Exploratory Borings : Techniques and Equipments

Boreholes are required to

Collect soil samples (disturbed or undisturbed)
Perform field tests

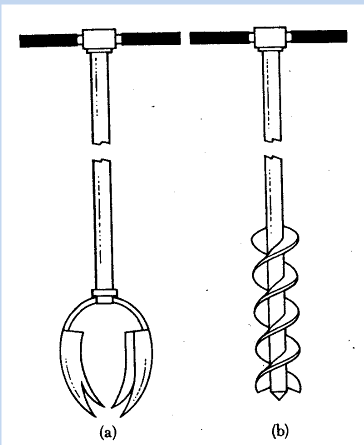
Boring methods

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

Auger boring :Simplest way to make a hole in the ground

Different types of Augers

(1) Hand operated



Post hole Auger **Helical auger**

Used for making holes of low depths (3 ~ 5 m)
Usually used for projects like railroad, highway, airport construction
Casing are used for soils if boreholes will not stand unsupported
Soil samples are highly disturbed

L3/P3

Hand Auger

L3/P4

(2) Machine operated (continuous flight auger) (a) Solid stem (b) Hollow stem

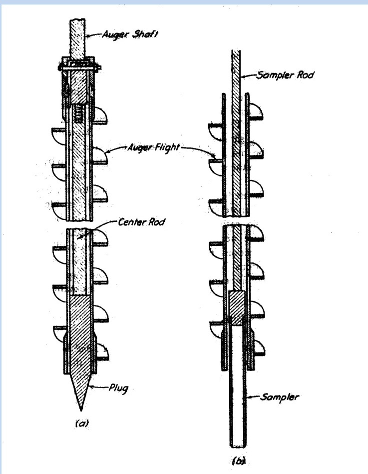


FIGURE 5.3. Hollow-stem auger. (a) Plugged while advancing auger. (b) Plug removed and sampler inserted to sample soil below auger.

L3/P5

The continuous flight auger is almost exclusively used at present since it has a number of advantages over other methods, such as the following:

Bowels/PGPS/p.177

1. It is very rapid.
2. Samples are less disturbed than from wash borings.
3. It is easier to visually detect stratum changes from spoil from the flights—but recognizing that current spoil is from strata already penetrated.
4. Rock drilling can be done with the same drill rig by changing bits.
5. The hole does not require casing when the hollow stem auger is used since additional testing and sample recovery can be made through the stem.
6. Penetration testing and undisturbed samples can be recovered by either pulling the auger (solid stem) or through the hollow stem after removal of the bit plug. Care is necessary in pulling the auger (or the plug) that a differential water head does not cause a "quick" state in the soil at the bottom of the hole.

Boreholes up to about 60-70 m (200-230 ft) can be made.
Sections are usually 1-2 m (3-6 ft) long
Common solid stem augers : OD- 2-5/8 in., 3-1/4 in, 4 in, 4-1/2 in
Common hollow stem augers (ID x OD) : 2.5 in x 6.25 in, 2.75 x 7 in, 3 in x 8 in, 3.25 x 9 in

5

L3/P6

Wash boring

Video

- A casing (≈ 2-3m long) is driven into the ground.
- The soil inside the casing is removed by means of a chopping bit attached to a drill rod.
- Water is forced through the drill rod and exits at a very high velocity through the openings at the bottom of the chopping bit.
- The water carries up the fragments of soils through the annular space between the casing and wash pipe. The water overflows the top of the casing through a T-connection.
- At specified depths SPT test or sampling can be done. For this purpose the drill rod is removed and SPT spoon or Shelby tube is attached to the bottom of the drill rod.

Video-Wash boring

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Wash boring…….contd.

L3/P7

Cutter / Chisel

Water Jet Exiting Cutter Head

7

L3/P8

Rotary drilling

- A rapidly rotating drilling bit attached to the bottom of the drill rod cut and grind the soil. Usually the equipment is truck mounted.
- The soil particles are removed by circulating water or drilling fluid similar to that in wash boring.
- For sampling the drilling rod is raised and replaced by a sampler.
- Boreholes of 2-8 inch diameter can easily be made

8

L3/P9

Percussion drilling

- Usually used to make boreholes in hard soil and rock.
- A heavy drilling bit is alternately raised and dropped to chop/grind the underlying hard material.
- The chopped particle are brought up by water circulation.
- The bore hole may be kept dry except for a small amount of water that forms a slurry with the material ground up by the bit.
- When ground material/slurry accumulates, the drilling tools are removed from the hole and the slurry is cleaned out with a bailer.
- Not suitable for site exploration if intact samples are to be obtained for identification and testing.

