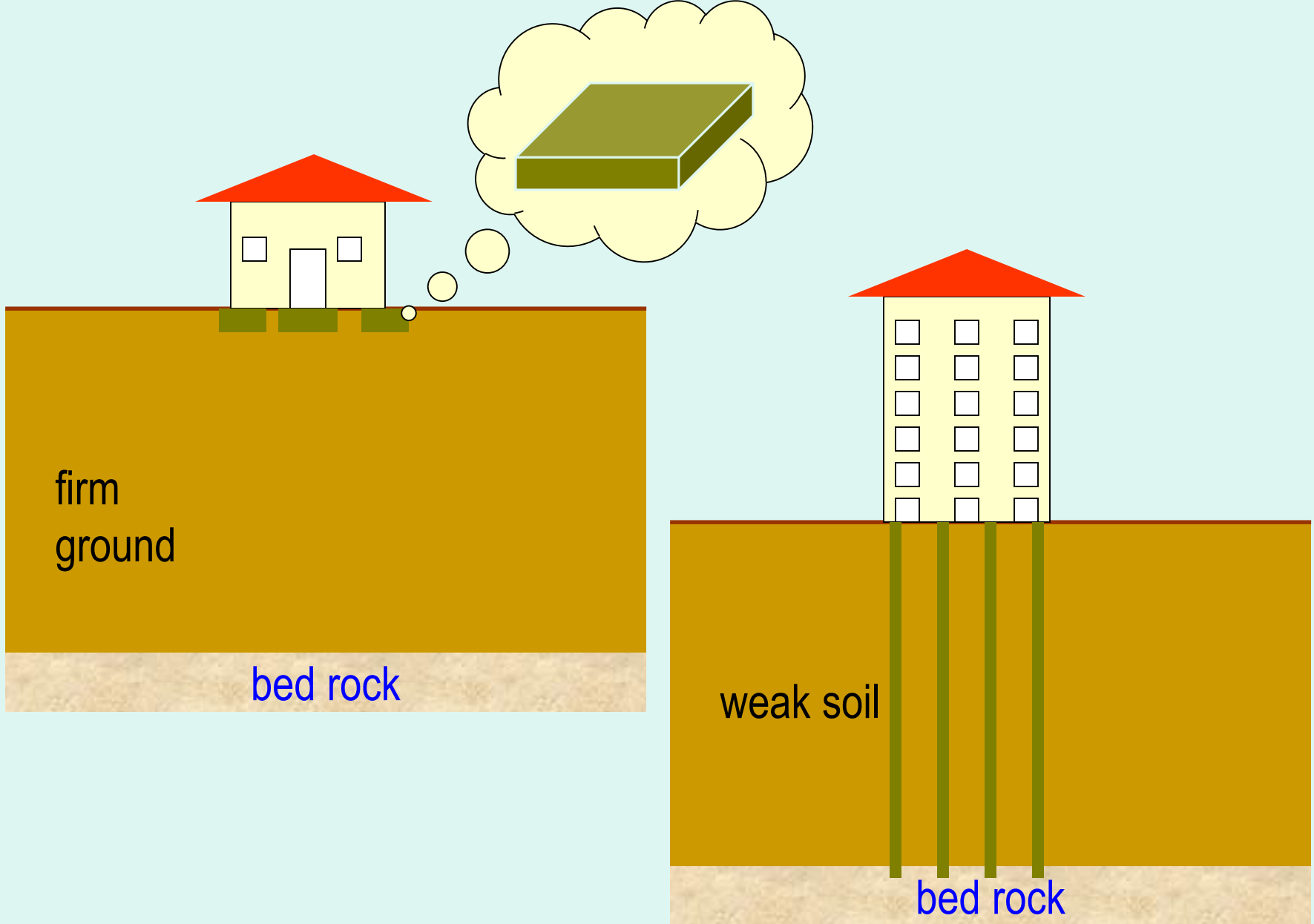


Chapter-II- Foundation Types and Their Selections



- **Definition:** The lowest artificially built part of a structure which transmits the load of the structure to the ground is called foundation.
- The foundation of a structure is always constructed below ground level to increase the lateral stability of the structure.



Purposes Of Foundations

- Foundations are used for the following purposes:
 - i. To distribute the load of the structure over a large bearing area so as to bring intensity of loading within the safe bearing capacity of the soil lying underneath.
 - ii. To load the bearing surface at a uniform rate so as to prevent unequal settlement.
 - iii. To prevent the lateral movement of the supporting material.
 - iv. To secure a level and firm bed for building operations.
 - v. To increase the stability of the structure as a whole.

Types of Foundations

Foundations can be broadly classified into the following two categories:

- Shallow foundations
- Deep foundations

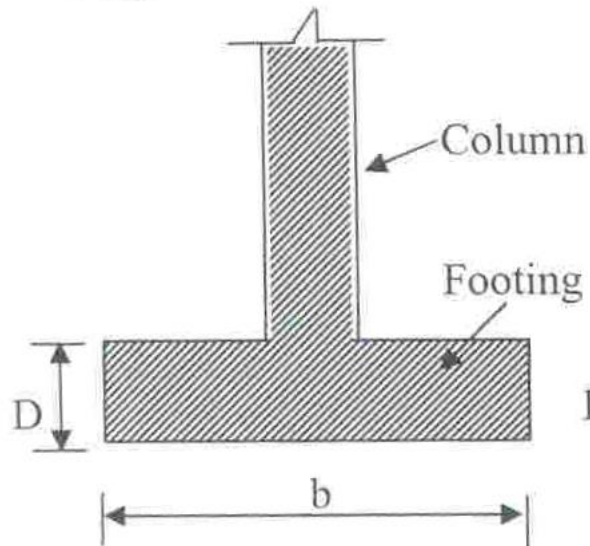
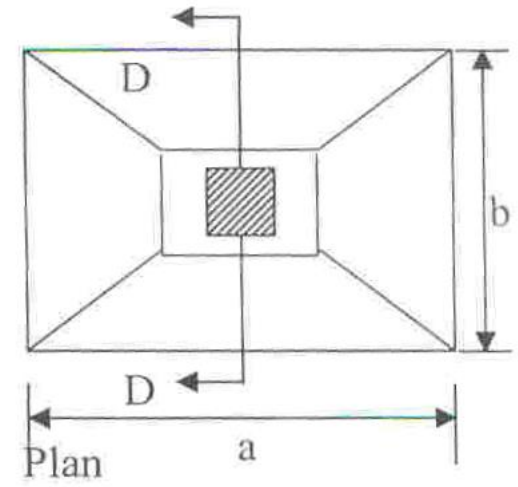
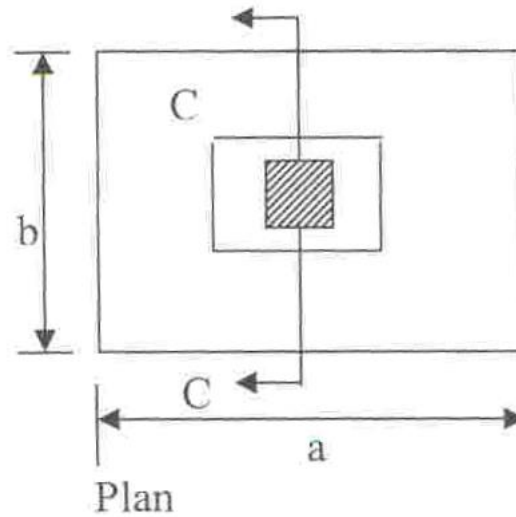
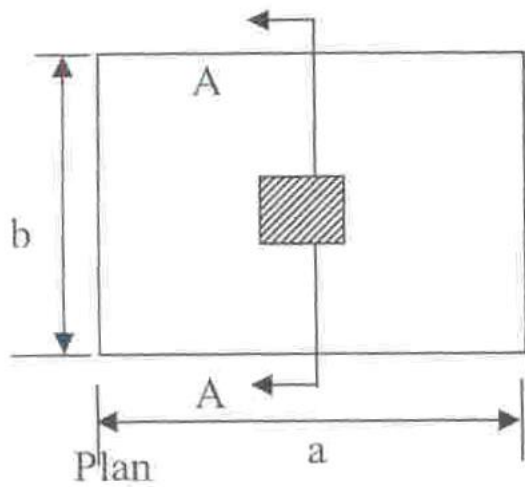
1. **Shallow Foundations :-** The foundations provided immediately beneath the lowest part of the structure, near to the ground level are known as shallow foundations.

Shallow foundations are further classified into the following types:

- » **Spread or Isolated footings**
- » **Combined footing**
- » **Cantilever footing**
- » **Continuous or wall footing**
- » **Raft foundation**

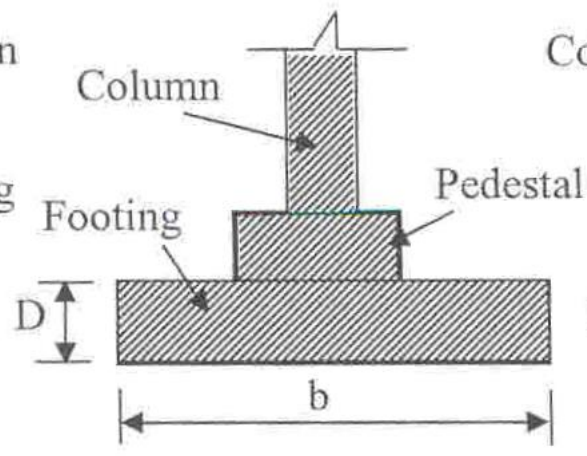
Spread or Isolated Footings: used to support individual column.

- These are the most common type of foundation, primarily because of their **cost and ease of construction**.
- They are most often used:
 - in small to medium size structures,
 - on sites with moderate to good soil conditions,
 - on some large structures when they are located at sites underlain by exceptionally good soil or shallow bedrock.
- Isolated footings are **stepped type, simple type or slope type**



