Scoring Indicators

COURSE NAME:GROUND IMPROVEMENT TECHNIQUES

COURSE CODE :**5014B**

QID: 2109230019

Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			**9**
I. 1	Cohesive or clay soil		1	
I. 2	100 %		1	
I. 3	Optimum Moisture Content(OMC)		1	
I. 4	Grouting		1	
I. 5	D15/D85		1	
I. 6	Thermoplastics		1	
I. 7	Geomembranes		1	
I. 8	Air voids and water voids		1	
I. 9	mm2/sec or cm2/sec or m2/year . (should have the unit of area/time)		1	
	PART B			24
II. 1	Any 6 methods(1/2 mark each) Various mechanical methods for ground improvement include: 1. Compaction: 2. Dynamic Compaction: 3. Vibro-Compaction 4. Stone Columns (Vibro-Replacement 5. Deep Soil Mixing 6. Preloading: 7. Dynamic Replacement: 8. Grouting: 9. Geosynthetic Reinforcement: 10. Soil Nailing: 11. Micropiles: 12. Underpinning:. 14. Blasting		3	
II. 2	Dewatering systems are used to remove excess water from construction sites, mines, tunnels, and other areas where water accumulation can be problematic. There are		3	

	several dewatering methods and systems available, including: 1. **Wellpoint System:** 2. **Deep Well System:**. 3. **Open Sump and ditches :**. 4. **Vacuum- Dewatering:** 5. **Gravity Drainage:** 6. **Geotextile Tubes:** 7. **Artificial Ground Freezing:**. 8. **Horizontal Drains (Wick Drains):** 9. **Electro-Osmosis:**	Any 6		
II. 3	**Soil compaction** is performed to improve the engineering properties of soil, including its shear strength, bearing capacity, and resistance to settlement. • Compaction tests, such as the Standard Proctor and Modified Proctor tests, are performed in the laboratory to determine the optimum moisture content and maximum dry unit weight for a given soil. • Field compaction tests, using nuclear density gauges or sand cone tests, are conducted to assess the achieved density in the field during construction. **Compaction Curve:** A compaction curve is a graphical representation that shows the relationship between the moisture content of a soil sample and its dry unit weight (density) after compaction. It is a crucial tool in determining the optimum moisture content and maximum dry unit weight for compaction. Diagramatic representation of curve (1 mark)	1·5 1·5	3	
II. 4	Grouts can be classified into two main categories based on their consistency and flow behavior: solution grouts and suspension grouts. These categories refer to how the solid components are dispersed in the liquid phase of the grout. Here's an explanation of each type: **1. Solution Grouts:** Solution grouts are grouts in which the solid components are completely dissolved in the liquid phase, resulting in a homogenous solution.	1·5	3	

- **Consistency**: Solution grouts have a uniform and liquid-like consistency with no discernible solid particles.
- **Use**: They are typically used for injection and permeation grouting, where the grout needs to penetrate and fill fine cracks, fissures, and voids in soils and structures.
- **Examples**:
    - Chemical grouts, such as sodium silicate or polyurethane-based grouts, that are used for soil stabilization, void filling, and sealing leaks.
    - Cement grouts that have been mixed with water to create a uniform, flowable solution for injection into cracks or fissures.
- **Properties**:
    - Low viscosity for ease of injection.
    - Good penetration ability.
    - Rapid curing or setting characteristics, depending on the type of grout.

2. Suspension Grouts: Suspension grouts are grouts in which solid particles are suspended or dispersed in the liquid phase, creating a slurry-like consistency.

- **Consistency**: Suspension grouts have a thicker and more viscous consistency compared to solution grouts due to the presence of solid particles.
- **Use**: They are typically used for various applications where a thicker, non-flowable grout is needed, such as backfilling, support of boreholes, and certain construction projects.
- **Examples**:
    - Cement-based grouts, where cement particles are suspended in water to create a slurry. These are often used for filling underground cavities, foundation support, and grouting around tunnel linings.
    - Bentonite-based grouts, which use bentonite clay as the solid component suspended in water, primarily used for sealing boreholes and controlling groundwater flow.

	• **Properties**:
	  • Higher viscosity compared to solution grouts.
	  • Reduced penetration ability due to the thicker consistency.
	  • Longer setting times, allowing for adjustment and placement.			