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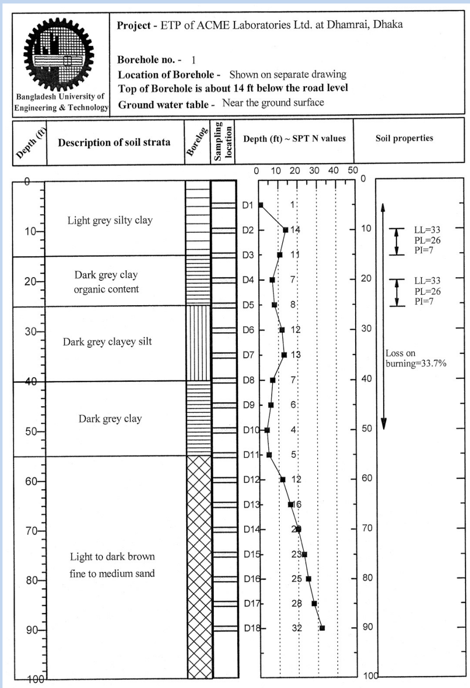
Bore-log

The detailed information gathered from each borehole is presented in a graphical form termed as 'boring log' or 'bore-log'

A bore-log usually contains:

1. Name and address of drilling company
2. Project name & Location of site
3. Date of boring
4. Bore-hole number and type of boring
5. Sub-surface stratification
6. RL of GL and elevation of water table
7. SPT-N value
8. Number, type and depth of soil sample collected



L3/P10

L3/P11

DHAKA SOIL — BORING LOG

CLIENT : CHITTAGONG PORT AUTHORITY (CPA)
PROJECT : SERVICE JETTY AND DOCK OFFICE
LOCATION : CHITTAGONG PORT.
BORE HOLE NO. 07

RIVER BED LEVEL : - 1.5 m from Jetty
RIVER WATER LEVEL : - 0.60 m from River Bed
DATE : 14-07-2013 TIME : 09:00 am

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	6"	6"	6"	SPT	STANDARD PENETRA-TION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft	INDEX / REMARKS
12-07-2013 to 13-07-2013	D-1		1.5	1.5	Light brown soft CLAY medium plastic.		100 mm (4") ϕ	1	1	1	2		1.5m
	U-1												UD 2.10 to 2.55m
	D-2			3.0	Grey soft to very soft CLAY medium plastic.			1	2	2	4		3.0m
	D-3		4.5					1	0	1	1		4.5m
	D-4							2	3	10	13		6.0m
	D-5							4	5	6	11		7.5m
	D-6			9.0	Grey medium dense silty FINE SAND trace mica			6	7	10	17		9.0m
	D-7							3	5	7	12		10.5m
	D-8							3	4	6	10		12.0m
	D-9		13.5					5	7	10	17		13.5m
	D-10							40	50	-	50	over 6"	15.0m
	D-11							45	50	-	50	over 6.5"	16.5m
	D-12							50	-	-	50	over 10"	18.0m
	D-13							50	-	-	50	over 12"	19.5m
	D-14				Grey very hard clayey SILT & shell with fine sand.			50	-	-	50	over 12"	21.0m
	D-15							50	-	-	50	over 14"	22.5m
	D-16							50	-	-	50	over 15"	24.0m
	D-17							50	-	-	50	over 16"	25.5m
	D-18							50	-	-	50	over 14"	27.0m
	D-19							50	-	-	50	over 14"	28.5m
	D-20							50	-	-	50	over 14"	30.0m

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Contd. next page

L3/P12

DHAKA SOIL — BORING LOG

CLIENT : CHITTAGONG PORT AUTHORITY (CPA)
PROJECT : SERVICE JETTY AND DOCK OFFICE
LOCATION : CHITTAGONG PORT.
BORE HOLE NO. 07

RIVER BED LEVEL : - 1.5 m from Jetty
RIVER WATER LEVEL : - 0.60 m from River Bed
DATE : 14-07-2013 TIME : 09:00 am

DATE	NUMBER OF SAMPLE	TYPE OF SAMPLE	DEPTH (m)	THICKNESS (m)	DESCRIPTION OF MATERIALS	LOG	DIAMETER OF BORING	6"	6"	6"	SPT	STANDARD PENETRA-TION RESISTANCE (S P T) BLOWS PER 0.30m / 1ft	INDEX / REMARKS
12-07-2013 to 13-07-2013	D-21						100 mm (4") ϕ	50	-	-	50	over 12"	33.0m
	D-22							50	-	-	50	over 12"	36.0m
	D-23			37.5	Grey very hard clayey SILT & shell with fine sand.			50	-	-	50	over 12"	39.0m
	D-24							50	-	-	50	over 12"	42.0m
	D-25							50	-	-	50	over 13"	45.0m
	D-26							50	-	-	50	over 14"	48.0m
	D-27		51.0					50	-	-	50	over 15"	51.0m

