



Soil Exploration

Today's Lecture

- Purpose of Soil Exploration
- Different methods
 1. Test trenches and Pits
 2. Auger and Wash Boring
 3. Rotary Drilling
 4. Geophysical Methods
- Soil Sampling (Disturbed and Undisturbed)

COMMON STAGES IN SITE INVESTIGATION

Desk Study

- Site Reconnaissance
- Field Investigations
 - a) Preliminary Ground Investigation
 - b) Detailed Ground Investigation
- Laboratory Testing
- Report Writing
- Follow up Investigations during design & construction
- Appraisal of performance

SOIL INVESTIGATION

- **Determination of surface and subsurface soil conditions and features in an area of proposed construction that may influence the design and construction and address expected post construction problems.**

SCOPE OF INVESTIGATION

- **Simple visual examination of soil at the surface or from shallow test pits.**
- **Detailed study of soil and groundwater to a reasonable depth (influence zone) by sampling from bore holes, shafts and audits and in-situ and laboratory tests.**

~~PURPOSE OF SOIL INVESTIGATION~~

The site investigation provides first hand information for;

- **Selection of foundation type.**
- **Design of foundations.**
- **Contractors to quote realistic and competitive tenders.**
- **Planning construction techniques.**
- **Selection of appropriate construction equipment (especially for excavation and foundations).**
- **Feasibility studies of the site.**
- **Estimating development cost for the site.**
- **Study of environmental impacts of the proposed construction.**



PURPOSE OF SOIL INVESTIGATION:

- Selection of borrow areas for embankments.
- Need for any suitable soil improvements.
- Requirement of any surface or subsurface drainage.
- Selection of the most suitable and economical route for highways with respect to soil conditions.
- Selecting areas (better soil) for engineering structures where there is flexibility in relocating the structure thus realizing considerable savings in foundation costs.
- The design of extension works to existing structures.
- the investigation of the cases where failure has occurred, to know the causes and design of remedial works.



Engineering Limited
 1000
 1000
 1000, Ontario

Log of Borehole:

Project No.:

