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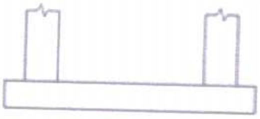
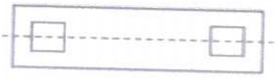
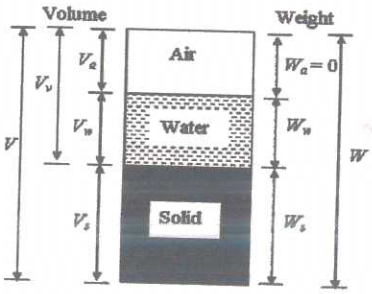
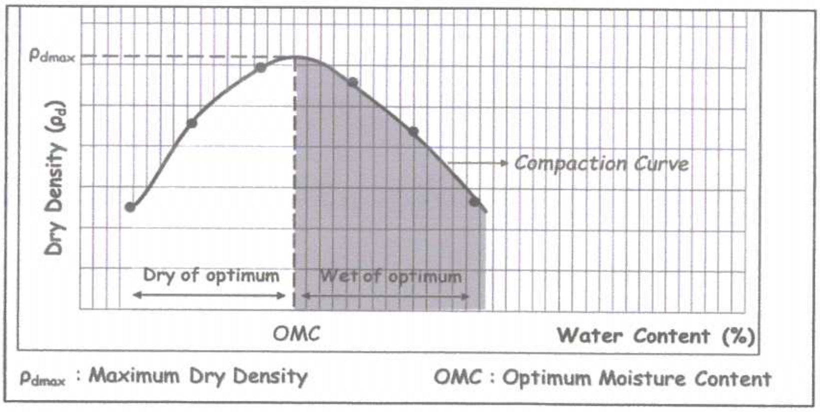
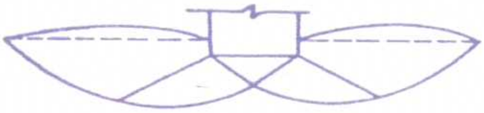
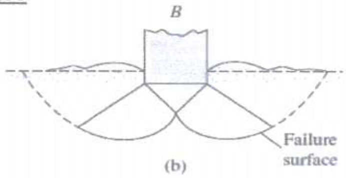
SCHEME OF VALUATION
(Scoring Indicators)

Revision: 2015

Course Name: Geotechnical Engineering **Course Code: 5013**

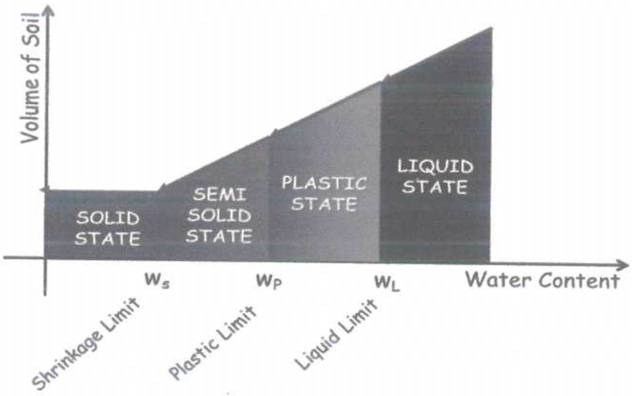
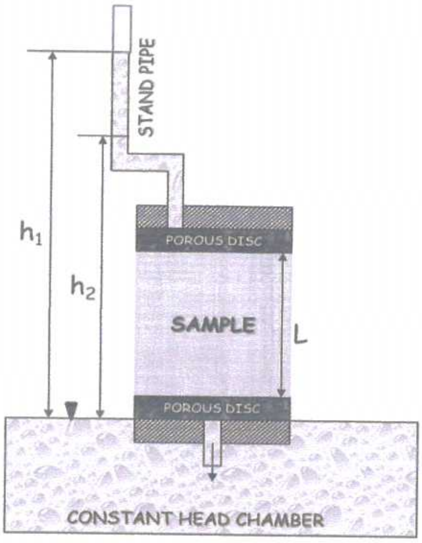
Qst. No	Scoring Indicator	Split up Score	Sub Total	Total
	PART A			
I.1	Unconsolidated material composed of solid particles formed by disintegration of rocks.	2	2	
I.2	$\rho_d = \rho/(1 + w)$ ρ_d = Dry density ρ = Bulk density w = water content	2	2	
I.3	Free Water : Water that can move through the pores under the action of gravity Held Water : Water that is retained in pores and can not flow by gravity	1 1	2	
I.4	Disturbed Sample : Samples with natural structure of soil gets disturbed while sampling. Undisturbed Sample : Samples with natural structure of soil and water content are retained while sampling	1 1	2	
I.5	 Elevation  Plan	1 1	2	10
	PART B			
II.1		3	6	

