MACHINE FOUNDATION

INTRODUCTION

- In addition to the static loads due to weight of the machine and the foundation itself, the machine foundations are subjected to dynamic loads.
- The nature of dynamic load depends upon the type of machine.

In general machine can be grouped into three categories:

- Reciprocating machines
- Impact machines
- Rotary machines.

Reciprocating machines

- These machine produce periodic, unbalanced force, e.g., reciprocating engines and compressors.
- The unbalanced force in such machines varies sinusoidally.
- The operating speeds of such machines are usually less that 600 rpm.

Impact machines

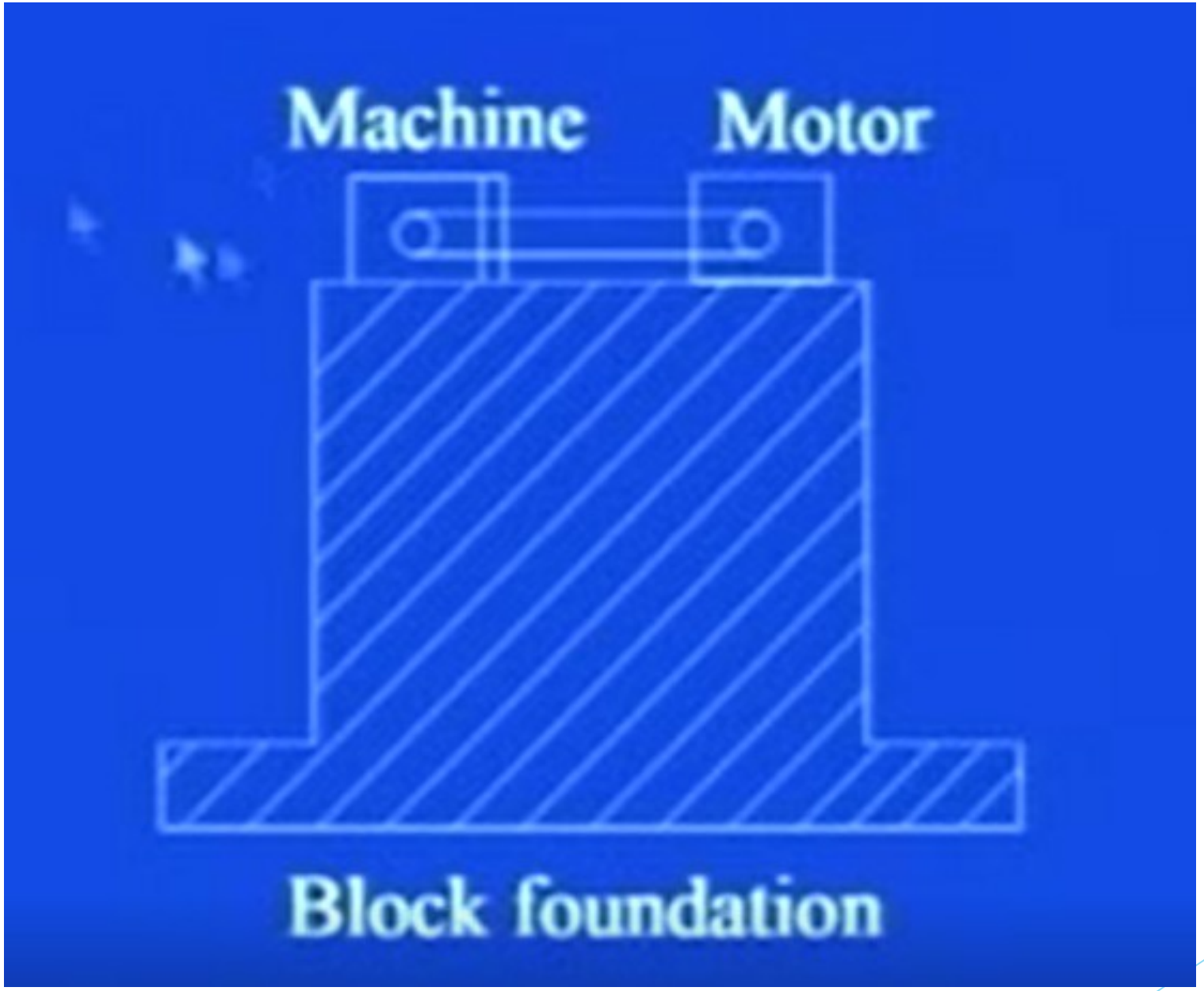
- Machines that produce impact loads, e.g., forge hammers, form this group of machines.
- In such machines, dynamic load builds up in a very short period of time and then dies out completely.
- The speed of operation of these machines is 60 to 150 blows per minute.

Rotary machines

- Medium and high speed machines, e.g., turbo-generators and rotary compressors.
- Operating speed vary from 1500 to 10000 rpm.

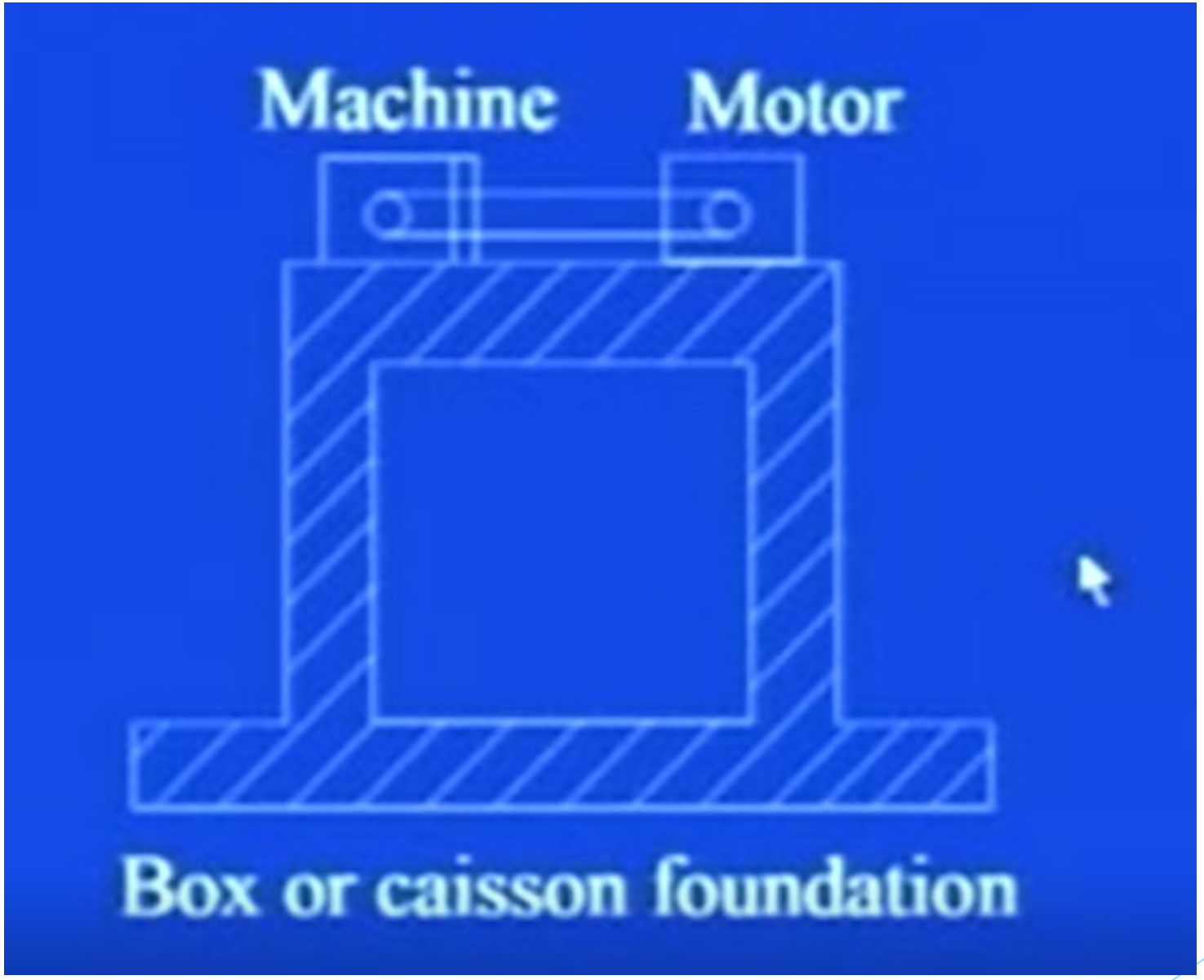
Suitable type of foundation

- The type of foundation that is suitable for a machine depends on the type of machine.
- For the reciprocating machines, block foundation is usually provided.
- A block foundation consists of a pedestal integrated with footing.
- A block foundation has a large mass and hence a smaller natural frequency.