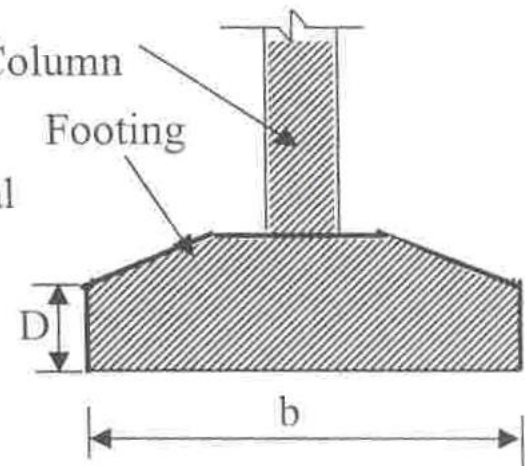
Section A-A

Single spread footing



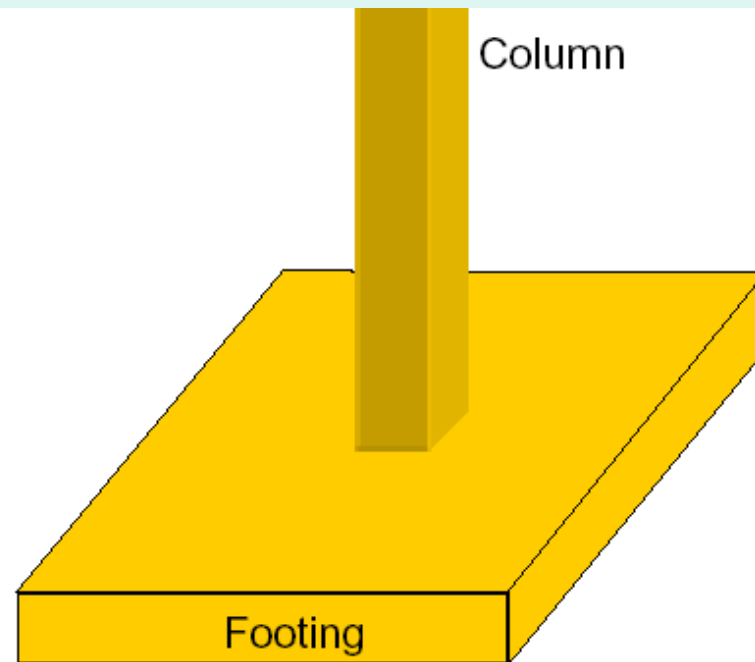
Section C-C

Stepped spread footing



Section D-D

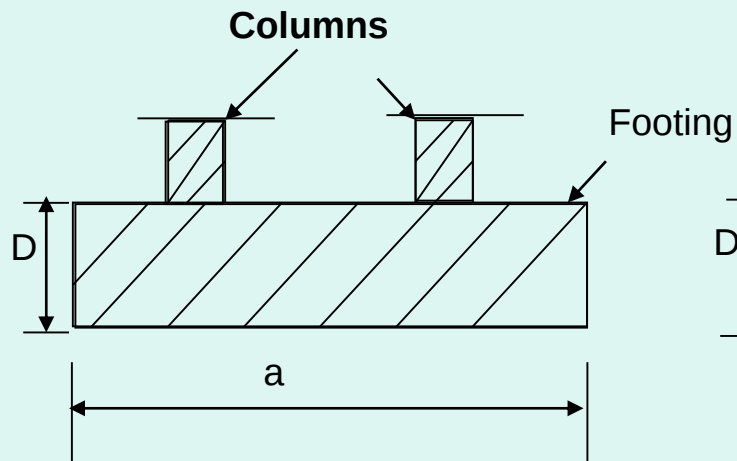
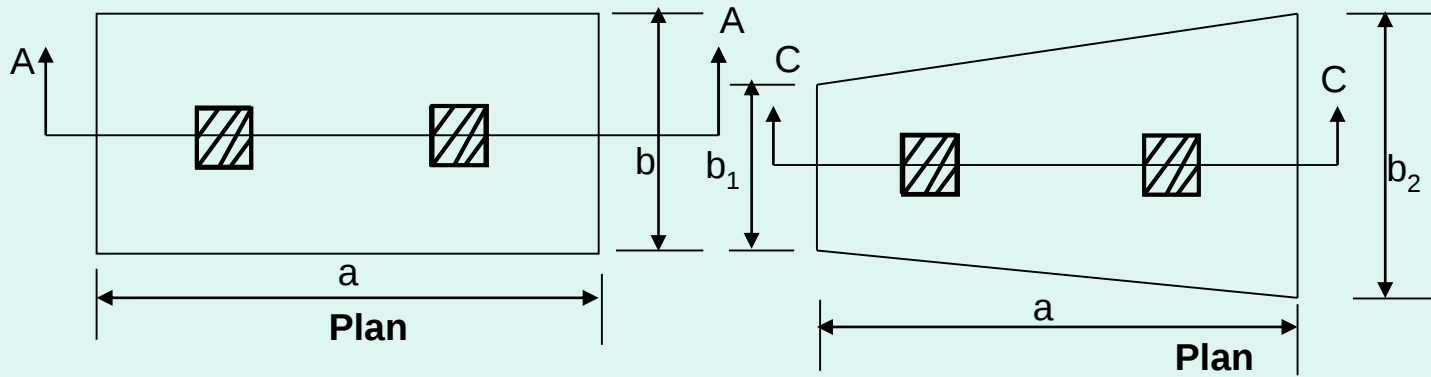
Sloped spread footing



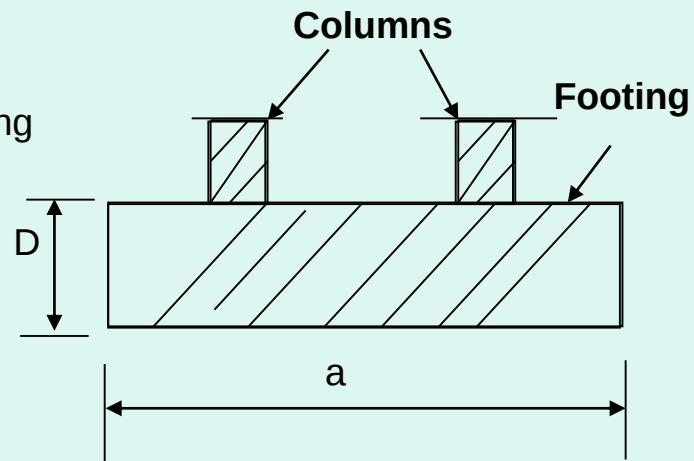
Isolated Footing

Combined Footing: supports two or sometimes three column in a row.

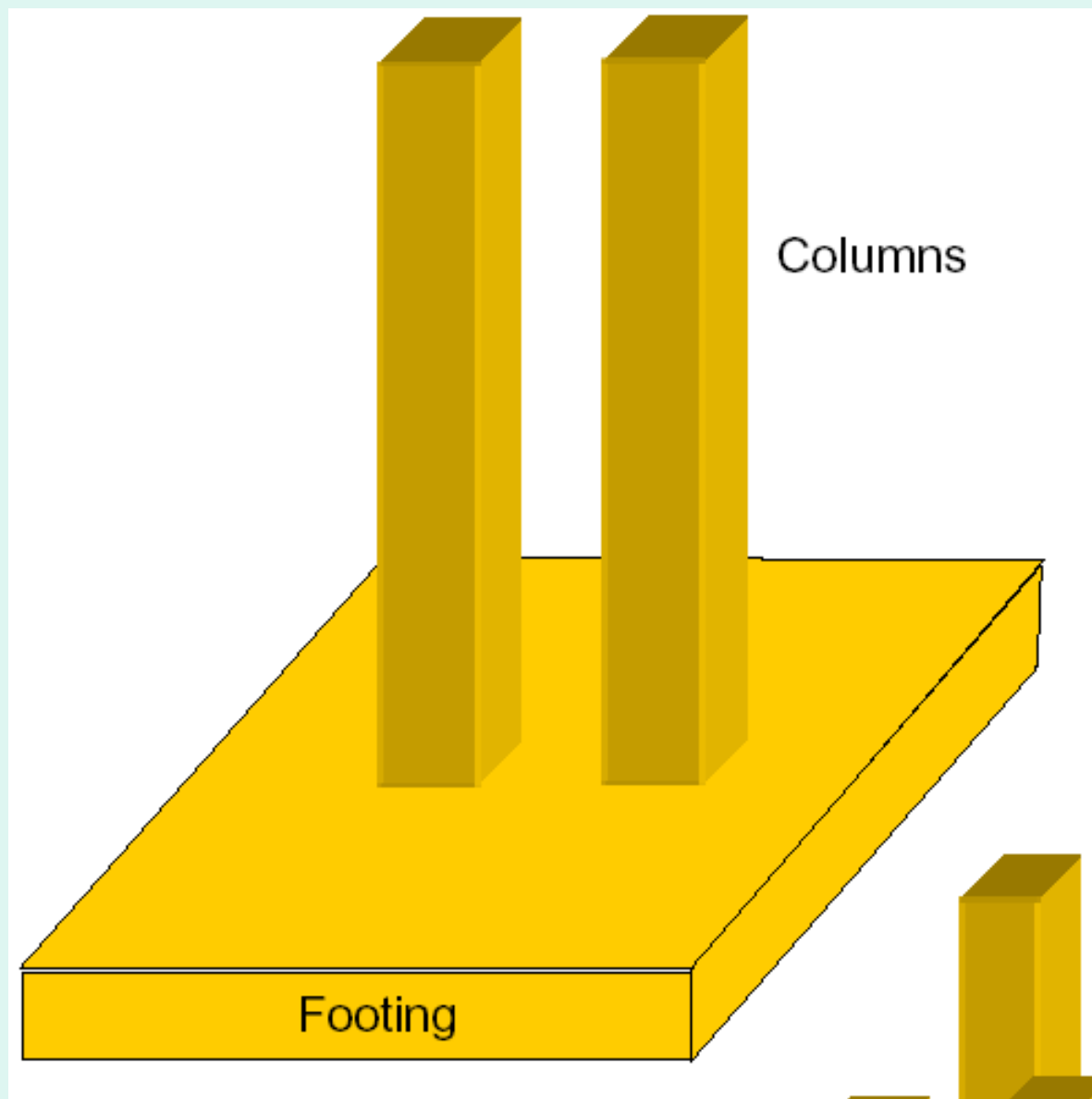
- Combined footing is used when property lines, equipment locations, column spacing or other considerations limit the footing clearance at the column locations.
- Combined footing can be:
 - rectangular in shape if both the columns carry equal loads, or
 - trapezoidal if there is a space limitation and they carry unequal loads.



Section A.A
Combined footing (rectangular)