	Soil grains are irregular and has voids in between when arranged. These voids are filled by either water or air. Solid grains, water and air constitutes three phases of soil. For easier analysis these three phases are arranged one above the other and diagram thus obtained is called three phase diagram of soil	3	
II.2	Well Graded Soil : Soil sample containing particles of all sizes in good proportion.	2	6
	Uniformly Graded Soil : Soil sample containing particles only of similar size.	2	
	Gap Graded Soil : Soil sample containing particles with some of the intermediate sized particles are missing	2	
II.3	Factors Affecting Permeability 1.Structure of soil mass 2.Particle Size 3.Void ratio 4.Properties of water 5.Specific Surface Area 6.Shape of Particles 7.Degree of saturation 8.Adsorbed Water 9.Impurities in water *(Any six of above points can be given full credit)*	6x1 = 6	6
II.4		3	6
	Maximum Dry Density : Dry density initially increases with the increase in water content and reaches the maximum value known as the maximum dry density. Beyond maximum dry density with the increase in water content dry density decreases	1.5	
	Optimum Moisture Content : The water content corresponding to maximum dry density is known as optimum water content or optimum moisture content (OMC).	1.5	

II.5	General Shear Failure 	1	6	42 (Max. 30 Marks)
	Occurs generally in dense sand or stiff clay Failure is charachteristed by clearly visible heaves on the sides of foundation	2		
	Local Shear Failure 	1		
	Occurs generally in medium dense sand or medium stiff clay. Small heaves occurs at sides if there is substantial settlement	2		
II.6	Limitations of Plate Load Test 1. Size effect 2. Scale effect 3. Time effect 4. Interpretation of failure load 5. Reaction load 6. Water table	6x1 = 6	6	
II.7	**Pile Erection Methods** 1. Hammer Driving Hammer driving is done using pile driving rig which has a hoist mechanism, a guiding frame, and a hammer device. Generally operated hammers are drop hammer, single acting hammer, double acting hammer and diesel hammers. 2. Vibratory Pile Drivers Consists of two weights (exciters) which rotates in opposite directions.The vertical components of the centrifugal force of two exciters gets added up and apply downward impact force on pile which drives the pile down. 3. Jetting Techniques Water under pressure is applied at the bottom of pile by means of a pipe which washes and loosen the hard layer. Used when a thin hard layer of soil is present above soft soil layer. 4. Partial Auguring Method A hole is drilled using an auger to certain depth. The pile is then inserted in this hole and is further driven by hammers.Used for driving inclined piles. *(Any three methods with explanation can be given full credit)*	3x2 = 6	6	

