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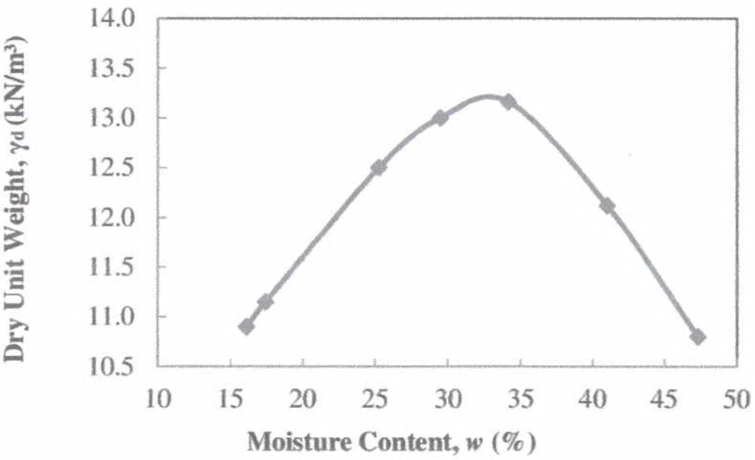
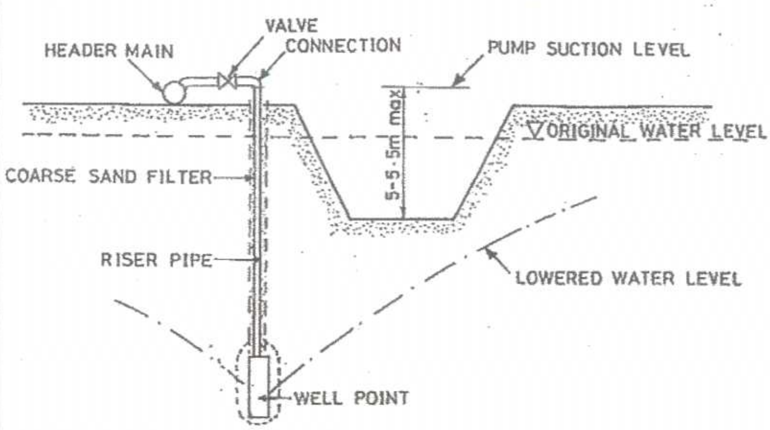
April: 2024

