Questions on Piers and caissons

Q.1) State the circumstances under which it is advantageous to adopt caisson/well foundation than to provide piled foundation.

Ans:- Pile foundations are usually adopted for multi-storeyed buildings or for bridges across drains etc, where moderate to heavy loadings are expected. Well foundations are adopted for heavier structures particularly for structures across rivers, where lot of scouring is involved such as for supporting the piers of the bridge portion of a barrage. Well foundation may also have to be selected for structures supported on soils containing layers of boulders, through which piles cannot be driven.

Q.2) Explain how the information obtained during subsoil exploration becomes useful while sinking of a well foundation.

Ans:- From the sub-soil exploration data the information regarding type of soil, depths of the different strata and their thickness, loose pockets as well as presence of boulders can be known. This information would be of immense help to avoid tilting of well, measures against obstruction while sinking of well and the phenomena of blowing up of the foundation strata can be avoided.

Q.3) Draw labelled sketch of pneumatic caisson.

![Pneumatic Caisson Diagram]

Functions of components:- (1) Well steining: - The function of well steining is to give stability and to overcome friction during sinking of well.
(2) Cutting edge: - The cutting edge facilitates the cutting of the soil strata while sinking the well.
(3) Working chamber: - The working chamber provides space for the workers to work in the pneumatic caisson during the sinking operation.
(4) Air lock: - The air lock seals the air entry and helps in increasing the pressure inside the caisson.
(5) The air shaft and the hoisting cable facilitates the removal of the muck.

Q.4) Explain, the functioning of pneumatic caisson and caisson disease?

Ans: - Pneumatic caissons are closed at top and open at bottom during sinking. Such a caisson has a working chamber at the bottom, in which compressed air is maintained at the required pressure to prevent the entry of water into the chamber when working under water. The height of chamber is at least 2.5m so as to enable the workers to work under in the chamber. The air pressure in the chamber is kept slightly more than the water pressure outside the chamber, so that no water enters
the caisson while excavating. Such a caisson is necessary when it is not possible to excavate during sinking through a shaft. Where difficulty of obstruction during sinking is likely to be there, then pneumatic caissons are used.

The maximum pressure in the working chamber has however to be controlled, since the maximum limit of human endurance is about 3.5 Kg/cm$^2$ above atmospheric pressure which is equivalent to 35m under water. Hence the pneumatic caisson cannot be sunk lower than 35m.

**Caisson disease:** During the sinking operation of pneumatic caisson, men have to work under compressed air. Usually there is no problem to enter the compressed air or to work in it so long as the pressure is not high. But at high pressures men suffer from giddiness, pains in ears or bursting of eardrums or blood vessels in nose. The trouble starts when decompression starts and men are affected and what is referred as caisson disease.

During working under compressed air excessive nitrogen is absorbed in the human system as one inhales air under high pressure. The trouble starts when decompression starts. This decompression causes effervescence of the excessive nitrogen in the blood vessels and causes trouble. The gas is thrown out in the form of bubbles. The rapid decompression process causes large air bubbles to stick to blood vessels which obstruct the flow of blood and may burst the blood vessels. Therefore decompression at a slow rate is a precaution against caisson disease.

**Q.5**) Draw sketches to explain correction of tilt of a well foundation.

**Q.6**) Draw a neat and labelled sketch showing sand island method.

**Q.7**) Shapes and factors deciding shape of caisson foundation.

**Q.8**) Explain various parts of a well foundation.

**Q.9**) Develop sketches of double D shaped well foundation on plan and section and explain the function and dimensioning of each of components. Assume controlling diameter as 5 m.

**Ans:**
Q.10) Following are the details of site for well foundation:

(i) Ground level 100.000 m R.L
(ii) G.W.T 98.000 m R.L.
(iii) Mixed clayey soil from 100.000 m R.L to 95.000 m R.L.
(iv) Sandy strata from 95.00m R.L to 92.000 m R.L.
(v) Mixed soil below. Explain the method of sinking of well and possible difficulty likely to be met. Detailed sketch necessary.

**Ans:** Sinking of well-- A well is ready to be set in after having cast the curb and having built first short stage masonry over it. The well is sunk by excavating material from inside under the curb. Initially excavation and scooping out of soil is done by sending down workers. When power winches are available clayey strata can also be successfully excavated with the help of big grabs having tempered steel teeth. Additional kentledge is applied to overcome skin friction as the well sinks to greater depth. There are more chances of the well to tilt and shift in clayey strata.

