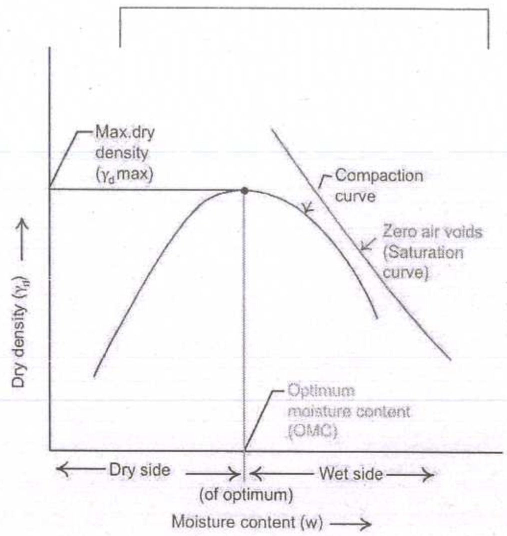
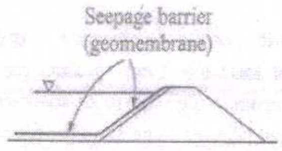
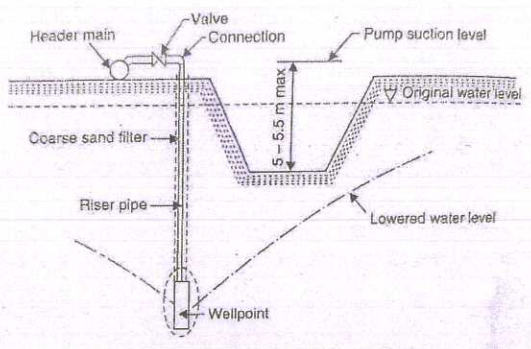
105 13/11/23 15 Nov-23

Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			9
I. 1	Special type of auger with a hollow drill rod	1	1	
I. 2	Electro-osmosis	1	1	
I. 3	Soil cement	1	1	
I. 4	Permeation or penetration/Compaction or controlled displacement/3. Hydraulic fracturing or uncontrolled displacement	any 1	1	
I. 5	Thixotropy	1	1	
I. 6	Tensile stress	1	1	
I. 7	shape of rigid bars, rods or pipes (nails)	any two	1	
I. 8	Consolidometer/odeometer	1	1	
I. 9	Sand drains and prefabricated drains	(1/2 mark*2)	1	
	PART B			24
II. 1	Compaction is measured quantitatively in terms of dry density. For a given amount of compaction (i.e., compactive effort) there exists for each soil a moisture content termed the "optimum moisture content" at which a maximum dry density is achieved	2	3	
		1		

II. 2	These rollers consist basically of drums with numerous club-shaped tapered projections. The mass of the drum can be varied by adding ballast. The area of each projection may be 4,000 to 6,500 mm^2. The projections or feet penetrate into the layer during the rolling operations. During compaction, the initial passes compact the lower portion of a lift. In successive passes, compaction is obtained in the middle and the top sections of the layer. For effective rolling, the lift thickness should be small and the contact pressure under the projections very high, of the order of 1,500 to 7,500 kN/m^2. These rollers are most suitable for plastic and non-plastic fine-grained soils. Although not suitable for clean granular soils, they may be used in such soils too if more than 20% fines are present. Due to the excellent bonding caused by the kneading effect of the sheep's foot, these rollers are generally recommended for water-retaining earthworks.	3	3	
II. 3	• Surface water control like ditches, training walls, open excavations, embankments.• Gravity drainage. • Well-point systems with suction pumps.• Shallow (bored) wells with pumps.• Deep (bored) wells with pumps.• Eductor system• Drainage galleries. Removal of large quantities of water for dam abutments, cut-offs,landslides etc. Large quantities of water can be drained into gallery (small diametertunnel) and disposed of by conventional large – scale pumps.• Electro-osmosis. Used in low permeability soils (silts, silty clays, some peats) when no other method is suitable. Direct current electricity is applied from anodes (steel rods) to cathodes (well-points, i.e. small diameter filter wells)	Any three method (1 mark*3)	3	
II. 4	Construction sites are dewatered for the following purposes: •To provide suitable working surface of the bottom of the excavation • To stabilize the banks of the excavation thus avoiding the hazards of slides and sloughing • To prevent disturbance of the soil at the bottom of excavation caused by boils or piping,	(1 mark*3)	3	

