CE 8001 / Ground Improvement Techniques

UNIT 1

1. What are the major problematic soils?

1. Collapsible soils
2. Liquefiable soils
3. Waste materials
4. Expansive and shrinkage
5. Marshy and soft soils
6. Karst deposits

2 . What is expansive soil? Give one example.

Expansive soils are soils that expand when water is added, and shrink when they dry out. This continuous change in soil volume can because homes built on this soil to move unevenly and crack.

Ex. Deccan plateau and in some parts of Andhra Pradesh

Minimum volume like liquid limit is highest water content in the range of about 100 percent and the shrinkage limit could be as low as 10 percent.

4. What is a collapsible soil?

These collapsible soils are nothing but the soils, which have a tendency to collapse upon loading. Many of the reasons such as, the stable or unstable meta structure or capillary structures nullification are some of the reasons for this collapsible nature of the soil. Suppose the soil is partly saturated and when it comes in contact with water, the moment there is a contact with water all the capillary structures are destroyed. Because of this, there is a volume change; it is in fact a reduction in volume and that leads to collapse.

5. What are the difficulties faced with soft clay?

When the soft soil is so poor, it is very difficult to construct anything, because the bearing capacity is very low, shear strength is low, consolidation settlements are going to be very high and permeability is very low. These are all very peculiar. So, this needs to be improved.

7. Name the various soil deposits found in India.

1. Black cotton soil
2. Laterites and murmurs
3. Alluvial soil
4. Desert soil
5. Boulder soil

8. Name any four ground improvement techniques. (AUC MAY/JUNE 2013)

1. CompactioPile 2.Blasting
3. Pre-Compression
4. Stone Column
5. Vibrofloatation
6. Grouting 7.Electro Osmosis
8. Thermal Treatment

9. What is the need for improving the ground? (AUC MAY/JUNE 2013)

Reclamation of unusable land

- Betterment of soil properties for improved performance
- Cost effective design of foundations

10. Briefly write the role played by ground improvement in foundation engineering.

- Improves bearing capacity
- Reduces foundation settlements
- Enables construction on granular fil s
- Provides temporary underpinning
- Provides excavation support
- Reduction of foundation dimensions
- Construction of shallow foundations
- Enables dry working conditions for foundation excavations

11. Define ground improvement. (AUC NOV /DEC 2012)

Ground improvement technique is the process of improving the geo-technical characteristics of soil used in construction.

The soil at a construction site is not always totally suitable for supporting structures such as buildings, bridges, highways and dams. For example, In granular soils, in-situ soil may be very loose and indicate large elastic settlement. Under these conditions, soil needs to be dandified to increase its unit weight and shear strength.

12. What is compaction? When is it adopted?

The compaction is process of increasing density of soil means of suitable compaction device . it is predominantly adopted for cohesive soils and also however cohesion less soil can be also compacted by a suitable device .

13. What is dewatering? What are the various methods of dewatering?

Dewatering is the process of continuous removal of water to lower the ground

- water table to the required depth
- Different methods of dewatering are
- Sumps and ditches
- Well point system
- Deep well system
- Vacuum dewatering
- Electro-osmotic dewatering

14. When is pre-loading adopted as a ground improvement technique?

Preloading or pre-compression is the process of placing additional vertical stress on a compressible soil to remove pore water over time

The pore water dissipation reduces the total volume causing settlement

Surcharging is an economical method for ground improvement

15. What is advantage of using vertical drains along with pre-loading?

The main applications of this method are in areas of transportation, highway Embankments, housing projects, hazardous waste remediation and in reducing negative skin friction on pile foundations

Vertical drains are nowadays primarily constructed with prefabricated vertical drains

16. How are heating and freezing used to improve ground?

Heating soils permanently alters the properties of the soil

Depending on the soil, temperatures can range between 300 and 1,000° C

The expected property changes are increase in shear strength and modulus of elasticity Its application areas include immobilization of contaminant and soil stabilization

Freezing

Ground freezing is the use of refrigeration to convert in situ pore water to ice

The ice then acts as a cement or glue,
bonding together adjacent particles of soil or blocks of rock to increase their combined strength and make them impervious

Freezing is mainly adopted for

- Temporary underpinning
- Support for excavation
- Slope stabilization
- Contaminant containment
- To prevent ground water from entering excavation

17. What is a lime column?

Lime column is the process in which soft clays and silts are mixed with dry unslaked lime to form a column of treated soil

This process uses a mixing tool that combines the lime with in-situ material during treatment.