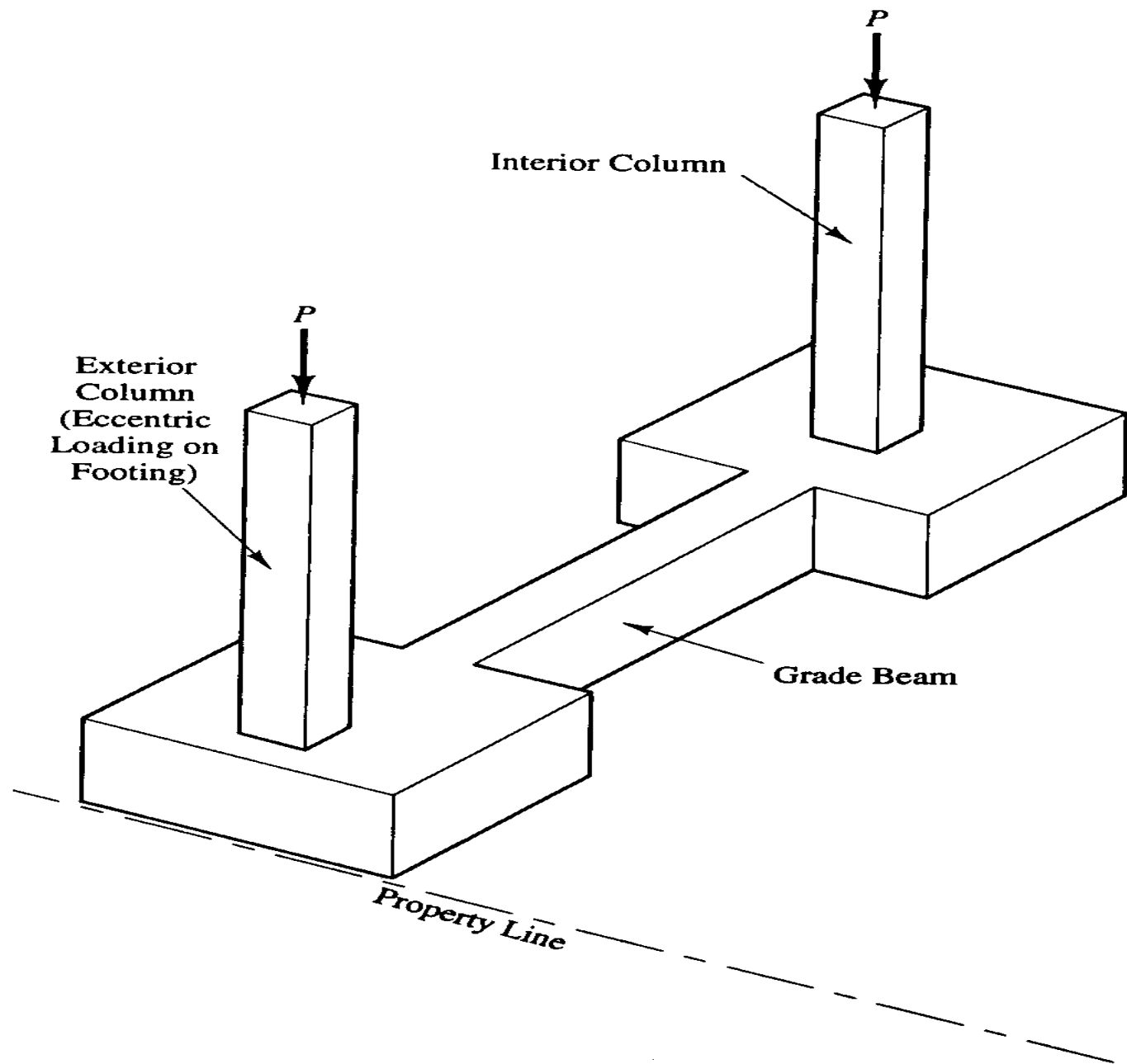


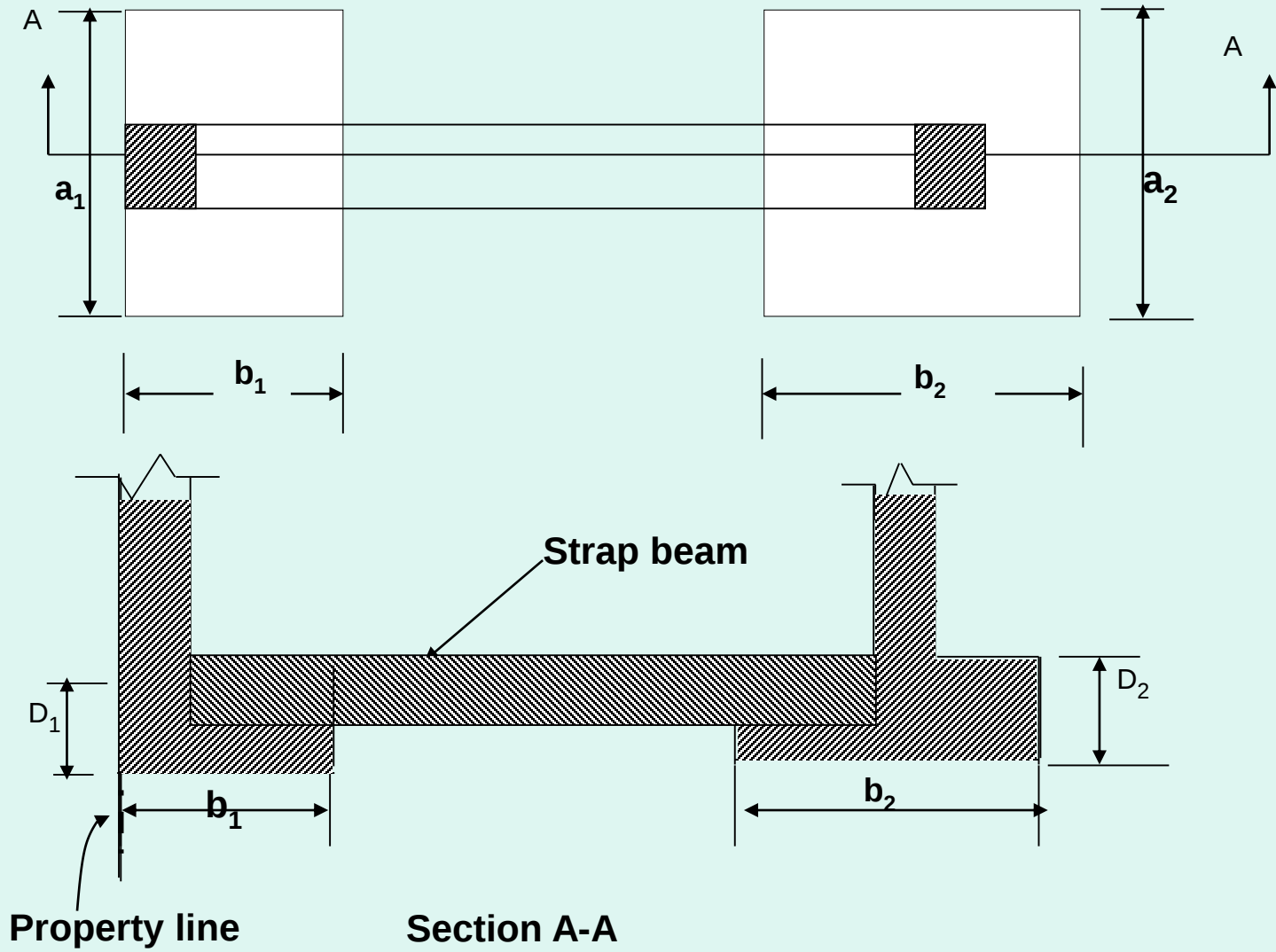
Section C.C
Combined footing (trapezoidal)



Cantilever or Strap Footing: consists of two individual footings connected by a beam called a strap.

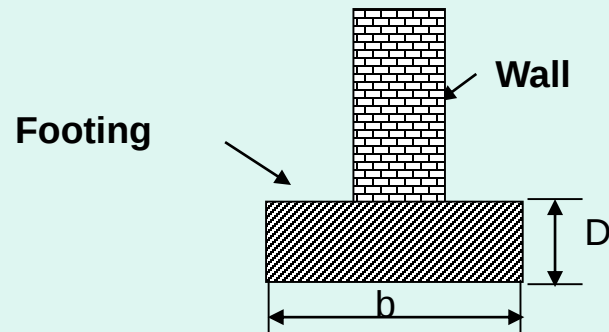
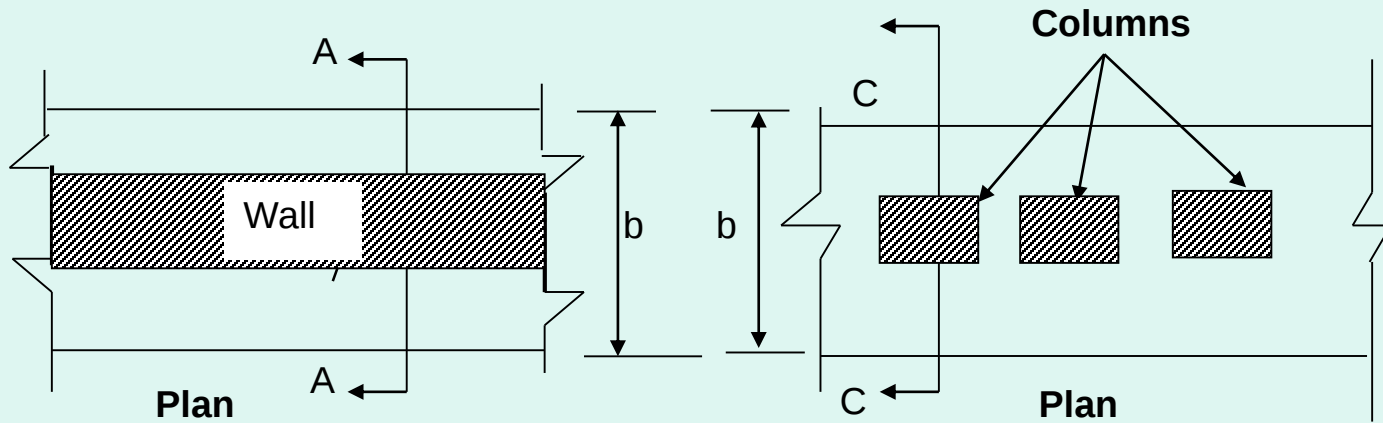
- Cantilever footing may be used:
 - where the distance between the columns is so great that a trapezoidal combined footing becomes quite narrow, with resulting high bending moments.
- The strap beam does not remain in contact with soil so a strap doesn't transfer any pressure to the soil.





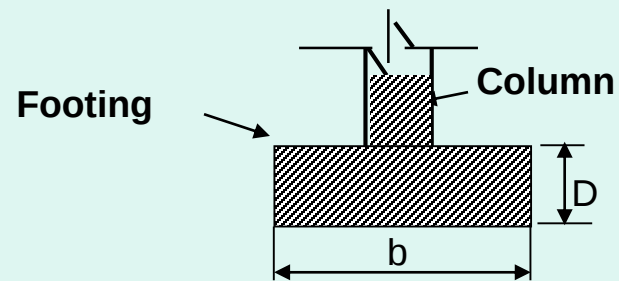
Continuous or wall footing or strip footing:

- In this type of footing, a single continuous reinforced concrete slab is provided as foundation of load bearing wall.
- A strip footing is also provided for a row of columns which are so closely spaced that their spread footings overlap or nearly touch each other.



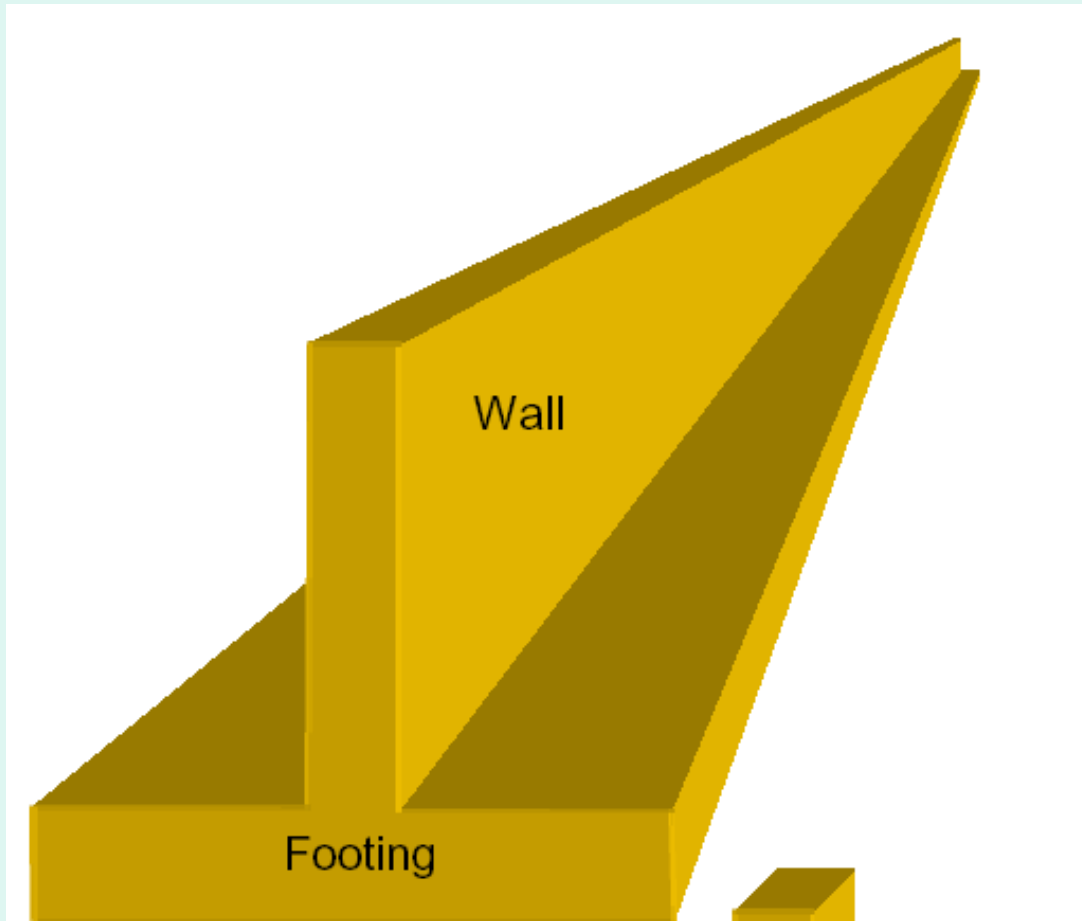
Section A.A

Wall on footing



Section C-C

Columns on footing



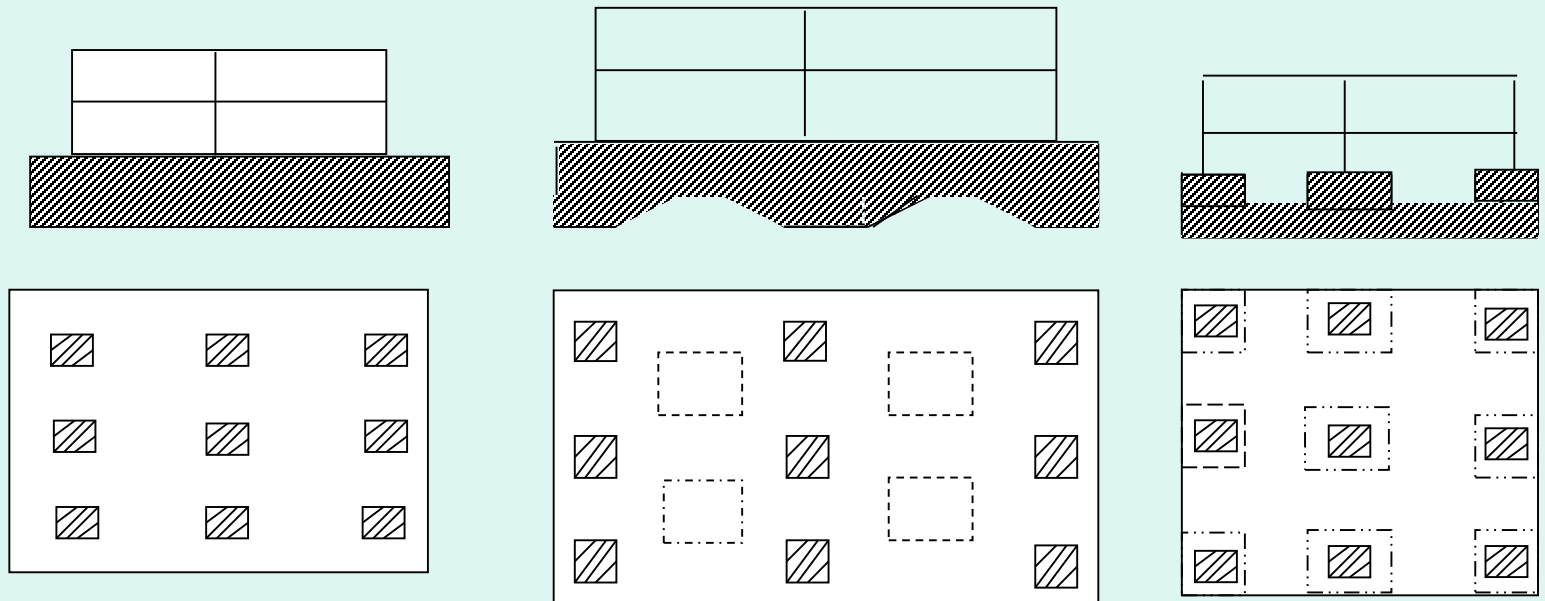
Mat (Raft) Foundation: is a combined footing that covers the entire area beneath a structure and supports all the columns.