Scoring Indicators

COURSE NAME: GROUND IMPROVEMENT TECHNIQUES

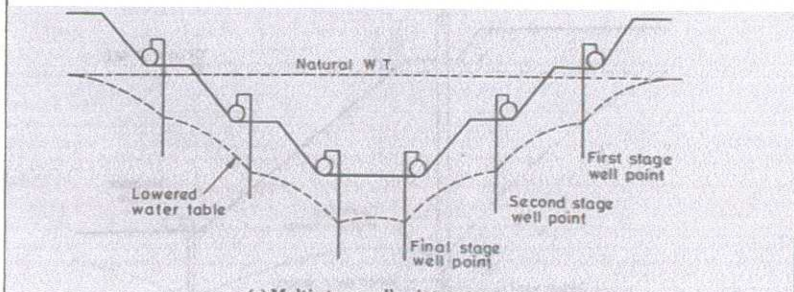
COURSE CODE: 5014B **QID: 2109230020**

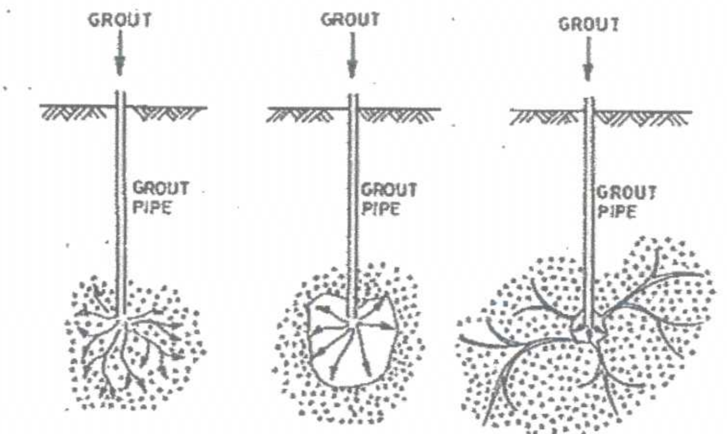
Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			**9**
I. 1	Collapsible soils Expansive clays and rocks Soft to firm clays having low bearing capacity Organic soils Loose sand and silts	Any 1	1	
I. 2	Dry density	1	1	
I. 3	Open sumps and ditches	1	1	
I. 4	Asphalt	1	1	
I. 5	The ratio of D_{15} of formation to D_{85} of grout is termed as Groutability ratio	1	1	
I. 6	• High-density polyethylene (HDPE) • Linear low-density polyethylene (LLDPE) • Polypropylene (PP) • Polyvinyl chloride (PVC) • Polyester (PET) • Expanded polystyrene (EPS) • Chlorosulphonated polyethylene (CSPE) • Ethylene propylene diene terpolymer (EPDM)	Any 1	1	
I. 7	Geogrids	1	1	
I. 8	Reduction in volume of saturated soil mass due to expulsion of water under static loading.	1	1	
I. 9	Initial consolidation Primary consolidation Secondary consolidation	All 3	1	
	PART B			24
II. 1	1. Soil type 2. Area and depth of treatment required 3. Type of structure and load distribution 4. Soil properties – strength, compressibility, permeability etc. 5. Permissible total and differential settlements 6. Availability of materials 7. Availability of skills and equipment 8. Environmental considerations 9. Local experience and preferences 10. Economics	Any 6 points	3	

II. 2	• The standard proctor test is a laboratory method of determining the optimal moisture content and maximum dry density of a given soil type for compaction purposes. • IS: 2720 (Part VII) 1980/87 recommends a **mould of 1000 ml capacity** with an **internal diameter of 100 mm** and an internal effective **height of 127.5 mm**. • The test consists of compacting soil at various water contents in the mould, in **three equal layers**, each layer being given **25 blows of the 2.6 kg** rammer dropped from a height of **310 mm**. • The dry density obtained in each test is determined by knowing the mass of the compacted soil and its water content. 	1 1 Expl OR fig - 1	3	
II. 3		Fig-3	3	
II. 4	1. Mechanical stabilization • soil-aggregate mixture • soil- clay mixture • sand-gravel mixture • stabilization of soil with soft aggregates 2. Chemical stabilization • Lime stabilization • Cement stabilization	List any 3 – 1.5 List any 3 – 1.5	3	

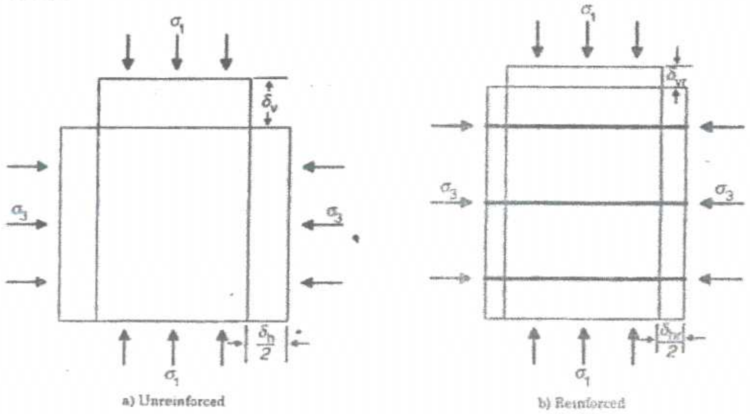
	• Sodium silicate • Calcium chloride • Bituminous material • Resinous material			
II. 5	• Shaping the soil to be treated • Pulverizing the soil • Adding water and cement • Mixing • Compacting • Finishing • Curing	All steps	3	
II. 6	1. **Suspensions:** Small particles of solids are distributed in a liquid dispersion medium. Example: cement and clay in water 2. **Emulsions:** A two phase system containing minute (colloidal) droplets of liquid in a disperse phase. Example: bitumen and water. Foams created by emulsifying a gas into the grout material, which could be cement or an organic chemical. Foaming agents increase surface tension; assist in forming bubbles by agitation. 3. **Solutions:** Liquid homogeneous molecular mixtures of two or more substances. Example: sodium silicate, organic resins, and a wide variety of chemical grouts.	1 X 3	3	
II. 7	• Minimum disturbance to the structure and surrounding ground • Minimum risk during construction. • Greater economy. • Supports all portions of structures. • Reduced need for extensive exploration. • Greater flexibility. • Groundwater not affected.	Any 3	3	
II. 8	• Mechanical properties of geosynthetics depends on the mechanical property of the fibre material, fibre structure, the yarn structure, and the structure of geosynthetics. • The most important mechanical property is the **tensile stress – strain characteristics** of the soil-geosynthetic interface. • **Burst and puncture strength** is to be tested in which load is applied perpendicular to the geosynthetics. • The **interface friction, fatigue resistance, creep resistance, tear-strength, abrasion resistance and seam strength** are the other important mechanical properties.	Any 3 properties	3	