Machine
Motor
Block foundation

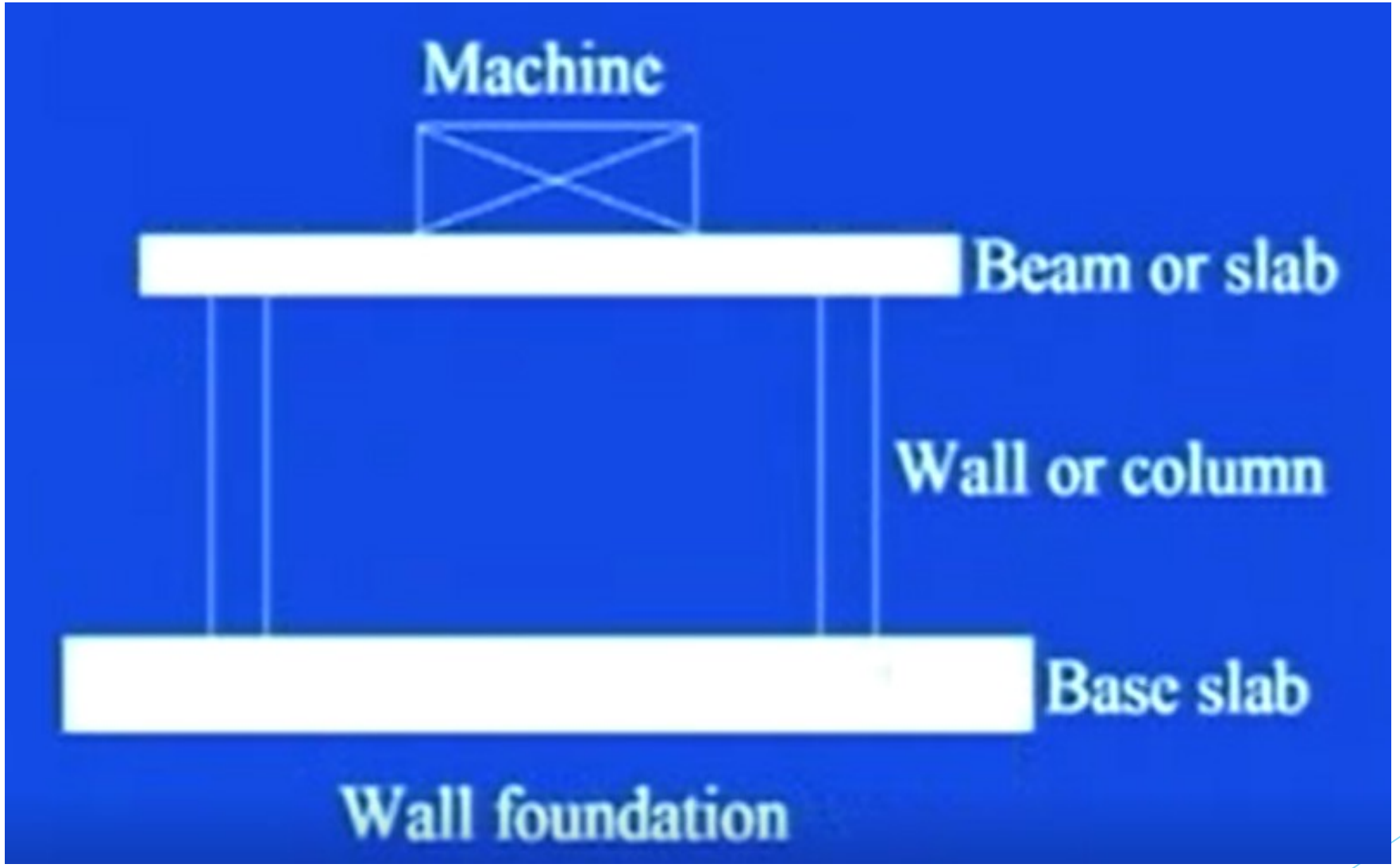
Suitable type of foundation

- If a relatively lighter foundation is preferred (as the mass of foundation reduces, its natural frequency increases), a box or a caisson type of foundation may be provided.


Machine
Motor
Box or caisson foundation

Suitable type of foundation

- Foundations for steam turbines are usually complex.
- These consist of a system of wall columns and beam slabs.
- Each element of such foundation is quite flexible.


Machine
Beam or slab
Wall or column
Base slab
Wall foundation

TERMINOLOGY

Vibration

- Time dependent, repeating motion of translational or rotational type of any body possessing mass and elasticity is termed as vibration.

- The vibratory motion of a body can be of three types, namely, periodic, random or transient.

Amplitude

The maximum displacement of a vibrating body from its mean position or position of static equilibrium.

Period

The time period in which the motion repeats itself.

Cycle

The motion completed in one period is the cycle of motion.

Damping

It is the resistance to motion due to friction and / or other causes.

Viscous damping

When the damping force is proportional to the velocity of the system.

Degree of freedom

Number of independent coordinates required to define a vibratory system.

Free vibration

Vibration of a system when it is displaced from its equilibrium position and left to vibrate.

Natural frequency

The frequency at which a system vibrates under the effect of forces inherent in the system.

Operating frequency

The frequency at which a machine is operating.

Aperiodic

When there is non-regularity of the system in crossing its equilibrium position during motion.

Steady state

When a system is under a sinusoidal forced vibration and the response of the system is also sinusoidal.

Transient

When a system is subjected to a sudden velocity.

Resonance

When the frequency of the exciting force (operating frequency of the machine) equals the natural frequency of the foundation-soil system, the condition of resonance is reached. At resonance, the amplitude of a vibrating system is the maximum.

DESIGN CRITERIA FOR SATISFACTORY ACTION OF A MACHINE FOUNDATION

For satisfactory performance of a machine foundation, the foundation should satisfy the following criteria:

Under static loads:

1. The foundation should be safe against shear failure of soil.

2. The foundation should not settle more than a certain permissible value.

Under dynamic loads:

1. There should be no resonance, i.e., the natural frequency of the foundation-soil system should either be larger than or smaller than the operating frequency of the machine.

2. The amplitudes of vibration under the operating frequency of the machine should be within permissible limits.

Under dynamic loads:

3. The vibrations should not be annoying to the persons or detrimental to other machines and structures. Richart (1962) developed some criteria for vertical vibrations, which can be taken as a guide for determining permissible limits of frequency and amplitude.

GEOSYNTHETICS

INTRO…..

- **Geosynthetics** are synthetic products used to stabilize terrain. They are generally polymeric products used to solve civil engineering problems.
- The material used in the manufacturing of geosynthetic are primarily synthetic polymers generally derived from rubber, fibre, glass and other material.
- Geosynthetics are material made from polymers such as polyester, PVC, polyethylene, nylon.

CLASSIFICATION

- Geotextile: are planer, permeable, polymeric textile product in the form of flexible sheets. Geotextile are classified are:
- Woven: made by weaving process, used for strength erosion control purpose
- Non-woven: made by bonding process, used for filtration and drainage

- Woven geotextile: A geotextile produce by interlacing, at right angles, two or more sets of yarns using a conventional weaving process with a weaving loom.
- Non-woven geotextile: A geotextile produced from directionally or randomly oriented fibre into a loose web by bonding with needle punching, chemical binding agent (glue).

- Knitted geotextile: A geotextile produced by interloping one or more yarn together with a knitting machine.
- Stitched geotextile: A geotextile in which fibres or yarn or both are interlocked by stitching or sewing.