Project: Port Sidney Oil Terminal

Client: Inter-Island Gas

Location: Port Sidney

Enclosure: 1

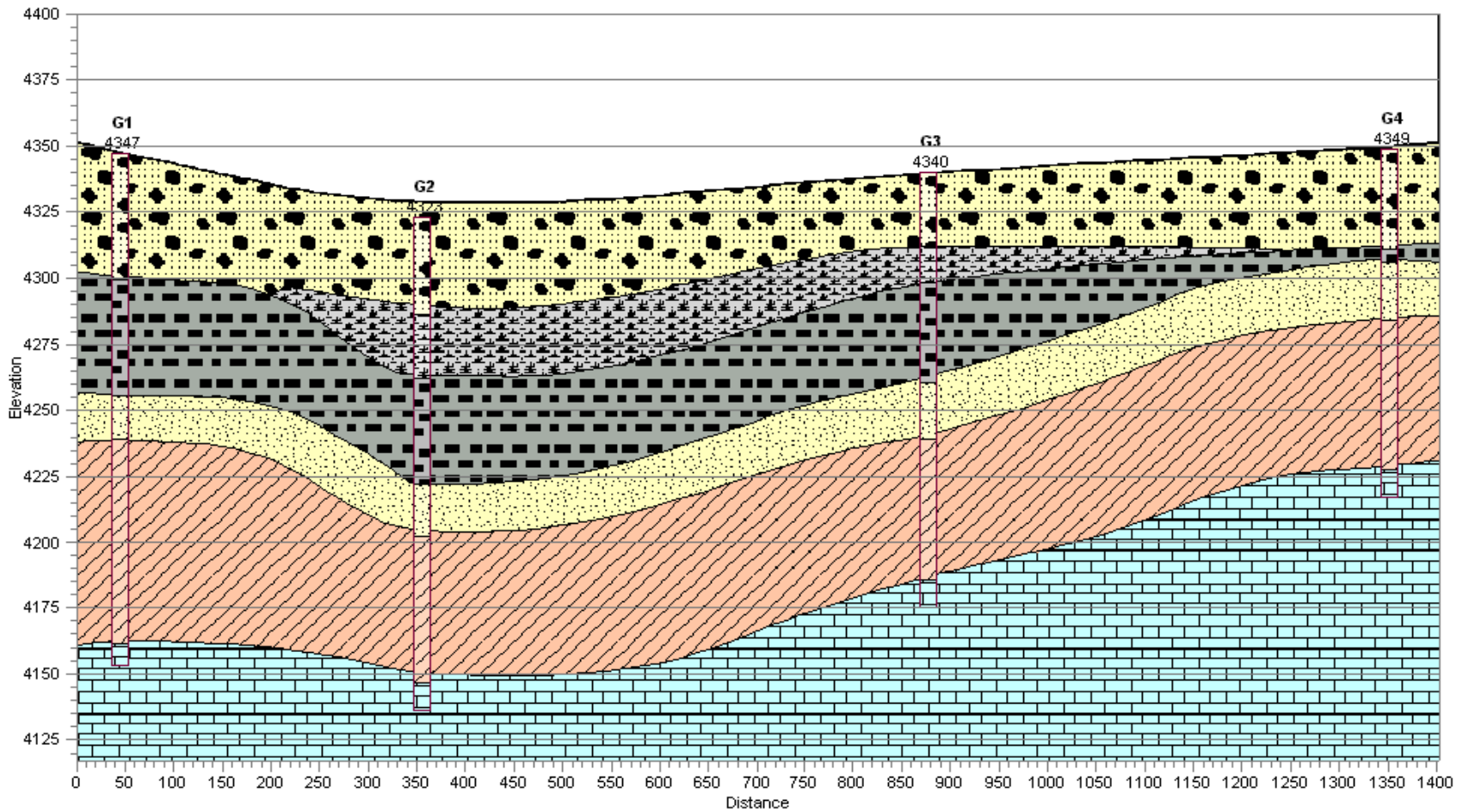
Project Manager: M. Fraser

SUBSURFACE PROFILE		SAMPLE				Well Completion Details
Description	Depth/Elev.	Number	Type	Recovery	Vapour	
Ground Surface	102 1 101 0					<p>Concrete Steel Well Cover 1" Steel Casing Bentonite Seal #2 Silica Sand Slot 10 Screen</p>
Asphalt						
Silt sand and gravel fill, some organic debris.	98	1	█	40	180	
Sandy Silt moist, brown to grey sandy silt with embedded gravel.	96	2	█	30	220	
Sand medium to fine sand, occasional clay lenses. Strong hydrocarbon odour.	95	3	█	75	380	
		4	█	60	450	
Clay mottled brown and grey silty clay. Some sandy lenses.	90	5	█	55	315	
	87	6	█	80	210	
Sand compact, coarse to medium sand. Shell fragments.	84	7	█	45	125	
	82					
	19					

Drilling Company
 S Auger
 2000

Hole Size: 12"
Datum: Local
Sheet: 1 of 1

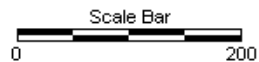
Boring Logs



GAEA Technologies
 44 Canadian Oaks Dr.
 Whitby, ON L1N 6W8
 CANADA

Project: Tutorial

Project Number: 2000-001
 Location: Someplace, somewhere
 Drawn By: M. Fraser
 Date: 11/02/2000



Legend

- | | | |
|------|------|-----------|
| Till | Coal | Clay |
| Peat | Sand | Limestone |

Plan View



METHODS OF INVESTIGATION



METHODS OF INVESTIGATION

The methods to determine the sequence, thickness and lateral extent of the soil strata and, where appropriate the level of bedrock.