18. What is vibro-compaction? In which soils is it adopted?

Vibrio-Compaction, sometimes referred to as Vibroflotation, is the rearrangement of soil particles into a denser configuration by the use of powerful depth vibrators

It is mainly adopted to reduce settlements, reduce liquefaction hazard and permit construction on granular fills

It can be adopted in sands and silty sands with excellent to good results Its applicability is poor in silts and cannot be adopted for clays

19. What is stone column? What are the methods of installing a stone column?

The vibro Rig displaces the soil by vibrating a mandrel into the ground to the required depth or refusal, whichever is achieved first

The mandrel Is withdrawn and

The subsequent void filled with a clean stone

The mandrel is then re-introduced to the in-filled void and taken down close to the base of the previously formed void, displacing the stone laterally into the surrounding soil

20. What are the various methods of grouting?

- Suspension grouts
- Solution Grouts Colloidal
- solution grouts

Unit II

1. **What is the need for drainage and dewatering?**

- To provide suitable working surface of the bottom of the excavation.
- To stabilize the banks of the excavation thus avoiding the hazards of slides and sloughing.
- To prevent disturbance of the soil at the bottom of excavation caused by boils or piping. Such disturbances may reduce the bearing power of the soil.
- Lowering the water table can also be utilized to increase the effective weight of the soil and consolidate the soil layers. Reducing lateral loads on sheeting and bracing is another way of use.

2. **What are the various methods of dewatering?**

- Surface water control like ditches, training walls, embankments. Simple methods of diverting surface water, open excavations. Simple pumping equipment.
- Gravity drainage.Relatively impermeable soils. Open excavations especially on sloping sites. Simple pumping equipment.
- Sump pumping
- Wellpoint systems with suction pumps.
- Shallow (bored) wells with pumps. Deep (bored) wells with pumps. Eductor system
- 8. Drainage galleries. Removal of large quantities of water for dam abutments, cut- offs, landslides etc. Large quantities of water can be drained into gallery (small diameter tunnel) and disposed of by conventional large – scale pumps.
- 9. Electro-osmosis. Used in low permeability soils (silts, silty clays, some peats) when no other method is suitable. Direct current electricity is applied from anodes (steel rods) to cathodes (well-points, i.e. small diameter filter wells)

3. **How are sumps and ditches used in dewatering?**

A sump is merely a hole in the ground from which water is being pumped for the purpose of removing water from the adjoining area .They are used with ditches leading to them in large excavations. Up to maximum of 8m below pump installation level; for greater depths a submersible pump is required.

4. **What are the advantages of sumps and ditches in dewatering?**
   - It is the most widely used and economical of all methods of ground water lowering. This method
   - is also more appropriate in situations where boulders or other massive obstructions are met in the ground.
5. **What is a well point system?**

This type of dewatering system is effective in soils constituted primarily of sand fraction or other soil containing seams of such materials. In gravels spacing required may be too close and impracticable. In clays it is also not used because it is too slow.

6. **What are the different types of well point systems?**
   - single stage well point multistage well
   - point
   - well points in braced excavations deep well
   - drainage
7. **When are deep wells used for dewatering? (AUC NOV /DEC 2012)**

Deep well systems are of use in gravels to silty fine sands and in water bearing rocks. They are priority or use with deep excavations and where artesian water is present below an impermeable stratum.

If this type of installation is to be designed economically the ground permeability must be assessed from full scale pumping tests.

8. What is the principle behind vacuum dewatering?

Gravity methods, such as well points and deep wells are not much effective in the fine- grained soils with permeability in the range of 0.1 –10 x 10^{-3} mm/s.

Such soils can be dewatered satisfactorily by applying a vacuum to the piping system

9. What is electro-osmotic dewatering?

When an external electro motive force is applied across a soild liquid interface the movable diffuse double layer is displaced tangentially with respect to the fixed layer . this is electro osmosis. As the surface of fine grained soil particles causes negative charge, the positive ions in solution are attracted towards the soil particles and concentrate near the surfaces

10. What are the various types of drains?

- open drains closed drains
- horizontal drains foundation
- drains blanket drains
- interceptor drains
-

11. Define permeability and seepage.

Permeability of soil its capacity to transmit a fluid to pass through its interconnected void spaces . K = v/I

V= the discharge velocity I = hydraulic gradient

Water flows through the voids in a soil which are **in**terconnec**te**d. **Thi**s **fl**ow may **b**e ca**lle**d seepage, since the velocities are very small.