II.9	• **Internal stability** is first addressed to determine geotextile spacing, geotextile length, and overlap distance. This establishes the integrity of the MSE mass. • **External stability** against **overturning, sliding, and foundation failure** is investigated and the internal design verified or modified accordingly. This establishes that the MSE mass will remain stationary. • Miscellaneous considerations, including wall-facing details and external drainage are then ensured.	1.5 1.5	3	
II.10	• **SAND DRAINS**: When the time required for consolidation is less, sand drains are employed to eliminate deleterious differential settlements or to acquire sufficient additional shear strength. • Sand drains are vertical columns of sand or other pervious material inserted through compressible stratum at sufficiently close spacing so that the longest horizontal drainage path is less than the longest vertical path. • The rate of drainage can be increased by application of vertical sand drains in the embankment/sub-soil. Thus, the drains serve to hasten the consolidation process. • A sand blanket is placed over the top of the sand drains to connect the same. To accelerate the drainage, a surcharge load is placed on the sand blanket.	3	3	
	PART C			**42**
III	**Smooth wheel roller** • Compaction is achieved by application of pressure over the soil. • Suitable for coarse grained soil like gravel, sand etc. • Generally used in construction of road. **Sheep foot roller:** • Compaction is carried out by kneading action which provide comparatively strong bond between compacted layers of soil. • Suitable for cohesive soil. • Used in construction of earthen dam. **Pneumatic tyred roller:** • Compaction is carried out by the combined action of pressure and kneading. • Suitable for all types of soil but generally preferred for cohesive soil. • Used in construction of roadway, airfield and homogeneous dams. **Grid roller:** • It consists of a network of steel bars, which provide a grid like pattern on the steel drum	List – 2 Expl-5	7	

	• It provides high contact pressure and minimal kneading action • They are typically used for compaction of well graded coarse soils and weathered rocks, often in subgrade and sub base road projects			
IV	• For excavating more than 6m below water table, a multi stage well point system is used • Here, first of all ground is excavated upto subsoil water level & first stage well point is installed • After excavating upto 5m, second stage well points is installed to further lower water level for advancing depth of excavation • Thus excavation is carried out for deeper depths • Not suitable for >16m depth  (c) Multi-stage well point system.	4 Fig - 3	7	
V.	Bituminous stabilization of soil is an effective method using bituminous materials as bitumen, asphalt and tar. Bituminous materials stabilize the soil either by binding the particles together or protecting the soil from the deleterious effects of water or both these effects may occur together. The first mechanism takes place in cohesionless soils and the second one in cohesive soils. Among the bituminous materials most of the stabilization has been with asphalt. Soil stabilized by asphalt is termed as soil-asphalt. Asphalts are produced by three process: (i) vacuum distillation producing straight run asphalt (ii) high temperature pyrolysis producing cracked asphalt (iii) high temperature air blowing straight-run asphalt producing blown asphalt. Among these, straight-rum asphalt is commonly used in soil stabilization. Asphalt cannot be directly added to soil as it is too viscous. Its fluidity can be increased by heating, emulsifying in water or cutback with some solvent like gasoline. Both emulsions and cutbacks are used in soil stabilization. Soil-asphalt has varied applications, but mostly used in bases for highways and airfield pavements. All inorganic soils with which asphalt can be mixed can be stabilized. Organic matter of acid origin is detrimental to soil-asphalt. Bituminous stabilization cannot be effective in fine-grained soils with high PH and dissolved salts.	Any 7 points	7	