The common methods include

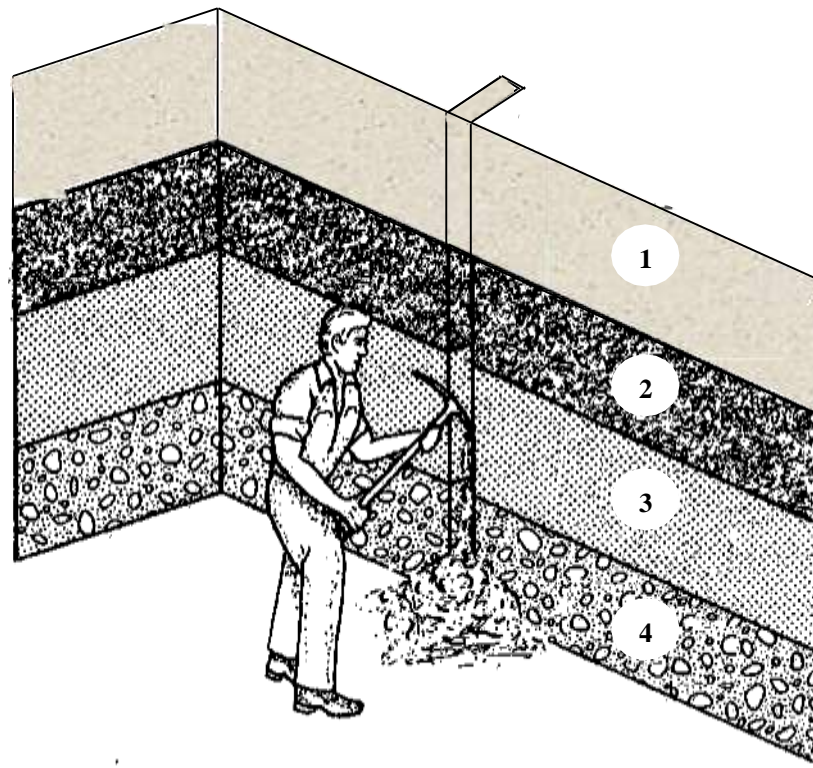
- Test pits
- Shafts and audits
- Boring or drilling



Test Pits

- The excavation of test pits is a simple and reliable method.
- The depth is limited to 4-5m only.
- The in-situ conditions are examined visually
- It is easy to obtain disturbed and undisturbed samples
- Block samples can be cut by hand tools and tube samples can be taken from the bottom of the pit.

Walls of the test pit indicate four layers (1) Clayey silt (2) Sandy silt (3) Clean sand (4) Sandy gravel





Boring or Drilling

Boring refers to advancing a hole in the ground.

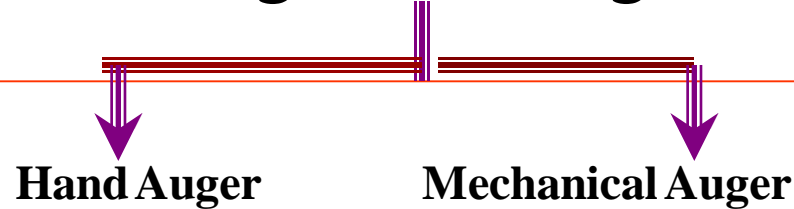
Boring is required for the following:

- To obtain representative soil and rock samples for laboratory tests.
- To identify the groundwater conditions.
- Performance of in-situ tests to assess appropriate soil characteristics.

Some of the common types of boring are as follows

- **Auger boring**
- **Wash boring**
- **Percussion boring**
- **Rotary drilling**