PART C

III.a	Given, Weight of wet soil, W = 0.195 kN Weight of wet soil, W_d = 0.156 kN Volume of soil sample, V = 0.01 m^3 Specific Gravity, G = 2.6 Unit weigth of water,γ_w = 10 kN/m^3 i) Water content, w = Ww/Ws = (0.195-0.156)/0.156 = 0.25 = **25%**	2	8	15
	ii) Bulk unit weight, γ = W/V = 0.195/0.01 = **19.5** kN/m^3	2		
	iii) Dry Density , γ_d = $\gamma/(1+w)$ = 19.5/(1+0.25) = **15.6** kN/m^3	2		
	iv) Void Ratio, e = $(G\gamma_w/\gamma_d)$ -1 = [(2.6*10)/15.6]-1 = **0.67**	2		
III.b	Determination of Liquid Limit by Casgrande's Apparatus • Take 125 grams of air dried soil sample passing through 425 μ sieve. • Mix it with distilled water to form a uniform paste • Portion of soil sample is kept on the brass cup. • A sharp groove is cut symmetrically through the sample using a standard grooving tool. • The handle is rotated at the rate of 2 rev/s • Continued till the groove closes by a length of 12mm. • Groove should be closed only by flow of soil, not by slippage. • A portion of sample is taken for water content determination.□ • Water content (w1) and number of blows at which grove closes by 12 mm (N1) are recorded. • Test is repeated for different water contents to get number of blows in the range 10 - 40 • Water content v/s no.of blows graph is plotted and the water content corresponding to 25 no. of blows is taken as the liquid limit from the graph.	7	7	
IV.a	Determination of Field Density of Soil by Core Cutter Method 1. Calculate the volume of cutter, V 2. Take the mass of cutter, M1 3. Clean & level the surface and using rammer insert cutter to soil 4. Take out the sample, remove dolly and trim edges 5. Take the mass of cutter with collected soil , M2	5		

	Field density, $\rho = \frac{M_2 - M_1}{V}$ M_1 : Mass of cutter M_2 : Mass of cutter + soil V : Volume of container Mass of soil $M = M_2 - M_1$	2	7	
IV.b		2	8	15
	Liquid Limit : Water content at which soil changes from liquid state to plastic state.	2		
	Plastic Limit : Water content below which soil stops behaving as a plastic material. (Boundary b/n plastic and semisolid states)	2		
	Shrinkagr Limit : Maximum water content below which reduction in water content will not cause decrease in volume of soil mass. (Boundary b/n semisolid and solid states)	2		
V.a	<u>Falling Head Permeability Test</u> 	2.5	7	

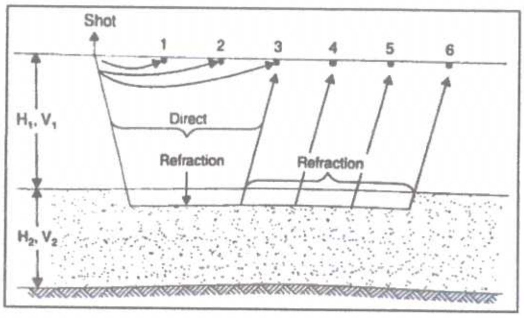
	• Soil specimen of length ‘L’ and area ‘A’ is kept in a mould between two porous discs. • A vertical stand pipe of area ‘a’ is fitted to top of sample. • The whole assembly is placed in a constant head chamber. □ • The soil is allowed get fully saturated • The water in the stand pipe flows through the soil and overflows through the constant head chamber • The water level in stand pipe falls from h1 to h2 in time t. □ • The coefficient of permeability is found by the equation, □	3.5		
	$\mathbf{k} = \frac{\mathbf{2.303\ aL}}{\mathbf{At}} \mathbf{\log_{10}} \left(\frac{\mathbf{h_1}}{\mathbf{h_2}}\right)$	1		
V.b	**Factors Affecting Compaction** 1. Water Content • Below OMC, As water content is increased soil particles get lubricated and slip over each other and move to densely packed positions. Hence dry density increases. • Beyond OMC, increase in water content does not decrease air voids but increases the total volume of voids (air + water) . Hence dry density decreases. 2. Amount of Compaction Increasing Compactive Effort • Increases dry density (MDD) • Decreases optimum moisture content (OMC) 3. Type of Soil • Coarse grained soil can be compacted to higher dry density than fine grained soil. • Well graded soil can be compacted to higher dry density than poorly graded soil. • Cohesive soils has more air voids and require more water than cohesion less soil. Hence has lesser dry density and higher OMC. 4. Method of Compation • Compaction curve obtained for different methods are different. • For same compactive effort, the curve obtained for compaction by kneading and by applying dynamic force are different. 5. Admixtures • The compaction characteristics of soil can be improved by addition of admixtures like lime, cement and bitumen. • Admixtures holds/binds the soil particles together *(Any four factors explained can be given full credit. Can give 2.5 marks if all the factors are only listed)*	4x2 = 8	8	15