- Foundation engineers often consider mats when dealing with any one of the following conditions:
 - The structural loads are so high or the soil conditions so poor that spread footings would be exceptionally large.

As a general rule of thumb, if spread footings would cover more than 50 percent of the building footprint area, a mat or some type of deep foundation will usually be more economical.

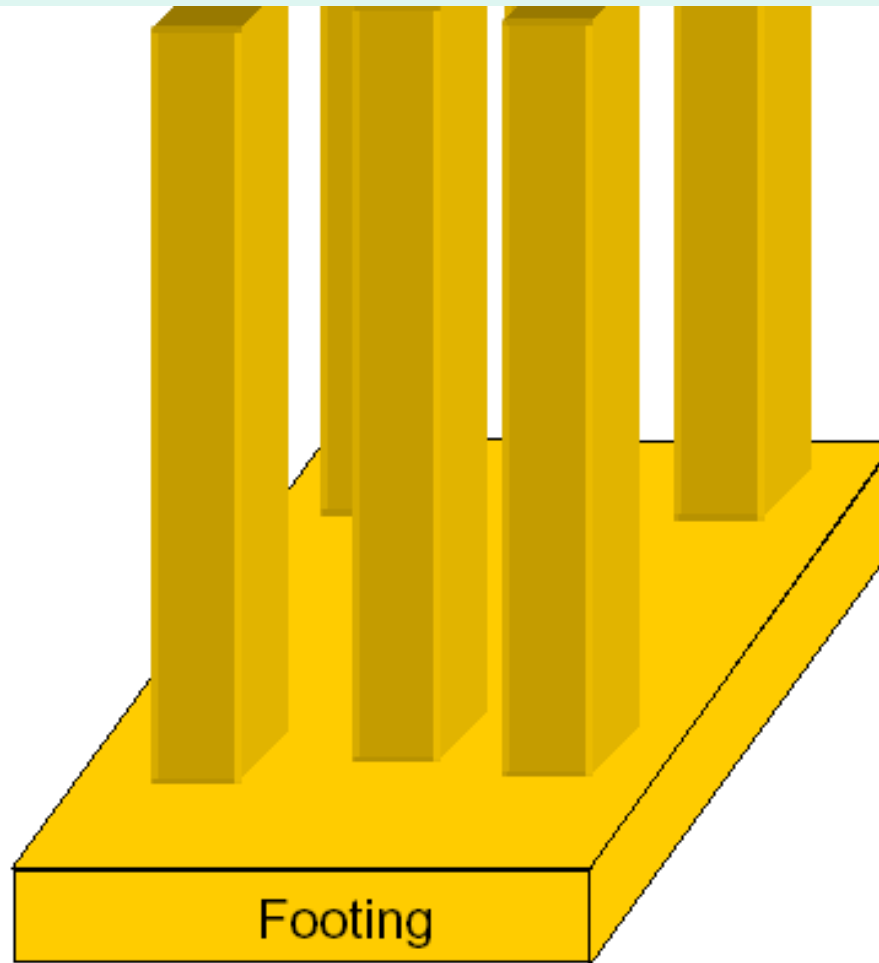
- The soil is very erratic and prone to excessive differential settlement.
 - The structural loads are erratic, and thus increase the likelihood of excessive differential settlement.

- The lateral loads are not uniformly distributed through the structure and thus may cause differential horizontal movement in spread footings.
- The uplift loads are larger than spread footings can accommodate.
- The bottom of the structure is located below ground water table, so waterproofing is an important concern. Because mats are monolithic, they are easier to waterproof.



Flat plate mat foundation

Two-way beam and slab
(Ribbed mat)



Mat or Raft Foundation

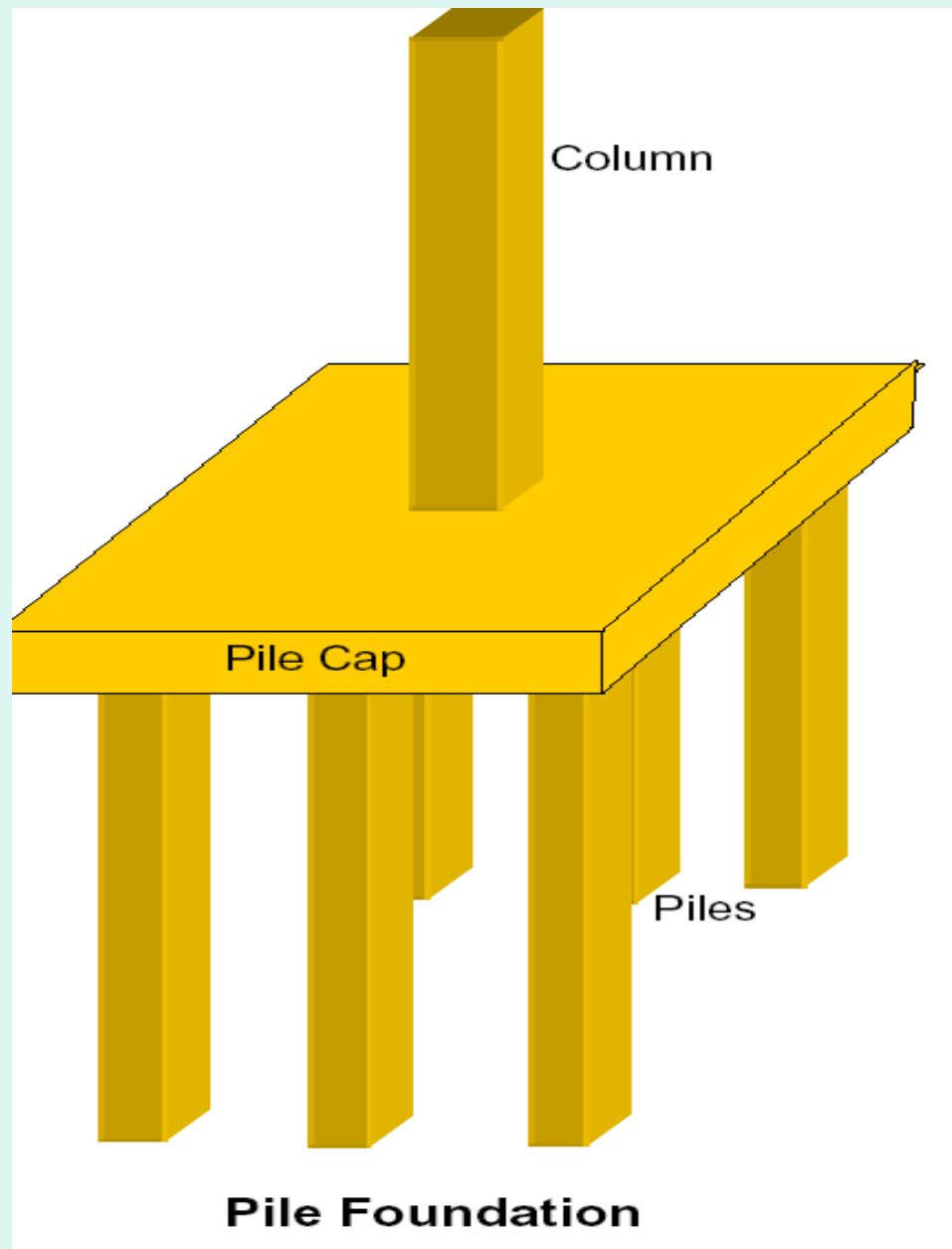
2.Deep Foundations: When the soil at or near the ground surface is not capable of supporting a structure, deep foundations are required to transfer the loads to deeper strata.

- Deep foundations are, therefore, used
 - » when surface soil is unsuitable for shallow foundation, and a firm stratum is so deep that it cannot be reached economically by shallow foundations.
- The most common types of deep foundations are **piles, piers and caissons**.
- **Pile:** is a slender structural member made of steel, concrete or wood.
 - A pile is either driven into the soil or formed in-situ by excavating a hole and filling it with concrete.





- **Pier:** A pier is a vertical column of relatively large cross-section than a pile.
 - » A pier is installed in a dry area excavating a cylindrical hole of large diameter to the desired depth and then backfilling it with concrete.
- **Caisson:** A caisson is a type of foundation of the shape of hollow prismatic box, which is built above the ground and then sunk to the required depth as a single unit.
- It is a watertight box or chamber used for laying foundation under water.
- A pier and caisson differ basically only in the method of construction



- **Selection of Foundation Type**
- In selecting the foundation type the following points must be considered
 - **Function of the structure**
 - **Loads it must carry**
 - **Subsurface conditions**
 - **Cost of foundation in comparison with the cost of the superstructure.**
- Having these points in mind one should apply the following steps in order to arrive at a decision.
 - Obtain at least approximate information concerning the nature of the superstructure and the loads to be transmitted to the foundation
 - Determine the subsurface condition in a general way.

- Consider each of the usual types of foundations in order to judge whether or not
 - **They could be constructed under existing conditions.**
 - **They are capable of carrying the required load.**
 - **They experience serious differential settlements.**
- The types that are found to be unsuitable should then be eliminated.
- Undertake a detailed study of the most promising types. Such a study may require additional information on loads and subsurface conditions.
- Determine the approximate size of footing or the approximate length and number of piles required
- Prepare an estimate for the cost of each promising type of foundation.
- Select the type that represents the most acceptable compromise between performance and cost.

INTRODUCTION TO SOIL REINFORCEMENT TECHNIQUE



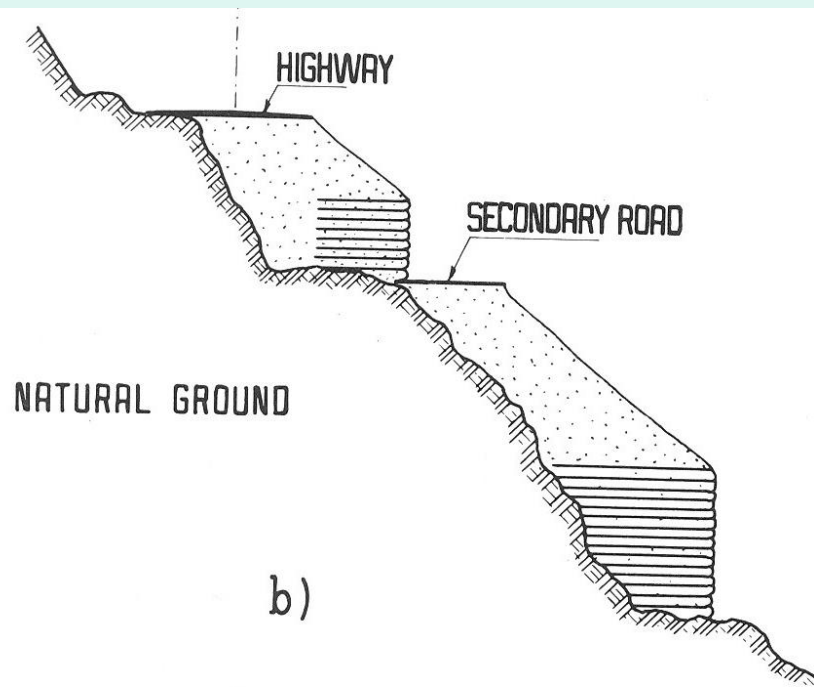
CONCEPT OF **REINFORCED EARTH (R.E.)**

Reinforced earth is a composite material formed by the friction between the earth and the reinforcement. By means of friction the soil transfers to the reinforcement the forces built up in the earth mass. The reinforcement thus develops tension and the earth behaves as if it has cohesion.