II. 5	Grouting is a construction and maintenance technique that involves injecting a fluid material into the ground, rock, or structures to improve their properties or fill voids. It serves various objectives in civil engineering Such as 1. **Sealing Leaks**: 2. **Foundation Stabilization**: 3. **Soil Improvement**: 4. **Void Filling**: 5. **Ground Improvement**: 6. **Support of Excavations**: 7. **Pipeline and Sewer Repair** 8. **Anchoring and Soil Nailing**: 9. **Tunneling**:	Any 6	3	
II. 6	**Bituminous Soil Stabilization :** Soil stabilization using bitumen, often referred to as bituminous soil stabilization, is a common technique employed in civil engineering and road construction to improve the engineering properties of soil materials. This process involves the addition of bituminous materials, such as bitumen or asphalt, to native soils to enhance their strength, durability, and resistance to water infiltration. **Materials and Equipment:** 1. **Bituminous Binder**: This can be in the form of bitumen (asphalt) or bituminous emulsions. The choice of binder depends on project requirements, local availability, and environmental considerations. 2. **Soil**: The native soil to be stabilized should be thoroughly tested for its characteristics, including gradation, plasticity, and moisture content.		3	

	3. **Compaction Equipment**: Compactors, such as vibratory rollers or pneumatic tire rollers, are used **Procedure for Soil Stabilization Using Bitumen:** 1. **Soil Analysis**: Conduct a comprehensive analysis of the native soil to determine its properties and characteristics. This includes gradation analysis, Atterberg limits (liquid limit, plastic limit), and moisture content testing. 2. **Design Mix**: Based on the soil analysis, design a bituminous mix that specifies the type and percentage of bituminous binder to be added to the soil. Generally, bitumen percentages for soil stabilization can range from 5% to 14% or more. 3. **Preparation of Bituminous Binder**: Heat and liquefy the bitumen to the specified temperature range (typically between 140°C and 160°C) to achieve proper mixing and coating of the soil particles. 4. **Mixing**: Introduce the bituminous binder into the soil using a pug mill, mechanical mixer, or in-place mixing equipment. The mixing process should be thorough to ensure that the binder coats the soil particles uniformly. 5. **Compaction**: Place the mixed material in the desired location and compact it using heavy compaction equipment. Achieve the specified compaction density to ensure adequate strength and stability. 6. **Curing**: Allow the stabilized soil to cure for a specified period, which can vary depending on the type of bitumen used and the environmental conditions. This curing period allows for the binder to set and bond with the soil particles. 7. **Quality Control**: Conduct quality control tests, including density, moisture content, and strength tests, to ensure that the stabilized soil meets the project's specifications.			
II. 7	Grouting is a crucial technique used in dam engineering to control seepage and enhance the safety and stability of dams.		3	

	Seepage control is essential because excessive water seepage through or beneath a dam can weaken the structure, erode the foundation, and potentially lead to dam failure. 1. **Curtain Grouting**: Curtain grouting involves the injection of grout into the ground adjacent to the dam to create a continuous impermeable barrier (grout curtain) that prevents water from flowing through the foundation or abutments. This technique is especially effective in preventing seepage beneath the dam. 2. **Blanket Grouting**: Blanket grouting is used to reduce seepage through the dam's body or embankment. Grout is injected into the body of the dam to fill voids, cracks, and permeable zones, effectively sealing potential pathways for seepage. 3. **Toe Grouting**: Grouting at the downstream toe of the dam can help prevent erosion and piping of the foundation soils, which can occur when water seeps through and carries away fine particles.			
II. 8	Geosynthetics functions 1. **Reinforcement**: 2. **Separation**: 3. **Filtration**: 4. **Drainage**: 5. **Erosion Control**: 6. **Barrier Properties**: 7. **Protection**: 8. **Reflective Cracking Mitigation**: 9. **Pavement Design**: 10. **Environmental Applications**: 11. **Soil Retention**:	Any $6 \times \frac{1}{2}$	3	
II.9	Geotextiles and geogrids are both types of geosynthetic materials used in civil engineering and construction for various soil and pavement-related applications. They serve different purposes and have distinct characteristics. **Geotextiles**: 1. **Material Composition**: Geotextiles are typically made from synthetic polymers such as polypropylene, polyester, or polyethylene. They are non-rigid and have a fabric-like texture. 2. **Function**:	1.5	3	