12. What are the requirements of drains should be satisfy. (AUC NOV /DEC 2010)

Sand drains consist of a column of pervious sand placed in a cased hole, either driven or drilled through the soil, with the casing subsequently removed. The ca-pacity of sand drains can be significantly increased by installation of a slotted 1% or 2-inch pipe inside the sand drain to conduct the water down to the more per-vious stratum.

13. Define sensitive clay (AUC NOV /DEC 2010)

Clay whose shear strength is decreased to a fraction of its former value on remolding at constant moisture content.

14. How the dewatering carried out for the construction of the bored tunnel .

(AUC MAY/JUNE 2013)

Groundwater Engineering provides complete dewatering solutions: Design of

- dewatering systems
- Well drilling and installation Pumping tests
- Equipment sales and rental Monitoring systems
- On-site operation and maintenance
-

• 15. What are the problems occurred to seepage of water (AUC MAY/JUNE 2012)

Common causes of water seepage :

1. Leakage in the drainage pipes of the upper, adjacent or your own flat.
2. Leakage in the water supply pipes of the upper, adjacent or your own flat.
3. Deteriorated waterproofing of floor slabs or bath-tub seals.
4. Seepage of waste water or rain water through roof / external wall

17. State the advantages and disadvantages of dewatering. (AUC NOV /DEC 2012) ADVANTAGES

Reduces the amount of sediment leaving the site

Allows for a more in-depth site assessment – additional necessary erosion control measures may

be identified

DISADVANTAGES

- Must abide by multiple government laws and standards and obtain appropriate permits
- Requires frequent maintenance
- May be costly

18. **Define Cutoffs**.

Cutoff curtains can be used to stop or minimize seepage into an excavation where the cutoff can be installed down to an impervious formation. Such cutoffs can be constructed by driving steel sheet piling, grouting existing soil with cement or chemical grout, excavating by means of a slurry trench and backfilling with a plastic mix of betonies and 'soil, in-stalling a concrete wall, possibly consisting of overlap-ping shafts, or freezing.

19. what are the types of drainage ?

Land Drainage: This is large scale drainage where the objective is to drain surplus

- water from a large area by such means as excavating large open drains, erecting dykes and levees and pumping. Such schemes are necessary in low lying areas and are mainly Civil Engineering work

ii) Field Drainage

This is the drainage that concerns us in agriculture. It is the removal of excess water fromthe root zone of crops.

20. **State electro osmotic consolidation**

Due to the applied electric potential the electrolysis of water occurs at the electrodes
$2H_2O \rightarrow O_2 (g) + 4H^+ + 4e^-$ oxidation (anode) $4H_2O + 4e^- \rightarrow 2H_2 (g) + 4OH^-$ reduction (cathode)

The clay particles have a â€œve charge. These â€œve charge produce an electro static surface property known as the double layer which creates a net abundance of cations

21. Define Dewatering.

Dewatering or construction dewatering are terms used to describe the action of removing groundwater or surface water from a construction site. Normally dewatering process is done by pumping or evaporation and is usually done before excavation for footings or to lower water table that might be causing problems during excavations. Dewatering can also be known as the process of removing water from soil by wet classification.

UNIT III

1. **What do you understand from the term in-situ densification?**

   Densification is the most popular liquefaction resistance measure but its performance is poorly understood. Therefore, evaluation of if and of how densification should be carried out in a particular field situation is currently based on semi-empirical principles derived from post-failure analysis of liquefaction effects.

