UNIT-4

REINFORCED EARTH

- The concept of combining two materials of different strengths characteristics to form a composite material of greater strength is quite familiar in civil engineering practices and is in use for ages.
- The reinforced concrete constructions are examples for such composite materials.
- It combines the high tensile strength of steel with the high compressive, but relatively low tensile strength of concrete.
- Likewise, soils which have little if any tensile strength can also be strengthened by the inclusion of materials with high tensile strength.
- This mobilization of tensile strength is obtained by surface interaction between the soil and the reinforcement through friction and adhesion.
- The reinforced soil is obtained by placing extensible or inextensible materials such as metallic strips or polymeric reinforcement within the soil to obtain the requisite properties.
- Soil reinforcement through metallic strips, grids or meshes and polymeric strips sheets is now a well-developed and widely accepted technique of earth improvement.
- Anchoring and soil nailing is also adopted to improve the soil properties. The use of reinforced earth technique is primarily due to its versatility, cost effectiveness and ease of construction.
- The reinforced earth technique is particularly useful in urban locations where availability of land is minimum and construction is required to take place with minimum disturbance traffic.

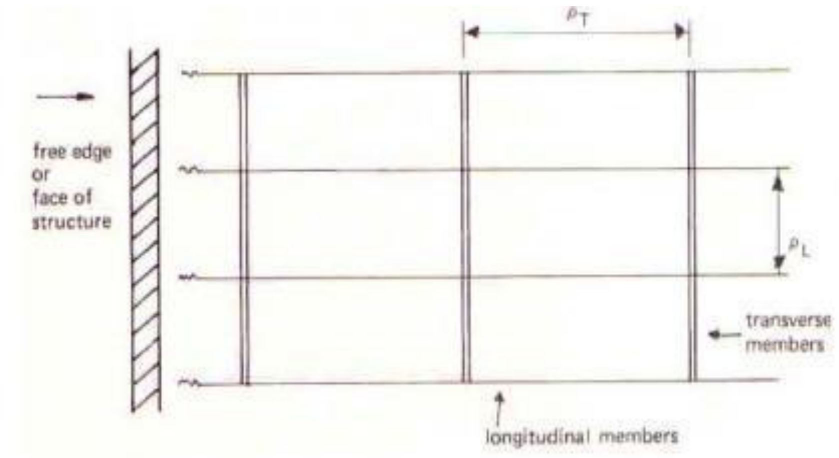
Types of reinforcing materials:

i) Strips: These are flexible linear element normally having their breadth, „ b‟ greater than their thickness, „t‟. Dimensions vary with application and structure, but are usually within the range t = 3-5 mm, b = 5-100 mm. The most common strips are metals. The form of stainless, galvanized or coated steel strips being either plain or having several protrusions such as ribs or gloves to increase the friction between the reinforcement and the fill. Strips can also be formed from aluminum, copper, polymers and glass fibre reinforced plastic (GRP). Reed and bamboo reinforcements are normally categorized as strips, as are chains.

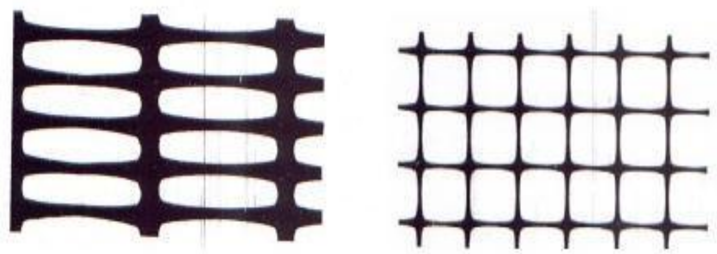
ii) Planks: Similar to strips except that their form of construction makes them stiff. Planks can be formed from timber, reinforced concrete or pre-stressed concrete. The dimensions of concrete planks vary; however, reinforcements with a thickness, „t‟ =

100 mm and breadth, b= 200–300 mm have been used. They have to be handled with care as they can be susceptible to cracking.

iii) Grids and Geogrids: Reinforcing elements formed from transverse and longitudinal members, in which the transverse members run parallel to the face or free edge of the structure and behave as abutments or anchors as shown



The main purpose is to retain the transverse members in position. Since the transverse members act as an abutment or anchor they need to be stiff relative to their length. The longitudinal members may be flexible having a high modulus of elasticity not susceptible to creep. The pitch of the longitudinal members, pL is determined by their load carrying capacity and the stiffness of the transverse element. A surplus of longitudinal and transverse elements is of no consequence provided the soil or fill can interlock with the grid. Mono and Bi Oriented grid as shown



