UNIT-4 (Part-2)

Well Foundation

→ Well foundations are originated in India and has been used in India for hundreds of years for providing deep foundations below the water level for monuments, bridges & aqueducts

→ Taj Mahal has got well foundation.

→ Well foundation is similar to open caisson (a large water tight camber, open at bottom)

→ Well foundation can be constructed on the dry bed or after making a sand island.

→ At locations where the depth of water is greater than 5 m to 6 m and velocity of water is high, wells can be fabricated on the river bed and then floated to the final position & grounded.

→ Great care is to be exercised while grounding a well to ensure that its position is correct. Once the well has touched the bed, sand bags are deposited around it to prevent scour.

→ The well may sink into the river bed by 50 to 60 cm under its own weight.

→ The well is sunk into the ground to the desired level by excavating through the dredge holes.

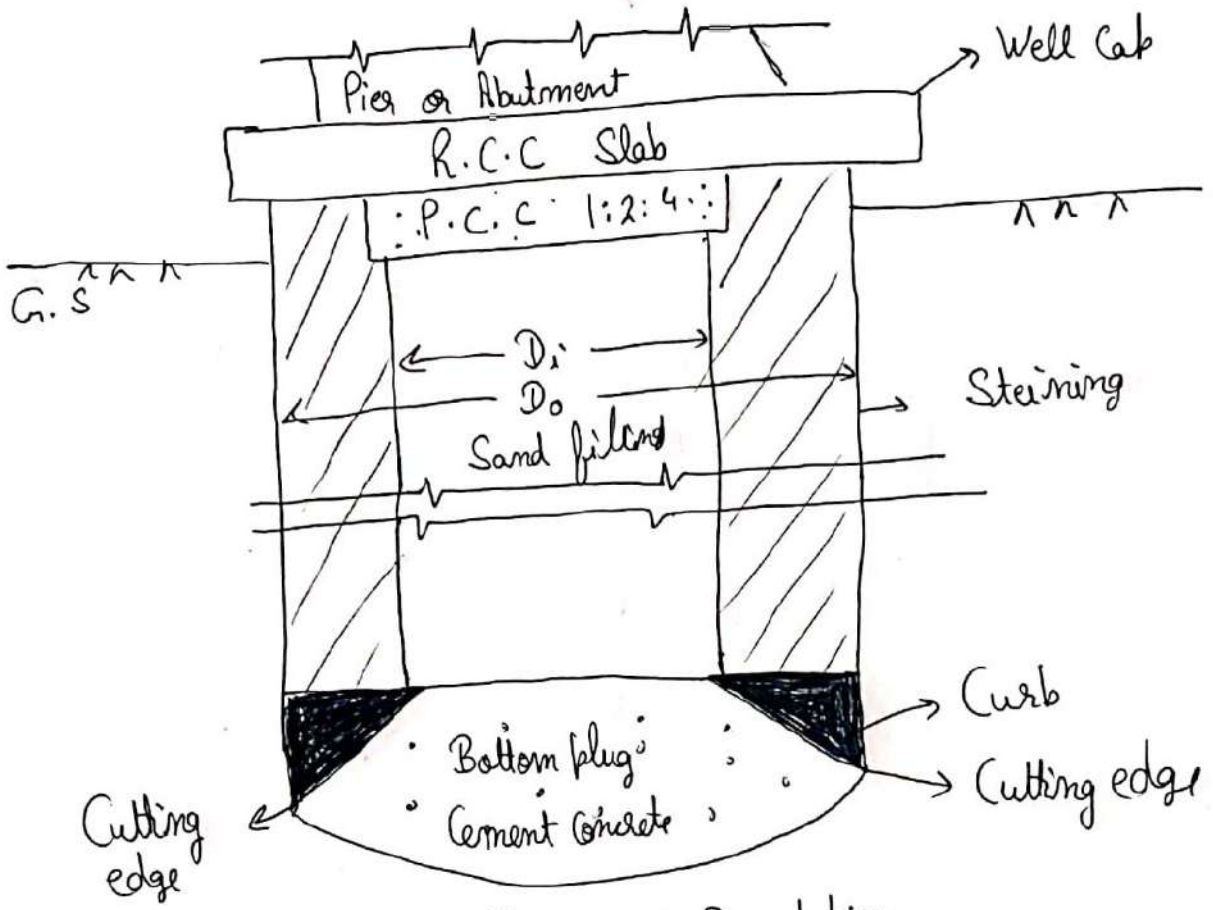


Fig. Well Foundation

→ A strong cutting edge is provided to facilitate sinking.

