Underwater concrete plays an important role in the construction of offshore structures. It may be used to tie together various elements in composite action (i.e., to tie piling to the footing).
Tremie Concrete

- The tremie concrete placement method uses a pipe, through which concrete is placed below water level.
- The lower end of the pipe is kept immersed in fresh concrete so that the rising concrete from the bottom displaces the water without washing out the cement content.

Tremie Concrete Mix

- Special mix with plasticizer
- High slump concrete with set retarders
- Smaller aggregate sizes
- Four-hour workability
- Designed for placement under water via tremie pipe
Concrete Technology

Tremie Concrete

Underwater Concrete Mixes:

- **Structural concrete**
  - **Coarse Aggregate**: Gravel of 3/4” max. size. Use 50-55% of the total aggregate by weight.
  - **Fine Aggregate**: Sand, 45-50% of the total aggregate by weight.
  - **Cement**: Type II ASTM (moderate heat of hydration), 600 lbs/ yd³.
  - **Pozzolans**: ASTM 616 Type N or F, 100 lbs/ yd³.

- **Water/Cement Ratio**: 0.42 (0.45 Maximum).
- **Water-Reducing Admixture** (preferably it is also plasticizer): Do not use superplasticizers.
- **Air-Entrainment Admixtures**: To give 6% total air.
- **Retarding Admixture**: To increase setting time to 4-24 hours, as required.
- **Slump**: 6 1/2 in. ± 1 in.

This mix will develop compressive strength in the range of 5,600 – 7,000 psi at 28 days.

It will flow out on a slope of 6:1 to 8:1 horizontal/vertical and, if properly placed, should give nominal segregation and laitance.
Placement of Tremie Concrete

- The placement of tremie concrete is carried out through a tube, usually 10-to 12-in. pipe.
- The pipe may be sectional but joints should be flanged and bolted, with soft rubber gasket, so as to prevent any in-leakage of water.
- The tremie pipe must have sufficient wall thickness so that it negatively buoyant when empty.

Placement of Tremie Concrete

- Install a steel plate on the bottom end with a soft rubber gasket. The plate is tied with twine to the pipe.
Concrete Delivery on Transit Mixers

Placing Concrete from a Delivery Barge
Initiation of Tremie Placement

Initiation of Placement using the Dry Pipe Method with an End Plate as the Seal

Tremie Pipe

Breaking Tremie Tube - In this operation the contractor is removing a 20' section from the 140' + tremie tube to continue the first full depth placement in the UR pylon. Concrete placed will be about 400 CYs.
Tremie Concrete - Application

- Tremie concrete procedures was used to repair damage to a reef in the Florida Keys caused by vessel impact.
- The impact site was located in six to ten feet of water off Miami, in a region of the reef frequented by sight-seeing boats and recreational divers. The ship impact destroyed the living surface of the reef over an area of approximately 50-ft by 70-ft, forming a shallow crater in the reef.

Diver Places underwater tremie concrete between reef units and bottom. Bottom of the barge can been seen just a few feet above the diver's head.
Placement of Tremie Concrete

- Tremie pipe on the bottom
- All connections tight
- Notches in bottom of pipe
- Place “rabbit” in top of tremie pipe
- Keep minimum 5.0 feet into concrete
- Keep tremie tied down with stout ropes

Placement of Tremie Concrete

- The placement is started by placing the sealed pipe on the bottom and then partially filling it with the tremie concrete mix.
- When tremie has been filled to a reasonable distance (distance required to overcome the frictional head ≈1-2 m) above the balancing head of fresh concrete versus surrounding liquid, the pipe is raised 150 mm, allowing the concrete to flow out.
- The lower end of the pipe is kept embedded in fresh concrete, but no deeper than where the concrete has taken the initial set (with retarder to prevent the initial set, the depth of embedment becomes less sensitive).
**Placement of Tremie Concrete**

- The tip of the tremie pipe should always be immersed about 1 m as a minimum so as to prevent water inflow into the pipe.
- The flow of concrete should be smooth, consistent with the rate at which concrete can be delivered into the hopper at the top.
- The method of delivery should provide relatively even feed to the hopper rather than large batches being suddenly dumped.
- When large areas are to be covered, multiple tremie pipes should be used.
- The distance tremie can flow without excessive segregation is between 6 and 20 m.

**Flow Patterns of Tremie Concrete**

\[
H = \frac{(W_c h + W_w D + F_R)}{W_c}
\]

- \(H\) = The height of concrete inside the tremie
- \(h\) = The tremie embedment depth in concrete
- \(D\) = Water depth above the concrete

Hydrostatic Balance Point
Placement of Tremie Concrete

- Ensure smooth transition between placements.
- Use air lift to remove slurry and maintain uniformity.

Tremie Pipe Spacing

- Spacing should be 3-5 times the depth of tremie placements.
Soldier Pile - Tremie Concrete (SPTC)

- SPTC is used for very difficult conditions in soft ground with a high water table.
- Soldier piles are set in predrilled holes, and the space between flanges of adjacent soldier piles is excavated and filled with bentonite slurry.
- Reinforcement is lowered into the trenches and tremie concrete is placed. As tremie concrete displaces the slurry, it is collected and recycled for future use.
- The final product is a continuous concrete wall beneath the ground surface prior to excavation. After completion of the wall, excavation and interior bracing can begin.
Soldier Pile - Tremie Concrete

Slurry Trench

Typical free-hanging mechanical clamshell for slurry trench excavation
Soldier Pile - Tremie Concrete

free-hanging mechanical clamshell
Slurry Trench Method (Cont’d)

- Used in cases of troublesome dewatering and excavation support problems.
- It involves constructing an impervious barrier beneath the ground surface.
- The excavated material is replaced with heavy clay slurry (the lateral pressure from the slurry will keep the trench open).

Slurry Trench Method (Cont’d)

- After the excavation is completed, concrete placement follows using tremie concrete method, from bottom to the top of excavation.
- As tremie concrete displaces the slurry, it is collected and recycled for future use.
- When the concrete is cured, the construction site is enclosed within a rigid, impervious barrier.
- This method has been employed to depths exceeding 200 feet.