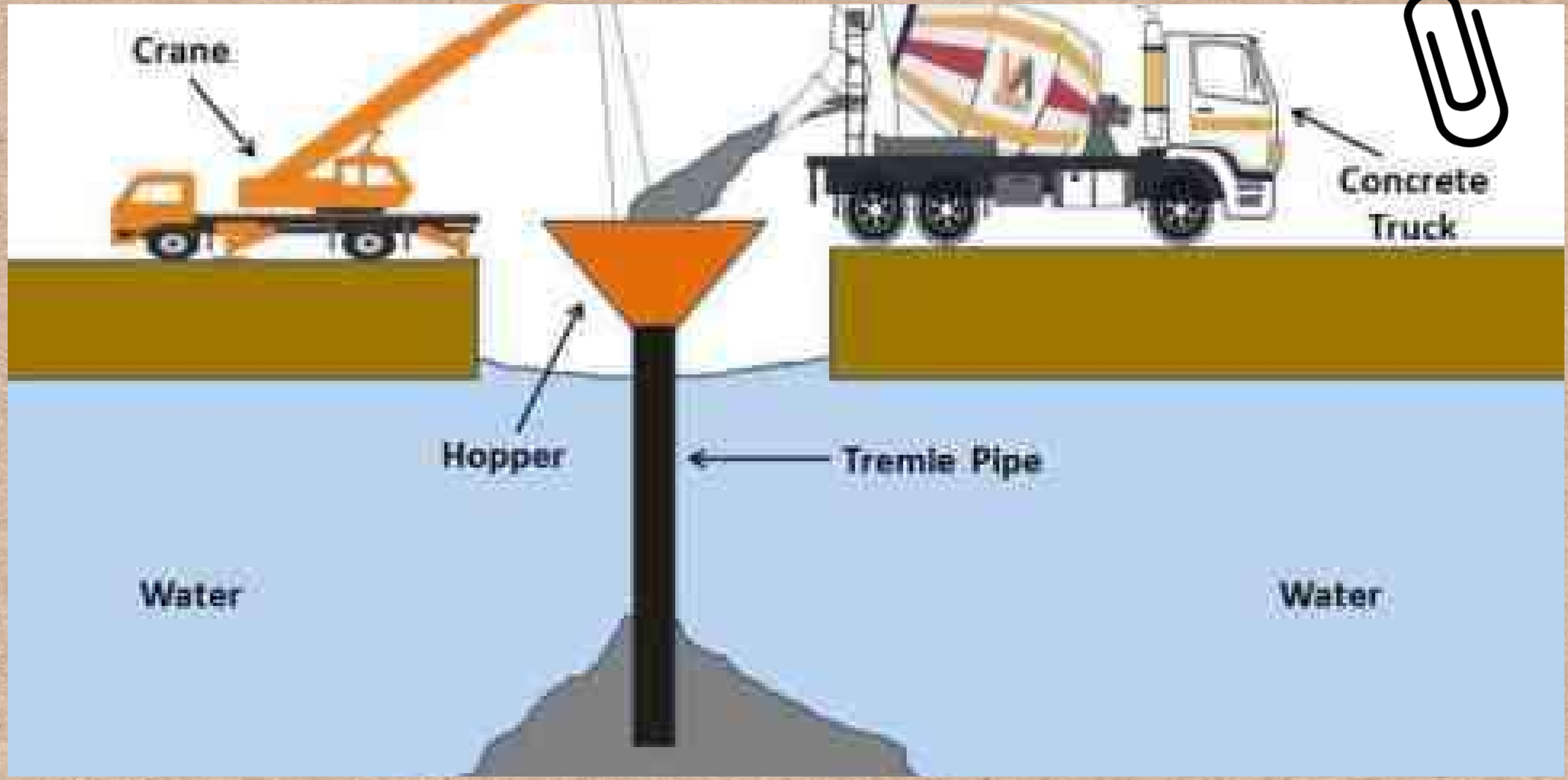
REINFORCEMENT

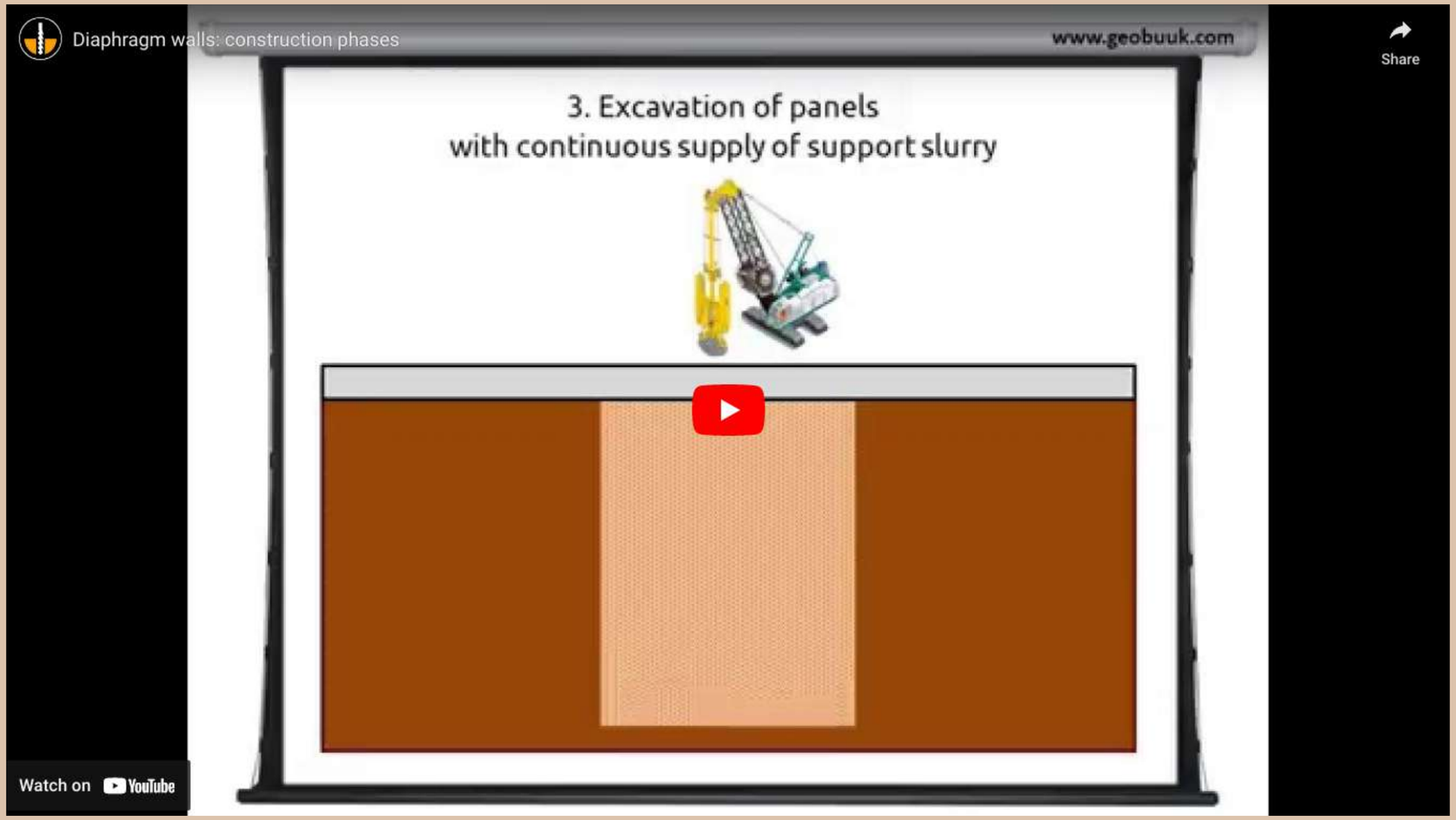
Reinforcement is inserted in the form of a steel cage, but may be required to lap a few sections in order to reach the required length.

CONCRETING

Placing of concrete is done using tremie pipes to avoid the segregation of concrete. As concrete being poured down, bentonite will be displaced due to its lower density than concrete. Bentonite is then collected and reused.

CONCRETING





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GENERAL PROCEDURE OF CONSTRUCTION

- The excavation is carried out using a heavy self guided mechanical grab suspended from a large crawler crane
- The diaphragm walls were excavated and constructed in discrete panels of between 2.8 and 7m lengths, with a depth reaching 30m
- As the excavation proceeds, support fluid was added into the excavation to maintain the stability of the surrounding ground and to prevent a collapse. this fluid is called bentonite.