→ The tapered portion of the well above cutting edge is known as well curb.

→ The walls of the well is known as steining. Steining is made of brick masonary, stone masonary, plain or reinforced concrete. Steining becomes an integral part of the structure, so it must be properly designed for the imposed load.

→ Steining should be heavy enough to overcome frictional resistance during sinking.

→ After the well has been sunk to final position, the bottom plug is formed by concreting. Bottom plug serves as base of the well.

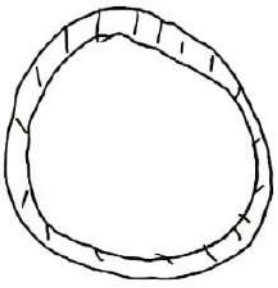
→ The well is filled with sand partly or completely.
→ At the top of the well, a top plug is formed by concreting. A R.C.C well cap is provided at top to transmit load of superstructure to the well.

** Elements of Well foundation :

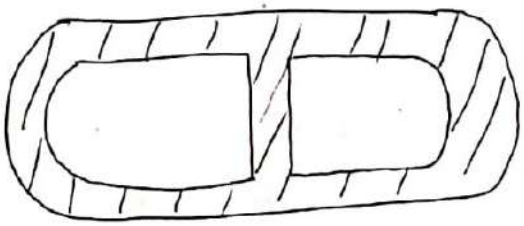
⇒ Different shapes of well :

1) The most commonly used shape is circular as it has high structural strength and is convenient in sinking. Chances of tilting is also minimum. Max. diameter is generally limited to 9 m. Circular shape is not suitable if piers are excessively long, making structure uneconomical.

2) Double-D Wells are generally used for the piers and abutments of bridges which are too long to be accomodated on circular well of 9 m diameter. The well of this shape can also be sunk easily. ~~However~~ However considerable bending moments are caused in steining due to diff. in pressure between outside and inside of well.

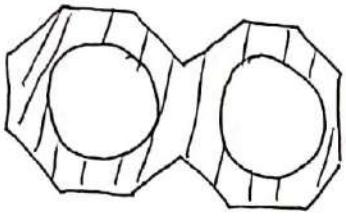


Circular Well



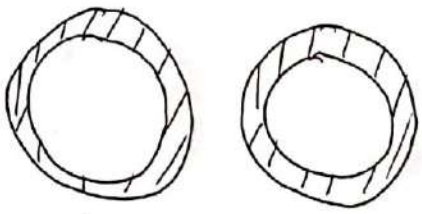
Double-D

3) Double Octagonal Well: These are better than the Double-D wells in many respects. The square corners are eliminated and bending stresses are considerably reduced. However they offer greater resistance to sinking on account of increased surface area.



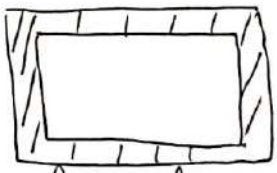
⇐ Double Octagonal

4) Twin Circular: These are two independent wells placed very close to each other & having a common well cap. These wells are sunk simultaneously. These wells are suitable where the length of pier is considerable, which cannot be accomodated on Double-D or double octagonal well. Twin Circular are advantageous when depth of sinking is small & bearing capacity of soil is high.

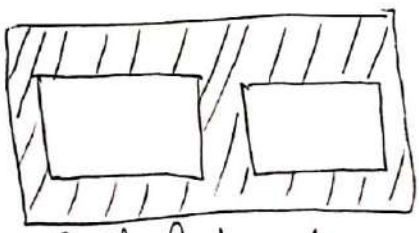


⇒ Twin Circular

5) Rectangular: These are generally used for bridge foundation having depth upto 7-8m. For larg foundation, double rectangular wells are used. Bending stresses in steining are very high in rectangular wells.