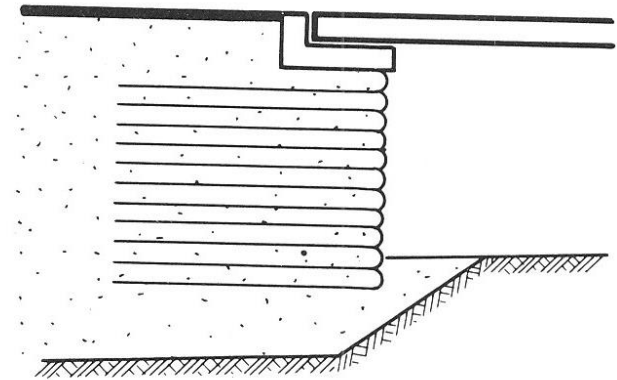
Application of Reinforced Earth

- | | |
|---|--|
| <ul style="list-style-type: none">• Bridge works• Dam Embankments• Foundations• Highways• Industrial sites• Military
(Army Bunkers)• Root Pile system | <ul style="list-style-type: none">• Land Reclamation• Pipe works
(Buried pipe structure)• Housing on hill slopes• Sports Structures• Sea wall & Waterways structures |
|---|--|

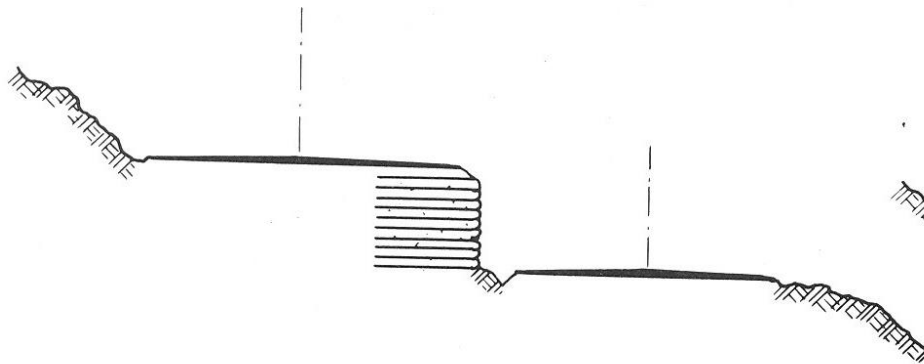
Locations for use of Reinforced Earth



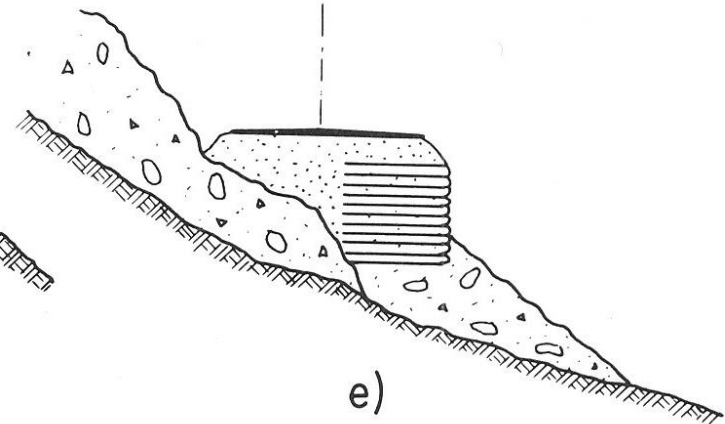
b)



c)

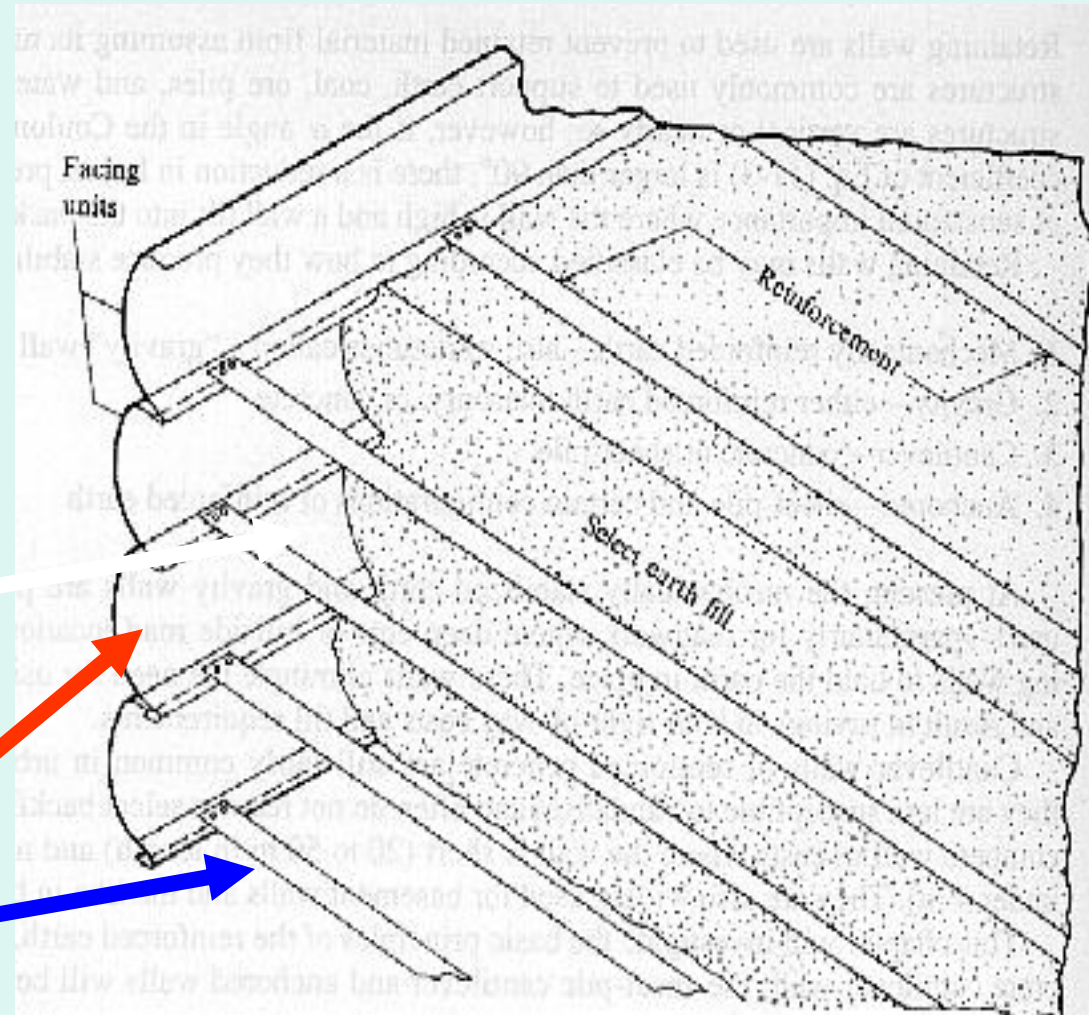


d)



e)

COMPONENTS OF R.E.

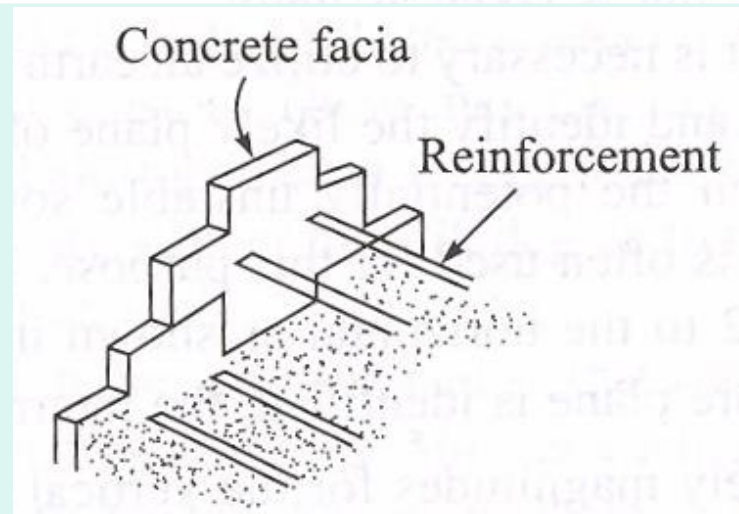
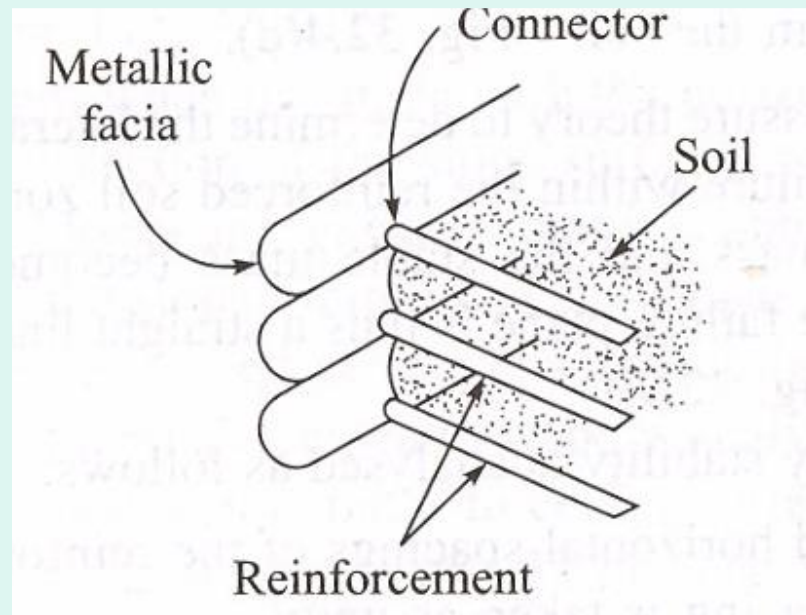


- **Compacted Soil**
- **Wall Facing Elements**
- **Reinforcing Elements**

COMPONENTS OF R.E.