Main functions of geotextile are:

- Separation
- Reinforcement
- Drainage
- Filtration
- Erosion control

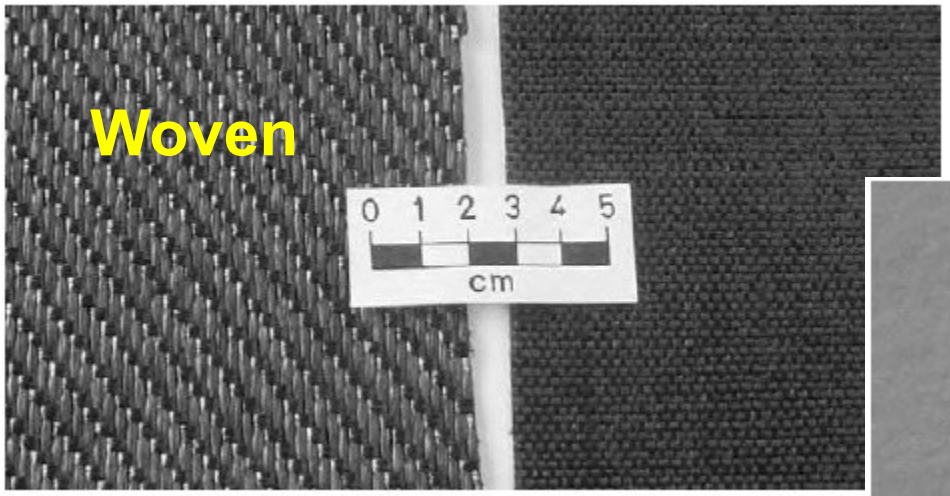
TYPES OF GEO-MATERIALS (GEOSYNTHETICS FAMILY)

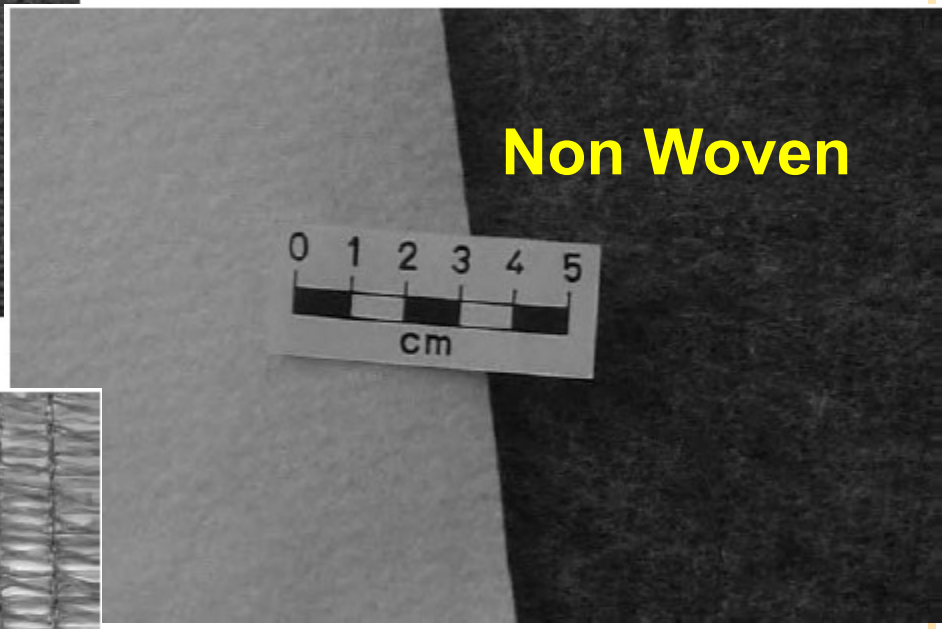
1. Geotextile.
2. Geogrid.
3. Geonet.
4. Geo Membrane
5. GeoComposites
6. Geofoam
7. Geocell
8. Geomat
9. Geomesh
10. Geopipe
11. Geospacer

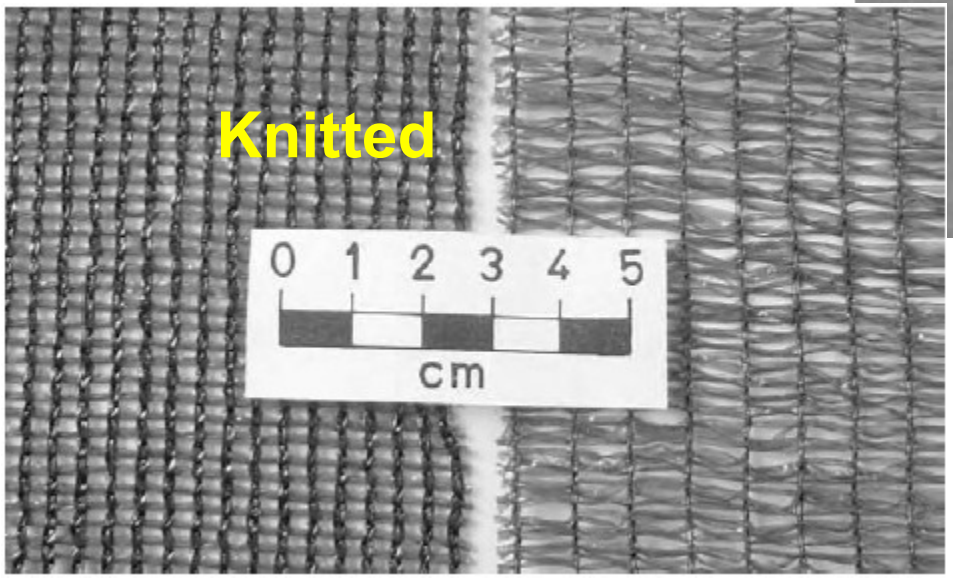
GEOTEXTILE

- Woven and non-woven geotextile are widely used in applications such as soil stabilization, turf reinforcement, erosion control, separation, filtration and drainage. Geotextile can be classified into two types, biodegradable and non-biodegradable geotextile.

1. GEOTEXTILE



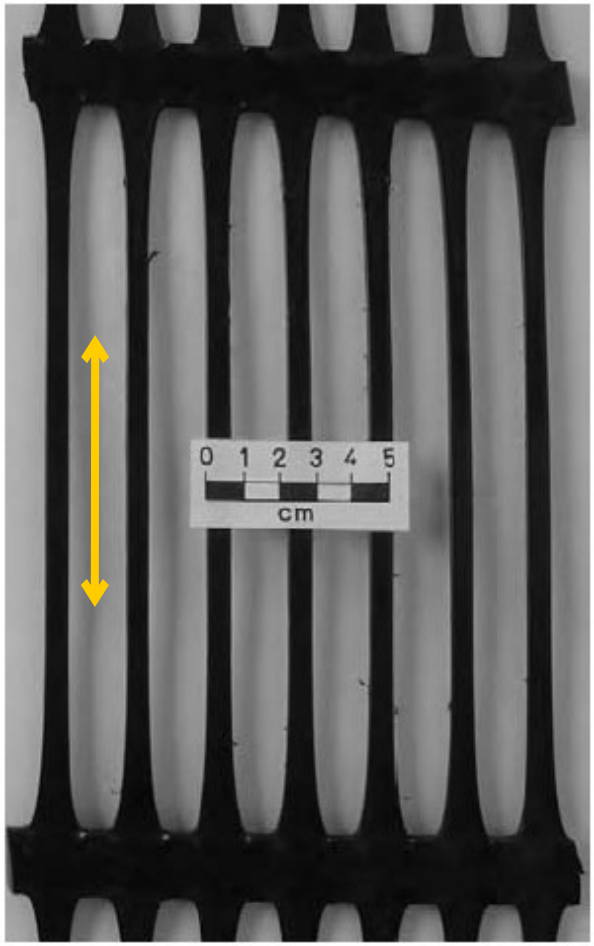




- Biodegradable geotextile are made of natural fibers. **Natural coconut fiber products** are typically used in areas looking to establish vegetation.
- Non-biodegradable geotextile are made of synthetic materials, for example polyesters and polypropylene.
- Because of the advances in technology, non-biodegradable geotextile are preferred compared to biodegradable geotextile.

- **Non-Woven textile**: A geotextile produced from directionally or randomly oriented fibres into a loose web by bonding with chemical binding agent (glue, rubber, etc.), or heat treatment (melting), etc.
- **Woven textile**: A textile produce by interlacing at right angles.
- **Knitted geotextile**: A geotextile produced by interloping one or more yarn together with knitting machine.