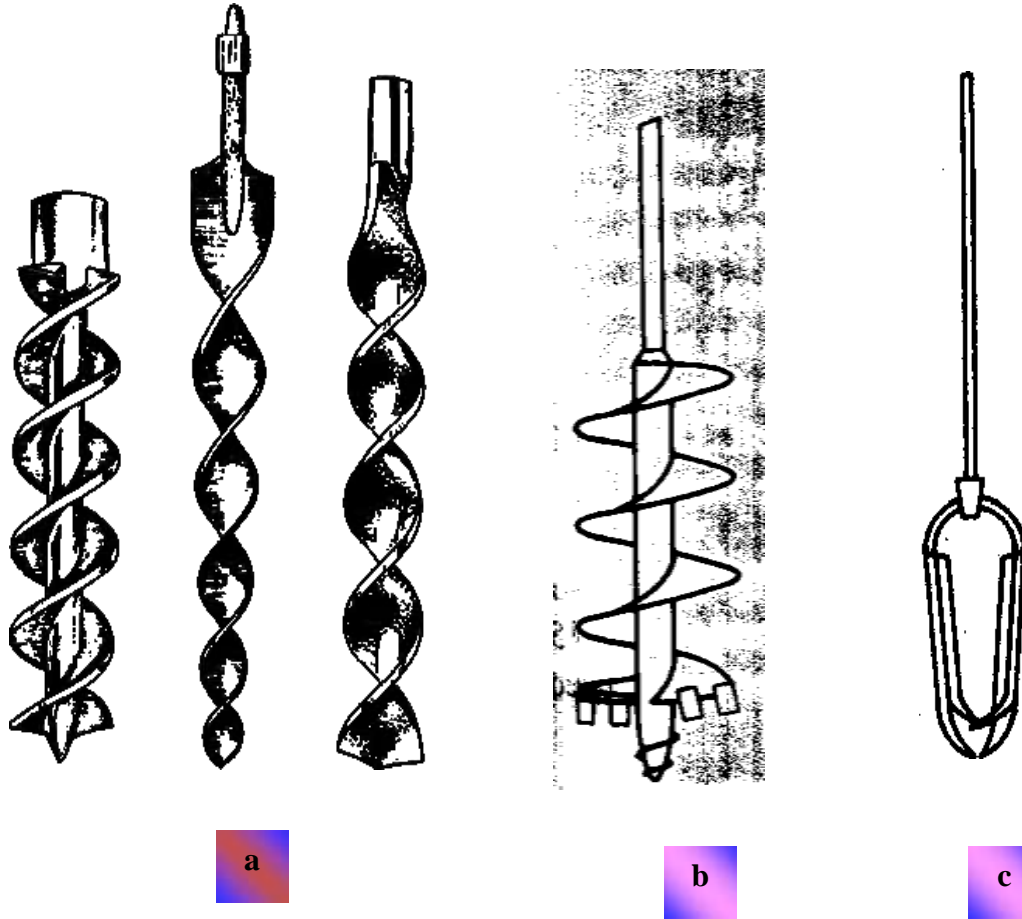
Auger Boring



Hand Auger

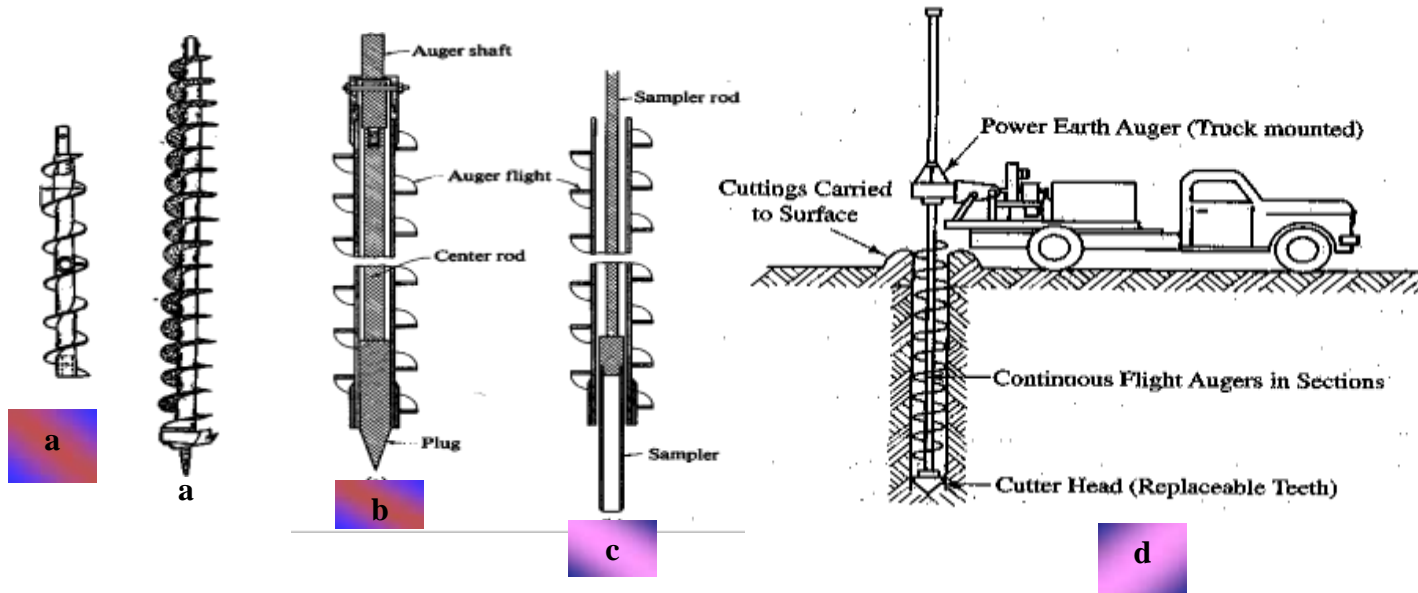
- ✿ It is the simplest method of boring used for small projects in soft cohesive soils.
- ✿ For hard soil and soil containing gravels boring with hand auger becomes difficult.
- ➡ Hand-augered holes can be made upto about 20m depth, although depth greater than about 8-10m is usually not practical.
- ✿ The length of the auger blade varies from 0.3-0.5m.
- ✿ The auger is rotated until it is full of soil, then it is withdrawn to remove the soil and the soil type present at various depths is noted.
- ✿ Repeated with drawl of auger for soil removal makes boring difficult below 8-10m depth.
- ✿ The soil samples collected in this manner are disturbed samples and can be used for classification test. Auger boring may not be possible in very soft clay or coarse sand because the hole tends to collapse when auger is removed