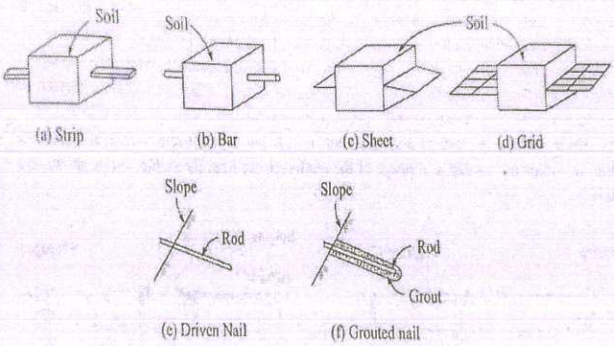
II. 5	soil stabilizations :Soil stabilization is referred to as a procedure in which a special soil is proportioned/added/or removed, or a cementing material, or other chemical material is added to a natural soil material to improve one or more of its properties One of the more common methods of stabilization includes the mixing of natural coarse-grained soil and fine-grained soil to obtain a mixture that develops adequate internal friction and cohesion and thereby provides a material that is workable during placement but will remain stable further. stabilization can also be achieved by mechanically mixing the natural soil and stabilizing material together so as to obtain a homogeneous mixture	3	3	
II. 6	One of the more common methods of stabilization includes the mixing of natural coarse-grained soil and fine-grained soil to obtain a mixture that develops adequate internal friction and cohesion and thereby provides a material that is workable during placement but will remain stable further Improvement of soil property by proportioning of coarse and fine grained soils is commonly referred to as mechanical stabilization. Rearrangement of soil particles by some mechanical means (say by compaction) is also referred to as mechanical stabilization.	3	3	
II. 7	Viscosity: Viscosity refers to the resistance of a fluid (in this case, the grout) to flow. It is a measure of the internal friction within the grout. Rigidity: Rigidity refers to the stiffness or hardness of the grout after it has set or cured. A rigid grout is one that provides structural support and can bear loads without significant deformation. Permanence: Permanence refers to the long-term stability and durability of the grout once it has hardened or cured. A permanent grout retains its properties and performance over an extended period without significant degradation or deterioration.	1 1 1	3	
II. 8	Reinforced earth consists of a compacted soil mass within which reinforcing elements or membranes, usually in the form of horizontal strips of metal (such as galvanised steel, stainless steel or aluminium alloys), rods of metals, wire grids, fibre glass strips/rods, bamboos or geotextiles, are embedded. A reinforced earth wall consists of three components :1. Wall facing element 2. reinforcing element 3. Compacted earth fill	2 1	3	

II.9	 (a) On upstream face of embankment	1	3	
	The reduction or elimination of seepage of water through a water retaining embankment is achieved by placing an impervious geosynthetic on the upstream slope of the embankment.Geosynthetics that are impermeable in the cross-plane and in-plane directions perform the function of hydraulic barriers when placed in a soil mass by preventing seepage of water through the soil mass	2		
II.10	The compression of a saturated soil under a steady static pressure is known as consolidation. It is entirely due to expulsion of water from the voids. It is similar to the action of squeezing of water from a saturated sponge under pressure. The soil behaves as a saturated sponge. As the consolidation of soils occurs, the water escapes. The solid particles shift from one position to the other by rolling and sliding and thus attain a closer packing.	3	3	