2.GEO GRID



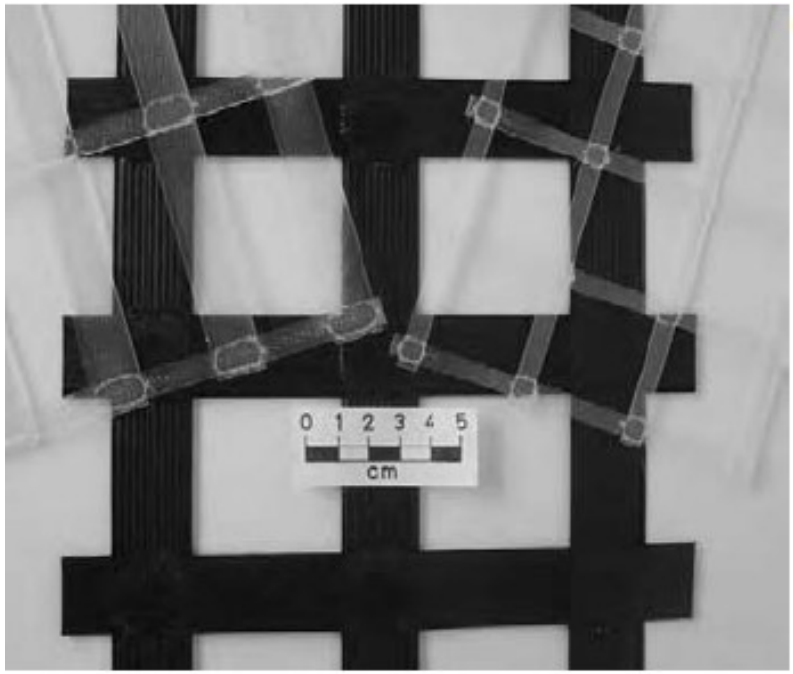
(i) Uniaxial

(ii) Biaxial

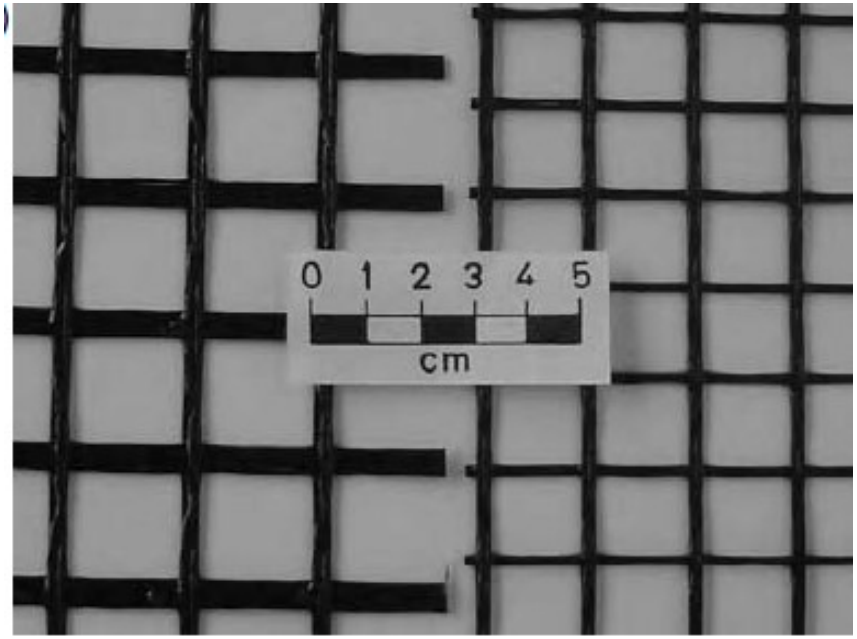
GEOGRID

- **Uniaxial geogrid**: it is produced by longitudinal stretching of regularly punched polymer sheet.
- It has higher tensile strength in longitudinal direction than in transverse direction.

- **Biaxial geogrid**: It is produced by stretching in both longitudinal and transverse directions of regularly punched polymer sheet.
- Reinforcing function is achieved by positive interlocking of fill material into apertures or opening while in a geotextile, the reinforcing function is achieved by the surface friction between the fabric and soil fill.
- The main function of geogrid is as reinforcement.