2. **What are the various methods of in-situ densification?**
   - rapid impact compaction deep
   - dynamic compaction ibro
   - compaction method

3. **What are the merits and demerits of dynamic compaction?**

   Merits

   a. Simplest and most basic method
   b. Depth of compaction up to 20m
   c. All types of soil can be compacted
   d. Produces equal settlements more quickly compared to surcharge loading
   e. Can treat above and below water table

   Demerits

   Can cause loosening of soil on surface Can cause distress to nearby structures

4. **What is dynamic consolidation? (AUC MAY/JUNE 2013)**
   - The application of this method is same for cohesive soils but more time is required
   - Several blows are applied to one location followed by one to four weeks of rest, the

   b. process is then repeated

5. **What are the advantages of Rapid impact compaction?**
   - Energy is delivered at a rate of 40 to 60 blows per minute
   - The foot, measuring 5 feet in diameter, is maintained in contact with the ground

6. **What is vibro-flotation?**

   Vibro-compaction, sometimes referred to as

   b. vibro-flotation is a deep compaction ground
   c. treatment technique for densifying granular soils in-situ by means of a vibrating probe, or
   d. “vibroflot”
      - It is mainly adopted to reduce settlements, reduceliquefactionhazardandpermit

   e. construction on granular fills

7. **What are the applications of vibro-flotation?**

   Vibro-compaction increases both the moist and submerged unit weights of the soil and improves the angle of internal friction. Consequently, bearingcapacity is increased

   Anticipated foundation settlements are reduced due to increases in compressibility modulii, resulting from pre-straining prior to loading

   Resistance to liquefaction is improved since void ratios are decreased and confining pressures are increased

8. **Differentiate top feed from bottom feed method.**

   In this technique, jetting water is used to remove soft material, stabilize the probe hole, and ensure that the stone backfill reaches the tip of the vibrator

   This is the most commonly used and most cost-efficient of the deep vibratory methods

   However, handling of the spoil generated by the process may make this method more difficult to use in confined sites or in environmentally sensitive areas

   This technique uses the same vibrator probes as standard Vibro-Replacement Stone Columns, butwith the addition of a hopper and supply tube to feed the stone backfill directly to the tip of the vibrator

   Bottom Feed Vibro-Replacement is a completely dry operation where the vibrator remains in the ground

during the construction processThe elimination of flushing water in turn eliminates the generation of spoil, extending the range of sites that can be treated

9. How is a rammed stone column installed?

The hammering causes the sand to fill the voids in the stones and hence full compaction is achieved

The Length of the stone Column should be more than LcLc>= [P-Ac(9cpt)]/(πdc) Where,
P= Total load on stone column
Ac= Cross-sectional area of stone column D
= Average diameter of stone column
c, cpt= Side and point cohesion

10. What is a sand compaction pile?

a. *Sand* compaction piling (SCP) also known as Vibro-composer method, is a
b. cost-effective
c. method of ground improvement which is
d. commonly used to improve soft seabed soils
e. prior to land reclamation works.
   - This method involves driving closely-spaced sand columns into the soft seabed to form
f. a grid ofsand columns, which imparts higher strength and stiffness to the improved ground.

11. Differentiate lime pile from sand compaction pile.

(AUC NOV /DEC 2012)

Lime piles are small diameter boreholes formed in the ground filled with lime

a. • It is different from lime columns which are large diameter columns of lime stabilized material
b. which are mixed in place
   - *Sand* compaction piling (SCP) also known as Vibro-composer method, is a
c. cost-effective method of ground improvement which is commonly used to improve soft seabed soils
d. prior to land reclamation works.

11. What is the principle behind pre compression?

- Preloading increases the pore pressure in the soil
- The excess pore pressure developed is slowly

b. dissipated by expulsion of pore water resulting in consolidation of soil
   - This increases the effective stress since

c. $\sigma' = \sigma - u$
d. As u decreases, σ' increases

12. Write the various methods of preloading.

a. Heaping of materials
   - Embankment loading
   - Time – 3-8 months
   - Height – 1.5m (min) to 18m (max) commonly 3-8m
   - Settlement – 0.3 to 1m, 2m in exceptional cases
   - Final structure as preload
   - Lowering of water table
   - Hydro-compaction
   - Vacuum preloading
   - Jacking techniqueWith vertical drains

13. What is the function of vertical drain?

- Vertical drains are installed under a surcharge load to accelerate the drainage of

impervious

b. soils and thus speed up consolidation

c. • These drains provide a shorter path for the water to flow through to get away from the soil
   • Time to drain clay layers can be reduced from years to a couple of months

14. Write the various types of vertical drains used in ground improvement.

- Sand Drain
- Sand Wicks
- Plastic Drains
- Prefabricated Drain (Wick Drains)

15. Compare sand drains and wick drains.

- These are ready-made small diameter sanddrains whıch are contained in long canvas

bags(approximately 10 cm in diameter)

