Module 1 : Site Exploration and Geotechnical Investigation

Lecture 2 : Boring Methods of Exploration [Section 2.1 : Different Types of of Boring Methods]

Objectives

In this section you will learn the following

- Displacement borings
- Wash boring
- Auger boring
- Rotary drilling
- Percussion drilling
- Continuous sampling

Module 1 : Site Exploration and Geotechnical Investigation

Lecture 2 : Boring Methods of Exploration [Section 2.1 : Different Types of of Boring Methods]

Boring methods of exploration

The boring methods are used for exploration at greater depths where direct methods fail. These provide both disturbed as well as undisturbed samples depending upon the method of boring. In selecting the boring method for a particular job, consideration should be made for the following:

- The materials to be encountered and the relative efficiency of the various boring methods in such materials.
- The available facility and accuracy with which changes in the soil and ground water conditions can be determined.
- Possible disturbance of the material to be sampled.

The different types of boring methods are :

1. Displacement boring.
2. Wash boring.
3. Auger boring.
4. Rotary drilling.
5. Percussion drilling.
6. Continuous sampling.

1. Displacement borings

It is combined method of sampling & boring operation. Closed bottom sampler, slit cup, or piston type is forced in to the ground up to the desired depth. Then the sampler is detached from soil below it, by rotating the piston, & finally the piston is released or withdrawn. The sampler is then again forced further down & sample is taken. After withdrawal of sampler & removal of sample from sampler, the sampler is kept in closed condition & again used for another depth.

Features **:**

- Simple and economic method if excessive caving does not occur. Therefore not suitable for loose sand.
- Major changes of soil character can be detected by means of penetration resistance.
- These are 25mm to 75mm holes.
- It requires fairly continuous sampling in stiff and dense soil, either to protect the sampler from damage or to avoid objectionably heavy construction pit.

2. Wash boring:

It is a popular method due to the use of limited equipments. The advantage of this is the use of inexpensive and easily portable handling and drilling equipments. Here first an open hole is formed on the ground so that the soil sampling or rock drilling operation can be done below the hole. The hole is advanced by chopping and twisting action of the light bit. Cutting is done by forced water and water jet under pressure through the rods operated inside the hole.

In India the “Dheki” operation is used, i.e., a pipe of 5cm diameter is held vertically and filled with water using horizontal lever arrangement and by the process of suction and application of pressure, soil slurry comes out of the tube and pipe goes down. This can be done upto a depth of 8m –10m (excluding the depth of hole already formed beforehand)

Just by noting the change of colour of soil coming out with the change of soil character can be identified by any experienced person. It gives completely disturbed sample and is not suitable for very soft soil, fine to medium grained cohesionless soil and in cemented soil.