GENERAL PROCEDURE OF CONSTRUCTION

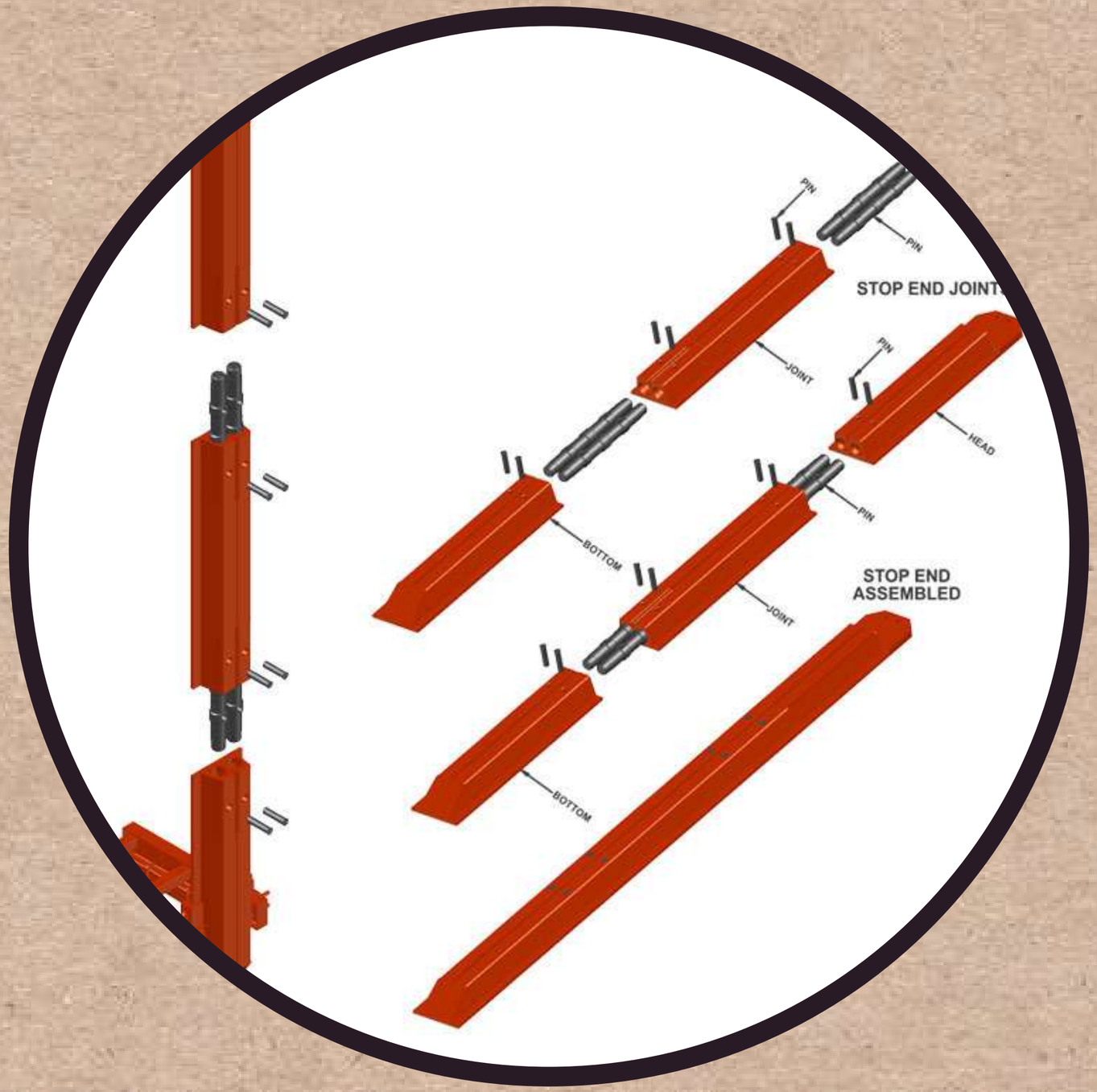
- A heavy chisel may be used if an obstruction of hard strata is encountered , to break up the obstruction for removal by the grab.
- When the excavation is completed , a submersible pump connected to tremie pipe will be lowered into the panel excavation down to the toe level. this pumped the fluid down to the toe level and then from the bottom of the excavation back to a descending unit, in order to seperate the bentonite from the suspended particles contained in it. at the same time, fresh fluid will be added to the top of the excavation to maintain the stability of the ground.