	Geotextiles primarily serve as a separation and filtration layer in soil applications. They separate different soil layers, preventing the mixing of materials, and provide filtration to allow water to pass through while retaining soil particles. 3. **Applications**: Common applications of geotextiles include erosion control, road and railway construction, embankment reinforcement, subsurface drainage, and landscaping. They are also used in retaining walls and landfills. 4. **Strength**: Geotextiles have relatively low tensile strength compared to geogrids. They are not designed to provide significant structural support but rather to enhance the performance of other soil-related materials. **Geogrids**: 1. **Material Composition**: Geogrids are made from materials like high-density polyethylene (HDPE), polypropylene, or polyester. They have a rigid or grid-like structure, often in the form of a mesh or ribbed pattern. **Function**: Geogrids are primarily used to provide reinforcement and structural support to soils and other materials. They improve the load-bearing capacity of weak soils and distribute loads more effectively. 3. **Applications**: Geogrids are commonly used in applications like retaining wall construction, slope stabilization, road and pavement reinforcement, and soil retention systems. They are also employed in geotechnical engineering for reinforcing foundations and embankments. 4. **Strength**: Geogrids are known for their high tensile strength and stiffness. They can withstand significant loads and are designed to distribute these loads across a wider area, reducing stress on the soil.	1.5		
II.10	**Sand Drains:** 1. **Purpose and Overview:** Sand drains, also known as sand wicks or sand columns, are a ground improvement technique used in geotechnical engineering to accelerate the consolidation or dewatering of saturated soils, particularly soft and compressible silts and clays.			

	2. **Construction Process:** Sand drains are typically constructed by driving or inserting vertical columns of coarse sand or gravel into the soft soil at regular intervals. The sand columns act as drainage conduits, allowing water to flow out of the saturated soil more quickly than it would through the soil itself. 3. **Function and Mechanism:** The primary function of sand drains is to reduce the time required for consolidation of soft soils. As excess pore water pressure builds up in the soil due to loading, water is drawn into the sand columns through capillary action and flows upward, thus accelerating the consolidation process. This drainage reduces the risk of long-term settlement and instability of structures built on the improved ground.			
III.	Shallow surface compaction of soil is a common construction and landscaping practice used to increase the density and stability of the upper layers of soil. Different types of rollers are used for this purpose, each with its unique characteristics and suitability for specific applications. Here are some of the common types of rollers used for shallow surface compaction of soil: 1. **Smooth-Wheeled Rollers**: • **Function**: Smooth-wheeled rollers have a single, smooth, and cylindrical drum made of steel or other materials. They are primarily used for final surface compaction and finishing. • **Applications**: These rollers are suitable for compacting granular soils, asphalt, and fine-grained soils. They are often used in road construction and pavement projects. 2. **Vibratory Rollers**: • **Function**: Vibratory rollers have a drum that can vibrate at high frequencies, imparting vertical oscillations to the soil. This dynamic compaction helps achieve higher compaction densities and is especially effective with cohesive soils.			

- **Applications**: Vibratory rollers are commonly used for compacting granular soils, cohesive soils, and asphalt. They are known for their efficiency and are often used in road construction and site preparation.

3. **Pneumatic Rollers**:
   - **Function**: Pneumatic rollers have rubber tires filled with air, allowing for variable pressure adjustment. These rollers knead the soil as they roll, improving compaction.
   - **Applications**: Pneumatic rollers are suitable for compacting cohesive soils, loose sand, and gravel. They are also used for asphalt compaction and are particularly useful in achieving a smooth finish.
4. **Sheepsfoot Rollers**:
   - **Function**: Sheepsfoot rollers have cylindrical or drum-shaped wheels with protruding lugs or feet. These feet penetrate and knead the soil, making them effective for cohesive soils.
   - **Applications**: Sheepsfoot rollers are commonly used for compacting clay soils, silt, and other cohesive materials. They help reduce voids and improve soil structure.
5. **Padfoot Rollers**:
   - **Function**: Padfoot rollers are similar to sheepsfoot rollers but have pads instead of feet. The pads can be smooth or have lugs, depending on the application.
   - **Applications**: They are used for compacting cohesive soils, and the choice between smooth or lugged pads depends on the specific soil conditions and compaction requirements.
6. **Tamping Rollers**:
   - **Function**: Tamping rollers use a series of individual steel or iron compactors that impact the soil surface through a series of blows. This method achieves compaction through dynamic force.