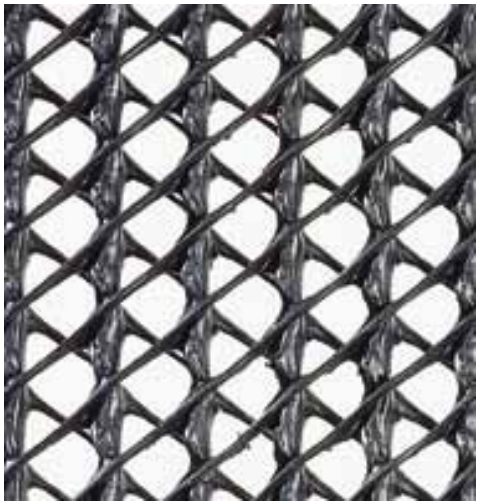


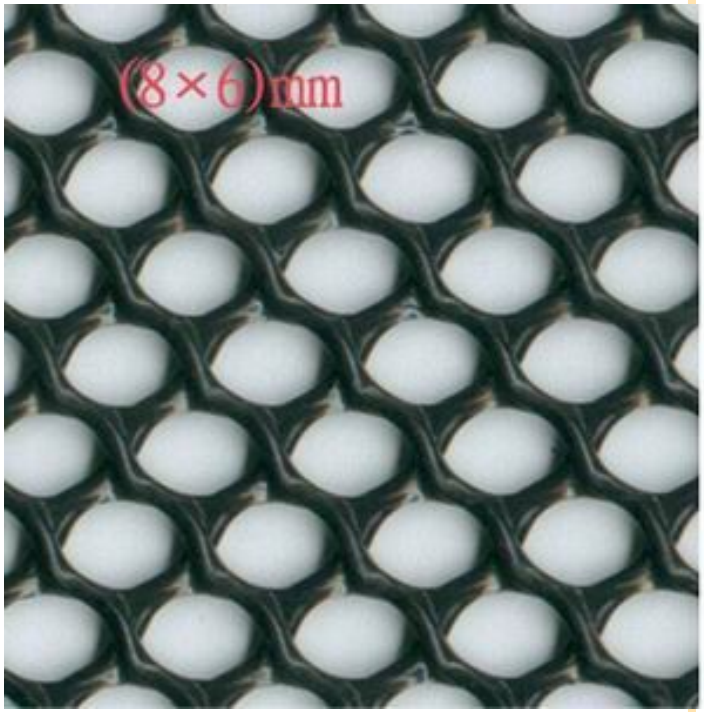
(iii) Bonded

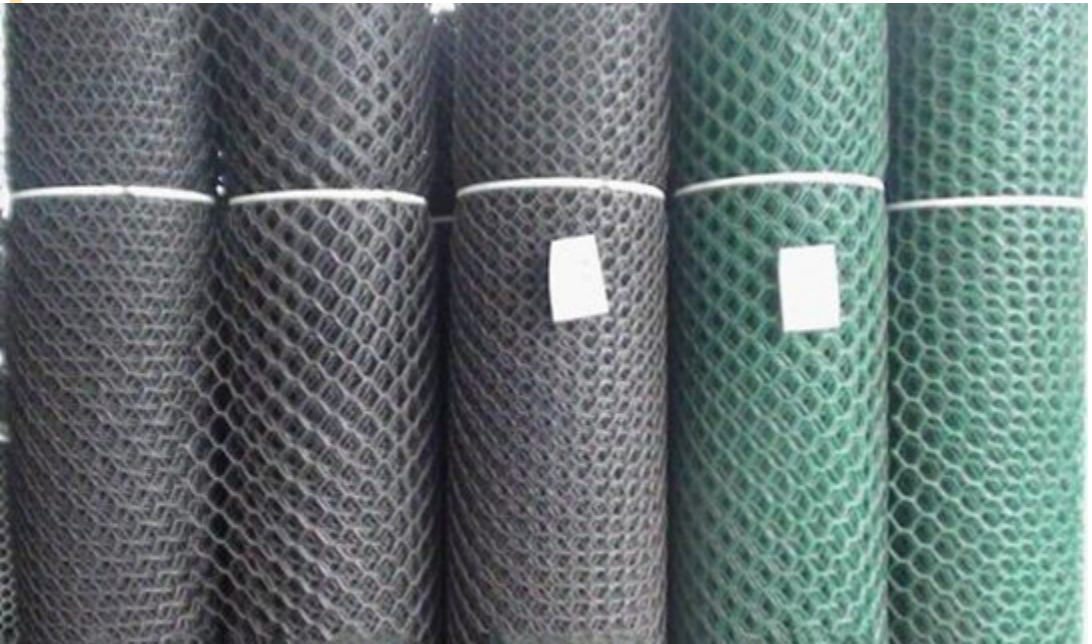


(iv) Woven

3. GEONET.



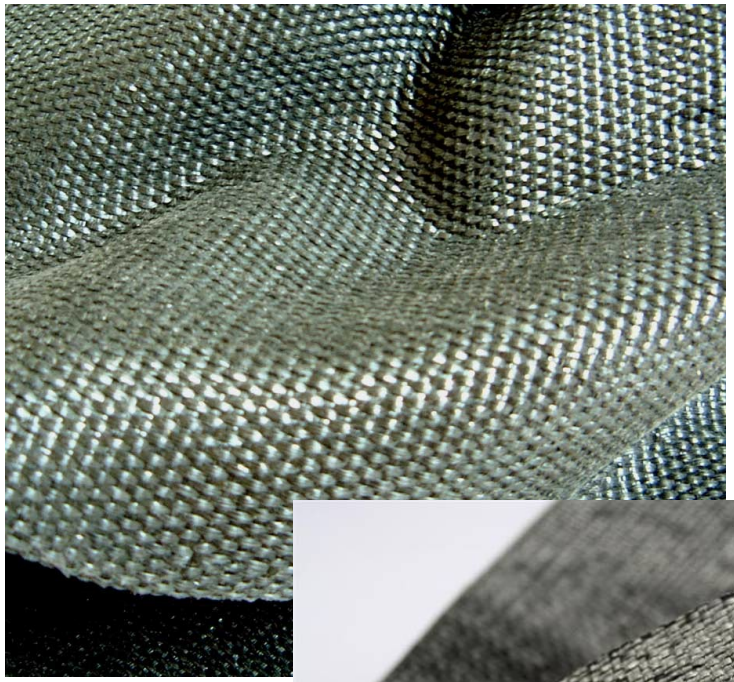


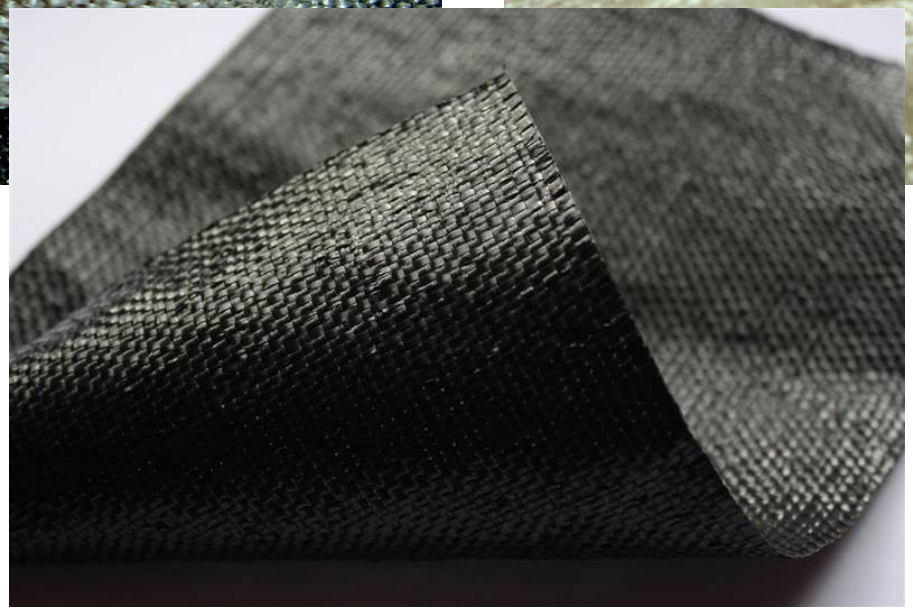


GEONETS

- These include High Density Polyethylene and Low Density Polyethylene nets and have function similar to geogrid.
- The main function of geogrid is as reinforcement.

4. GEO MEMBRANE





GEOMEMBRANE

- A **geomembrane** is very low permeability synthetic membrane liner or barrier used with any geotechnical engineering related material so as to control fluid (or gas) migration in a human-made project, structure, or system. Geomembranes are made from relatively thin continuous polymeric sheets.

5. GEOCOMPOSITES

- Combination of one or more type of geosynthtics for modified function.

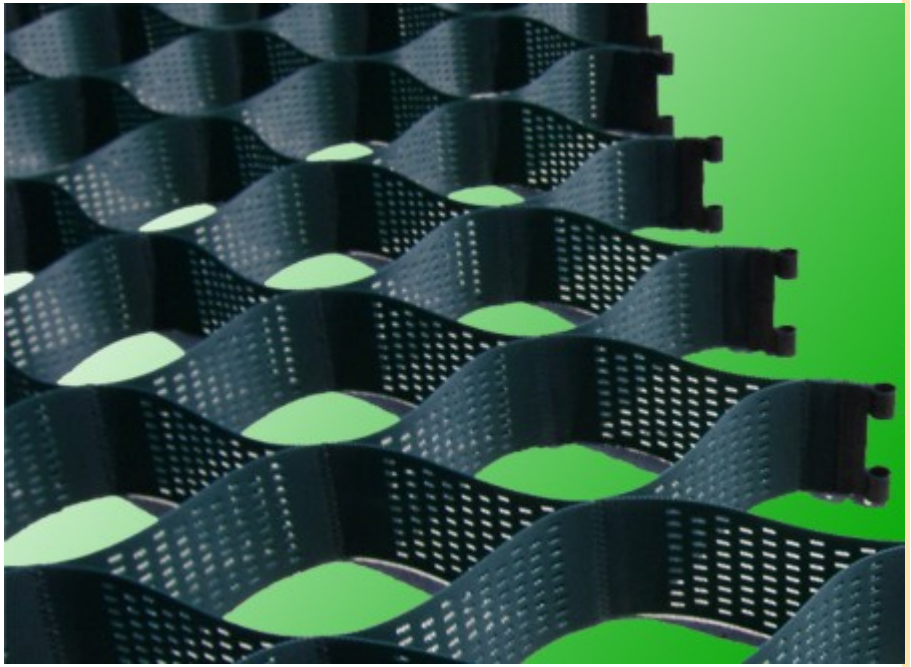
6.GEOFOAM

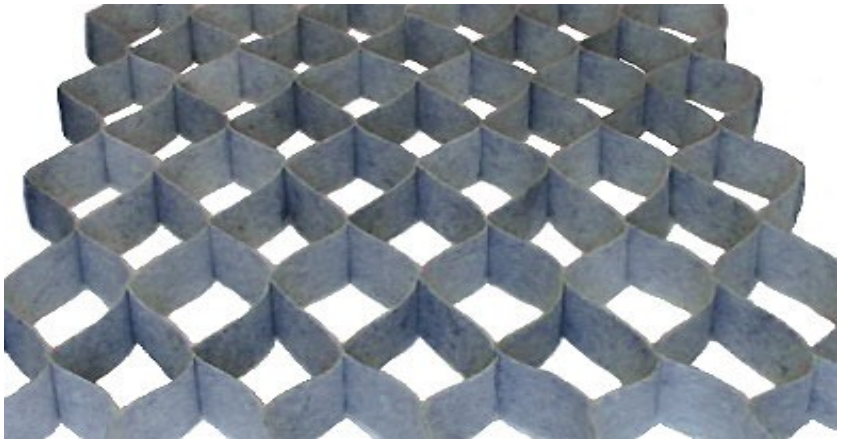
Foam like material, provided for functions mentioned below:

- Moisture retention.
- Erosion protection.

Generally gives temporary solution of the problem.