Helical (worm types) Augers *b. Short flight Auger*
c. Iwan (posthole) Auger



Mechanical Auger

- ❁ Mechanical Auger means power operated augers. The power required to rotate the auger depends on the type and size of auger and the type of soil.
- ❁ Downwards pressure can be applied hydraulically, mechanically or by dead weight





a. Continuous Flight Auger

b. Hollow-stem auger plugged during advancing bore

c. Plug removed and sampler inserted


d. Truck mounted auger boring machine

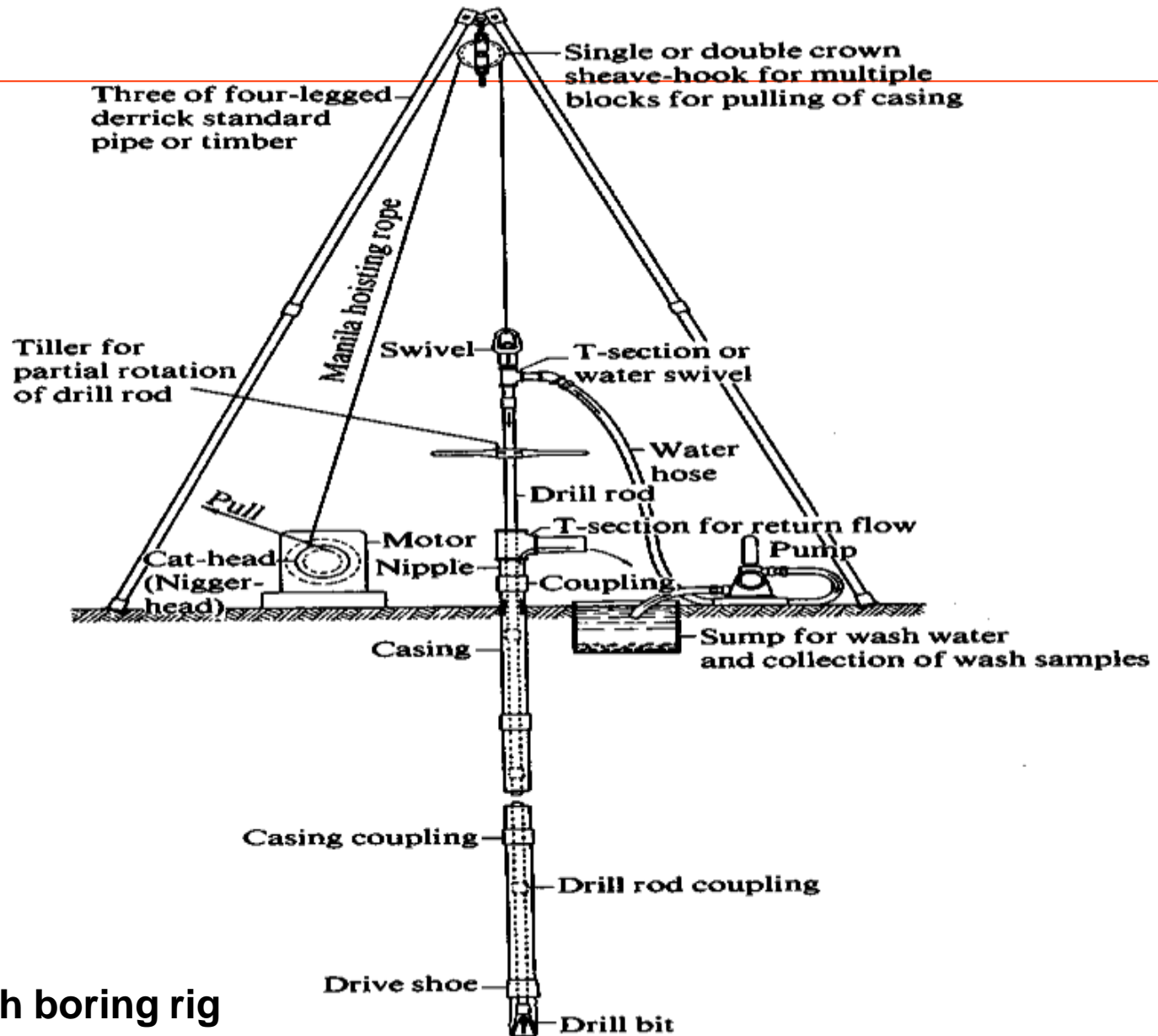
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- ❁ The diameter of the flight auger usually is between 75 to 300mm, although diameters up to 1m and bucket augers up to 2m are available.
 - ❁ Borehole depths up to 50m are possible with continuous-flight augers.
 - ❁ The most common method is to use continuous flight augers. Continuous flight augers can be solid stem or hollow stem with internal diameter of 75-150mm.
 - ❁ Hollow stem augers are used when undisturbed samples are required. Plug is withdrawn and sampler is lowered down and driven in to the soil below the auger.
 - ❁ If bed rock is reached drilling can also take place through the hollow stem.
 - ❁ As the auger acts as a casing it can be used in sand below water table. The possibility of rising sand in to the stem by hydrostatic pressure can be avoided by filling the stem with water up to the water table