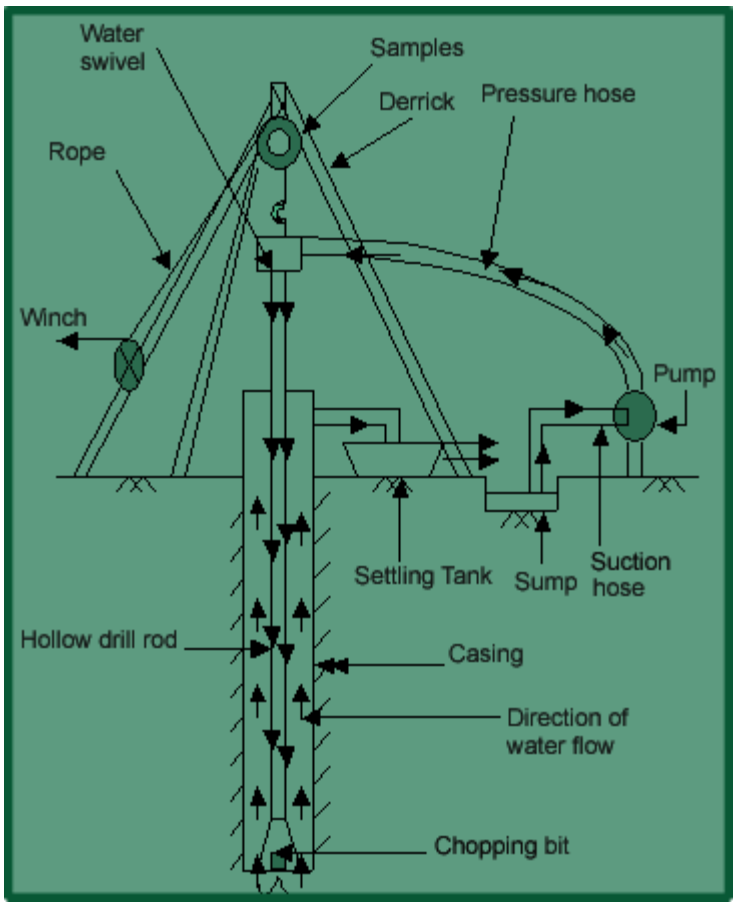

Fig.1.1 Wash Boring

3. Auger boring

This method is fast and economical, using simple, light, flexible and inexpensive instruments for large to small holes. It is very suitable for soft to stiff cohesive soils and also can be used to determine ground water table. Soil removed by this is disturbed but it is better than wash boring, percussion or rotary drilling. It is not suitable for very hard or cemented soils, very soft soils, as then the flow into the hole can occur and also for fully saturated cohesionless soil.

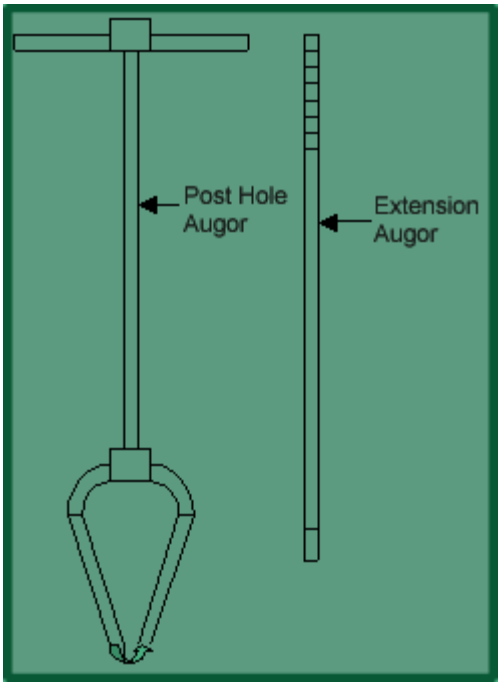

Fig.1.2 Augers

4. Rotary drilling

Rotary drilling method of boring is useful in case of highly resistant strata. It is related to finding out the rock strata and also to access the quality of rocks from cracks, fissures and joints. It can conveniently be used in sands and silts also. Here, the bore holes are advanced in depth by rotary percussion method which is similar to wash boring technique. A heavy string of the drill rod is used for choking action. The broken rock or soil fragments are removed by circulating water or drilling mud pumped through the drill rods and bit up through the bore hole from which it is collected in a settling tank for recirculation. If the depth is small and the soil stable, water alone can be used. However, drilling fluids are useful as they serve to stabilize the bore hole. Drilling mud is slurry of bentonite in water. The drilling fluid causes stabilizing effect to the bore hole partly due to higher specific gravity as compared with water and partly due to formation of mud cake on the sides of the hole. As the stabilizing effect is imparted by these drilling fluids no casing is required if drilling fluid is used. This method is suitable for boring holes of diameter 10cm, or more preferably 15 to20cm in most of the rocks. It is uneconomical for holes less than 10cm diameter. The depth of various strata can be detected by inspection of cuttings.