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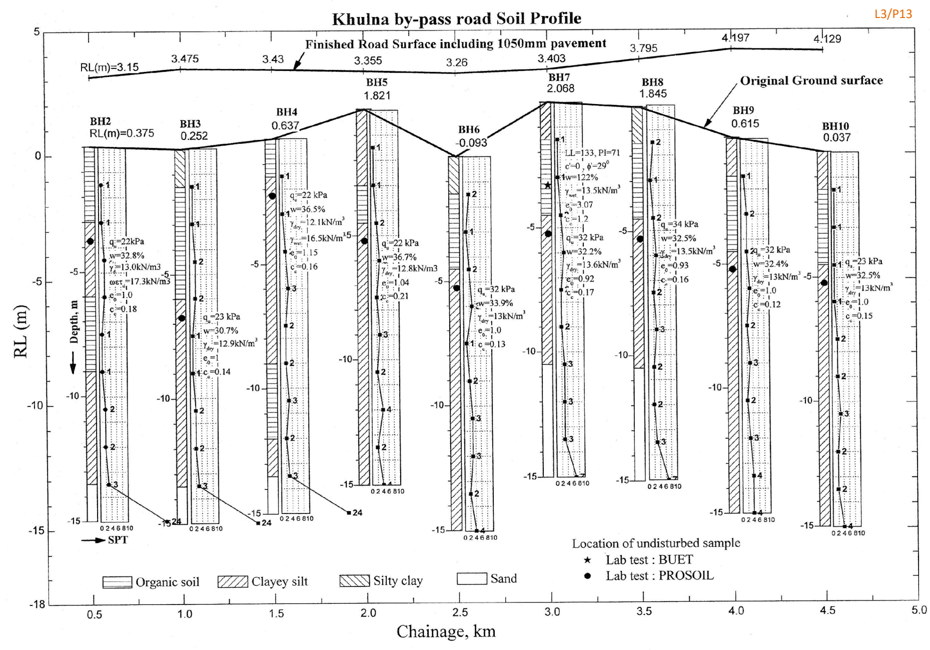
L3/P13



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L3/P14

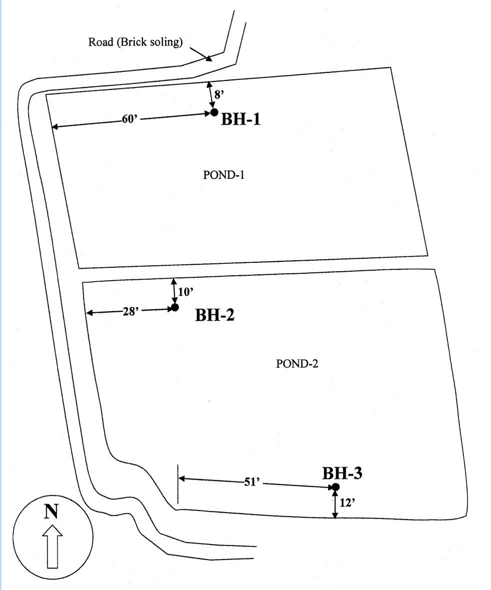

Fig. Schematic drawing showing location of boreholes.

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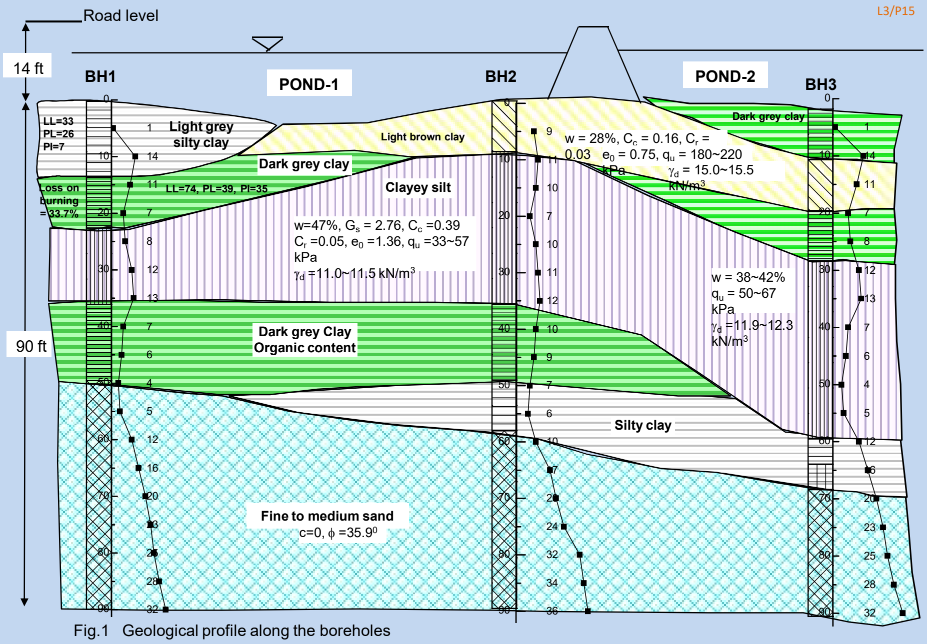