7.GEOCELL





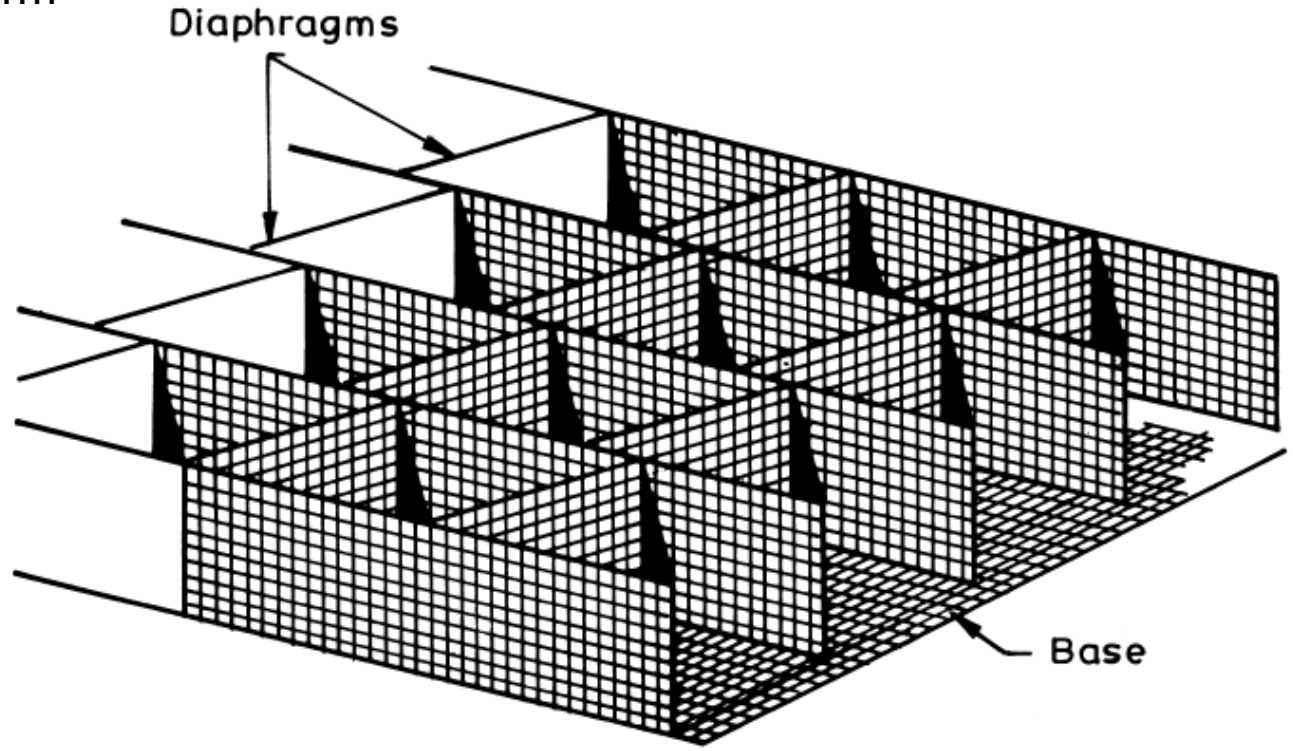
GEOCELL

- A three- dimensional, permeable, polymeric honeycomb or web structure, assembled from geogrids.

GEO CELL

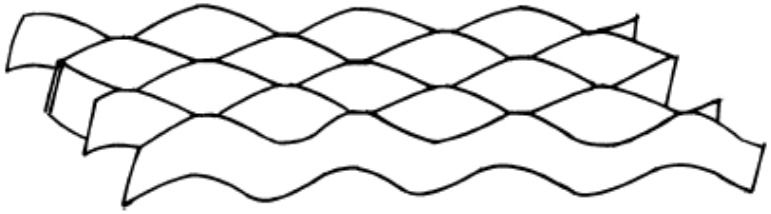
(a) Geocell – (i) site assembled, (ii) factory produced (A) collapsed form, (B) expanded form

(a)-(i)



(a)-(ii)(A)

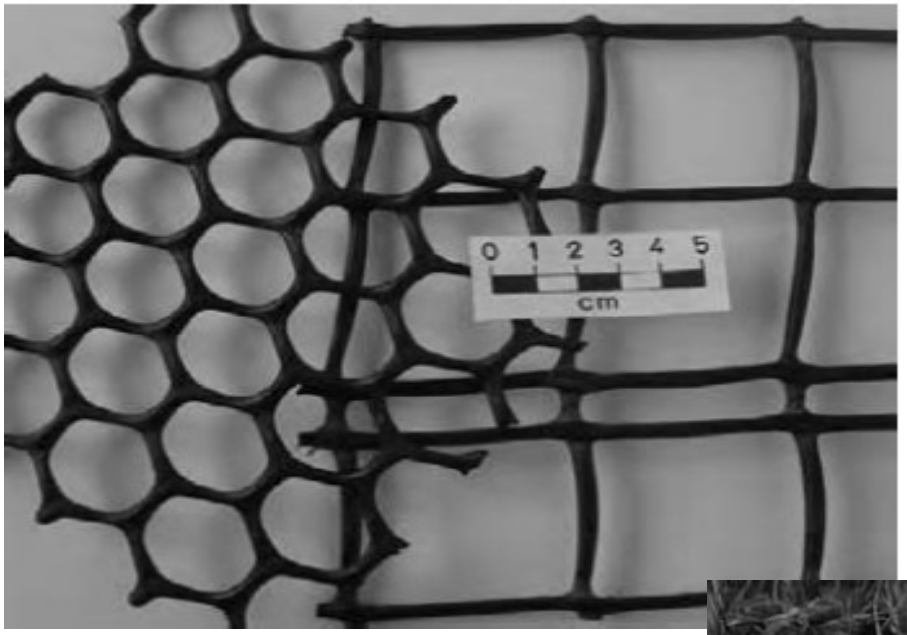
(a)-(ii)(B)

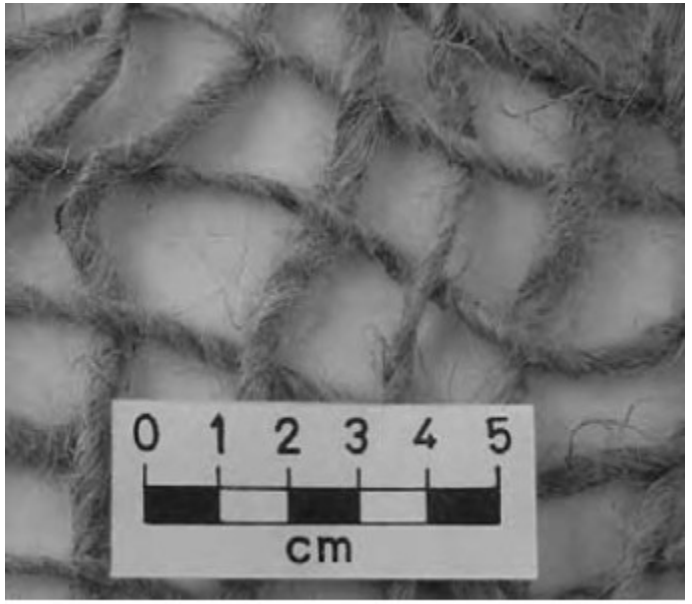


8.GEOMAT

Used to reinforce the roots of vegetation and to extend the erosion control.

9.GEOMESH



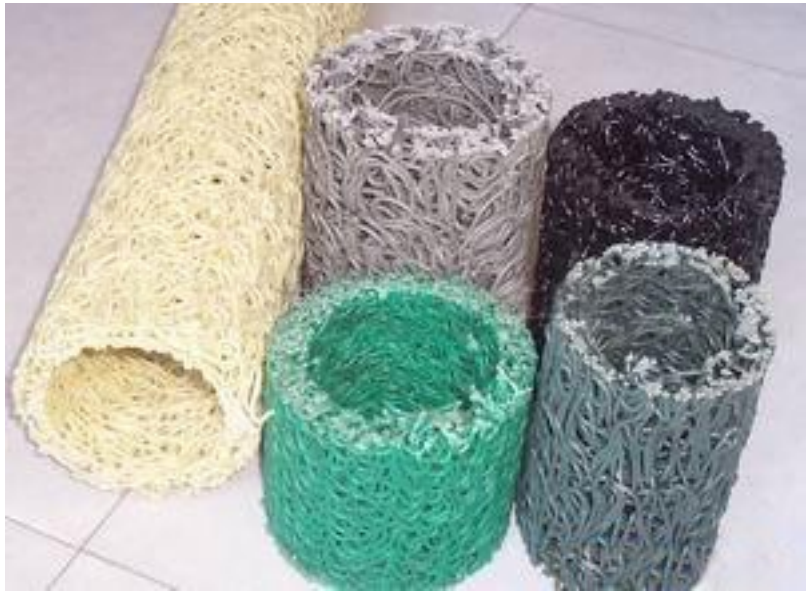


Use for erosion control work

GEOMESH

- A geosynthetic with planar woven structure having large pores sizes, which vary from several mm to cm for use in mainly erosion control.

