Building Construction
(Substructure)

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Construction of Substructure

Foundation
- Part of building constructed below ground level
- Direct in Contact with substrata
- All the load is transmitted to soil by Foundation
Method of Setting out Foundation Trenches

Setting out or *Ground Tracing or Layout* is a process of laying down certain lines and marks on the ground before the excavation of foundation trenches actually gets started.

• **Purpose:**
  1. Excavation of foundation starts immediately after this process.
  2. Lines and Marks set out by this process serve as a Guide and provide checks in the construction of the foundation work.

Procedure: Setting out Foundation Trenches

1. A line which can easily be established is selected (AB).
2. Line AB will act as the Base line and entire building can be traced out such that Points A and B are on Centre Line.
3. The center line wooden pegs are driven in ground and they project about 25-50mm above ground. Nails are put on top of the pegs.
4. Two more pegs are driven at equal distance on either side of center line peg such that distance between them becomes equal to width of foundation. With the help of these pegs, foundation can be easily traced.

5. Strings are tied to respective pegs and lines are marked with the help of Pickaxe. Lime powder is spread along these lines to make them prominently seen.

Procedure: Setting out Foundation Trenches

6. Along center line pegs, the masonry pillars of section 1bk x 1bk are constructed, height of pillar is kept till plinth level. All pillars are kept at same level using Dumpy level. Pillars are placed at sufficient distance so that they don’t cause obstruction to work.

7. Top surface of pillars is plastered and grooves/cuts are made (they show center line)

8. Work of Excavation can now start!
Procedure: Setting out Foundation Trenches

Following points are to be kept in mind:

1. **Depth of Excavation is checked by** fixing a string along the grooves on opposite pillars and holding the **boning rod**. Length of boning rod should be equal to depth of foundation trenches, measured from Plinth level.

2. **For checking width**, centerline is transferred to bottom of trench by means of a **plumb bob**. Wooden stick/steel bar of dia 6mm is taken and moved in trench.

Procedure: Setting out Foundation Trenches

Following points are to be kept in mind:

3. **Rectangles** laid on ground should be checked by measuring diagonals.

4. When trenches are excavated to required depth, bed of foundation is should be prepared in level.

5. Generally, in foundation
   - Lime : sand : BrickBats = 1:2:4
   - Plain Cement : sand : BrickBats = 1:2:4 or 1:2:8
   - Cement Concrete : sand : BrickBats = 1:2:12
Dewatering of Foundation Trenches

1. **Pumping**: centrifugal motor is used to pump out water
2. **Constructing Sumps and Side Drains**
3. **Cement Grouting**: Mixture of cement, sand and water
4. **Well Point System**: Well point pipe and riser pipe are used to pump out water

Dewatering of Foundation Trenches

5. **Chemical process/Chemical Grouting**:  
   - (inorganic: Sodium Silicate, lignosulphate)  
   - (Organic Compound: epoxy, resins)
6. **Freezing Process**: pore water is frozen to ice
7. **Electro osmosis Process**:  
   - Positive electrode (anode) and negative electrode (cathode) is used and current is passed. Cathode is provided in well, so water accumulates there and is pumped out
General requirements of Foundation:
- Should not settle in excess to permissible value
- Safe against Shear
- Should not get affected by seasonal water table fluctuation
Shallow Foundation

- **Isolated (Spread Footing)**
  - Supports only one column

- **Strap Footing**
  - Helps to join two footings

- **Strip/Continuous Footing**
  - $L \gg B$

- **Combined Footing**
  - Footing supports more than one column

- **Raft/ Mat Foundation**
  - Single slab supports all columns
Bearing Capacity

- **Gross Pressure Intensity:**
  \[ q_e = \frac{P}{B_f} + \gamma D_f \]

- **Net Pressure Intensity:**
  - When Backfill is provided
    \[ q_{net} = \frac{P}{B_f^2} \]
    \[ q_{net} = q_e - \gamma D_f \]
  - When no backfill is provided
    \[ q_{net} = \frac{P}{B_f^2} - \gamma D_f \]

Bearing Capacity

- **Ultimate Bearing Intensity:**
  \[ q_u = \text{max}(q_e) \]

- **Net Ultimate Pressure Intensity:**
  \[ q_{nu} = \text{max}(q_{net}) \]
  \[ q_{nu} = q_u - \gamma D_f \]

- **Gross Safe Bearing Capacity**
  \[ q_s = \frac{q_{nu}}{FOS} + \gamma D_f \]

- **Net Safe Bearing Capacity**
  \[ q_{ns} = \frac{q_{nu}}{FOS} \]

*Note:*
- No factor of safety is considered while dealing with settlement criteria
- No FOS is considered while dealing with unit wt of soil
Bearing Capacity

• Safe Bearing Pressure:
  • Maximum intensity of loading that can be allowed on soil without settlement exceeding the permissible value

\[
A = \text{minimum of } (q_{ps}, q_{ts})
\]

Bearing Capacity

- Analytical Methods
- Field Test Methods
  - General Shear failure \( \phi > 36^\circ \)
  - Local Shear Failure \( \phi < 29^\circ \)
  - punching shear failure \( \phi < 29^\circ \)
  - Standard Penetration Test
  - Plate load test
  - Static Cone Penetration test
Terzaghi Bearing capacity in GSF