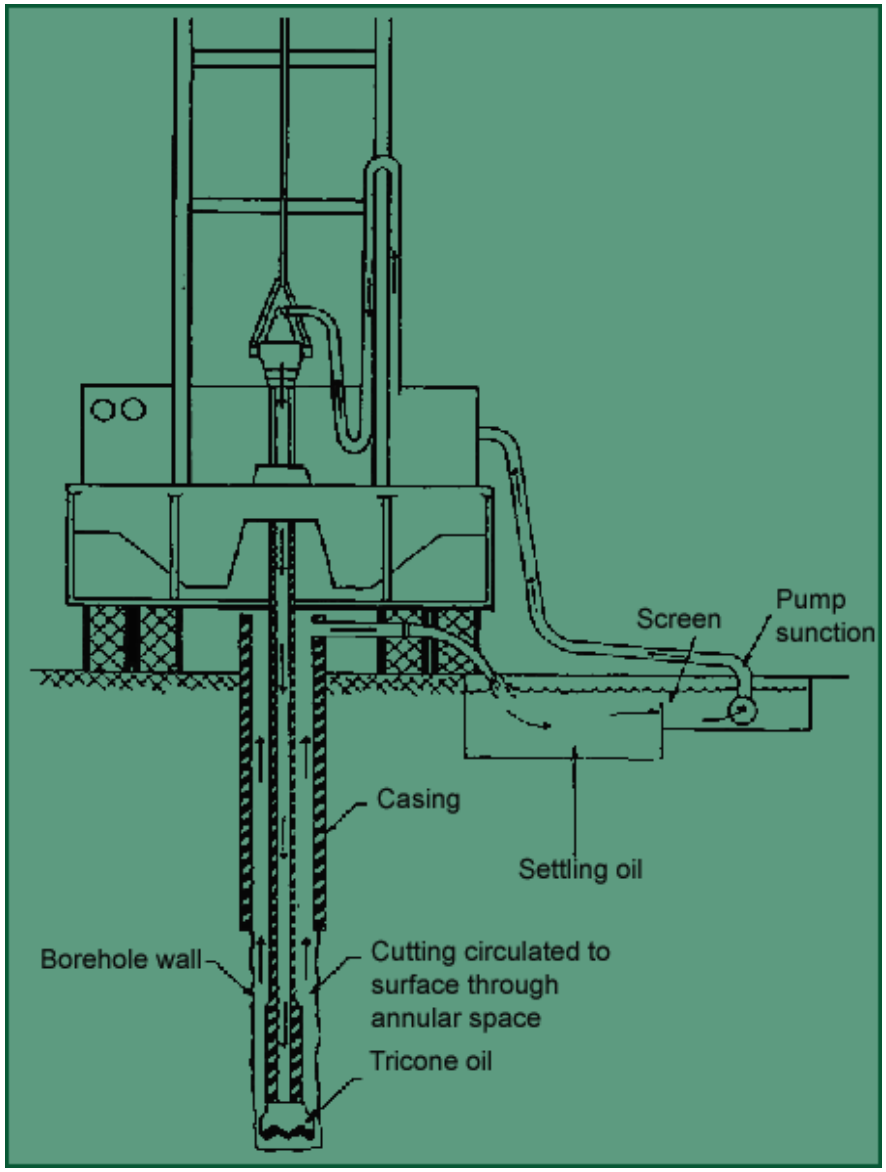

Fig.1.3 Rotary Drilling System

5. Percussion drilling

In case of hard soils or soft rock, auger boring or wash boring cannot be employed. For such strata, percussion drilling is usually adopted. Here advancement of hole is done by alternatively lifting and dropping a heavy drilling bit which is attached to the lower end of the drilling bit which is attached to the cable. Addition of sand increases the cutting action of the drilling bit in clays. Whereas, when coarse cohesionless soil is encountered, clay might have to be added to increase the carrying capacity of slurry. After the carrying capacity of the soil is reached, churn bit is removed and the slurry is removed using bailers and sand pumps. Change in soil character is identified by the composition of the outgoing slurry. The stroke of bit varies according to the ground condition. Generally, it is 45-100cm in depth with rate of 35-60 drops/min. It is not economical for hole of diameter less than 10cm. It can be used in most of the soils and rocks and can drill any material. One main disadvantage of this process is that the material at the bottom of the hole is disturbed by heavy blows of the chisel and hence it is not possible to get good quality undisturbed samples. It cannot detect thin strata as well.