VI.a	For Laminar flow conditions in a homogeneous soil, the rate of flow (v) is proportional to hydraulic gradient (i).	2	3	
	$v \alpha i$ $v = k i$ k is the coefficient of permeability.	1		
VI.b	Discharge Velocity : Velocity of flow corresponding to total cross sectional area.(Velocity represented in Darcy's Equation) $v = \frac{q}{A}$	2	4	
	Seepage Velocity : Velocity of flow corresponding to area of voids. (Actual flow velocity) $v_s = \frac{q}{A_v}$	2		
VI.c	**Field Methods of Compaction** 1. Tampers • Used to compact soils adjacent to buildings or confined areas. • Conventional rammers are with block of iron attached to a wooden rod and operated with hands. • Mechanical rammers are operated by compressed air or gasoline power. • Not economical when large quantity of soil is involved 2. Rollers • Smoothwheeled rollers which compact soil by tamping action is used for surface finishing • Pneumatic tyred rollers which compact soil by kneading action. • Sheep foot rollers which compact soil by kneading and tamping combined action. Useful for cohesive soil 3. Vibratory Compactors • Vibrations are induced on soil during compaction. • Vibratory Rollers : When vibrators are mount to a drum. • Vibrating Plate Compactors : Vibrators are mount on plate. • Useful for compacting granular (cohesion less soils). 4. Vibrofloatation Method • The vibroflot penetrates to desired depth by waterjet - PENETRATION • Vibrator is activated and soil is compacted horizontally - COMPACTION • Sand is backfilled in the gap and the vibroflot is raised - BACKFILLING			15

	5. Terraprobe Method • A vibratory pile drive gives vibrations to terraprobe and it penetrates into soil. • After reaching the depth the probe is raised back. • Penetrated into soil at 1.5 m intervals. • No need of backfill 6. Compaction by Pounding • Also known as dynamic compaction. • A heavy mass (2 to 50Mg) is dropped from a height of (7 to 35m) from ground surface. • At each location 5-10 poundings are given. • Useful for compacting loose soil to greater depth. 7. Compaction by Explosives • Used for fully saturated cohesion less soil. • The buried explosives while blasting, generates shockwaves and vibration. • Vibrations and shockwaves transfers through particles makes them closer and thus compacts. 8. Precompression • Used for cohesive soils. • Before the application of actual design load the soil is preloaded with earth fill. • Settlement takes place due to the applied preload. • After required compression is achieved, the fill is removed. 9. Compaction Piles • Used for cohesion less soils. • A pipe pile is driven into the soil. • Due to driving of pile, surrounding soil is compacted. • Pipe is removed and the hole is backfilled with sand. *(Any four factors explained can be given full credit. Can give 0.5 marks each if the method is only listed)*	4x2 = 8	8	
VII.a	i) SEISMIC REFRACTION METHOD Works on the principle, • Elastic shock waves have different velocities in different materials. • At the interface of two different materials, the waves get partially reflected and partially refracted Procedure is, 1. At a surface point in the site shock waves are created by hammer			

blows.

2. Geophones (detectors) are located at different intervals on soil surface
3. Waves that travel directly through the surface or through upper stratum and picked up first by geophones- primary waves
4. The waves that travels down get refracted at the interface and picked up by geophones (refracted waves)
5. The time at which each geophone detects a signal is noted. Velocity is found from distance-time plot.