Fig.1 Geological profile along the boreholes

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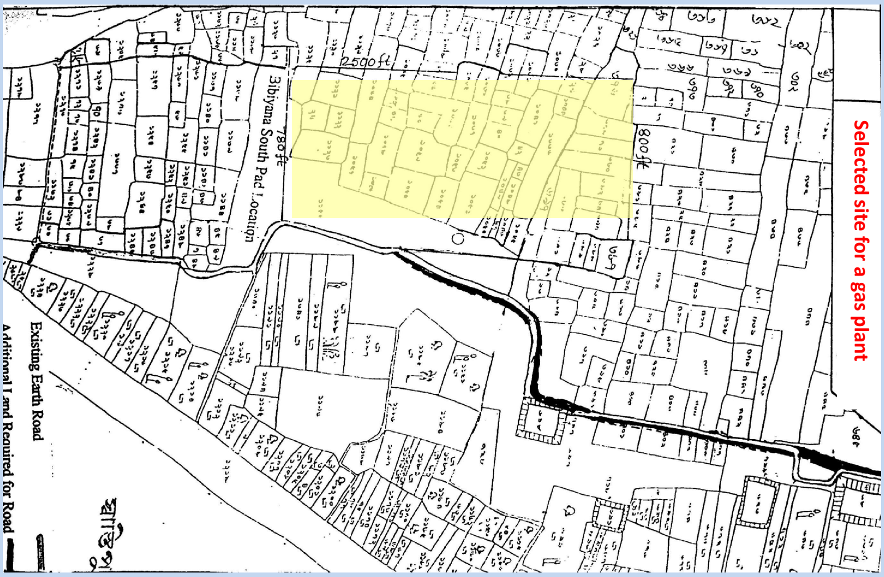
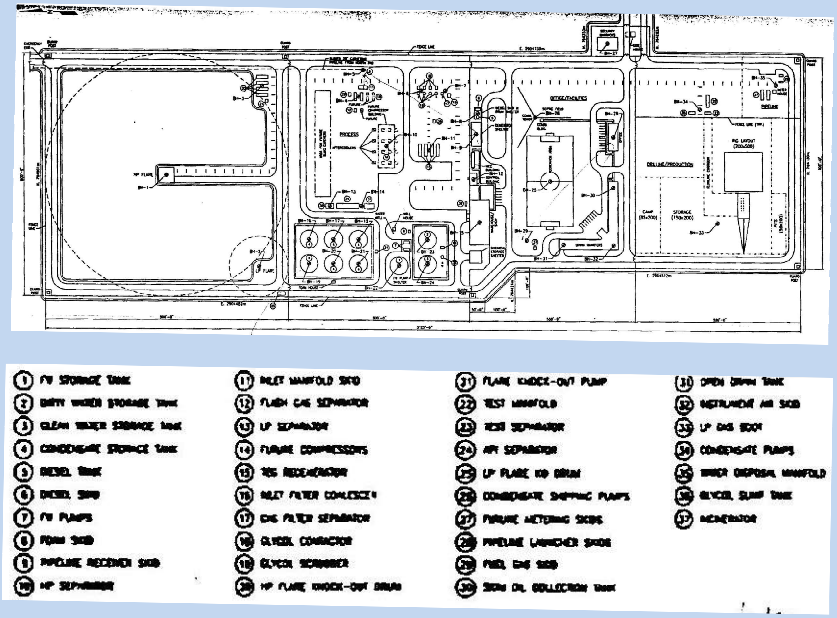
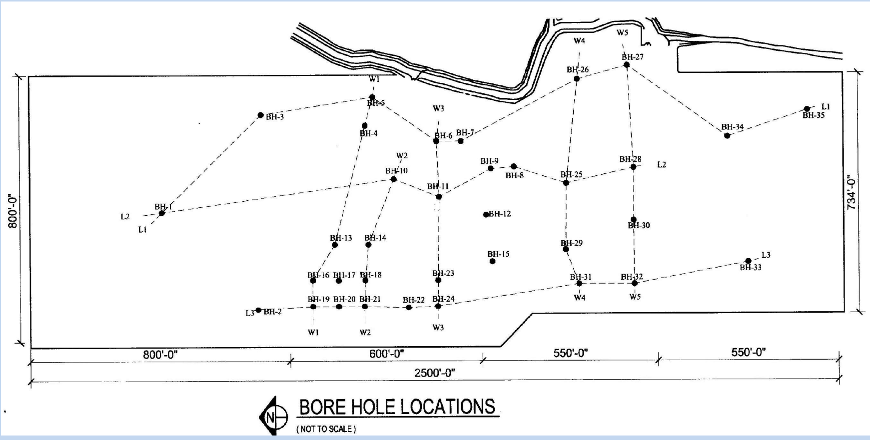