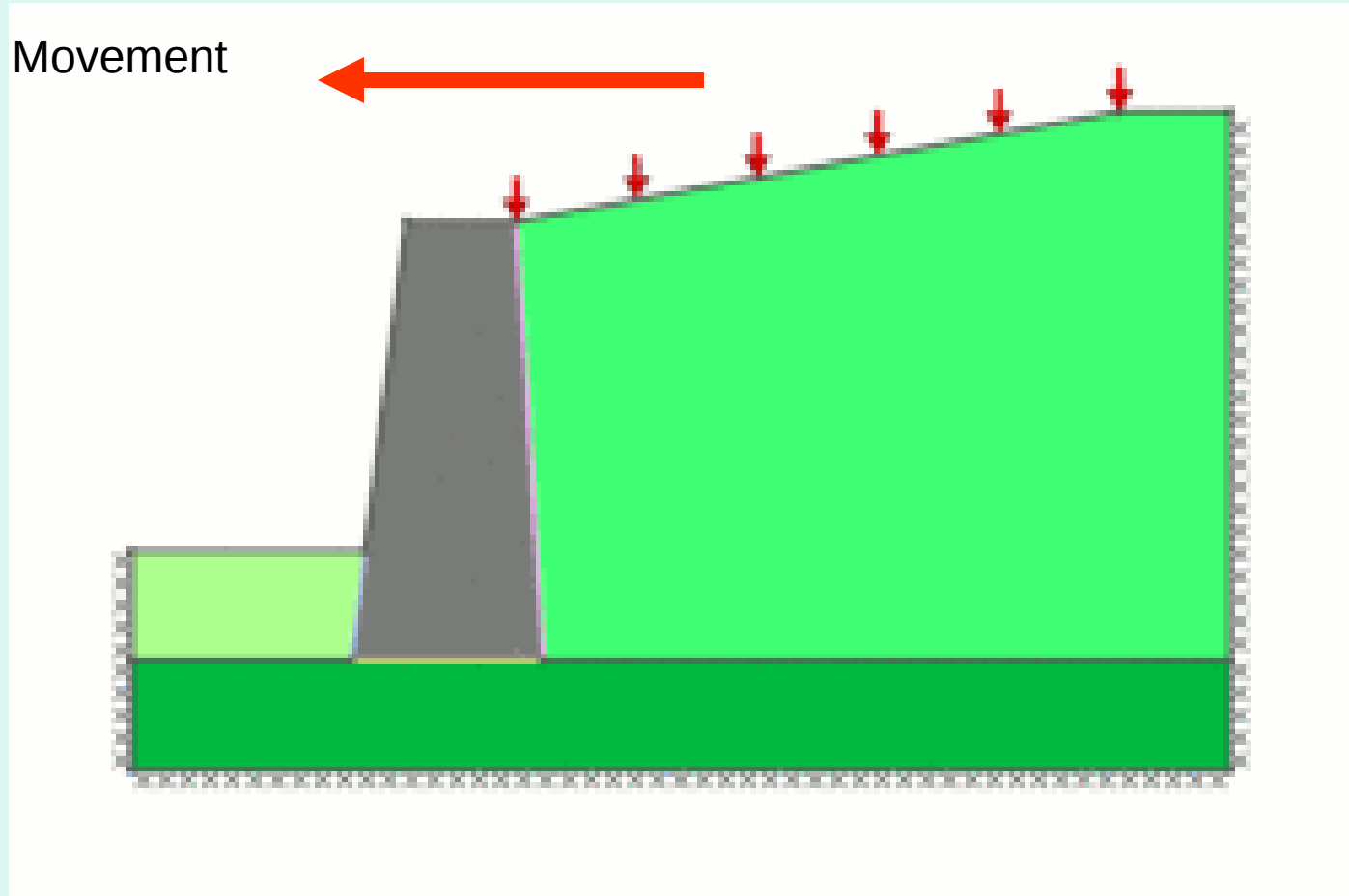


Traditional
Earth Reinforcement



Modern Earth Reinforcement

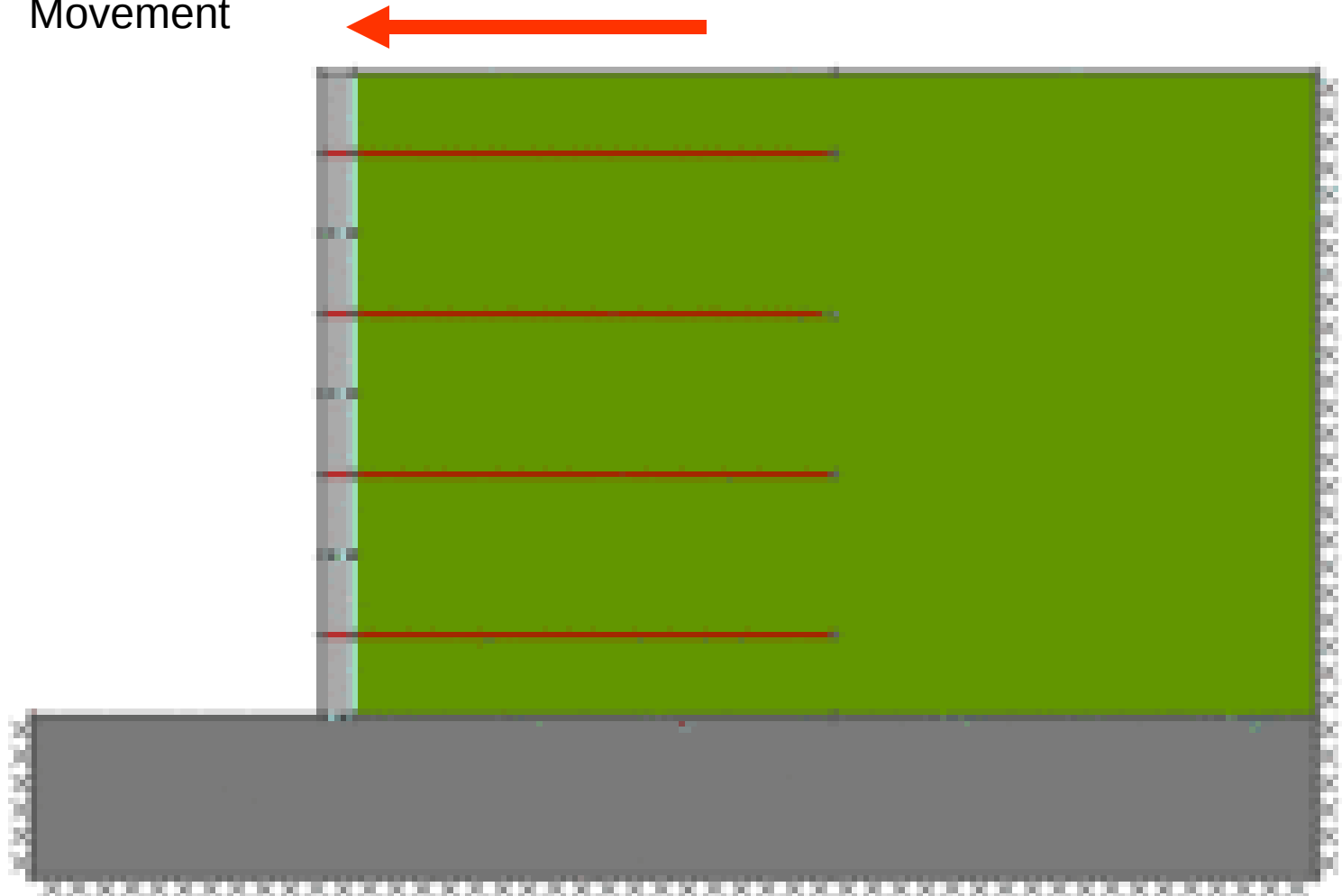
Animations of Gravity wall Slipping



Animations of Reinforced Earth wall

Face failure

Movement



MATERIAL SELECTION

1. SOIL

- Development of sufficient **friction** between **earth** and **reinforcement**.
 - No interstitial **pore water pressure** develops within the reinforced earth structures
 - The **placing and compaction** of the earth fill layers can be accomplished easily
 - The soil must conform to certain **electro-chemical conditions** to **avoid corrosion**
-
- The backfill should be from **non-organic soils** such as **sand** and **Gravel** which are **not affected** by **biological activity**.
 - Have **good drainage**.
 - Primarily cohesion less soils are used.

MATERIAL SELECTION:

Requirements of Reinforcement For R.E.

- Reinforced members are composed of thin wide strips also called **ties**.
- Should be **flexible** to ease placement.
- Should have adequate **tensile strengths**.
- Should have adequate **service life** taking in to account **corrosion** and **weathering**.

MATERIAL SELECTION:

3. REINFORCING STRIPS/MATERIAL

- Based on electro-chemical properties of back fill.
- Can be chosen from metal, geo-synthetics etc based on durability criteria.
- Select fixtures accordingly used to connect strips to the facing elements.

MATERIAL SELECTION:

4. FACING ELEMENTS (outer skin)

- Should retain the back fill between the layers of reinforcements.
- Made of either metal units or precast concrete panels.
- ~~It should be able to deform without distortion.~~
- Can be chosen from metal and concrete.
- Based on durability and stability criteria.
- Aesthetics can be equally important when used in urban areas.

Types of Reinforcement Material (wall facing & Reinforcing elements)

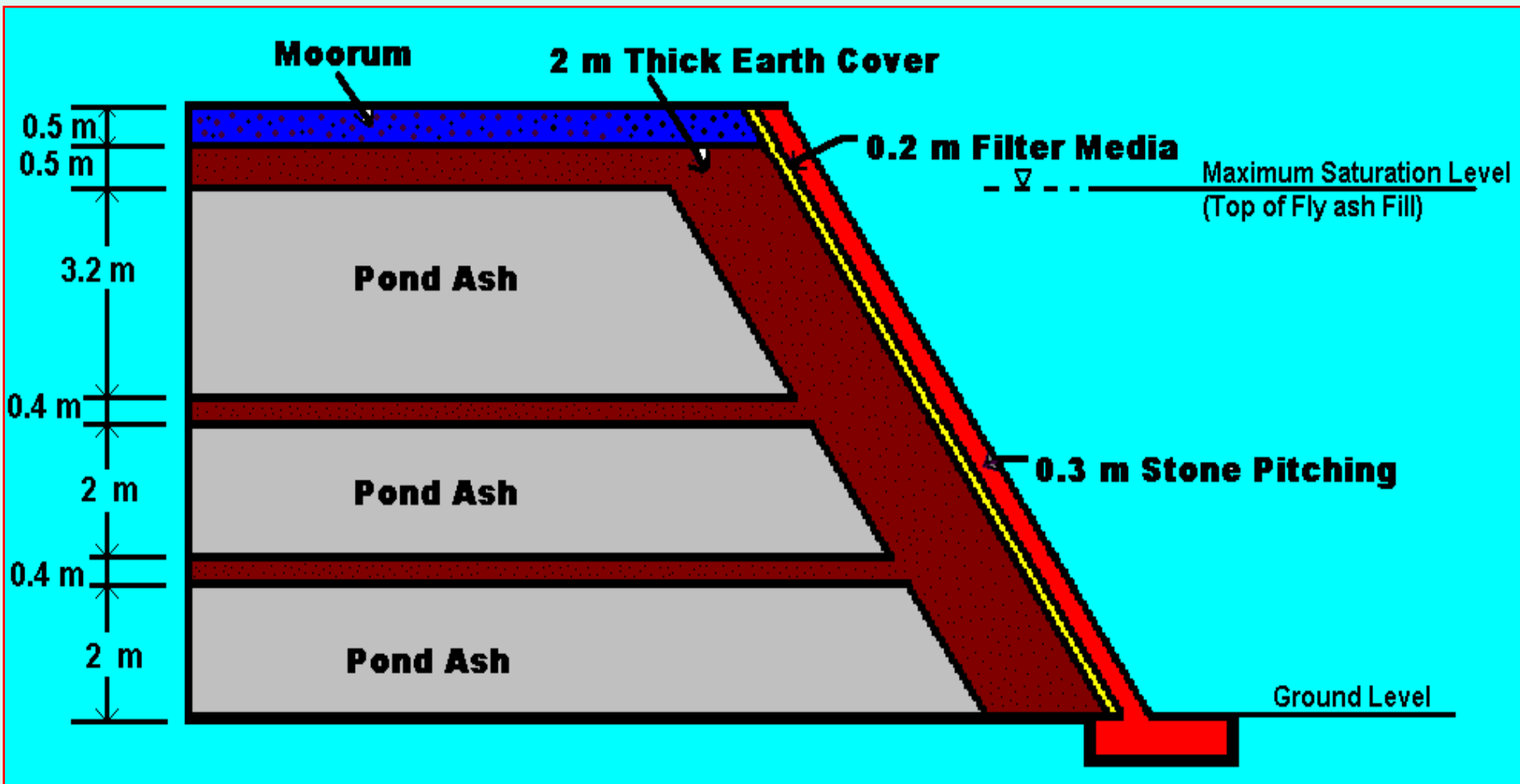
Wall Facing Elements

- **Steel**
- **Aluminum**
- **Plastic**
- **Fibre**
- **Glass**
- **Reinforced Concrete**
- **Used Rubber**

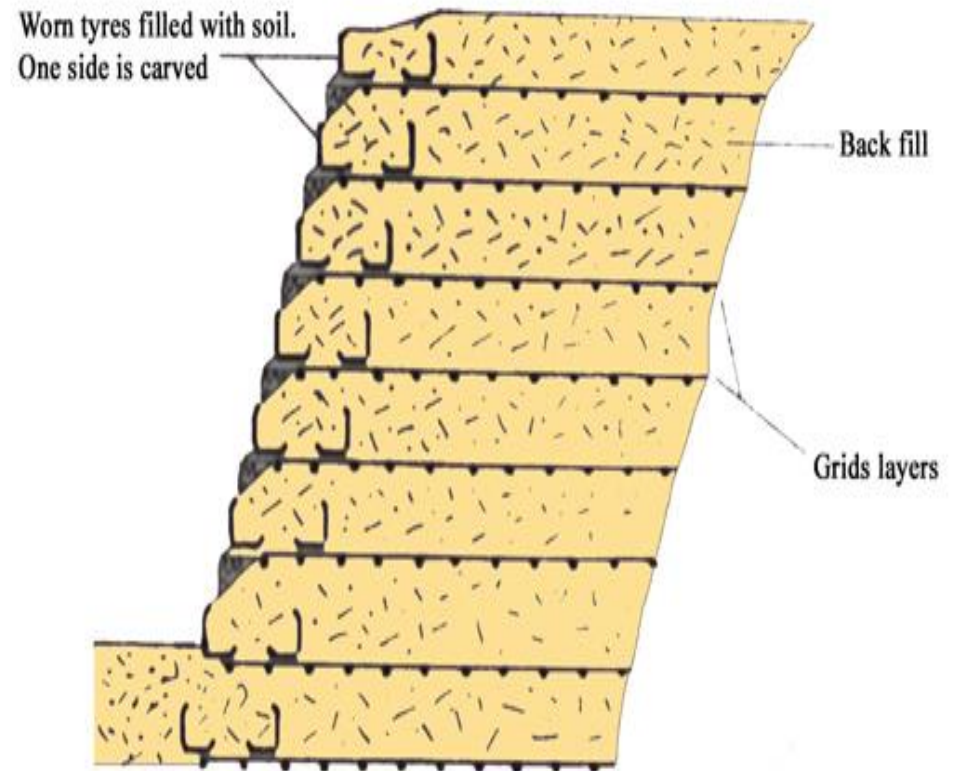
Reinforcing Elements

- Rods of galvanized steel
- Strips/rods Stainless steel/Aluminum
- Fibre glass strips
- Galvanized iron grids
- Glass-fibre Reinforced plastics (GRP)
- Bamboos
- Geo-synthetic reinforcement like Geo-textiles, Geo-grids Geo-strips, Geo-fabrics