(a) Mono Oriented geogrid (b) Bi- Oriented geogrid

Grids can be formed from steel in the form of plain or galvanized weld mesh, or from expanded metal. Grids formed from polymers are known as “Geogrids” and are normally in the form of an expanded proprietary plastic product.

iv) Sheet reinforcement: May be formed from metal such as galvanized steel sheet, fabric (textile) or expanded metal not meeting the criteria for a grid.

v) Nailing: Earth may be protected by geo-synthetics with earth nailing.

vi) Anchors: Flexible linear elements having one or more pronounced protrusions or distortions which act as abutments or anchors in the fill or soil. They may be formed from steel, rope, plastic (textile) or combinations of materials such as webbing and tyres, steel and tyres, or steel and concrete

vii) Composite reinforcement: Reinforcement can be in the form of combinations of materials and material forms such as sheets and strips, grid and strips and anchors, depending on the requirements.

The Components Of Reinforced Earth

SOIL

- It should be granular, cohesion less material, not too much silt or clay having particle size not more than 125 mm.
- Not more than 10 percent of the particles shall pass 75 micron sieve & the earth reinforcement coefficient of friction to be either higher than or equal to 0.4 & Plasticity Index < 6.
- The soil must have moisture content suitable for compaction.
- The materials shall be substantially free of shale or other soft, poor durability particles.

SKIN

- Skin is the facing element of the reinforced soil wall.
- These elements keep the reinforcement at a desired elevation in the reinforced soil wall and also protect the granular at the edge falling off.
- Made of either metal units or precast concrete panels.

REINFORCING MATERIAL

A variety of materials can be used as reinforcing materials

- Steel
- Concrete
- Glass fibre
- Wood
- Rubber
- Aluminum
- Reinforcement may take the form of strips, grids, anchors & sheet material, chains, planks, rope, vegetation and combinations of these or other material forms.