	• **Applications**: Tamping rollers are suitable for compacting cohesive soils, granular soils, and asphalt. They are often used for patchwork and repair work.				
IV.	**Stone columns & mechanism** **Definition**: • Stone columns, also known as vibro stone columns or aggregate piers, are a ground improvement technique-They involve the installation of vertical columns of compacted stone or aggregate material into the ground to enhance its load-bearing capacity and reduce settlement. • They have two functions- they act as vertical drains as well as reinforcing elements **Purpose**: • Stone columns are used to improve the properties of weak or loose soils, such as silts, clays, and loose sands, making them suitable for supporting structures. • They are commonly employed in construction projects to mitigate settlement and increase the stability of foundations. **Installation Process**: • The installation process generally involves the following steps: • A vibrating probe is inserted into the ground to the desired depth, typically exceeding the depth of the weak soil layer. • As the probe is withdrawn, it displaces the surrounding soil, creating a cavity. • Crushed stone or aggregate material is simultaneously injected into the cavity. • The vibration and compaction of the stone material result in the formation of a dense column. • The process is repeated at regular intervals to create a grid of stone columns across the area.				

V.	Grouting is a versatile construction and geotechnical engineering technique used for various applications to enhance the stability, durability, and functionality of structures and subsurface environments. Here are some common applications of grouting: 1. **Foundation Support and Underpinning**: 2. **Soil Stabilization**: 3. **Tunneling and Underground Construction**: 4. **Dams and Reservoirs**: 5. **Groundwater Control**: 6. **Soil Improvement**: 7. **Pipeline and Utility Duct Sealing**: 8. **Rock and Soil Anchoring**: 9. **Cavity and Void Filling**: 10. **Concrete Repair and Crack Injection**:			
VI.	**Cement Stabilization:** Cement stabilization is a construction and geotechnical engineering technique that involves mixing cement into soil to improve its engineering properties. This process enhances the soil's strength, durability, and workability, making it suitable for a variety of construction applications. 1. **Purpose**: • Cement stabilization is primarily used to modify the properties of soil, making it suitable for construction and infrastructure projects. • It aims to improve the load-bearing capacity, reduce settlement, and increase the durability of the treated soil. 2. **Materials**: • Portland cement is the most commonly used cementitious material for stabilization. It is mixed with the soil in predetermined proportions. **Process**: • The cement and soil are mixed together thoroughly, either in situ (on-site) or in a central mixing plant, to achieve a homogeneous mixture. • The mixture is then compacted to the desired density, often using heavy construction equipment like compactors or rollers.			

	• Water may be added to achieve the optimum moisture content for compaction.			
VII.	Soil reinforcement is a geotechnical engineering technique that involves enhancing the load-bearing capacity and stability of soil by introducing reinforcing materials. The primary mechanisms of soil reinforcement include improving the soil's shear strength, reducing settlement, and distributing applied loads more efficiently.This helps in • Improved Shear Strength: • Load Distribution: • Reduced Settlements • Provides confinement and lateral support • Provides slope stability and earth retension • Resistance against settlements (explanation of the above points , 1 mark each)			
VIII.	Geosynthetics are synthetic materials. The various applications of geosynthetics in civil engineering, 1. **Erosion Control**: 2. **Road and Pavement Construction**: 3. **Retaining Walls and Slope Stability**: 4. **Landfills and Waste Management**: 5. **Water Management and Drainage**: 6. **Pond and Reservoir Liners**: 7. **Coastal and Marine Engineering**: 8. **Railway and Airport Pavements**: 9. **Geotechnical Engineering**: 10. **Vegetated Reinforcement**: 11. **Agriculture and Aquaculture**: 12. **Tunneling and Mining**:			
IX.	The various types of Geosynthetics and their functions are, **1. Geotextiles:** **Function:** Separation and Filtration Geotextiles are used to separate different soil layers, preventing the mixing of materials and maintaining the integrity of the structure. They also act as filters, allowing water to pass through while retaining soil particles. 2. **Geogrids:**			

Function: Reinforcement and Soil Stabilization

Geogrids provide structural support and reinforcement to weak soils. They distribute loads more effectively, improve the load-bearing capacity of the soil, and stabilize slopes and embankments.