6. Continuous sampling

The sampling operation advances the borehole and the boring is accomplished entirely by taking samples continuously. The casing is used to prevent the caving in soils. It provides more reliable and detail information on soil condition than the other methods. Therefore it is used extensively in detailed and special foundation exploration for important structures. It is slower method and more expensive than intermittent sampling. When modern rotary drilling rigs or power driven augers are not available, continuous sampling may be used to advantage for advancing larger diameter borings in stiff and tough strata of clay and mixed soil. In the Boston district, corps of Engineers has made faster progress and reduced cost by use of continuous sampling in advancing 3-inch diameter borings through compact gravelly glacial till, which is difficult to penetrate by any boring method.

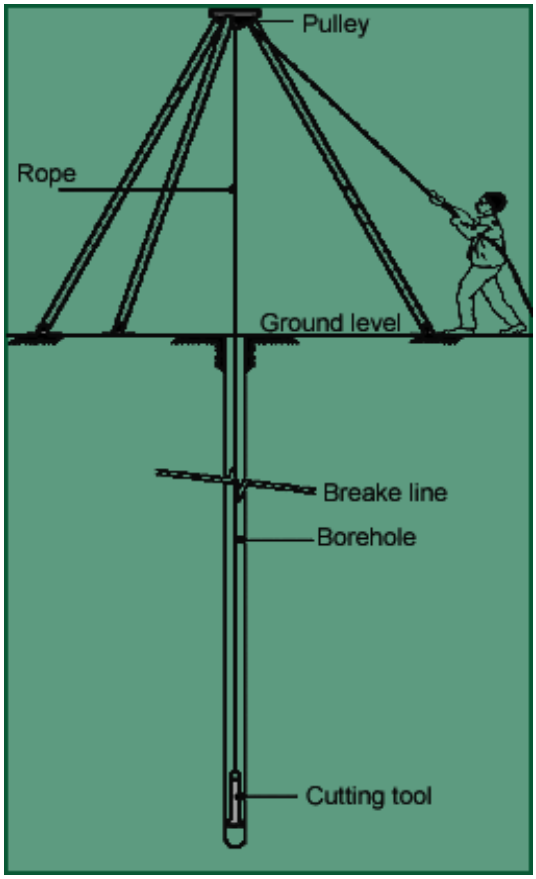

Fig.1.4 Percussion Drilling

Module 1 : Site Exploration and Geotechnical Investigation

Lecture 2 : Boring Methods of Exploration [Section 2.1 : Different Types of of Boring Methods]

Recap

In this section you have learnt the following

- Displacement borings
- Wash boring
- Auger boring
- Rotary drilling
- Percussion drilling
- Continuous sampling

Congratulations, you have finished Lecture 2. To view the next lecture select it from the left hand side menu of the page

These waves are classified as direct, reflected and refracted waves. The direct wave travel in approximately straight line from the source of impulse. The reflected and refracted wave undergoes a change in direction when they encounter a boundary separating media of different seismic velocities (Refer fig. 1.7). This method is more suited to the shallow explorations for civil engineering purpose. The time required for the impulse to travel from the shot point to various points on the ground surface is determined by means of geophones which transform the vibrations into electrical currents and transmit them to a recording unit or oscillograph, equipped with a timing mechanism.

Assumptions

The various assumptions involved are:

- All soil layers are horizontal.
- The layer is sufficiently thick to produce a response.
- Each layer is homogeneous and isotropic.
- Velocity should increase with depth, following the Snell's law as given in fig. 1.6.