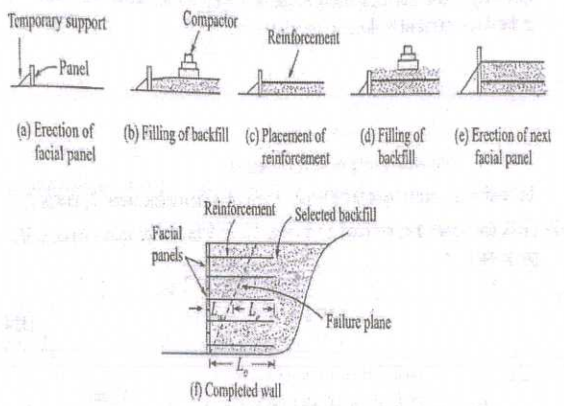
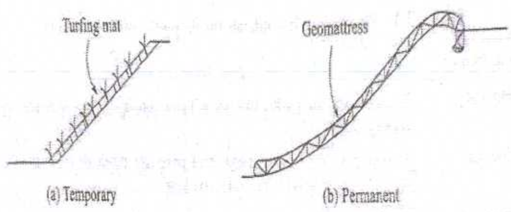
	PART C			42
III.*	Four groups of ground improvement Techniques are distinguished:1. Mechanical modification: Soil density is increased by the application of mechanical force, including compaction of surface layers by static vibrator such as compact roller and plate vibrators 2. Hydraulic modification: • Free pore water is forced out of soil via drains or wells.• Coarse grained soils; it is achieved by lowering the ground water level through pumping from boreholes, or trenches.• In fine grained soils the long term application of external loads (preloading) or electrical forces (electrometic stabilization) 3. Physical and chemical modification: • Stabilization by physical mixing adhesives with surface layers or columns of soil.• Adhesive includes natural soils industrial byproducts or waste. Materials or cementations or other chemicals which react with each other and/or the ground.• When adhesives are injected via boreholes under pressure into voids within the ground or between it and a structure the processis called grouting.• Soil stabilization by heating and by freezing the ground is considered thermal methods of modifications 4. Modification by inclusion and Confinement• Reinforcement by fibres,strips,bars and fabrics imparts tensile strength to a constructed soil mass• In situ reinforcement is achieved by nails and anchors.Stable earth retaining structure can also be formed by confining soil with concrete steel or fabric elements	2 2 2 1	7	7
~~III.2~~ IV	 *FIGURE 3.5.* Single-stage Wellpoint Installation.	3	7	7

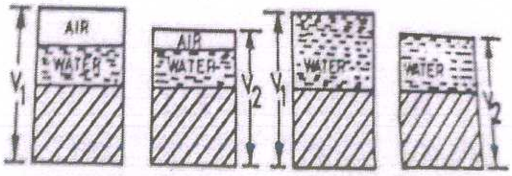
	A typical wellpoint system consists of a series of small diameters wells (known as wellpoints) connected via a header pipe, to the suction side of a suitable wellpoint pump. The pump creates a vacuum in the header pipe, drawing water up out of the ground. For long pipeline trenches, horizontal wellpoints may be installed by special trenching machines.A well-point is 5-7.5 cm diameter metal or plastic pipe 60 cm – 120 cm long which is perforated and covered with a screen. The lower end of the pipe has a driving head with water holes for jetting. Well-points are connected to 5.0-7.5 cm diameter pipes known as riser pipes and are inserted into the ground by driving or jetting. The upper ends of the riser pipes lead to a header pipe which, in turn, connected to a pump. The ground water is drawn by the pump into the well-points through the header pipe and discharged. This type of dewatering system is effective in soils constituted primarily of sand fraction or other soil containing seams of such materials. The capacity of a single wellpoint with a 50 mm riser is about 10 litres/m. Spacing of wellpoints depends on the permeability of the soil and on the availability of time to affect the drawdown. In fine to coarse sands or sandy gravels a spacing of 0.75 to 1 m is satisfactory. A spacing of 1.5 m may be necessary in silty sands of fairly low permeability. In highly permeable coarse gravels, they may need to be as close as 0.3 m centres. In general, a well pointing equipment comprises of 50 to 60 wellpoints to a single 150- or 200-mm pump with a separate jetting pump. The wellpoint pump has an air/water separator and a vacuum pump as well as the normal centrifugal pump.These systems are briefly described in the followings.1. Single Stage Well Point system 2.Multistage Well Point system	4		