3. **Geocells**:

Function: Soil Confinement and Erosion Control

- Geocells are three-dimensional cellular structures made from interconnected panels. They are used to confine and reinforce soil, particularly in applications like erosion control, slope protection, and load support in pavements.

4. **Geomembranes**:

Function: Barrier and Containment

Geomembranes are impermeable liners used to create barriers in various applications, including landfills, ponds, and reservoirs. They prevent the migration of liquids or gases and protect the environment from contamination.

5. **Geonets**:

Function: Drainage and Soil Reinforcement

Geonets provide a pathway for water to drain away from structures and soil. They are often used in combination with geotextiles to create drainage systems and reduce hydrostatic pressure.

6. **Geosynthetic Clay Liners (GCLs)**:

Function: Barrier, Containment, and Sealing

GCLs consist of a layer of bentonite sandwiched between two geotextiles. They are used to create liners in landfill caps, wastewater containment ponds, and other applications requiring effective sealing.

7. **Geocomposites**:

Function: Combining Multiple Functions

Geocomposites combine two or more types of geosynthetics to perform multiple functions simultaneously. For example, a geocomposite may consist of a geotextile and a geogrid to provide both separation and reinforcement.

8. **Geofoam**:

Function: Lightweight Fill Material

Geofoam is a lightweight, expanded polystyrene material used as fill in applications where traditional soil fill would be too heavy. It reduces the load on underlying soils and structures.

9. **Geopipes**:

Function: Drainage and Erosion Control

Geopipes are perforated pipes encased in a geotextile or geogrid envelope. They are used for subsurface drainage and erosion control in retaining walls, slopes, and sports fields.

10. **Geotubes**:

Function: Dewatering and Sediment Control

	Geotubes are large, tubular containers filled with slurry or sediment. They are used for dewatering, shoreline protection, and controlling sediment in industrial processes.			
X.	The specific functions of geosynthetics when used as soil reinforcement include: 1. **Increased Tensile Strength**: 2. **Load Distribution**: 3. **Soil Confinement**: 4. **Slope Stability**: 5. **Retaining Wall Reinforcement**: 6. **Embankment and Roadway Construction**: 7. **Erosion Control**: 8. **Soft Soil Improvement** 9. **Construction Over Landfills**: 10. **Reduced Settlement**: 11. **Sustainability**:			
XI.	Preloading techniques are commonly used in geotechnical engineering to accelerate the settlement of compressible soils, such as soft clays or silts, in preparation for construction projects. These techniques involve applying a controlled and gradual load to the ground over a specific period, which allows for soil consolidation and settlement to occur before the actual construction begins. Here are some important notes on preloading techniques: **Objective**: The primary objective of preloading techniques is to reduce settlement and ensure the stability of structures built on compressible or weak soils. 2. **Types of Preloading Techniques**: There are two main types of preloading techniques: **Surcharge Preloading**: In surcharge preloading, a temporary load, typically in the form of soil or other materials, is placed on the ground surface. This load increases the stress on the underlying compressible soil, causing it to consolidate and settle. **Prefabricated Vertical Drains (PVDs)**: PVDs are vertical columns or wick drains installed in the ground to provide a pathway for water to escape and speed up the			

consolidation process. They are often used in conjunction with surcharge preloading.

3. **Process**:

In surcharge preloading, a layer of fill material is placed over the soft soil area to be consolidated. The fill is usually surcharged to a height greater than the expected settlement. As the surcharge load settles, it compresses the underlying soil. The consolidation process is monitored over time, and once settlement stabilizes, construction can proceed.

4. **Duration**:

The duration of preloading varies depending on factors such as soil type, thickness, and the required degree of consolidation. It can range from several months to a few years.

The process continues until the rate of settlement diminishes and reaches an acceptable level.