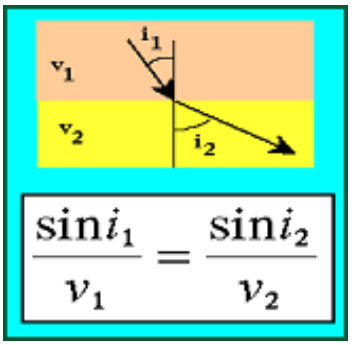

Fig. 1.6 Snell's law

i_1 is the angle of incidence,

i_2 is the angle of refraction,

v_1 and v_2 are the velocity in two different mediums.

The assumption made is $v_2 > v_1$.

Procedure

The detectors are generally placed at varying distance from the shot point but along the straight line. The arrival time of the first impulse at each geophone is utilized. If the successfully deeper strata transmit the waves with increasingly greater velocities, the path traveled by the first impulse will be similar to those shown in fig. 1.7. Those recorded by the nearest recorders pass entirely through the overburden, whereas those first reaching the farther detectors travel downward through the lower- velocity material, horizontally within the higher velocity stratum, and return to the surface as shown in the fig. 1.7. By plotting the travel times

(AT_1 and AT_2) as a function of the distances between the geophones and the shot points (L_1 and L_2) as shown in fig. 1.8, a curve is obtained which indicates the wave velocity in each stratum and which may be used to determine the depths to the boundaries between the strata.

$$H_1 = \frac{l_1 V_1}{2Cos\alpha} = \frac{L_1}{2}\sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$$

$$H_2 = \frac{l_2 V_2}{2Cos\beta} = 0.85H_1 + \frac{L_2 - L_1}{2}\sqrt{\frac{V_3 - V_2}{V_3 + V_2}}$$

Where,

H_1 and H_2 are the depths of the strata,

$l_1 = AB_1$,

$l_2 = AC_1 - AB_1$,

Sin $\alpha = (V_1 - V_2)$

Sin $\beta = (V_2 / V_3)$

(Refer figs. 1.7 and 1.8)