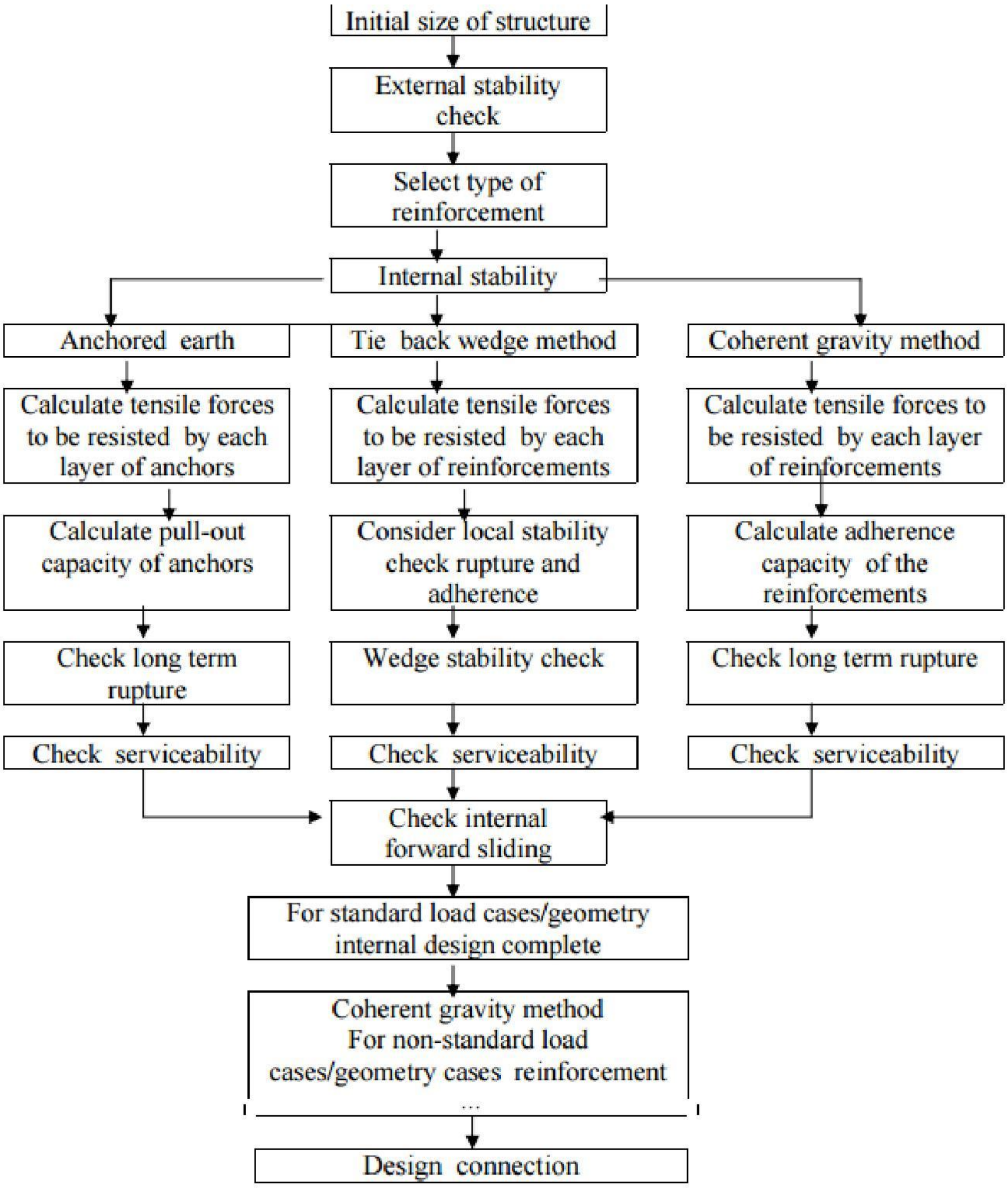
THE DESIGN PRINCIPLES OF REINFORCED EARTH WALL

- Rankine or Columb earth pressure theory should be used
- Active earth pressure or passive earth pressure or at rest earth pressure are adopted.
- The various forces acting horizontal, vertical and shear stress should be distributed on reinforced earth.
- Suitable geometry surface failure is assumed on reinforced earth Reinforcing strip length can resist the failure occurred by the slippage.
- Safety factors are required and calculated from Rankine, Active earth pressure theory.
- The earth pressures on a reinforced earth walls can be calculated by both horizontal and vertical earth pressures

Factors affecting the behavior and Performance of Reinforced Soil

REINFORCEMENT	REINFORMENT DISTRIBUTION	SOIL	SOIL STATE	CONSTRUCTION
Forms(fibers,grid,anchor, bar,strip)	Location	Particle size	Density	Geometry of structure
Surface properties				compaction
Dimensions	Orientation	Grading	Over burden	Construction system
Strength		Mineral Content	States of stress	Aesthetics
Stiffness	Spacing	Index properties	Degree of Saturation	Durability

The Design Procedure For Reinforced Earth Wall In Form Of A Flowchart



Stability Checks:

External Stability (as for any earth-retaining structure)

The external stability of a reinforced soil wall is easily investigated since it behaves essentially as a rigid body and conforms to the simple laws of statics external stability assessment should consider the effects of dead loads, other loads (live load, dynamic load etc.) and forces acting on the structure. The failure for sliding, overturning, tilting/bearing and slip should be checked by external stability

- Sliding
- Overturning
- Bearing Capacity

Short and long term stability of soil needs to be considered to allow for the construction and in-service condition as well as in changes in pore water pressure. Passive earth pressure acting on the foot of the wall/structure below ground level may be ignored while considering various forces for stabilization.

Internal Stability (MSE retaining structures)

Stability within a reinforced structure is achieved by the reinforcing elements carrying tensile forces and then transferring to the soil by friction, friction and adhesion, or friction and bearing. In addition forces can be transferred the soil through fill trapped by the elements of the grid. The fill is than able to support the associated shear and compressive forces. In the case of anchored earth such as soil nailing, stability within a structure is achieved by the anchor elements carrying tensile forces and transferring these by friction along the anchor shaft or anchor loop and bearing of the anchor to the surrounding fill.

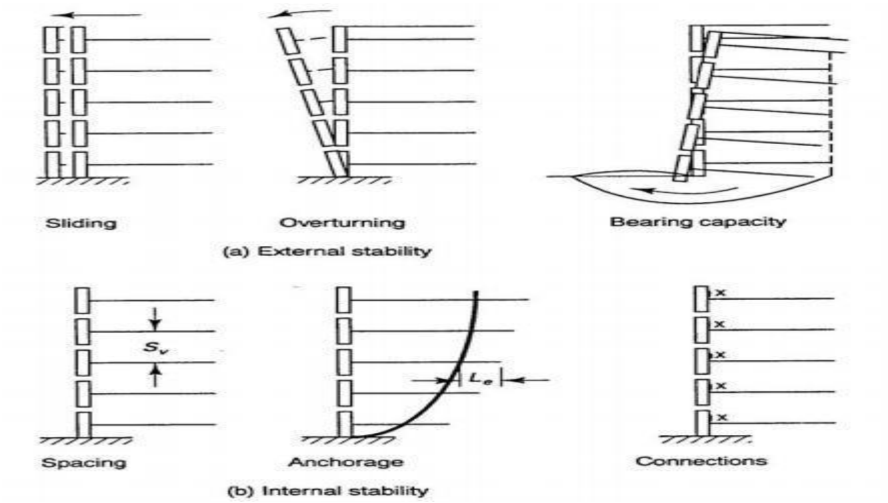
- Reinforcement Failure
- Pullout
- Failure of Reinforcement/Facing Connection