10.GEOPIPE

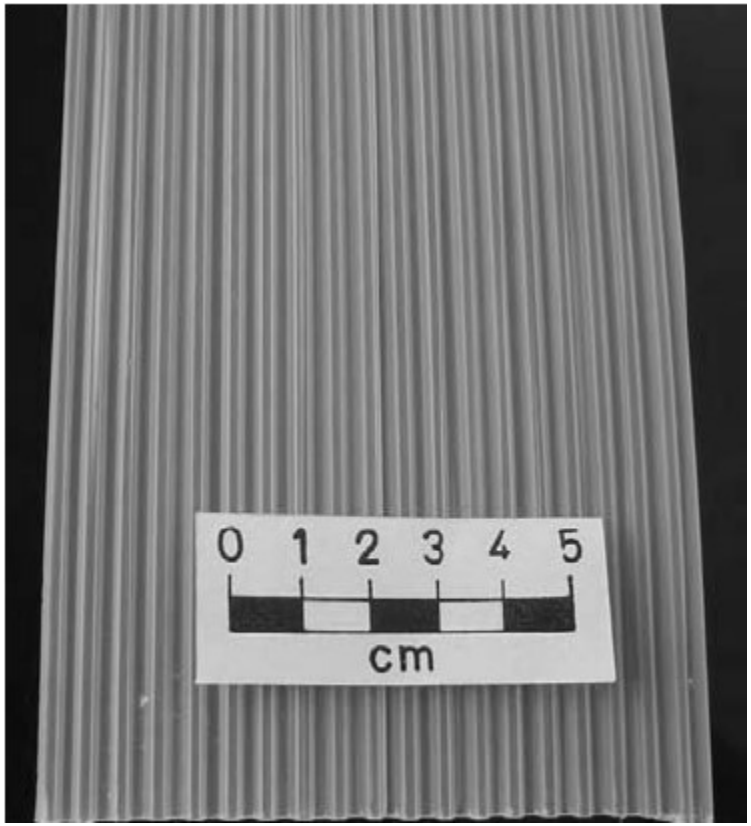


GEOPIPES

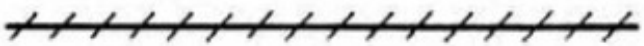
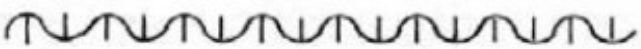
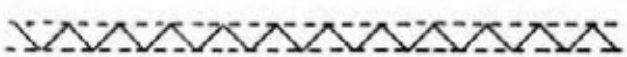
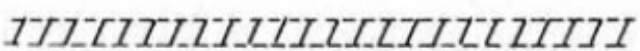
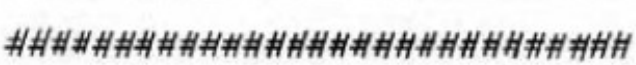
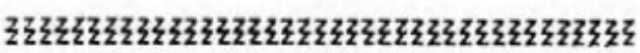
- A plastic pipe placed beneath the ground surface and subsequently backfilled.

11.GEOSPACER

- A three dimensional polymeric moulded structure consisting of corrugated plates with large voids.



TYPES OF GEOSYNTHETICS & THEIR SYMBOLS

Abbreviations	Graphical symbols	Geosynthetic products
GTX		Geotextile
GMB		Geomembrane
GBA		Geobar
GBL		Geoblanket
GCD		Geocomposite drain with geotextile on both sides
GCE		Geocell
GCL		Geocomposite clay liner
GEC		Surficial geosynthetic erosion control
GEK		Electrokinetic geosynthetic
GGR		Geogrid
GMA		Geomat
GMT		Geomattress
GNT		Geonet
GSP		Geospacer
GST		Geostrip

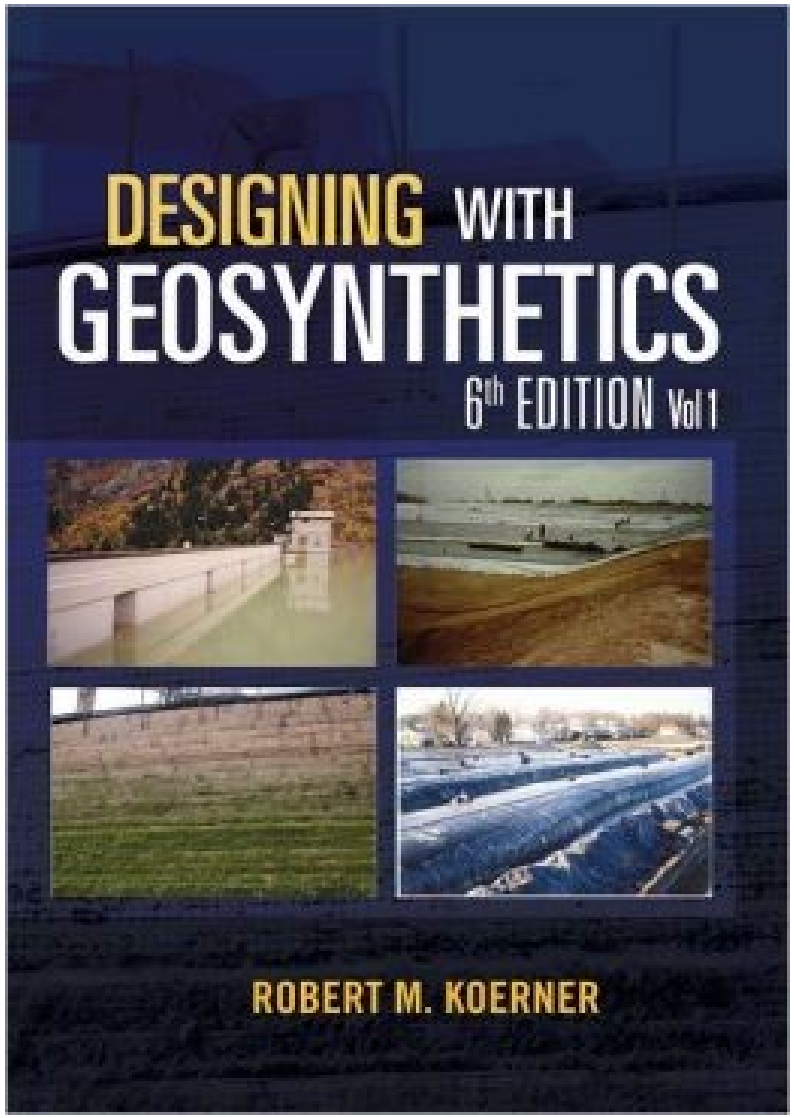
POLYMERS COMMONLY USED FOR THE MANUFACTURE OF GEOSYNTHETICS

Types of polymer	*Abbreviations*
Polypropylene	PP
Polyester (polyethylene terephthalate)	PET
Polyethylene	
Low density polyethylene	LDPE
Very low density polyethylene	VLDPE
Linear low density polyethylene	LLDPE
Medium density polyethylene	MDPE
High density polyethylene	HDPE
Chlorinated polyethylene	CPE
Chlorosulfonated polyethylene	CSPE
Polyvinyl chloride	PVC
Polyamide	PA
Polystyrene	PS

Notes
The basic materials consist mainly of the elements carbon, hydrogen, and sometimes nitrogen and chlorine; they are produced from coal and petroleum oil.

Geosynthetics	*Polymers used for manufacturing*
Geotextiles	PP, PET, PE, PA
Geogrids	PET, PP, HDPE
Geonets	MDPE, HDPE
Geomembranes	HDPE, LLDPE, VLDPE, PVC, CPE, CSPE, PP
Geofoams	EPS
Geopipes	HDPE, PVC, PP

REFERENCE BOOK:



Ground Improvement Techniques

- Ground Improvement or Ground treatment is defined as “controlle d alteration of the state, nature or mass behavior of ground materi als to achieve an intended satisfactory response to existing or proj ected environmental and engineering actions”

Ground Improvement for Cohesive soil

- Pre compression
- Sand drain
- Wick drain
- Stone columns

Ground Improvement for Cohesiveless soil

- Vibroflotation
- Terra Probe
- Dynamic Impaction
- Compaction by blast
- Compaction piles

Ground Improvement by Vibration

- Vibration can be used to compact soils and fills. Similar to Vibrating roll ers used to compact relatively thin layers of earth fill and bituminous ro ad materials. It involves using vibration to densify the ground in place a nd to depth either by penetrating the ground with a vibrator or inducing very high level of energy at the ground surface or at defined points with in the ground.