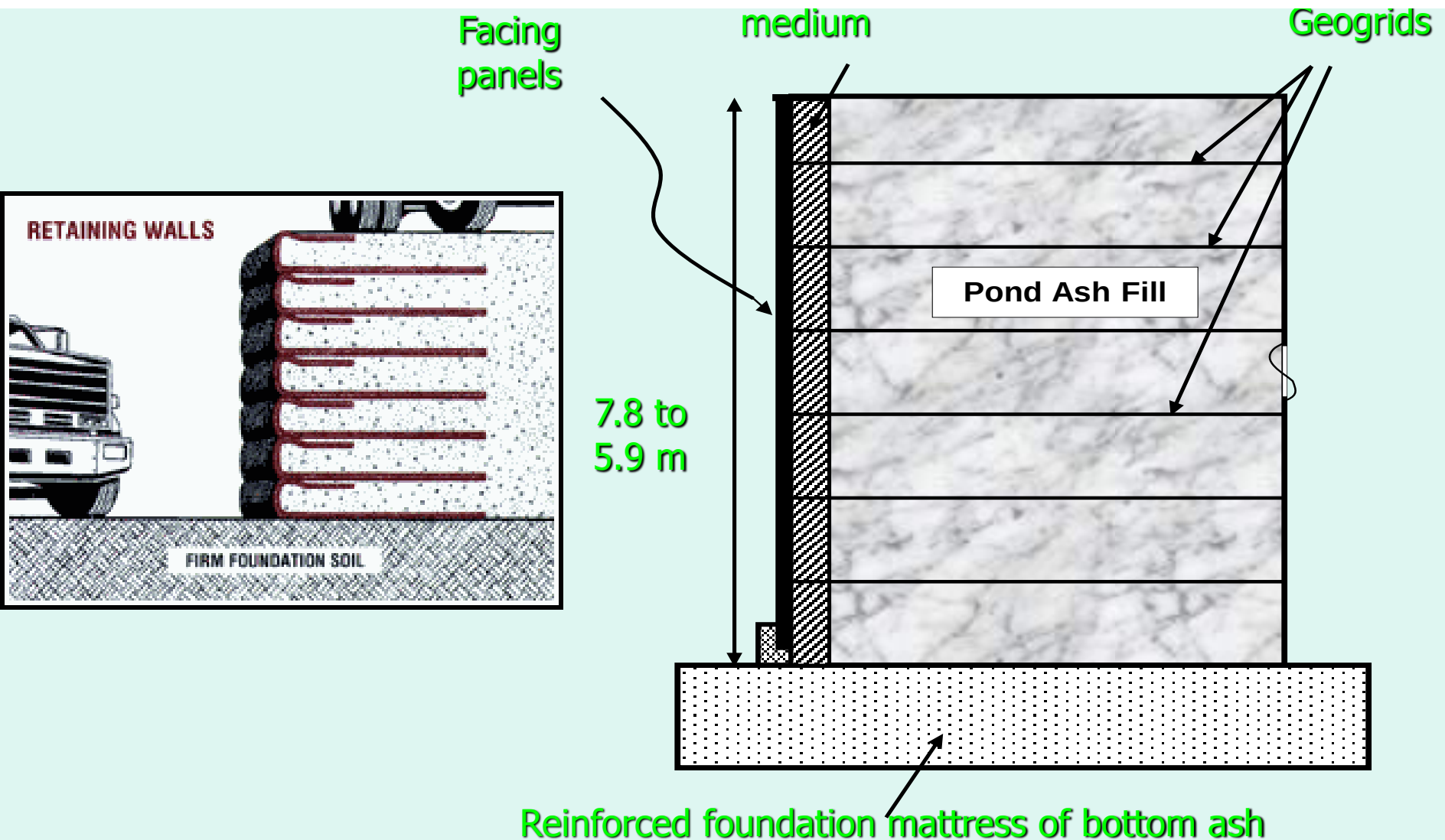
Approach embankment for second Nizamuddin bridge at Delhi



Worn out Tyres with soil as facing Element in an reinforced Earth fill



Okhla flyover approach embankment



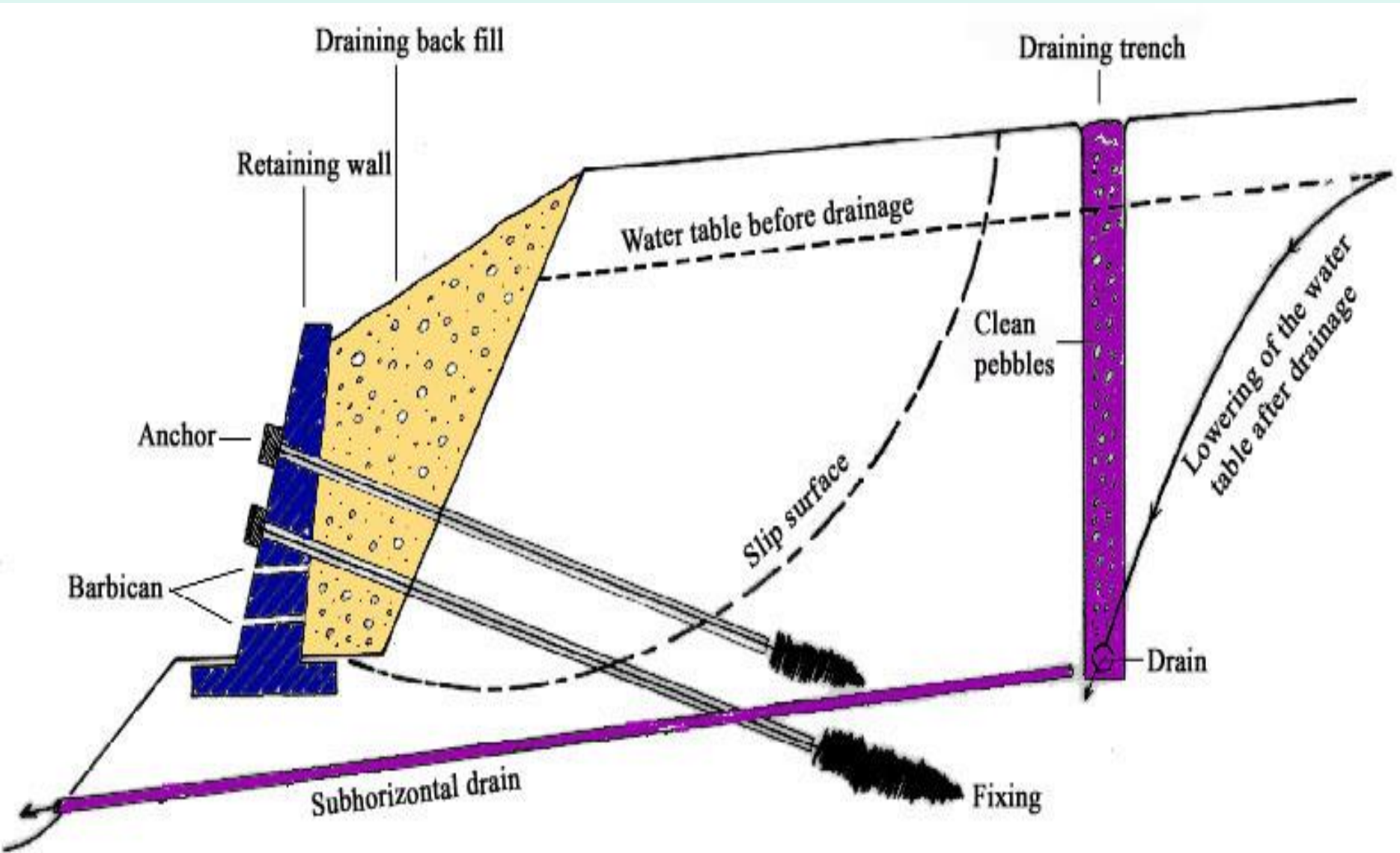
Steel Trip Reinforcement



Galvanized Iron Geo-grid



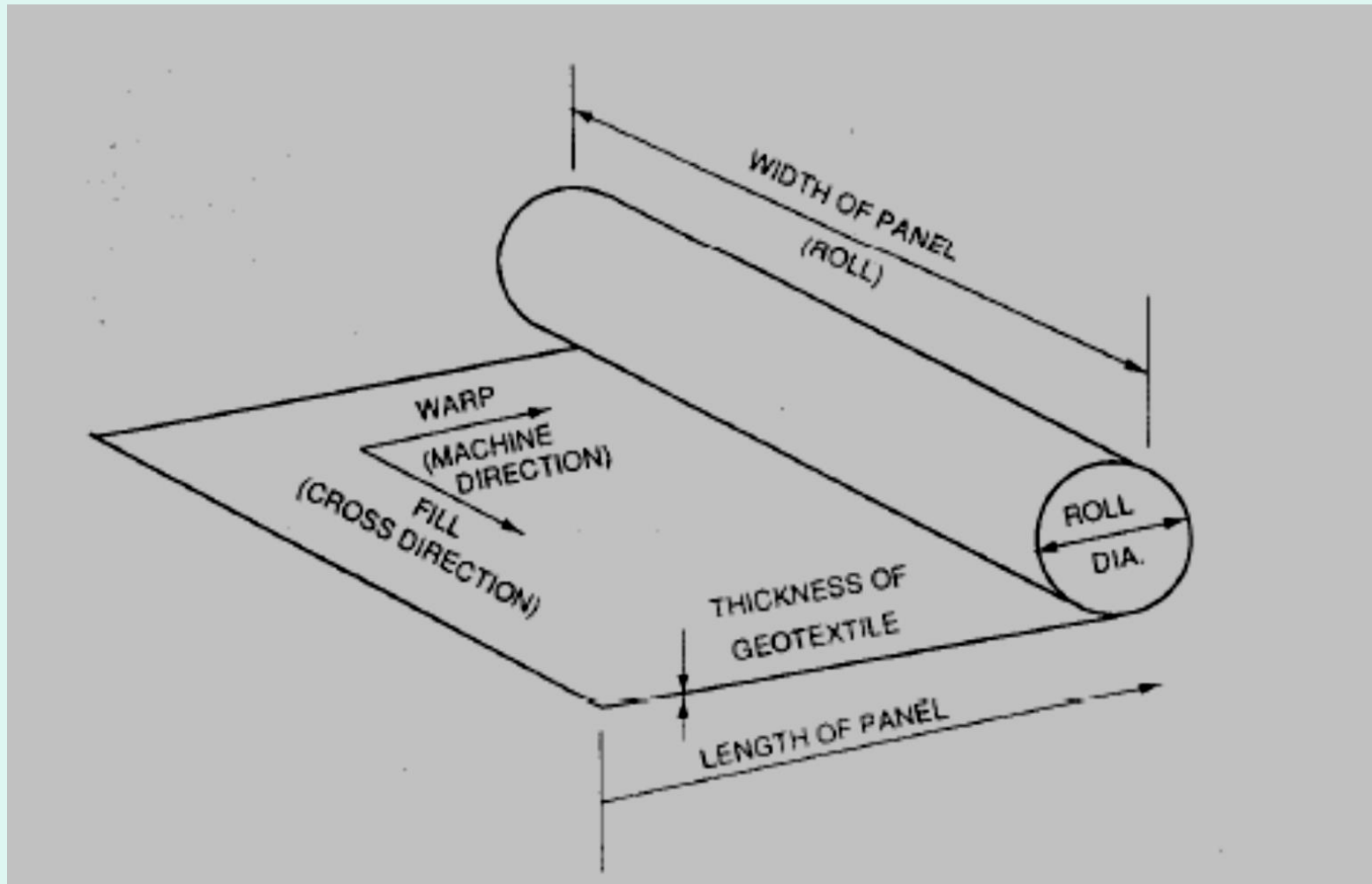
Combination Drainage and Earth Reinforcement Techniques for Ground Improvement



Requisite Properties

- It must be tough enough to withstand rigorous placement during installation process –tensile strength, shear strength, resistance to ultra violet light
- It must be strong and tough enough to withstand static & dynamic loads burst strength, puncture strength, abrasion resistance, elongation at failures
- It must be resistant to excessive clogging or blending permeability.
- It must be resistant to rot. Insects and rodents and to chemicals & diesel fuel.