Rectangular



Double Rectangular

⇒ Grip length: The well should be sunk below the maximum scour level to sufficient depth such that the resistance from the sides is able to resist the lateral forces acting on the well.

- The depth of bottom of well below the max. scour level is known as grip length.
- The depth of foundation should be chosen considering the grip length and bearing capacity of soil.
- The depth of scour can be ascertained through actual soundings at or near the site proposed for the bridge during or immediately after a flood. [Sounding Rods are used]
- The maximum scour would be greater than the measured scour because design discharge is grater than flood discharge for which soundings have been made.
- Moreover, there would be an increase in the velocity of water due to obstruction of flow caused by construction of bridge. An extra allowance should be made in the measured scour due to proximity of piers.
- In case actual soundings cannot be made, the normal depth of scour in alluvial soil may be calculated by Lacey's formula:

$$d = 0.473 (Q/f)^{1/3}$$

d = normal depth of scour (in m)

Q = Design discharge (m^3/sec)

f = silt factor

$$f = 1.76 \sqrt{d_m}$$ d_m = mean size of particle (in mm)

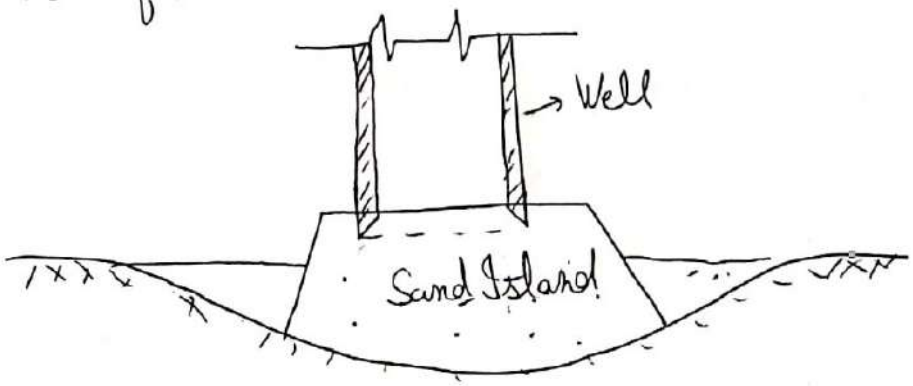
Note: The grip length for wells on railway bridges is generally taken as 50% of the maximum scour depth.
For road bridges, a grip length 30% of max. scour depth is generally provided.

Note: Scouring can be defined as a process due to which the particles of soil or rock around periphery of abutment or pier of bridge over a water body, gets eroded and removed over a certain depth called scour depth.

⇒ Well Sinking:

The sinking operation consists of following steps:

1) Laying the Well Curb: If the river bed is dry, the cutting edge over which the well curb is to be built is placed at the required position after excavating the river bed to about 15 cm. If the depth of water is upto 5 m, a sand island is made before placing the curb.
The size of island should be large enough to accomodate the well with adequate working space around it.
- If the depth is more than 5 m, it is generally economical to build the curb on dry ground at the river bank and float it to the site.



2) Well Steining: After sinking the well curb, the steining is raised by about 1.5 m at a time and its sinking is done after allowing atleast 24 hrs for setting.
The steining is build using straight edges, preferably of angle iron.
Once the steining has acquired a grip of about 6 m in ground, the steining can be raised by about 3 m at a time.
The height of steining built at any stage should be such that well does not lose stability.

3) Sinking process: Sinking process is begun after having cast the curb and the first stage of steining and allowing enough time for curing.
The well is sunk by excavating material from inside the curb manually or mechanically.
To accelerate the process of sinking, additional loading known as Kentledge is applied on well, generally in the form of sand bags.
As the well is sunk friction resistance starts acting so kentledge is applied, but sometimes even kentledge is not sufficient to sink the well, in such cases the friction resistance developed is reduced by forcing jets of water on outer face.
In some cases pumping out of water from inside the well is effective in well sinking. However this method should be discouraged at early stage when depth is shallow.