Major ground treatment methods include;

- Vibro-compaction
- Vibro stone columns
- Dynamic compaction
- Rapid impact compaction
- Vibratory probing
- Compaction piles
- Blasting

Ground Improvement by Adding Load or Increasing Effective Stress

- Applying load on the ground causes it to compress. The extent and time required depends on the arrangement of the ground particles, on the degree of saturation, and on how freely the soil can drain. For loose and particularly unsaturated fills, adding load induces rapid settlement.

- Soft, saturated clays take months or years to consolidate under an add ed load while pore pressures dissipate and the effective stress in the s oil increases.

Major ground treatment methods include;

- Pre-compression
- Vertical drains
- Inundation
- Vacuum pre-loading
- Dewatering fine-grained soils
- Pressure berms

Ground Improvement by Structural Reinforcement

- Many ground improvement methods could be considered as form of rei nforcement. Stone columns are introduced materials that stiffen the gro und. Major ground treatment methods include;
- Reinforced soil
- Soil nailing
- Root or micro-piles
- Slope dowels
- Embankment piles

Ground Improvement by Admixtures

- The use of additives and admixtures, such as lime, cement, oils a nd bitumen and chemicals like sulphur, is one of the oldest and m ost widespread methods of improving a soil. Purpose of this meth od is to strengthen a locally available soil fill to construct a low-cos t road base.

- Cement stabilized soil or soil-cement, or to mix lime into highly pla stic clays is a typical example. Major ground treatment methods in clude;

- Lime columns (Swedish method)
- Lime and cement columns (Japanese method)
- Mix-in-place by single auger or Deep Soil Mixing
- Lime stabilization of slopes
- Lime stabilization of pavements
- Cement stabilization of pavement

Ground Improvement by Grouting

Grouting can be defined as controlled injection of material, usually in a fluid phase, into soil or rock in order to improve the physical chara cteristics of the ground. Major ground treatment methods include;

- Grouting processes
- Permeation grouting
- Hydrofracture grouting
- Jet grouting
- Compaction, squeeze and compensation grouting
- Cavity filling

Ground Improvement by Thermal Stabilization

- The removal of heat from the soil turning its pore water into ice is a very powerful technique rendering the ground impermeable and, for unconsolidated materials, making them stronger.
- Applying heat to clays to drive out free pore water and, at higher t emperatures, the water adsorbed on particle surfaces, creates a v ery hard, durable material, as when making brick or mud building blocks. Major ground treatment methods include;
- Artificial ground freezing
- Artificial ground heating

Grouting for ground improvement

- Intrusion grouting
- Compaction grouting
- permeation grouting
- jet grouting

WHAT IS GROUTING?

- Improvement of soil or rock through injection of grout, cement or chemical grout.

- Grouting may be divided into following :-

1. Intrusion grouting
2. Compaction grouting
3. Permeation grouting
4. Jet grouting
5. Compensation grouting

INTRUSION GROUTING

- The joints or fractures in soil or rock are filled with injection of grout
- Pipes are first inserted into the soil from surface and than the grout is added with pump
- Advantage is, it decreases the permeability of rocks
- Generally cement grout is used
- Water retaining structures like dams, it is used to reduce seepage

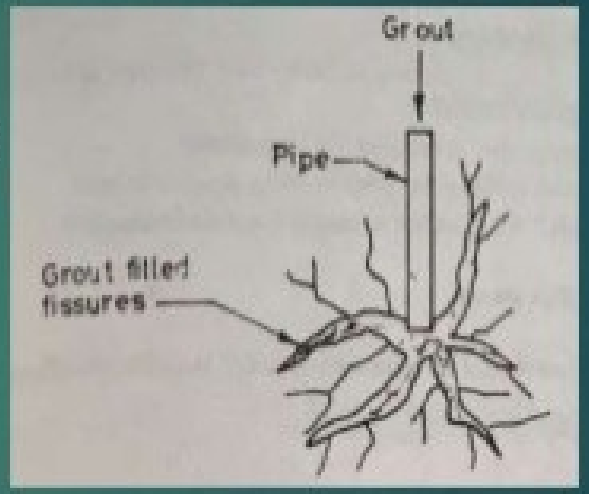


Fig 1. Intrusion Grouting

COMPACTION GROUTING (DISPLACEMENT GROUTING)

- Grout is inserted with pump at high pressure to form a series of intrusions in deposit
- 25 mm thick slump doesn't penetrate deep in soil and compact the adjacent soil
- Resulting increase in strength
- Generally used in loose soil as well as unsaturated fine-soil
- When to restore the structure having excessive settlement, compaction grouting is used to reduce the settlement

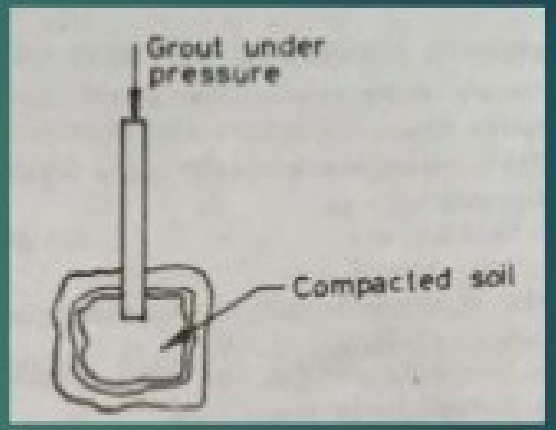


Fig 2. Compaction Grouting

PERMEATION GROUTING

- Thin grouting is inserted into soil that permeates into voids of soil
- The grout cures after a time and turns the soil into solid mass
- Generally used in fine-grained soil
- Makes the soil less compressible, strong and impermeable
- Applied to the projects of tunneling and stabilizing soil before excavation

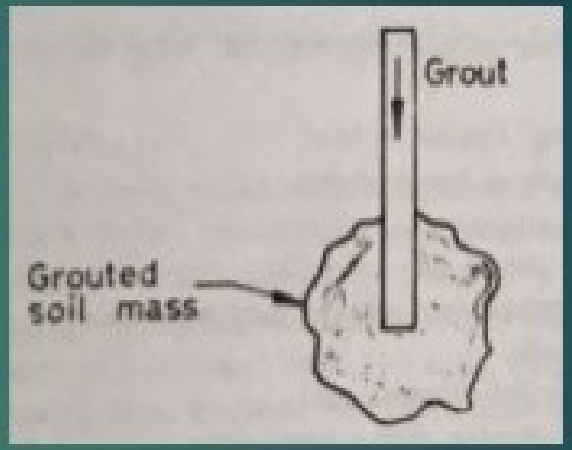


Fig 3. Permeation Grouting

JET GROUTING

- Pipe fitted with horizontal jets inserted into soil at require depth and with pressure grout is inserted
- Pipe is gradually raised and rotated while grouting still being injected
- Column is formed in the soil that makes the soil impermeable and strong
- Applied to water-logged area as well as in stabilization of soil before excavation and tunneling operations

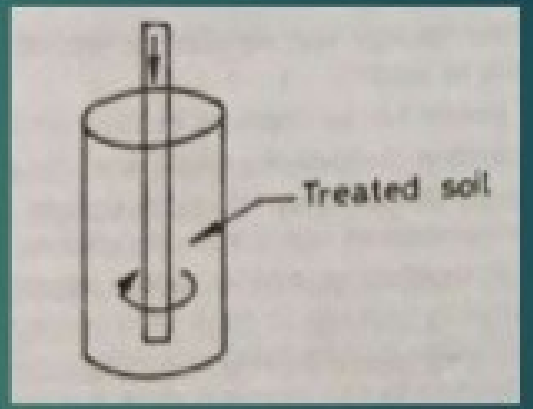


Fig 4. Jet Grouting