Dimensions and Directions of Woven Textile



Wall reinforced material fiberglass mesh to be used in soil for Geo-reinforcement



Exposure to sunlight **degrades** the physical properties of polymers. The rate of degradation is reduced by the addition of carbon black but not eliminated.

Geo-fabrics and Geo-synthetics

used for reinforcement, separation, filtration and drainage in roads, retaining walls, embankments...



Geo-fabrics and Geo-synthetics used on Pacific Highway



Use of Geo-textile for Filtration

The use of Geotextiles in filter applications is probably the **oldest**. In this application, the Geotextile is placed in contact with and down gradient of soil to be drained. Geotextile filter must allow water (or gas) to pass without significant build-up of hydrostatic pressure.

1. The plane of the Geotextile is normal to the expected direction of water flow. The capacity for flow of water normal to the plane of the Geotextile is referred to as **permittivity**.
2. Water and any particles suspended in the water which are **smaller than a given size, flow or pass through the Geotextile**. Those **soil particles larger than that size are stopped and prevented from being carried away**.
3. The geotextiles substitute serve the same function as the traditional granular filter.
4. A geotextile-lined drainage trench along the edge of a road pavement is an example using a geotextile as a filter.
5. **Slit film Geotextiles are not preferred** because **opening sizes are unpredictable**.

Use of Geo-textile for Drainage

- When functioning as a drain, a Geotextile acts **as a conduit** for the movement of liquids or gases in the plane of the Geotextile.
- Examples are Geotextile used as **wick drains** and **blanket drains**. The relatively thick non-woven Geo-textiles are the **products most commonly used**.
- Selection should be based on **transmissivity**, which is the capacity for in-plane flow.

Fig. Trench Drain Construction with Geotextile

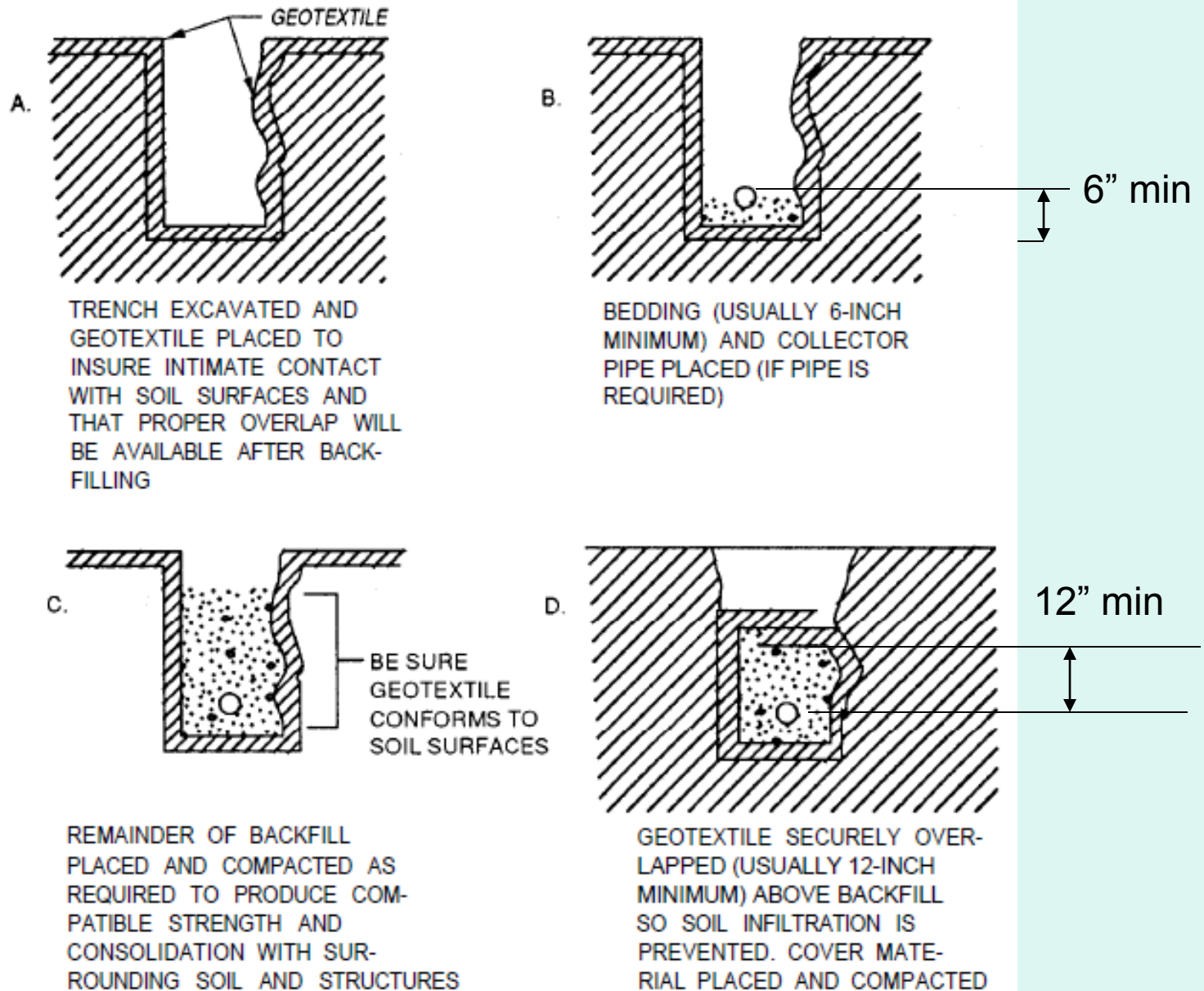
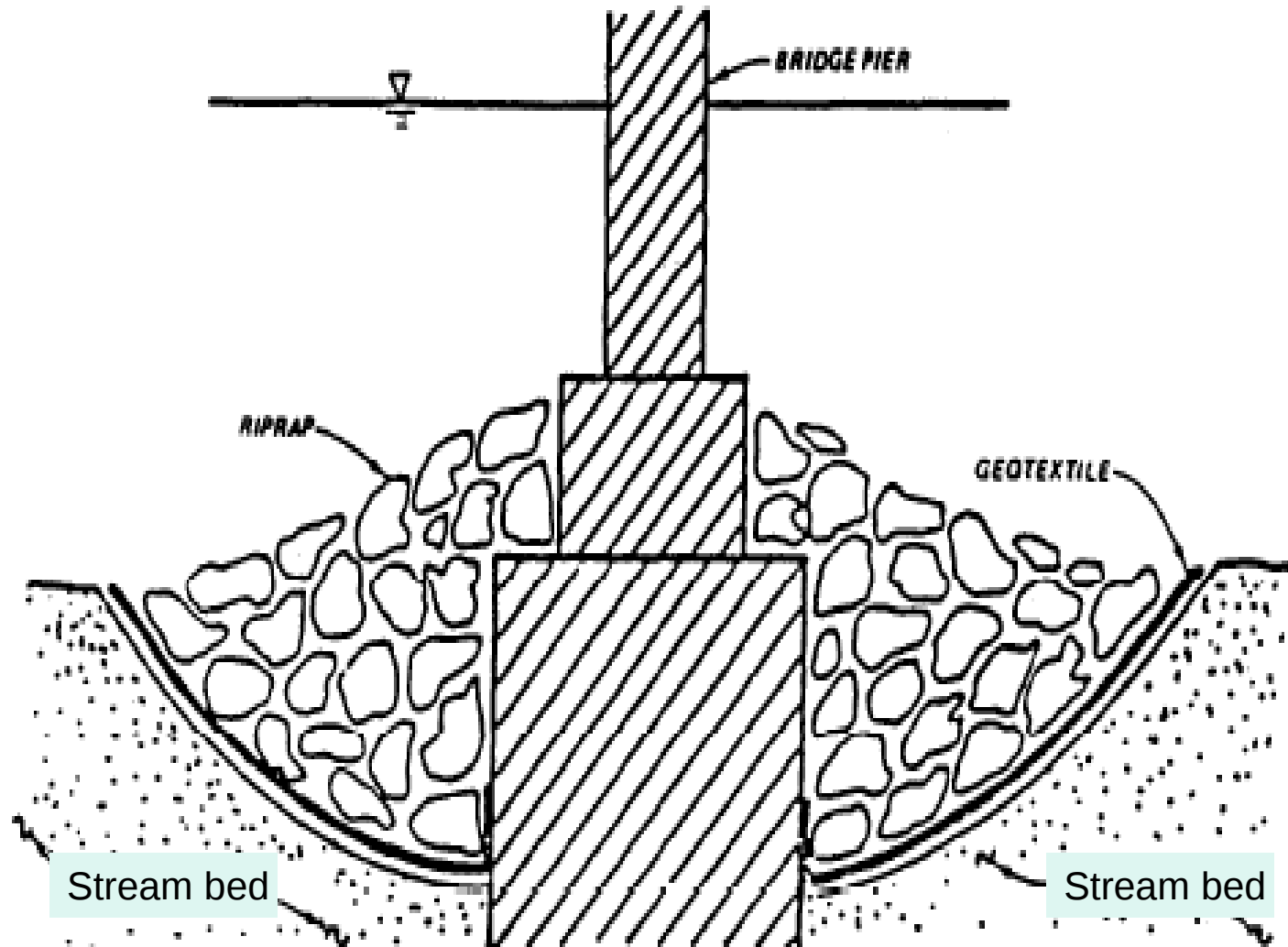


Fig. Geotextile Scour Protection for Bridge Pier



SCOUR PROTECTION FOR BRIDGE PIER

Use of Geo-textile for Separation

- Separation is the process of preventing two dissimilar materials from mixing. In this function, a Geotextile is most often required to prevent the undesirable mixing of fill and natural soils or two different types of fills.
- A Geotextile can be placed between a railroad sub-grade and track ballast to prevent contamination and resulting strength loss of the ballast by intrusion of the sub-grade soil.
- In construction of roads over soft soil, a Geotextile can be placed over the soft sub-grade, and then gravel or crushed stone placed on the Geotextile. The Geotextile prevents mixing of the two

Use of Geo-textile for Pavement Applications

- **Geotextile for asphalt concrete (AC) overlays on roads and airfields and the separation and reinforcement of materials in new construction.**

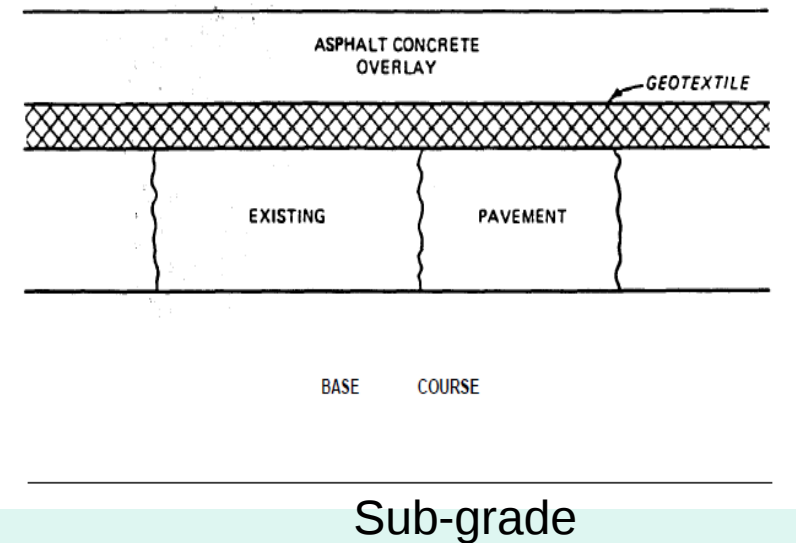


Fig. Geotextile in AC Overlays

ROCK BOLTS







Soil Nailing

- The fundamental concept of soil nailing consists of reinforcing the ground by passive inclusions, closely spaced, to create in-situ a coherent gravity structure and thereby to increase the overall shear strength of the in-situ soil and restrain its displacements.