VI.	1. **Permeation or Penetration:** the grout flows freely with minimal effect into the soil voids and rock seams. 2. **Compaction or controlled displacement**: grout remains more or less intact as a mass and exerts pressure on the soil or rock. 3. **Hydro-fracturing or uncontrolled displacement**: the grout rapidly penetrates into a fractured zone which is created when the grouting pressure is greater than the tensile strength of the soil or rock being grouted.  (a) Permeation grouting (penetration) (b) Compaction grouting (controlled displacement) (c) Hydrofracturing (uncontrolled displacement)	Expl - 3 Fig - 4	7	
VII.	There are eight specific types of geosynthetics: (1) geotextiles, (2) geogrids, (3) geonets, (4) geomembranes, (5) geosynthetic clay liners, (6) geofoam, (7) geopipes and (8) geocomposites. • geotextiles (GT) Majority are made from polypropylene fibers. Standard textile manufacturing. Available in woven (slit film, monofilament or multifilament) and nonwoven (needle punched or heat bonded) forms. Characterized by an open and porous structure. Mechanical and hydraulic properties vary widely. Very versatile in their primary function • geogrids (GG) Unitized, woven yarns or bonded straps. Structure allows for soil "strike-through". Bidirectional – equal strength in both directions. Unidirectional – main strength in machine direction. Focuses entirely on reinforcement applications. e.g: walls, steep slopes, base and foundation reinforcement • geomembranes (GM) Function is always containment. Represents a barrier to liquids and gases. Many types: HDPE, LLDPE, fPP, PVC, EPDM, etc. Manufactured rolls are field seamed. • geonets (GN) All are made from high density polyethylene. Results in parallel sets of ribs as an integral unit. Biplanar – flow is	List – 2 Explanation of each - 5	7	

	equal in all directions. Triplanar – flow much greater in machine direction. Function is always in-plane drainage and surfaces must be covered; usually with GT • geopipe (GP) It's really buried plastic pipe. Function is always drainage. HDPE and PVC most common. Both can be smooth walled or corrugated • geofoam (GF) EPS or XPS in block form. Lightweight fill on soft or sensitive soils. Relieves lateral pressure on walls and also used for insulation of frost-sensitive soil • Geosynthetic Clay Liners. Geosynthetic clay liners (GCLs) are rolls of factory-fabricated thin layers of bentonite clay sandwiched between two geotextiles or bonded to a geomembrane. Structural integrity of the composite is obtained by needle-punching, stitching, or adhesive bonding. GCLs are used as a composite component beneath a geomembrane or by themselves in environmental and containment applications as well as in transportation, geotechnical and hydraulic applications. • Geocomposites. Geocomposites consist of a combination of geotextiles, geogrids, geonets, and/or geomembranes in a factory-fabricated unit. Also, any one of these four materials can be combined with another synthetic material (e.g., deformed plastic sheets or steel cables) or with soil.			
VIII.	• Excavation: Earthwork in the excavation of soil for reinforced soil Wall (RS Wall) shall be as per construction drawing. After soil excavation, compaction should be done to avoid any kind of settlement in foundation soil. • Levelling Pad: An initial levelling pad of 150 mm thick using M20 grade plain cement concrete having a suitable width(300-350mm) to be provided below the first row of fascia layer. • The first layer of facia: It should be as per the design and drawing. During the first layer of facia placement, utmost care should be taken to maintain the alignment of the facing element. • Drainage material: Drainage material/filter media specification should be as per the design requirement. Drainage layer should be well compacted, and which is constructed in a layer-wise. • Placing of Reinforced soil behind drainage bay/filter media: Placing the reinforced soil backfill behind the drainage zone and compacting the same.	7	7	
IX.	1. Treatment basins – for liquid containment 2. Canals – for liquid containment 3. Disposal basins – for solid containment 4. Upstream face of dams – as impermeable barrier	List any 3 – 3	7	