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- ❁ The soil rises to the surface along the helical blades, obviating the necessity of withdrawal.
 - ❁ They are not suitable for soil bore that require casing, which demand removal of auger for driving the casing.
 - ❁ The presence of cobbles and boulders create problems with small-sized augers.
 - ❁ There is a possibility that different soil types may become mixed as they rise to the surface and it may be difficult to determine the depths of changes of strata. Experienced driller can however detect the change of strata by the change of speed and the sound of drilling.

Wash boring

- ❁ Water with high pressure pumped through hollow boring rods is released from narrow holes in a chisel attach to the lower end of the rods.
- ❁ The soil is loosened and broken by the water jet and the up-down moment of the chisel.
- ❁ The soil particles are carried in suspension to the surface between the rock and the borehole sites.
- ❁ The rods are raised and drop for chopping action of the chisel by means of winch.
- ❁ Wash boring can be used in most type of soil but the progress is slow in coarse gravel strata.


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- ❖ The accurate identification of soil strata is difficult due to mixing of the material as they are carried to the surface.
 - ❖ The method is unacceptable for obtaining soil samples.
 - ❖ It is only used for advancing the borehole to enable tube sample to be taken or field test to be carried at the hole bottom.
 - ❖ The advantage is that the soil immediately below the hole remains relatively un-disturbed



Wash boring rig

ROTARY DRILLING

- ❁ The rig consists of a derrick, power unit, winch, pump and a drill head to apply high-speed rotary drive and downward thrust to the drilling rods.
- ❁ Primarily intended for investigation in rock, but also used in soils.
- ❁ The drilling tool, (cutting bit or a coring bit) is attached to the lower end of hollow drilling rods
- ❁ The coring bit is fixed to the lower end of a core
- ❁ Water or drilling fluid is pumped down the hollow rods and passes under pressure through narrow holes in the bit or barrel
- ❁ The drilling fluid cools and lubricates the drilling tool and carries the loose debris to the surface between the rods and the side of the hole.



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- ⊗ The fluid (bentonite slurry) also provides some support to the sides of the hole if no casing is used
 - .
 - ⊗ There are two forms of rotary drilling, open-hole drilling and core drilling.
 - ⊗ Open- hole drilling, which is generally used in soils and weak rock, just for advancing the hole
 - ⊗ The drilling rods can then be removed to allow tube samples to be taken or *in-situ* tests to be carried out.
 - ⊗ In core drilling, which is used in rocks and hard clays, the diamond or tungsten carbide bit cuts an annular hole in the material and an intact core enters the barrel, to be removed as a sample. Typical core diameters are 41, 54 and 76mm, but can range up to 165 mm.