It is not desirable pumping out water unless the well has gone deep enough so that chances of tilt & shift are reduced. Great precaution is necessary if dewatering of well is done when it is at a shallow depth to avoid blowing of sand from under the cutting edge.

* Tilt & Shift:

→ Shifting & tilting occur generally during the sinking phase of well foundations. If proper care is not taken, they can cause problems which may lead to the weakening of the stability of foundations.

→ When the well is moved away horizontally from the desired position, it is called shifting of well foundation.

→ When the wall has sloped vertically it is called tilting.

* Measures to prevent Tilt & shift

1) The outer surface of the well curb and steining should be regular & smooth.
2) Diameter of well curb should be more than the outer diameter of steining. A difference of 4 to 8 cm is recommended
3) The well steining should be symmetrically placed over the curb.
4) The cutting edge should be uniformly thick and sharp.
5) All the sides should be uniformly dredged.

Note: The maximum tilt allowed in case of well foundation is 1 in 60

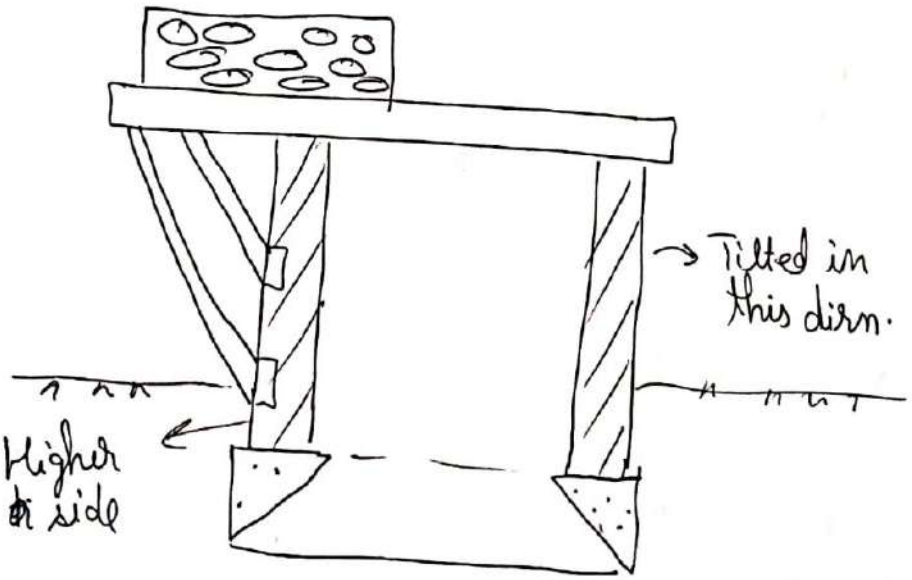
The shift in well foundation should not be more than 1% of depth of sunk.

Beyond the above limits, well foundations is considered as dangerous and in such cases remedial measures to rectify shifting & tilting should be followed.

⇒ Rectifying Methods:

Rectifying methods for shifting & tilting problems are:

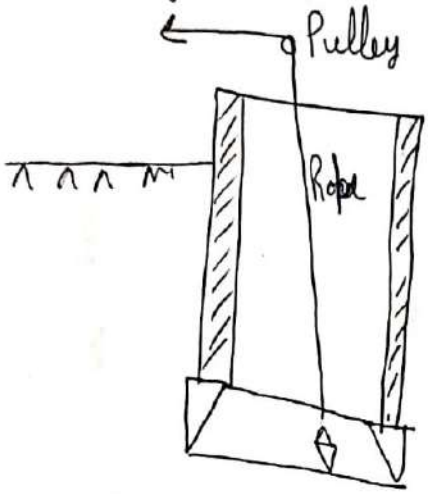
1) Eccentric loading: Well can be rectified by placing eccentric loading on the higher side.
A platform is constructed on higher side for this purpose.
Greater the depth of sinking of well, larger will be eccentricity and load.