	5. Curtain walls – as impermeable barrier 1. Industries generating toxic wastes are required to design treatment basin with geomembrane lining systems. In this application, chemical resistance and impermeability of the lining are important. 2. Canals are built for transportation of water for agricultural or industrial uses. Geomembrane lining system reduces the water loss through seepage. 3. Disposal basins are for the permanent storage of waste that cannot be treated adequately or economically. Geomembranes with drainage system are used at the bottom side and top of the basin to minimize the flow of leachate from the landfill. 4. Geomembranes are used on the upstream face for protection of embankment from wind and wave action. 5. Geomembranes are used in a narrow trench to construct a cut off wall system.	Expl any 2 - 4		
X.	Reinforced earth is composite material obtained by placing extensible or inextensible materials such as metallic strips or polymeric reinforcement within the soil to obtain the requisite properties. Soil has an inherently low tensile strength but a high compressive strength. An objective of incorporating soil reinforcement is to absorb tensile loads or shear stresses within the structure. In absence of the reinforcement, structure may fail in shear or by excess of the deformation When an axial load is applied to the reinforced soil, it generates an axial compressive strain and lateral tensile strain. If the reinforcement has an axial tensile stiffness greater than that of the soil, then lateral movements of the soil will only occur if soil can move relative to the reinforcement. Movement of the soil, relative to the reinforcement, will generate shear stresses at the soil/ reinforcement interface, these shear stresses are redistributed back into the soil in the form of internal confining stress. Due to this, the strain within the reinforced soil mass is less than the strain in unreinforced soil for the same amount of stresses.  a) Unreinforced b) Reinforced	Fig – 3 Explanation - 4	7	

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<td>XI.</td>
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<table>
<tr><th>No</th><th>Compaction</th><th>Consolidation</th></tr>
<tr><td>1</td><td>It is the compression of soil by the expulsion of air from the voids of the soil.</td><td>It is the compression of soil by the expulsion of water from voids of the soil.</td></tr>
<tr><td>2</td><td>It is a quick process.</td><td>It is a slow process.</td></tr>
<tr><td>3</td><td>Short term loading is required</td><td>Long term loading is required.</td></tr>
<tr><td>4</td><td>Loading is applied in a dynamic way.</td><td>Loading is static and constant.</td></tr>
<tr><td>5</td><td>Any type of soil either it is cohesion or Cohesionless can be compacted.</td><td>Consolidation applies to cohesive soils only.</td></tr>
<tr><td>6</td><td>Compaction is done purposely in order to get maximum dry density of soil.</td><td>Consolidation of soil occurs naturally due to structural loads from foundations.</td></tr>
<tr><td>7</td><td>It is done before the construction of structure.</td><td>It begins naturally along with the construction work.</td></tr>
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<tr>
<td>XII</td>
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1. Preloading
Applying external load for a long duration to cause desirable changes in the soil. Pre-loading inceases the pore water pressure of the soil and as the consolidation process occurs an increase in the effective stress takes place accompanied by surface settlement.
2. Preloading with surcharge fills
A surcharge fill along with permanent fill can cause more amount of settlement in shorter time.
3. Vertical drains
Preloading is enefficient when used alone in very thick soft clays or in soils with low permeability. Vertical drains are continuous vertical columns of pervious material installed in clayey soils. These drains provide a path way for the pore water to escape from the consolidating soil by travelling a shorter distance. Two types of vertical drains are sand drains and prefabricated vertical drains.
4. Dynamic consolidation
The densification of soil by dynamic consolidation (dynamic compaction, heavy tamping) is used as a means of improving silts and clays.
5. Consolidation by electro-osmosis
The elecro-osmosis process by which the pore water moves under the influence of an electrical potential effects in the decrease of water content in fine grained soil and thereby brings consolidation of soil.
</td>
<td>Listing any 3 – 3