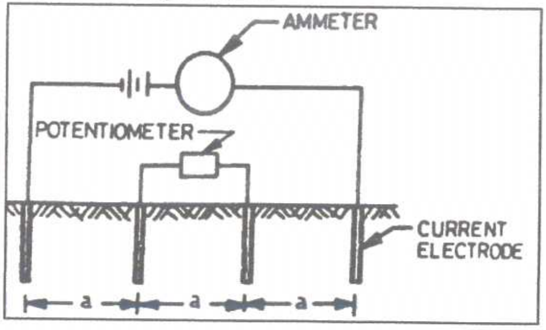


ii) ELECTRICAL RESISTIVITY METHOD

Works on the principle,

- The resistivity of any material depends upon the type of material, water content in it and many other factors
- So the value of resistivity gives an idea about the material

a) Electrical Profiling Method



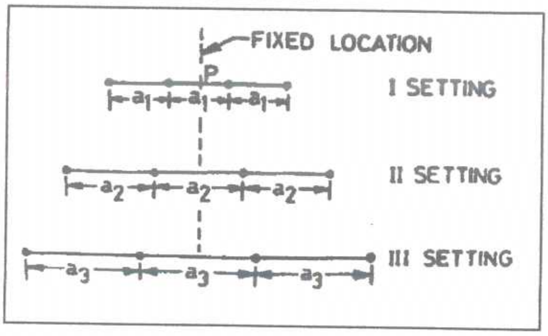
- Four electrodes are spaced at constant spacing and are driven into the ground.
- Two outer electrodes : Current Electrodes Two inner electrodes : Potential Electrodes
- DC current is applied at the current electrodes.
- Voltage drop between inner electrodes is measured using voltmeter and resistivity is calculated
- The depth at which the resistivity is measured is approximately equal to the spacing of electrodes.

4x2 = 8

8

- The electrodes are then moved along a line and soil strata is identified.
- The test is repeated for different spacing of electrodes to obtain soil strata at different depths.

b) Electrical Sounding Method



- Electrodes used as same as that of profiling method.
- Here spacing between electrodes are increased about a fixed point (P) in different steps (settings).
- In each setting the spacing of electrode will be equal to the depth of soil at which the investigation is carried out.
- Resistivity at each of these depths is calculated by the method as described in the electrical profiling method.
- The resistivity values at different depths gives an idea about the variation of the soil strata at different depths.

(Any two of the following three methods detailed explained with figures can be given full credity. Partial explanation of all the three methods also can be considered for full 8 marks credit)

VII.b STANDARD PENETRATION TEST

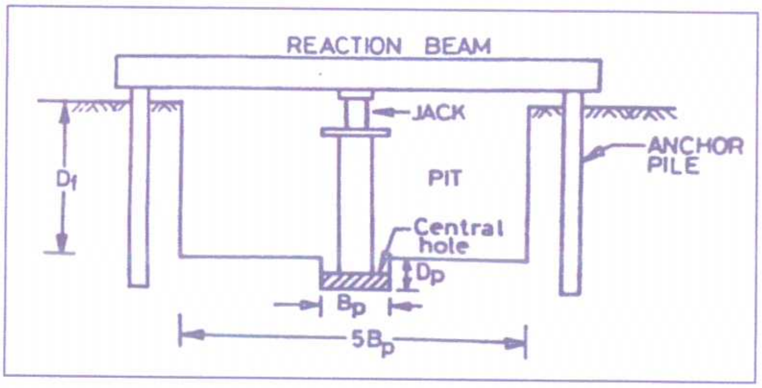
The test is conducted in a bore hole by means of a standard split spoon sampler. Once the drilling is done to the desired depth, the drilling tool is removed and the sampler is placed inside the bore hole. By means of a drop hammer of 63.5kg mass falling through a height of 750mm at the rate of 30 blows per minute, the sampler is driven into the soil. This is as per IS -2131:1963. The number of blows of hammer required to drive a depth of 150mm is counted. Further it is driven by 150 mm and the blows are counted. Similarly, the sampler is once again further driven by 150mm and the number of blows recorded. The number of blows recorded for the first 150mm not taken into consideration.. The number of blows recorded for last two 150mm intervals are added to give the standard penetration number (N).

7 7

15

VIII.a

PLATE LOAD TEST



3.5

- Field test to determine the allowable bearing pressure of soil.
- In the soil a pit of size 5Bp x 5Bp and depth equal to depth of foundation (Df) is excavated.
- A central hole of size BpxBp is excavated in the pit with depth of pit taken as Dp

$$D_p = \frac{D_f}{B_f} * B_p$$

D_p : Depth of plate hole
B_p : Width of plate
D_f : Depth of pit
B_f : Width of pit

- The plate is placed in the hole and load is applied through a hydraulic jack.
- The reaction to the jack is provided by a reaction beam. A loaded platform (kentledge) also can be used.