2) Excavation of higher Side:

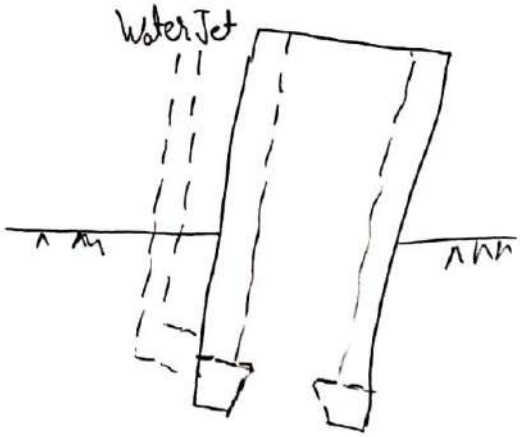
When well is tilted to one side, excavation should be increased on other side which is opposite to tilted side. This technique is only suitable in initial ~~stage~~ stages of well sinking.

Dredging is done by sliding rope from top and rope is pulled.

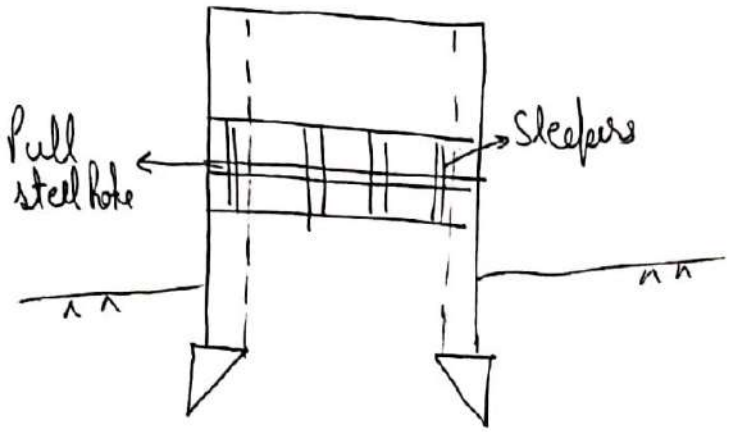


3) Water Jetting:

Water Jetting on external surface of well on higher side is another remedial measure. When water jet is forced towards surface of well, the friction between soil & well surface gets reduced and ~~the~~ the higher side of well becomes lowered to make well vertical.

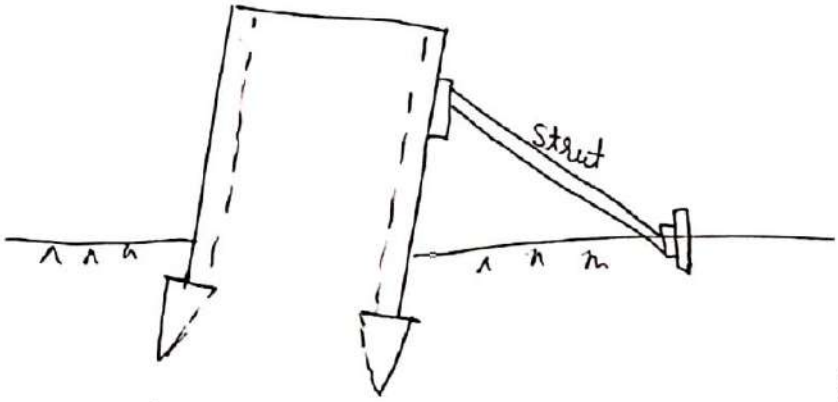


4) Pulling the well: Well can be pulled towards higher side using steel ropes, one or more steel ropes are wound around the well with vertical sleepers placed in between to distribute the pressure over larger area of well staining.



∈ Pulling the Rope

5) Using struts: By providing struts as supports on the lower side or tilted side of well, further tilting can be prevented.
Wooden sleepers are provided between struts and well steining and to ~~distribute~~ prevent damage to well steining & to distribute pressure to large area.



6) Pushing well by Jacks:
The tilt can be rectified by pushing the well with a suitable arrangement through mechanical or hydraulic jacks.