Continuous Foundation
\[ q_{ult} = cN_c + qN_q + 0.5\gamma BN_y \]

Square Foundation
\[ q_{ult} = 1.3cN_c + qN_q + 0.4\gamma BN_y \]

Circular Foundation
\[ q_{ult} = 1.3cN_c + qN_q + 0.3\gamma BN_y \]

Note: Terzaghi assumed GSF, so in case of Normal Shear Failure
1. \( c_m = \frac{2}{3} c \tan(\phi_m) = \frac{2}{3} \tan(\phi) \)
2. If \( \phi=0 \), As Per Terzaghi
   * \( N_c = 5.7 \)
   * \( N_q = 1 \)
   * \( N_y = 0 \)
   * \( N_z = 0 \)
3. If \( \phi=0 \), As Per Pradel
   * \( N_c = 5.16 \)
   * \( N_q = 1 \)
   * \( N_y = 0 \)
4. For purely cohesive soil, net ultimate capacity is dependent only on cohesion

Coffer Dam

- A **coffer dam** is defined as Temporary Structure which is constructed so as to remove water or soil from an area and make it possible to carry on the construction work under reasonably dry condition
Coffer Dam

Requirements of Coffer dam:
1. Generally constructed at site of work
2. Coffer dams have advantage where large area of site is to be enclosed and hard
   bed is at reasonable depth
3. **It should be water tight:** Either rest on impervious soil or a bed of concrete may
   be laid at bottom of coffer dam
4. Absolute water tightness is not required, Cofferdam should be cost effective
5. It should be designed for maximum water level and other destructive forces so
   as to make it stable against bursting, overturning and sliding
6. Water to be excluded by coffer dam can be ground water, water lying above
   ground level, deep or running water
7. Materials used are timber, Earth/soil/ steel and concrete
8. Type of construction depends upon depth, soil conditions, fluctuations in water
   level, availability of material, etc

Coffer Dam

Uses of Coffer Dam
1. **To Facilitate Pile driving operations**
2. **To place grillage and raft foundation**
3. **To construct Foundation for piers and abutments of bridges**
4. **To enclose a space for removal of sunken vessels**
Types of Coffer Dams

Factors to be considered for the type of coffer dam:

• Area to be protected
• The depth of water to be dealt (shallow/deep)
• Possibility of overtopping by tides and floods
• Nature of bed on which coffer dam rests (pervious/impervious)
• Material Availability
• Nature of velocity of flow of water (slow/ swift current)

Types of Coffer Dams

Some important types of coffer dams are:

1. Dikes:
   a. Dike is an embankment made of Earth, rock and sand bags
   b. Used for short duration, particularly to make more stable coffer dam behind them
   c. Types of Dikes:
      i. Earth Dikes/Earth filled Coffer Dams:
         • Top width 1 m
         • Free board 1m
         • Used for shallow depth 1.2m to 1.5m
         • Rip rap rock is provided to give protection against water
         • Never used where overtopping of water is there
      ii. Rock Dikes/ Rockfill Cofferdams
         • Can be used for depth upto 3m depth
         • Only Disadvantage is that it is not impervious
         • Sheet piles are used to prevent water seepage
Types of Coffer Dams

Some important types of coffer dams are:

1. Dikes:
   a. Types of Dikes:
      i. Earth Dikes/Earth filled Coffer Dams:
      ii. Rock Dikes/Rockfill Cofferdams
      iii. Sandbag Dikes
         • Mixture of sand and clay is used
         • Small quantity of cement in sand bags will help in making the cofferdam watertight
         • Voids of sand bags may exceed 40%, so care should be taken to remove the voids

2. Single Wall Cofferdams
   • When working area is small and small area is to be enclosed
   • Steel and wood (upto 10m) are used for sheet piles
   • This cofferdam is suitable upto 25m

3. Double Wall coffer dams:
   • When area to be enclosed is large, double wall is used to give stability
   • Types:
      • Ohio River Type (suitable for slow currents in river)
      • Wood or Steel Sheeting cofferdams with wales and tie rods

4. Cellular Cofferdams
   • These are made of steel sheet piles
   • Used for underwatering large areas
   • Diaphragm cells or circular cells are used
   • This type of coffer dam requires more material than previous but it has advantages
Types of Coffer Dams

5. Rock Filled Crib Cofferdams
   • It consists of timber cribs (open at bottom)
   • The pockets formed are filled with rock or gravel or sand
   • Timber used consists of rough logs
   • They can support in swift currents
   • No danger of overtopping

6. Concrete Cofferdams:
   • Small concrete dams used economically on many jobs
   • Pre cast RCC sheets and piles are used
   • Disadvantage for temporary cofferdam: **costly**

7. Suspended/movable Cofferdams:
   • Single unit of coffer dam is used several times
   • The coffer dam is lifted, floated and placed in another position

Prevention of leakage in Cofferdam

• Water that enters through cracks can be pumped out by using motor
• Clay, ash, sand, etc. may be dumped around the coffer dam to reduce the quantity of water entering inside the dam
• Proper compaction of the materials
• If leakage is serious, it is reduced by **providing Tarpaulin which is canvas coated in tar**
- Watch Videos
- Practise Quizzes
- Performance Analysis

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