Local stability check

The resistance of the reinforcing element should be checked against rupture and adherence failure whilst carrying the factored loads.

Wedge stability

The reinforcement structure will assume to fail internally in the form of wedge. It is not known at which level the wedge is originated. Therefore the wedge originate from different level to be checked. Checked for stability considering all the forces acting on it. Wedges are assumed to behave as rigid bodies and may be any size and shape. Stability of any wedge is maintained when friction forces acting on the potential failure plane in connection with the tensile resistance/ bond of the group of reinforcing elements or embedded in the fill beyond the plane are able to resist the applied loads tending to cause movement,



Geosynthetics

- Geo-synthetics are synthetic products used to stabilize terrain.
- These are human-made materials made from various types of polymers used to enhance, augment and make possible cost effective environmental, transportation and geotechnical engineering construction projects.
- They are used to provide one or more of the following functions; separation, reinforcement, filtration, drainage or liquid barrier.
- They are generally polymeric products used to solve civil engineering problems.
- These include eight main categories geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners,geofoam, geocells and geocomposites.
- The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required.
- They can also be used in exposed applications.
- Geo-synthetics are available in a wide range of forms and materials.

These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, hydraulic and private development applications including roads, airfields, railroads, embankments, retaining structures, reservoirs, canals, dams, landfill liners, land fill covers structures.

The Important Properties Of Geo-Synthetics Required For Reinforcement Function

Basic Physical Properties

a. Constituent material and method of manufacture b.

Mass per unit area

c. Thickness

d. Roll width, roll length

- Mechanicalproperties

a. Tensile strength

b. Tensile modulus

c. Seam strength

d. Interface friction

e. Fatigue resistance

f. Creep resistance

Hydraulic Properties

a. Compressibility
b. Opening size

c. Permittivity

d. Transmissivity

Constructability/survivability Properties
a. Strength and stiffness

b. Tear resistance

c. Puncture resistance

d. Penetration resistance

e. Burst resistance

f. Cutting resistance

g. Inflammability

h. Absorption

Durability (Longevity)

a. Abrasion resistance

b. Ultra-violet stability

c. Temperature stability

d. Chemical stability

e. Biological stability

f. Wetting & drying stability

The Functions Of Geo-Synthetics

- Reinforcement
- Filtration
- Separation
- Drainage
- Erosion Control
- Barrier/Protection

Reinforcement:

Reduction of Stress Intensity (Concentration) through Wider Distribution The stresses over the subgrade are higher in unreinforced flexible pavements than in geo-synthetic-reinforced pavement due to stress distribution factor

Reinforcement Mechanisms Induced by Geo-synthetics:

(a) Lateral Restraint

(b) Increased Bearing Capacity; and

(c) Membrane Tension Support

Filtration

Retaining soil particles subjected to hydraulic forces which allow the passage of liquids/gases. This function is often partnered with separation.

Separation

a. Preventing intermixing of soil types or soil/aggregate to maintain the integrity of each material yet still allow the free passage of liquids/gases. Commonly used in between sub-base/subgrade and around drainage materials.

b. Contamination of the base course layers leads to a reduction of strength, stiffness and drainage characteristics, promoting distress and early failure of roadway.

Drainage

Allowing fluids and gases to flow both through the plan of the material. Commonly used as components in geo-composites used for surface water runoff or for gas collection under membranes.

Separation and Drainage Functions

a. Piping Resistance: Apparent Opening Size - AOS (as related to soil retention),
b. Permeability: Flow capacity, and clogging potential.
c. Strength and Durability: Grab, Puncture strengths

Erosion Control

Protecting and reinforcing slopes and drainage channels from erosive agents whilst allowing the establishment of vegetation cover.

Barrier/Protection

Preventing or limiting localized damage to an adjacent material, usually a geomembrane used to line a lagoon or a landfill. Thick geotextiles prevent puncture or excessive strain in the membrane.