5. **Benefits**:

Preloading techniques are cost-effective compared to other methods of soil improvement. They make it possible to build on weak or compressible soils without extensive excavation or the use of deep foundations.

By reducing settlement before construction, preloading helps prevent damage to structures, infrastructure, and utilities.

6. **Challenges**:

Preloading can be time-consuming, and the duration of the consolidation process may delay construction projects.

It requires careful planning and monitoring to ensure that the desired degree of consolidation is achieved.

7. **Applications**:

Preloading techniques are commonly used in the construction of roads, highways, airports, landfills, and large infrastructure projects situated on soft or compressible soils.

XII.

Consolidation:	**Compaction**:
process that primarily deals with the expulsion of air and water from the soil	by the elimination of air voids in a relatively short period.
Slow process	Quick process
Loading is static and	Loading is applied in a

	constant.	dynamic way.			
	It begins naturally along with the construction work.	It is done before the construction of structure.			
	Only cohesive soil is preferred	Preferred for both cohesive and cohesionless soil			
	Occurs naturally	Done artificially to improve the density			
XIII.	Vertical drains, also known as wick drains or prefabricated vertical drains (PVDs), are geosynthetic materials used in geotechnical engineering to accelerate the consolidation and settlement of compressible soils. These drains are typically installed vertically into the ground to provide a pathway for excess pore water to escape, allowing the soil to consolidate more rapidly. Here are some important notes on vertical drains: 1. **Purpose**: The primary purpose of vertical drains is to expedite the consolidation process of soft or compressible soils. By facilitating the rapid removal of pore water, vertical drains help reduce settlement and improve the stability of foundations and structures built on such soils. 2. **Design and Construction**: Vertical drains are usually made of synthetic materials, such as polyethylene or polyester, and have a cylindrical shape. They are installed by driving or pushing them vertically into the ground to the desired depth. The spacing and depth of vertical drain installation are determined based on soil properties, expected settlement, and project requirements. Typically, they are spaced evenly across the area to be consolidated. 3. **Function**: Vertical drains work by providing a pathway for water to escape from the compressible soil. As excess pore water is expelled through the drains, the soil particles settle more closely together, leading to an increase in effective stress and faster consolidation. 4. **Advantages**: Accelerated Consolidation: Vertical drains significantly reduce the time required for soil consolidation compared to natural consolidation processes alone. Improved Stability: By reducing settlement and increasing soil strength, vertical drains enhance the stability of				

	structures, embankments, and other geotechnical projects. Cost Savings: Faster consolidation can lead to cost savings by reducing project duration and minimizing the need for over-excavation or additional soil improvement measures. 5. **Applications**: Vertical drains are commonly used in various geotechnical applications, including: Embankment and road construction on soft soils. Land reclamation projects in coastal areas. Ports and harbor construction where rapid consolidation is required. Reducing settlement beneath foundations of buildings and infrastructure. Mitigating liquefaction potential in seismic-prone regions.			
XIV.	Terzaghi's spring analogy is a helpful tool for explaining and understanding the consolidation process in soils, particularly in fine-grained soils like clays. **Diagram of spring analogy test** **1. Initial Conditions:** • Imagine a soil sample that is initially saturated with water and subjected to an applied load, such as the weight of a building or an embankment. **2. Soil Deformation:** • In this analogy, the soil is considered as a compressible spring. When the load is applied, the spring (soil) deforms vertically due to the immediate compression. **3. Excess Pore Water Pressure:** • As the soil compresses, it generates excess pore water pressure within the soil mass. This excess			

	pressure is analogous to the compression of air or gas within a spring when it is compressed. **4. Dissipation of Pore Water Pressure:** • Over time, the excess pore water pressure gradually dissipates as water flows out of the soil. This is similar to how the gas within a compressed spring slowly escapes. **5. Settlement:** The settlement of the soil continues as long as excess pore water pressure remains within the soil. As the pore water pressure dissipates, the settlement process slows down until the soil reaches its final, stable position. **6. Time-Settlement Relationship:** Engineers use Terzaghi's spring analogy to derive mathematical equations that describe the time-settlement relationship for a consolidating soil layer. The rate at which the excess pore water pressure dissipates and the soil settles can be quantified using parameters like the coefficient of consolidation.			