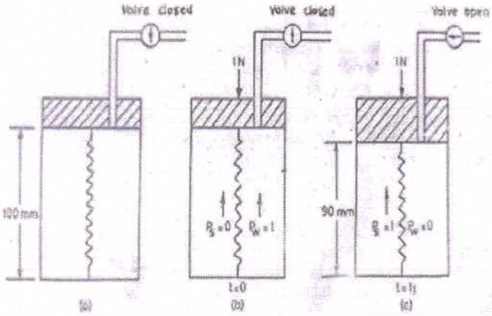
~~III. 3~~ V	Portland cement is one of the most successfully used soil stabilization. Cement and soil blended material is referred to as soil-cement. Most of bitumen stabilization has been with asphalt. Therefore, soil stabilised by asphalt may be referred to as soil-asphalt. Cement stabilized soil typically takes longer to cure than bitumen stabilized soil. Cement stabilized soil has higher compressive strength and can withstand heavier loads. Bitumen stabilized soil is more flexible and can adapt to changes in temperature and moisture better than cement stabilized soil. Bitumen stabilized soil has a lower carbon footprint and is more environmentally friendly Cement stabilized soil is generally more expensive Bitumen stabilized soil is often cheaper, but may require more maintenance over time	1mark*7 points	7	
~~III. 4~~ VI	Grouting is often employed to reduce seepage through soil and rock under dams. The process involves injecting a cementitious or chemical grout into the ground to fill voids and fractures, effectively reducing the flow of water. The grout forms a solid barrier that restricts seepage and improves the overall stability of the dam.Control of seepage of pervious dam foundations are accomplished by a variety of grouts and such grouts are usually placed deeply. It is customary to provide parallel rows of curtain grout lines in soilsAccordingly silicate solution grouting or clay suspensions were used in some places while in other places clay-cement grouts were used to have water tightness. Based on the degree of fracturing in the rock near its surface a shallow blanket grout is placed, through which a deep curtain grout injected. Cut-off walls are vertical barriers constructed in the ground to prevent seepage from passing through or under a structure. Grouting is often employed to enhance the effectiveness of cut-off walls in controlling seepage through soil.In this application, grouting is used to fill gaps and voids in the soil adjacent to the cut-off wall, ensuring a more impermeable barrier. The grout is injected into the soil through boreholes or other access points, forming a consolidated mass that restricts the flow of water. When this technique as well as other cut-off methods are successful not only is the quantity of seepage through the foundation reduced, but the pore water pressures beneath the downstream of the dam are also reduced.	7	7	

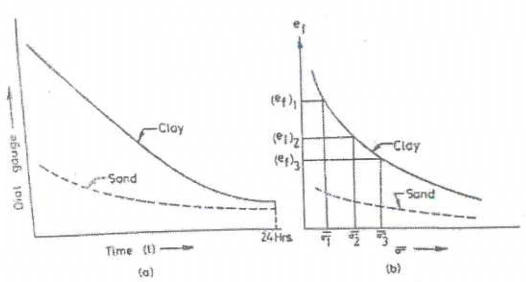
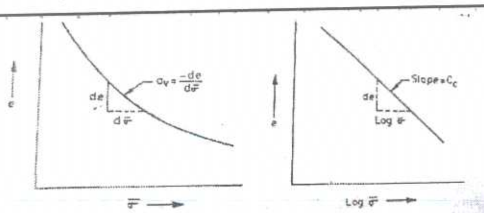
~~III.5~~ VII	The effectiveness of a reinforcing element embedded in soil is governed by the following factors: • the capacity of the element to withstand tensile stresses, i.e. its tensile strength, • the amount of extension exhibited by the element under tensile stress, and • the shearing resistance (adherence) between the reinforcement and the surrounding soil i.e. the maximum stress that can be resisted by the soil-reinforcement interface before the reinforcement slips away from the soil. When the tensile strength of an element is low, it can break or yield and become ineffective. If the tensile strength is adequate but its extension under stress is high, then the soil may show large movement (settlement or lateral bulging) because of the inadequate stiffness of the soil-reinforcement system. And finally, if the reinforcement is sufficiently strong and rigid but there is inadequate adherence between the soil and the reinforcement, then relative movement can occur, making the reinforcement ineffective. It is important to note that amongst metal strips, geogrids and geotextiles, metal reinforcements exhibit the highest tensile strength and the least extensibility, whereas geogrids offer the highest soil-reinforcement shearing resistance per unit surface area. Hence these two types of reinforcements are used widely	4 3	7	7
~~III.6~~ VIII	 Figures(a)-(d) show the shapes of reinforcing elements that can be placed in soil during construction, say, of an embankment or a backfill	2 1	7	7