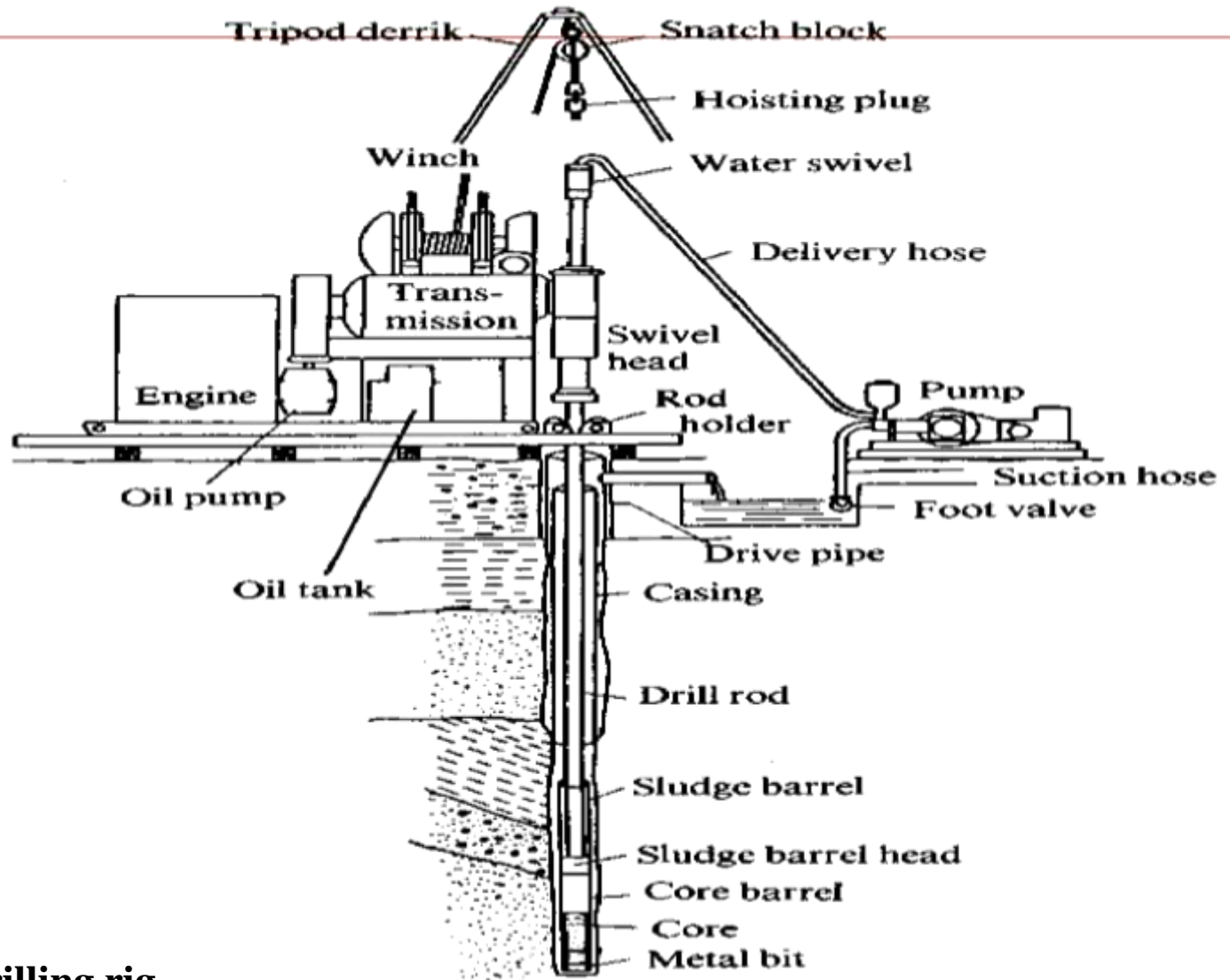


Advantages

The advantage of rotary drilling in soils is that progress is much faster than with other investigation methods and disturbance of the soil below the borehole is slight.

Limitations

-  The method is not suitable if the soil contains a high percentage of gravel/cobbles, as they tend to rotate beneath the bit and are not broken up.
-  The natural water content of the material is liable to be increased due to contact with the drilling fluid



Rotary Drilling rig

GEOPHYSICAL METHOD

- **Although boring and test pits provide definite results but they are time consuming and expensive.**
- **Subsurface conditions are known only at the bore or test pit location.**
- **The subsurface conditions between the boring need to be interpolated or estimated.**
- **Geophysical methods are more quick and cheaper.**
- **They provide thorough coverage of the entire area.**
- **The results of Geophysical testing however are less definitive and require subjective interpretation.**
- **Therefore both methods are important. In case geophysical testing is major in scope, few borings and sampling will be required for accurate determination of soil properties.**
- **If boring is major in scope then few geophysical lines will be required to know the conditions in-between the borings.**