Expl – any 2 - 4</td>
<td>7</td>
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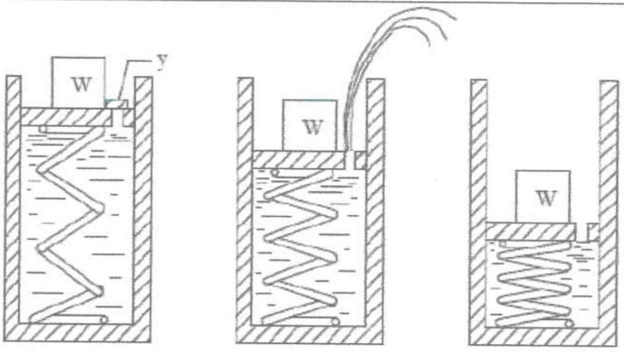
XIII.	 (a) (b) (c) Terzaghi's soil-spring analogy model consists of a cylindrical vessel with piston and springs. The space between the springs is filled with water and the pistons are perforated. The consolidation process in clay subjected to loading is same as behaviour of spring-piston model. The springs surrounded by water represents the soil and water in the vessel represents the water filling the voids in the soil. The compression is one-dimensional and water can drain out only in vertical direction and in the model, flow can take place only upwards.	Fig – 3 Expl - 4	7	
XIV.	**Vertical drains** are continuous vertical columns of pervious material installed in clayey soils. These drains provide a pathway for the pore water to escape from the consolidating soil by travelling a shorter distance than would be necessary without them. Further, they allow the flow inside the soil to take place along the horizontal which is the direction of least resistance. Thus, it serves the purpose of collecting and discharging the expelled water faster during the process of consolidation. The two common types of vertical drains are sand drains and prefabricated vertical drains. **Sand drains** are vertical columns of sand or other pervious material inserted through compressible stratum at sufficiently close spacing so that the longest horizontal drainage path is less than the longest vertical path. **Prefabricated Vertical Drains**, also known as Wick Drains or band drains are prefabricated geotextile filter-wrapped plastic strips with moulded channels. These act as drainage paths to take pore water out of soft compressible soils that consolidate faster under a constant surcharge load.	3 2 2	7	

Set-1

BLUE PRINT

Mark Distribution

Module	Hr / Module	(hi / ∑Hi) * 123	TYPE OF QUESTIONS							
			PART A		PART B		PART C		TOTAL	
			No of Questions	Marks	No of Questions	Marks	No of Questions	Marks	No of Questions	Marks
I	10	28.6	3	3	3	9	2	14	8	26
II	10	28.6	2	2	4	12	2	14	8	28
III	12	34.3	2	2	2	6	4	28	8	36
IV	11	31.5	2	2	1	3	4	28	7	33
Total	43	123.00	9	9	10	30	12	84	31	123

Cognitive Level Wise Question Analysis

Mark Distribution

Cognitive Level	% Marks	Marks	TYPE OF QUESTIONS							
			PART A		PART B		PART C		TOTAL	
			No of Questions	Marks	No of Questions	Marks	No of Questions	Marks	No of Questions	Marks
R	30	36.9	6	6	3	9	2	14	11	29
U	50	61.5	2	2	5	15	8	56	15	73
A	20	24.6	1	1	2	6	2	14	5	21
Total	**100**	123	9	9	10	30	12	84	31	123