JOINT DESIGN USED FOR DIAPHRAGM WALL

Stop end pipes

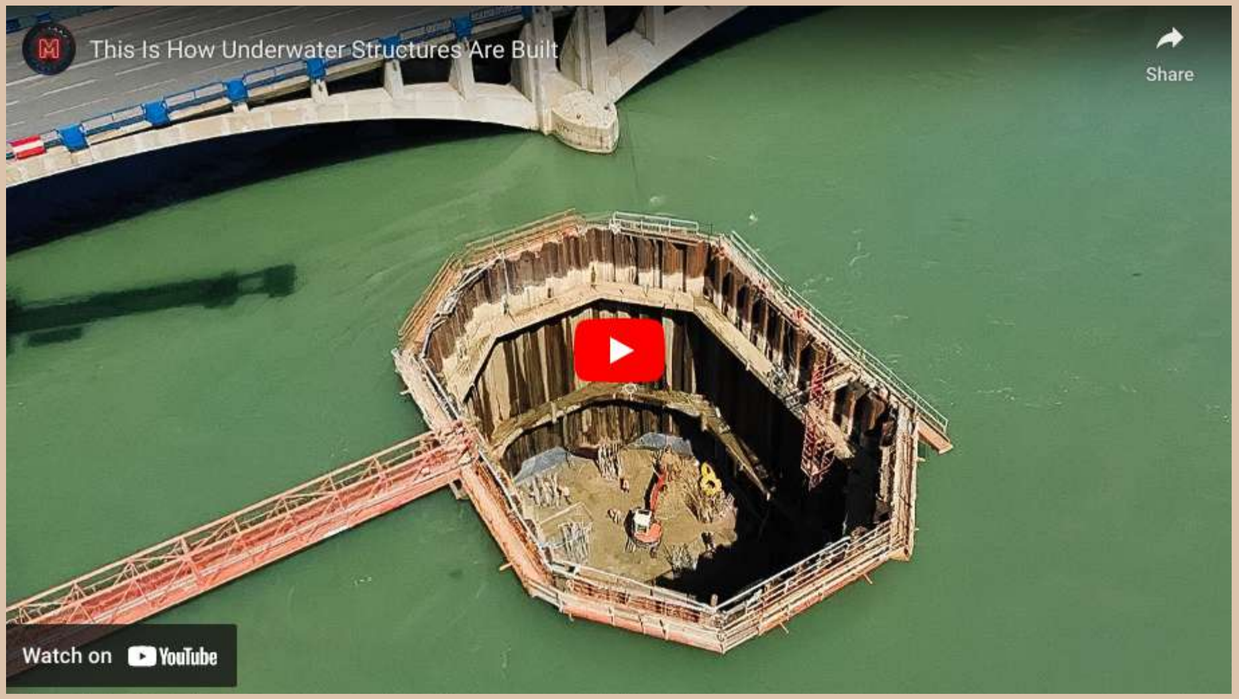
Sheet piling

The Milan joint



Stop end pipes

Sheet piling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Major advantages of diaphragm walls

- can be used as permanent structural walls
- water retainable
- can be installed to deeper depths and for load bearing element
- less temporary propping needed
- can be applied for top down construction method
- rigid structure so that ground movement induced by basement excavation is less than other flexible retaining wall
- vibration and noise generated from installation of diaphragm wall is less than other methods.

Materials used for the construction of diaphragm wall

- **Ordinary Portland Cement**
- Aggregate: Course aggregate of size 20mm.
- Sand: Well graded sand consisting of 50% coarse sand
- Water: clear water
- Admixtures: if required chemical admixtures shall be used as per IS456:1978
- Reinforcement: mild steel bars
- Bentonite: Bentonite used shall conform to IS12584:1989
- Clay: Clay shall be conform to IS1498:1970
- Concrete Mix: For plastic concrete diaphragm wall the water cement ratio shall not be greater than 0.5

General key points

WHAT IS THE SLUMP FOR A DIAPHRAGM WALL ?

To reach optimum workability it is advisable to maintain the slump around 170-190mm

THICKNESS OF DIAPHRAGM WALL

Acc. to IS:14344-1996 clause 9.3.4 , minimum thickness 500mm and maximum 1500mm

General key points

REQIREMENTS OF SLURRY

Bentonite slurry is made by passing dry powder through water jet. a conical hopper is used with bottom nozzle through which water is pumped under pressure. the bentonite powder is poured directly from top and when it falls down the hopper, it gets agitated in the water. After getting circulated , the mixed bentonite thus falls in the tank.

Table 1 Requirements of Slurry
(*Clause* 11.1.1)

Property	Method of Test	Permissible Value at 20°C
Density	Mud balance or hydrometer	1.04 to 1.25 g/ml
*p*H value	*p*H indicator paper strips	9.5 to 12
Viscosity	Marsh cone method	28 to 42 seconds
Plastic	Fann Viscometer	< 20 cP
Viscosity	Shearometer	1.4 to 10 N/m^2
10-minutes gel strength	or vane shear apparatus	(14 to 100 $dyne/cm^2$)
Sand content	75-microns sieve	1% to 25%

THANK YOU

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