- They are usually installed by close mandreltechnique
- They are relatively cheap
- Sand drains are basically boreholes filled with sand
  - For the displacement type of sand drains, a closed mandrel is driven or pushed into the ground with resulting displacement in both vertical and horizontal directions

16. What are the applications of sand pile. (AUC NOV /DEC 2010)

- **Advantages:**

i. Economical for moderate depths upto 15m
ii. Treated grounds generally has uniform properties
iii. Soft clay strength is improved upto 50%

- **Disadvantages:**

i. Soil at shallow depth may have less density and density decreases radially
ii. Too close spacing may result in constructiondifficulties while too wide spacing may lead to no effect (2.5 < (Spacing/diameter) < 4)

17. Define dynamic compaction . (AUC MAY/JUNE 2013)

Simply put, densification consists of in-situ densification of loose sands and gravels.Densification occurs through application of energy in various forms including dropping weights, induced vibrations, jetting action

UNIT IV

1. **Define geosynthetics. (AUC NOV /DEC 2012)**

Geosynthetics are artificial fibres used in conjunction with soil or rock as an integral part of a man made project

They are mainly grouped into two categories

a. Geotextiles – permeable

b. Geomembrane – impermeable

2. What are the various types of geosynthetics?

- Geonets Geomats
- Geosynthetic clay liners
- Geofoam
- Geocells
- Geocomposites
- Geotextiles
- Geogrids
- Geomembranes

3. **How does the use of a geosynthetic as a filter differ from that of Drainage? (AUC NOV /DEC 2010)**

- Filtration applications are highway underdrain systems, retaining wall drainage, landfill leachate collection systems, as silt fences and curtains, and as flexible forms for bags, tubes and container
- Drainage applications for these different geosynthetics are retaining walls, sport fields, dams, canals, reservoirs, and capillary breaks

4. **Write a brief note on geosynthetics as reinforcement.**

Containment involves geomembranes, geosynthetic clay liners, or some geocomposites which function as liquid or gas barriers

Landfill liners and covers make critical use of these geosynthetics

All hydraulic applications (tunnels, dams, canals, reservoir liners, and floating covers) use these geosynthetics as well

5. **Define soil nailing.**

Soil nails are more or less rigid bars driven into soil or pushed into boreholes which are filled with grout.Together with the insitu soil, they are intended to form a coherent structural entity supporting on excavation or arresting the movement of on unstable slope.

6. **Define Geotextiles.**

- Continuous sheets of woven, nonwoven, knitted or stitch bonded fibres or yarns
- Flexible and permeable
  - Appearance of a fabric
- Usually PET or PP

7. **Define Geogrids.**

- Open grid like appearance
- Principally for reinforcement of soil • PP, PET, or PE

8. **Define Geonets**

- Open grid like material formed by two (or three) sets of coarse, parallel, extruded polymeric strands intersecting at an constant acute angle
- HDPE

9. **Define Geopipes**

- Perforated or solid wall pipes

- May be wrapped with a geotextile
- HDPE

10. **Define Geomembranes**

- Continuous flexible sheets from one or more synthetic materials
- Relatively impermeable
- 1.5mm to 3mm thick, HDPE, LLDPE

11. **What is Geosynthetic Clay Liners**

- Bentonite clay layer between two or more geotextiles, in some cases with a geomembrane
- Relatively impermeable

12. **What is mean by Geocells**

- Three dimensional honeycomb like structure formed by strips of joined polymeric sheets, usually HDPE or LDPE

13. **Define Geofoam**

Lightweight blocks or slabs formed by expanded polystyrene (EPS)

Used for thermal insulation, as lightweight fill or compressible vertical layer against rigid walls

14. **Define Geocomposites**

- Combination of two of more geosynthetic types
- Geotextile – geogrid • Geopipe - geotextile • Geotextile – geonet
- Geonet – geomembrane
- Non-woven geotextile – woven geotextile

15. **Define ground stabilization**

Increase bearing capacity over weak subgrades • Reduce fill thickness

- More favourable stress distribution • Reduce lateral fill movement
- Increase lifetime
- Pavements and railways
- Working platforms / Crane pads
- Strength in multiple directions, most biaxial

16. **What is mean by reinforced soil? (AUC MAY/JUNE 2013)**

Theoretically any soil can be used as a fill material
Conventionally well graded cohesionless soils are used as fill material but are costly
Cohesive soils are cheap and easily available but have long term durability problems
A convenient compromise is a fill material that has both cohesiveand Frictional properties.