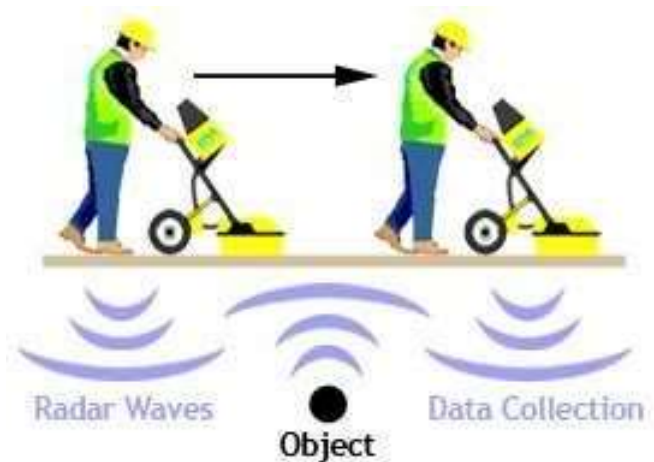
Site Evaluation Direct Methods

- **Boreholes/Probes**
- **Test Pits/Trenches**
- **Cores**



Geophysical Techniques Indirect Methods

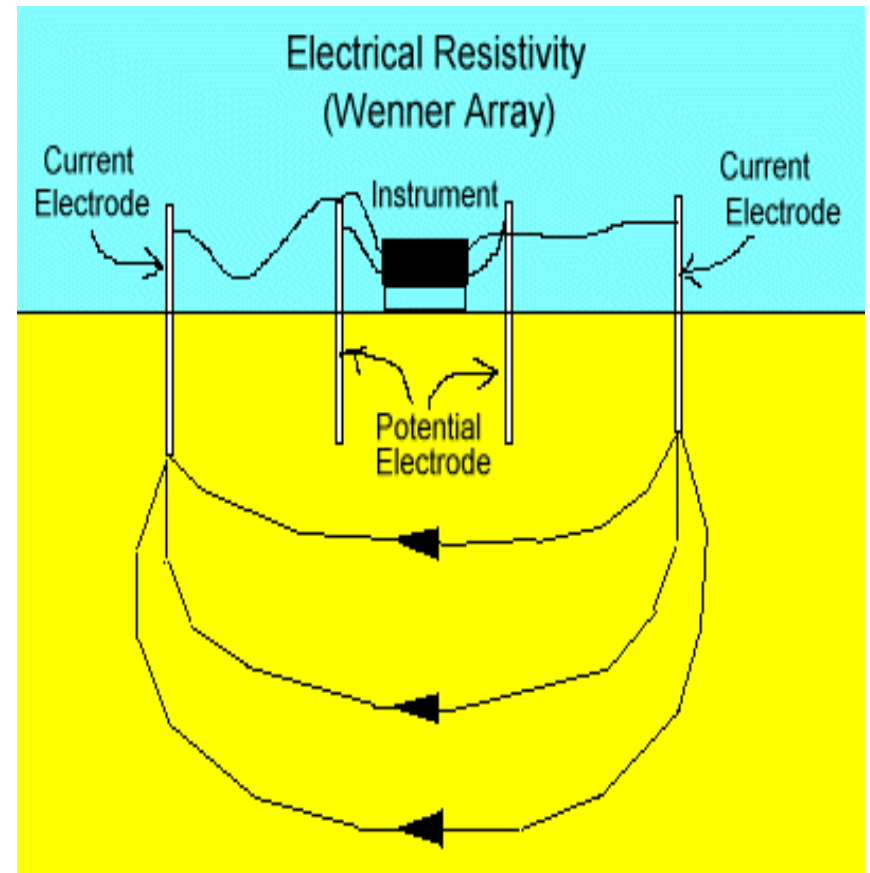
- **Ground Penetrating Radar (GPR)**
- **Electromagnetic (EM)**
- **Magnetic**
- **Utility Locating**
- **Seismic**
- **Electrical Resistivity**
- **Gravity**
- **Very Low Frequency (VLF)**



Geophysical Techniques Indirect Methods

Advantages

- **Non-Destructive**
- **Cost Effective**
- **Provides Preliminary or Supplemental Information**





Soil Sampling

- Split Spoon/SPT sampler
- Thin-wall tube/Shelby tube
- Augers



Soil Sampling

- Disturbed
 - In situ structure not retained
 - Water content, classification, compaction
- Undisturbed
 - Less disturbed
 - Shear strength, consolidation, permeability