	behind an earth-retaining structure. These are strips, bars, sheets or grids. They are just placed or in the case of sheets and grids spread on the horizontal soil surface by rolling out. On the other hand, for reinforcing existing soil formations we drive or drill-place-grout elements. They are in the shape of rigid bars, rods or pipes and are referred to as soil nails-see Figs. (e) and (f). Reinforcement strips are linear elements, usually made of steel having thickness of about 5 to 15 mm, width of 50 to 100 mm and length of several meters. Strips are flexible linear elements having their breadth greater than their thickness. Sheet reinforcements are made of woven or non-woven geotextiles and have the appearance of a thick cloth. Grids are mesh-like reinforcing elements having apertures of 50 to 200 mm. They may be made of steel wires, such as welded mesh, or of polymeric material in which case they are referred to as geogrids. Steel bars, rods or tubes used have diameters of 20 to 70 mm. They are either placed on the soil or, when used as soil nails, they are driven into the soil by percussion hammering, rotary action, vibrations or 'firing'. They can also be grouted after insertion in predrilled holes of diameter 100-150 mm	1 1 1 1		
~~III. 7~~ IX	Reinforced earth consists of a compacted soil mass within which reinforcing elements or membranes, usually in the form of horizontal strips of metal (such as galvanised steel, stainless steel or aluminium alloys), rods of metals, wire grids, fibre glass strips/rods, bamboos or geotextiles, are embedded. The first layer of reinforcement strips is placed at the level ground surface and the backfilling is done with granular soil, compacting it in the processes of laying. The entire process of laying strips and backfilling and compacting is continued till the required height of the reinforced earth wall is attained. It is vital that the fill should be adequately drained to prevent it from becoming saturated.Construction takes place from bottom upwards and the reinforcement is placed sequentially as layers of soil are compacted, one after the other, as shown in FigConstruction stages: 1. Erection of facial panel, 2. Filling of backfill, 3. Placement of reinforcement, 4. Filling of next layer back fill, 5. Erection of next facial panel, 6. Complted wall	3 2	7	7

		2 (completed wall)		
~~III. 8~~ X	Geosynthetics can be used for temporary or permanent erosion control measures along side slopes. Temporary erosion control geosynthetics comprise of natural biodegradable fibers such as jute. They are spread on the slope in the form of grids or mats and they prevent erosion until vegetative growth occurs; thereafter they degrade-see Fig (a). Permanent erosion control geosynthetics are porous synthetic polymeric products that furnish erosion control, aid vegetative growth and become entangled with the vegetation to provide reinforcement to the root system. They can also be geomattresses which cover a slope permanently	5	7	7
		2		
~~III. 9~~ XI	Compaction is an entirely different process than consolidation. It is important to note the following basic differences between the two processes, even though both the processes cause a reduction in the volume. (1) Consolidation is a gradual process of reduction of volume under sustained, static loading; whereas compaction is a rapid process of reduction of volume by mechanical means such as rolling, tamping and	6	7	

	vibration.(2) Consolidation causes a reduction in volume of a saturated soil due to squeezing out of water from the soil; whereas in compaction, the volume of a partially saturated soil decreases because of expulsion of air from the voids at the unaltered water content (Fig.) (3) Consolidation is a process which occurs in nature when the saturated soil deposits are subjected to static loads caused by the weight of the buildings and other structures. In contrast, compaction is an artificial process which is done to increase the density (unit weight) of the soil to improve its properties before it is put to any use.			
	(a) COMPACTION (b) CONSOLIDATION	1		
~~III. 10~~ XII	The process of primary consolidation can be explained with the help of the spring analogy given by Terzaghi. Fig. shows a cylinder fitted with a tight-fitting piston having a valve. The cylinder is filled with water and contains a spring of specified stiffness. Let the initial length of the spring be 100 mm and the stiffness of spring be 10 mm/N. Let us assume that the piston is weightless and the spring and water are initially free of stress.When a load P (say, 1 N) is applied to the piston, with its valve closed, the entire load is taken by water. The spring canot deform under this load since water is incompressible.From equilibrium,If the valve is now gradually opened, water starts escaping from the cylinder. The spring starts sharing some load and a decrease in its length occurs.As more and more water escapes, the load carried by the spring increases.Eventually, when the steady conditions are established, the water stops escaping. Finally, the entire load is taken by spring. Thus, Pw= 0 and Ps = 1.00. This load causes a decreases in length of the spring by 10 mm. The final length is 90 mm. As the load carried by water is zero, it is again free of excess pressure.Now if the load P is increased to 2N, the process of transfer of load repeats and finally the spring takes the complete load and its length becomes 80 mm. Likewise, the process is repeated till the final increment of the load has been applied.Thus, we see that when there is a pressure	6	7	7