- A seating load of 7 kN/m^2 is first applied and then loads are applied at increments of 20% of estimated safe load or 1/10th of ultimate load.
- The settlements are recorded using a dial gauge after 1,5,10,20,40,60 minutes and at 1 hour intervals till failure or till a settlement of 25 mm has occurred.
- Load v/s settlement curve is plotted and ultimate load for plate is found out.

4.5

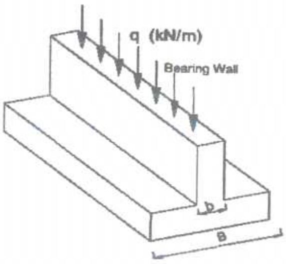
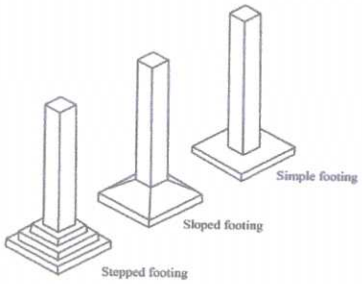
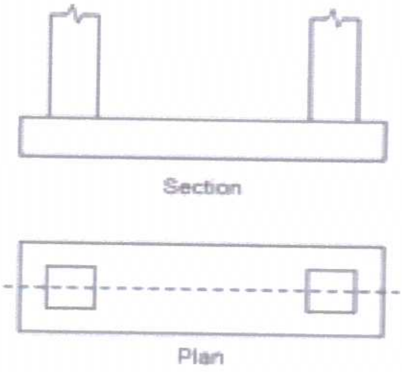
- Ultimate bearing capacity and settlement of foundation is found by,

CLAYEY SOIL, □qu (f) = qu (p)□
sf = sp [Bf/Bp]□
SANDY SOILS, □qu (f) = qu (p) [Bf/Bp]□
sf = sp [(Bf(Bp+0.3))/(Bp (Bf+0.3))]^2

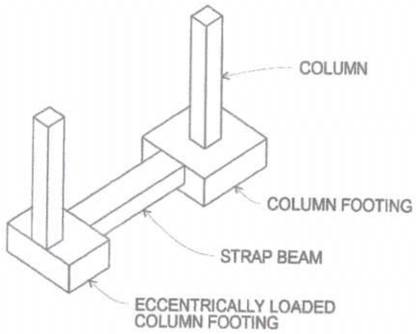
$q_u(p)$: Ultimate bearing capacity of plate
$q_u(f)$: Ultimate bearing capacity of footing
s_p : Settlement of plate
B_p : Width of plate
s_f : Settlement of footing
B_f : Width of footing

1

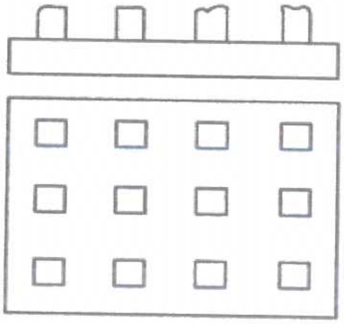
9

VIII.b	OBJECTIVES OF SITE EXPLORATION • To select type and depth of foundations • To determine the bearing capacity of soil • To estimate maximum probable settlements of soil • To establish ground water level and determine the properties of water • To predict lateral earth pressure against retaining walls • To select suitable construction technics • To predict probable foundation problems and solve them • To ascertain the suitability of soil as a construction material • To investigate the safety of existing structures and suggest remedial measures *(Any six points can be given full credit)*	6x1 = 6	6	15
IX.a	1. STRIP FOOTING OR CONTINOUS FOOTING  2. SPREAD FOOTING OR ISOLATED FOOTING  3. COMBINED FOOTING  	4x2 = 8		

4. STRAP OR CANTILEVER FOOTING



5. MAT OR RAFT FOOTING


Flat plate

(Any four footing with sketch can be given full credit)

8

IX.b

SINKING OF WELL

1. Laying of Well Curb

- In dry river bed an excavation of 15 cm is made and cutting edge is placed.
- If depth of water is less than 5m, a sand island is formed before placing cutting edge.
- If depth of water is more than 5m, curb is made on dry ground and then floated to site.
- After placing the cutting edge the shuttering for well curb is erected.
- Reinforcement for curb is placed and concreting is done continuously. Curb is allowed to set for one week.