**Ans:**

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Kentledge.

100.00 m

Clayey strata

95.00 m

Sand

92.00 m

Mixed soil

Well steining
The tilts and shifts are avoided by observing the following precautions:-
(1) By keeping the outer surface of the well regular and smooth.
(2) The cutting edges should be uniform.
(3) The dredging should be done uniformly on all sides in a circular well. Whenever the tilt exceeds 1 in 200, rectifying measures should be applied.
In sandy strata the normal method of kentledge and dredging may not be sufficient. In such a case frictional resistance developed on the periphery is reduced considerably by forcing jet of water on the outer face of the well around.

Q.11) It is proposed to provide well foundation for a railway bridge. Draw neat sketch of bridge pier from top of super structure to the bottom of foundation and show thereon the forces acting at various levels and explain how you decide their magnitude.

**Ans:** – **Deciding magnitudes of the forces acting on the well.**
Wind force acts laterally on the exposed portion of the bridge.
Dead load includes the weight of the superstructure and its selfweight.
Live load specified by IRC and code of practise for roads and bridges would serve as the guidelines.
**I.S code 875** specifies the wind load.

Water pressure is calculated as follows \( p = C V^2 \)
where, \( p \) is the pressure intensity, \( C \) is a constant the value of which depends on the shape of the well.
\( V \) is the velocity of flowing water.
**IRC code** also recommends the longitudinal forces.
Buoyant force equal to the weight of the displaced water should be considered.

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**Reducing skin friction during sinking of well:** As the well sinks deeper, the skin friction on the sides of the well increases progressively.
In order to overcome this increased skin friction, and the reduction in weight of the well due to buoyancy, additional loading, known as kentledge, may sometimes be applied on the well to ensure its sinking. Knetledge is generally in the form of earth filled empty cement.
bags placed on a suitable temporary platform erected on the top of the partially built well, as not to interfere with dredging. Sometimes even knetledge is not sufficient to sink the well. In such cases, the skin friction on the well sides is reduced by forcing jets of water on the outer face of the well. This method is, however, effective only in sandy strata. Sometimes when excavation becomes difficult, partial pumping out of water from the well is adopted to increase its effective weight to help in sinking. This process is known as running the wells. This technique of pumping out is avoided in early stages as it may cause localised blow out.

Q.12) Give comparison between Open caissons and pneumatic caissons.

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<thead>
<tr>
<th>Ans:– Factors</th>
<th>Open caisson</th>
<th>Pneumatic caisson</th>
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<tbody>
<tr>
<td>1) Cost of construction</td>
<td>Relatively cheap.</td>
<td>Costlier due to use of compressed air</td>
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<tr>
<td>2) Depth of sinking</td>
<td>Can extend to larger depths.</td>
<td>Depth is limited to 35m below outside water level.</td>
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<tr>
<td>3) Inspection of bottom of caisson.</td>
<td>Cannot be done.</td>
<td>Can be done due to dry working chamber.</td>
</tr>
<tr>
<td>4) Difficulty in maintaining verticality</td>
<td>Difficult.</td>
<td>Easier to control.</td>
</tr>
<tr>
<td>5) Quality control of concrete.</td>
<td>Difficult to judge.</td>
<td>Concrete is placed in dry conditions, hence reliable.</td>
</tr>
<tr>
<td>6) Progress of construction in boulderous strata.</td>
<td>Lots of difficulties.</td>
<td>No difficulties faced</td>
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Q.13) On what factors does the size and shape of a caisson depend on?

Ans:– The size of the caisson is generally governed by the following factors:–

(i) **Size and base:** The size of caisson should be proportioned at least 30cm wider than the base of the superstructure on each side in order to allow for a reasonable amount of inevitable tilting and misalignment.

(ii) **Area required from allowable soil pressure criteria.**

(iii) **Practical limit or minimum size:** Generally a cross-sectional area of about 2.5 x 2.5m is considered the smallest caisson economical and practical for sinking. Small caissons are frequently more costly than other types of deep foundations.

The shape of the caisson is influenced by the following factors:–

(i) **Size of the caisson:** The shape of the caissons supporting large superstructures is governed by the outline of the base of the superstructure. For smaller caissons, however, circular caissons are often economical.

(ii) **Waterway restrictions:** For bridge piers where reduction of channel area may restrict the flow or the navigation, a long shape may be desired.

(iii) **Ice floes or other floating objects:** Bridge piers should be made of circular or pointed sections on the upstream side extending to several feet above the high water level.