	increment, the whole of pressure is first taken by water. As the water escapes out of the system, the load transfer takes place from water to the spring till the spring is deformed by the full amount corresponding to the applied stress increment. This analogy can be applied to the consolidation process of a soil mass consisting of soil water system. The grain structure represents the spring while the voids filled with water represent the cylinder. The valve opening is represented by the permeability of the soil mass, and the rate of load transfer from water to soil depends upon the permeability and the boundary conditions (i.e. the drainage faces available).			
		1		
~~III.~~ ~~II~~ XIII	1. Dial gauge reading-time plot shows the plot between the dial gauge reading and time for a typical load increment for clay and sand samples. The plot between the dial gauge reading and time is required for determining the coefficient of consolidation, which is useful for obtaining the rate of consolidation in the field. shows the process of consolidation under a particular increment.	1	7	7
	2. Final void ratio-effective stress plot: The thickness of the specimen after 24 hours of application of the load increment is taken as the final thickness for that increment. shows the plot between the final void ratios reached under different load increments and the corresponding effective stresses under those increments.	1		

	3. Final void ratio-log σ plot The curve has concavity upward. The slope of the curve at different points is different. The slope decreases with an increase in effective stress. It is more common to plot the results on a semi-log graph, in which the final void ratio is plotted on the natural scale and the effective stress as abscissa on the log scale	2		
	4. Unloading and Reloading plot The curve AB indicates the decrease in void ratio with an increase in the effective stress. It is the loading curve. The curve BEC is obtained in unloading. This is known as expansion curve or swelling curve. If the specimen which has swelled to the point C is reloaded, the recompression curve CFD is obtained.	1		
	 Fig. 12.6. (*a*) Dial gauge reading-time plot. (*b*) Final void ratio–$\bar{\sigma}$ plot.	1		
	 (a) Fig. 12.7. (*a*) $e-\bar{\sigma}$ plot. (b) (*b*) $e-\log\bar{\sigma}$ plot.	1		

~~III.~~ ~~12~~ XIV	Vertical drains are continuous vertical columns of pervious (sand or fibrous) material installed in clayey soils. These drains provide the pathway for the pore water to escape from the consolidating soil by travelling a shorter distance than would be necessary without them. Installation of vertical drains in conjuction with preloading brings about the rapid dissipation of excess pore water pressure and thereby accelerating the primary consolidation.In order to signify the relevance or otherwise of the use of vertical drains a sequence of events that may lead to use of vertical drains is illustrated.Figure (a) represents a laboratory consolidation test result on a 20 mm thick specimen. From the time-compression curve, the time required for primary consolidation is 3.7 hrs. Figure (b) represents the time prediction for real problem without vertical drains. Extrapolating from the laboratory results to the real problem of a clay stratum of 6.3 m thick, with double drainage, time required for 70 and 88% consolidation have been estimated as 16 and 43 years respectively. As such a long time can not be accommodated in a construction project, vertical drains have been planned. Figure (c) represents the time prediction for the same real problem with vertical drains. Evidently the estimate shows an encouraging results and enhances support for the use of vertical drains.	4	7	7

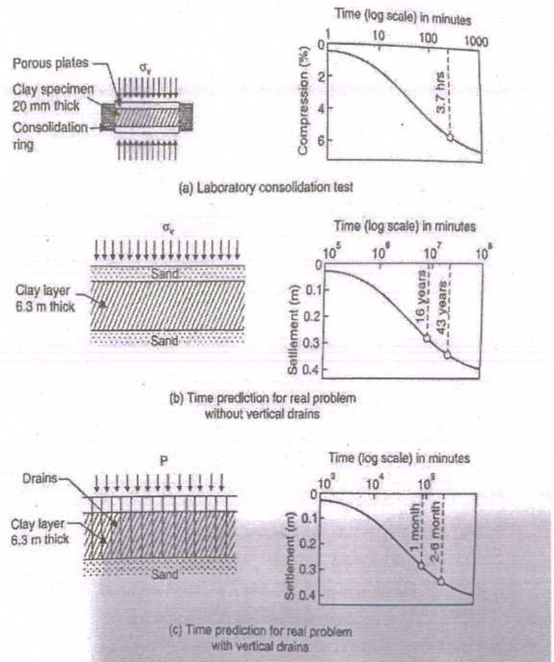
		3		

FIGURE 4.12. Comparisons between Time Curves.
(*Source: Stamatopoulos and Kotzias, 1985*)

25/9/23
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lecturer