17. **list of functions geotextiles of filters (AUC NOV /DEC 2012)**

Geosynthetics can allow water to pass across the plane while prevent or retain the soil particles Act similar to sand filter

- Allow water to move through soil while retaining upstream soil particles
- Prevent migration through drainage aggregate and pipes

UNIT V

1. Define grouting.

Grouting is defined as the process of injecting suitable fluid under pressure into the subsurface soil or rock to fill voids, cracks and fissures for the purpose of improving the soil. The fluid may be colloidal solutions, cement suspensions, chemical solutions etc.

2. Write the applications of grouting. (AUC MAY/JUNE 2013)

1. Producing mass concrete structures and piles
2. Fixing ground anchors for sheet pile walls, concrete pile walls, retaining walls tunnels etc
3. Repairing a ground underneath a formation or cracks
4. Defects on building masonry or pavement
5. Fixing the tendons in prestressed post tensioned concrete
6. Filling the void between the lining and rock face in tunnel works
7. Seepage control in soil
8. Soil stabilization and solidification
9. Vibration control

3. Write the various types of grouting.

- Suspension grouts Solution
- Grouts Colloidal solution
- grouts

4. What are the different types of grouts?

- Compaction grouting
- Permeation grouting
- Hydraulic fracturing Jet
- grouting

Name the different methods of grout injection.

Bottom up Top down
Circuit grouting Tube-a-manchette Point grouting
Electro-kinetic injection

5. What are the two methods of mechanical stabilization?

Removal &Replacement Dynamic compaction
Precompression
Insitu Replacement Blast Densification

6. How is stabilization of soil achieved by cement?

cement stabilisation - which uses higher percentages of cement and produces a stiff, semi- rigid pavement material.The design of cement-soil-water mixtures is based on selecting the minimum cement content required to provide sufficient strength and durability to enable the material to function as a satisfactory layer in the pavement structure. The amount of cement required is determined by laboratory testing, usually using the unconfined compressive strength test.

7. What are the methods adopted in construction of stabilized roads?

Stabilization with lime
Combined stabilization with lime and flyash Stabilization with cement
Stabilization with RRP-235
Cost and strength of stabilized layers
Change of the strength in an unconfined compression in connection with the comprehensiveness of the soil in lime and cement 7% and 5 kg RRP/100 m^2

10. What are the various stages of action in lime stabilization?

- gglomeration of fine clay particles, though base exchange;
- weak cementing action, due to calcium carbonate formation; and slow, long-
- term cementing action.

11. Write the various classes of chemicals used in stabilization of soil.

- pulverization; cement content; moisture content; mixing; compaction; finishing;

12. Define Suspension grouts and group grouts . (AUC NOV /DEC 2010)

Suspension grouts

These are multi-phase systems capable of forming sub systems after being subjected to natural sieving processes, with chemical properties which must ensure that they do not militate against controlled properties of setting and strength.

- Water in association with cement, lime, soil, etc., constitute suspensions.
- Emulsion (asphalt or bitumen) with water is a two-phase system which is also included under suspension.

Solution Grouts

- These are intimate one-phase system retaining an originally designed chemical balance until completion of the relevant reactions. Silicate

derivatives, lignosulphite derivatives, phenoplast resins etc. come under this category.

12. State the conditions required the injection grouting method ? (AUC NOV /DEC 2010)

The grouting process the basic information to be obtained is the weight for suspension grouts and volume for solution grouts flow rate along with pressures for both.
The measurements of weight or volume should be made accurately so as confirm mix proportions.
In solution grouting positive displacement meters may be used for these purpose

13. Discuss the basic function of grouting . (AUC MAY/JUNE 2013)

Grouting is defined as the process of injecting suitable fluid under pressure into the subsurface soil or rock to fill voids, cracks and fissures for the purpose of improving the soil.
The fluid may be colloidal solutions, cement suspensions, chemical solutions etc.

14. Write few words about jet grouting (AUC NOV /DEC 2012)

The jet grouting technique is developed in the 1960s. However, because of its unique properties, it is becoming quite popular in the civil engineering works. Its main applications are: -

- Grouting of clay / silt soils which is not suitable for TAM grouting technique.
- Jet grout wall and roof are used to reinforce tunnel portal excavation works.