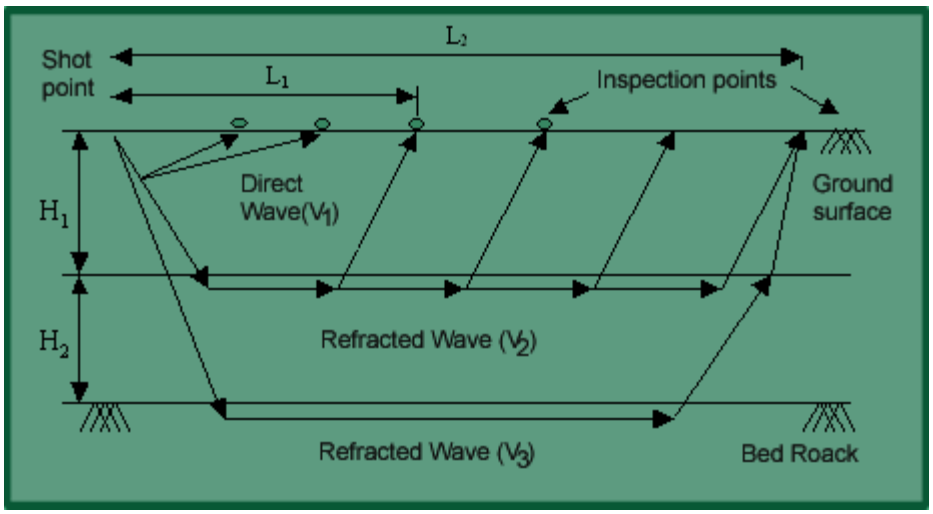

Fig. 1.7 Seismic refraction method

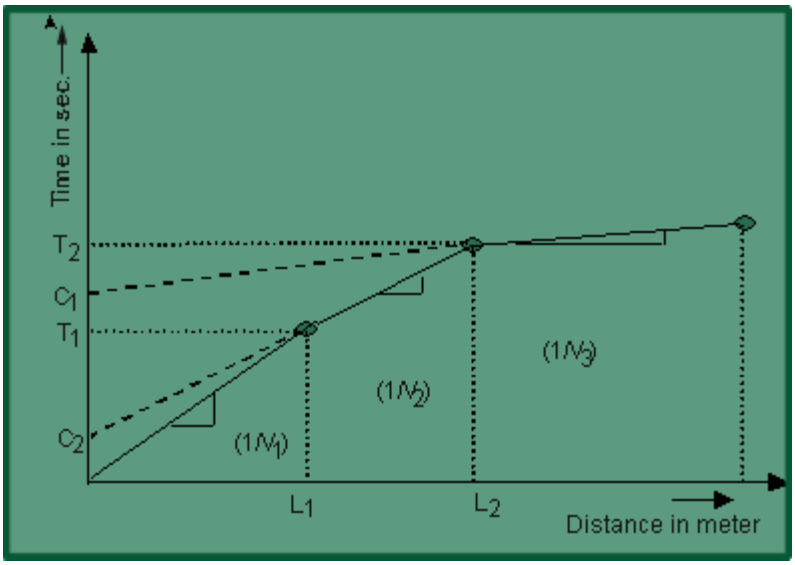

Fig. 1.8 Graph of Time vs Distance

Applications

- The various applications are:
- Depth and characterization of the bed rock surfaces,
- Buried channel location,
- Depth of the water table,
- Depth and continuity of the stratigraphy interfaces,
- Mapping of faults and other structural features.

- **Disadvantages :**

- Complete picture of stratification of layer upto 10m depth.
- Refraction observations generally employ fewer source and receiver locations and are thus relatively cheap to acquire.
- Little processing is done on refraction observations with the exception of trace scaling or filtering to help in the process of picking the arrival times of the initial ground motion.
- Because such a small portion of the recorded ground motion is used, developing models and interpretations is no more difficult than our previous efforts with other geophysical surveys.
- Provides seismic velocity information for estimating material properties.
- Provides greater vertical resolution than electrical, magnetic, or gravity methods.
- Data acquistion requires very limited intrusive activity is non-destructive.

Disadvantages :

- Blind zone effect: If $v_2 > v_1$, then wave refracts more towards normal then the thickness of the strata is neglected.
- Error also introduced due to some dissipation of the velocity as longer the path of travel, geophone receives the errorous readings.
- Error lies in all the assumptions.

2.1.3 Role of geophysical methods in solving geotechnical problems

- Gravitational and magnetic methods are used in mining and petroleum engineering. In geotechnical engineering, the gravitational method has very limited use for survey of unconsolidated sediments over the dense bedrock.
- Magnetic method is applied to locate dikes, faults and buried pipes and other concealed magnetic metal works.
- For dam and bridge sites, to locate depth of the solid rock, seismic and resistivity methods are used.
- For design of the underwater foundation resistivity method is used.
- For building sites to locate hard rock strata/ soft strata seismic method is used.
- Slope design and the landslide investigation can be done using seismic and the resistivity methods.
- To locate the shallow deposits, seismic and the resistivity methods can be used as in excavation work in sand, gravel deposits etc.
- Ground water investigation can be done using seismic and resistivity method.

In the evaluation of insitu concrete, geophysical methods are used to determine uniformity of concrete. detection of cracking, assessment of rate of corrosion etc.

Module 1 : Site Exploration and Geotechnical Investigation

Lecture 2 : Geophysical Exploration [Section 2.1 : Methods of Geophysical Exploration]

Recap

In this course you have learnt the following

- General Overview
- Different methods of geophysical explorations
- Electrical resistivity method
- Advantages
- Disadvantages
- Assumptions
- Procedure

Congratulations, you have finished Lecture 2. To view the next lecture select it from the left hand side menu of the page