2

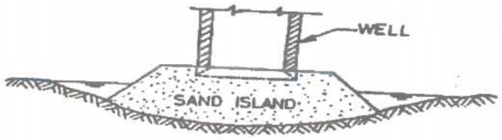
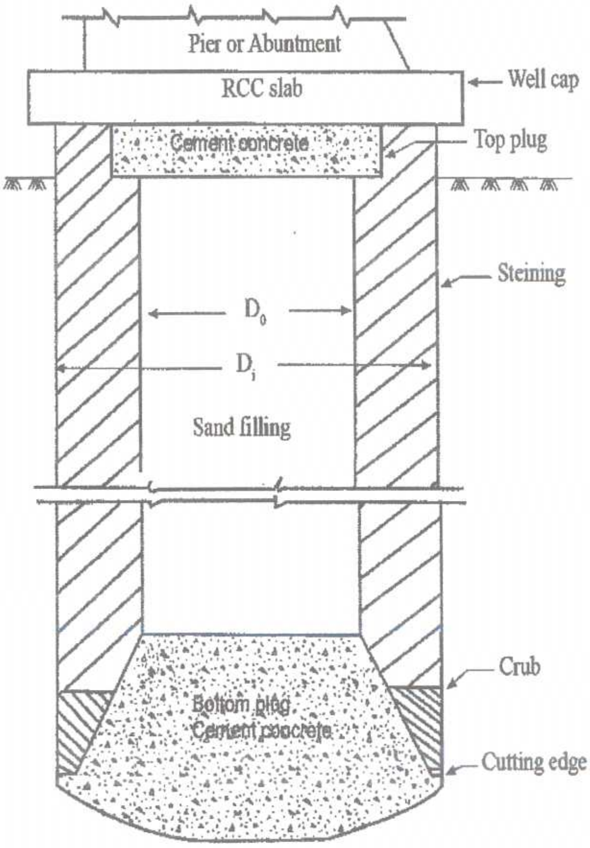


Fig. 27.20. Sand Island.

1

	2. Well Steining • After the curb is laid steining is built over curb at different steps of 1.5 m step at a time. • Steining is made using straight edges, usually iron angles. • Height of steining built at any stage should be such that the well does not lose its stability.	2		
	3. Sinking Process • Sinking process is started after casting the curb and the first stage of the steining. • When depth of water inside the well is upto 1m, dredging can be done manually. • If water depth is more excavation is done using jhams (type of spade). Also mechanically controlled grabs are used. • Initially well sinks by its own weight. • Then the frictional force on the walls of steining increases. • Hence to accelerate sinking additional loads are applied.	2	7	15
X.a	CLASSIFICATION OF PILE FOUNDATIONS 1. Based on Materials Used a) Steel piles b) Timber Pile c) Concrete Pile d) Concrete Pile 2. Based on Mode of Transfer of Load a) End bearing piles b) Friction piles c) Combined end bearing and friction piles 3. Based on Installation Method a) Driven Piles b) Driven and cast in-situ piles c) Bored and cast in-situ piles d) Screw piles e) Jacked piles 4. Based on Use of Piles a) Load bearing piles b) Compaction piles c) Tension piles d) Sheet piles e) Fender piles f) Anchor Piles 5. Classification based on Diplacement of Soil a) Displacement pile b) Non-displacement piles *(Any 4 criterias or 8 piles listed without criteria can be given full credit)*	4x2 = 8	8	

X.b	 Fig 1 Parts of a Well Foundation Sketch : 4 Marks Labelling : 3 Marks	7	7	15

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