Selected site for a gas plant
2500 ft
780 ft
800 ft
Bibiyana South Pad Location
Existing Earth Road
Additional Land Required for Road


1 FW STORAGE TANK
2 DIRTY WATER STORAGE TANK
3 CLEAN WATER STORAGE TANK
4 CONDENSATE STORAGE TANK
5 DIESEL TANK
6 DIESEL SKID
7 FW PUMPS
8 FOAM SKID
9 PIPELINE RECEIVER SKID
10 HP SEPARATOR
11 INLET MANIFOLD SKID
12 FLASH GAS SEPARATOR
13 LP SEPARATOR
14 FUTURE COMPRESSORS
15 TEG REGENERATOR
16 INLET FILTER COALESCER
17 GAS FILTER SEPARATOR
18 GLYCOL CONTACTOR
19 GLYCOL SCRUBBER
20 HP FLARE KNOCK-OUT DRUM
21 FLARE KNOCK-OUT PUMP
22 TEST MANIFOLD
23 TEST SEPARATOR
24 API SEPARATOR
25 LP FLARE KO DRUM
26 CONDENSATE SHIPPING PUMPS
27 FUTURE METERING SKIDS
28 PIPELINE LAUNCHER SKID
29 FUEL GAS SKID
30 SKIM OIL COLLECTION TANK
31 OPEN DRAIN TANK
32 INSTRUMENT AIR SKID
33 LP GAS BOOT
34 CONDENSATE PUMPS
35 WATER DISPOSAL MANIFOLD
36 GLYCOL SUMP TANK
37 INCINERATOR



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BORE HOLE DEPTH / LOCATION CHART

BORE HOLE NO.	DEPTH	N. COORDINATE	E. COORDINATE
BH-1	165' (50m)	N. 784775m	E. 2904809m
BH-2	165' (50m)	N. 784683m	E. 2904517m
BH-3	100' (30m)	N. 784680m	E. 2904609m
BH-4	100' (30m)	N. 784583m	E. 2904688m
BH-5	100' (30m)	N. 784578m	E. 2904715m
BH-6	100' (30m)	N. 784519m	E. 2904685m
BH-7	100' (30m)	N. 784494m	E. 2904605m
BH-8	100' (30m)	N. 784462m	E. 2904672m
BH-9	100' (30m)	N. 784463m	E. 2904651m
BH-10	100' (30m)	N. 784554m	E. 2904639m
BH-11	100' (30m)	N. 784511m	E. 2904635m
BH-12	100' (30m)	N. 784466m	E. 2904808m
BH-13	100' (30m)	N. 784611m	E. 2904578m
BH-14	100' (30m)	N. 784580m	E. 2904578m
BH-15	100' (30m)	N. 784480m	E. 2904583m
BH-16	100' (30m)	N. 784632m	E. 2904545m
BH-17	100' (30m)	N. 784607m	E. 2904545m
BH-18	100' (30m)	N. 784583m	E. 2904545m
BH-19	100' (30m)	N. 784632m	E. 2904520m
BH-20	100' (30m)	N. 784607m	E. 2904520m
BH-21	100' (30m)	N. 784583m	E. 2904520m
BH-22	100' (30m)	N. 784542m	E. 2904519m
BH-23	100' (30m)	N. 784513m	E. 2904545m
BH-24	100' (30m)	N. 784513m	E. 2904520m
BH-25	66' (20m)	N. 784389m	E. 2904604m
BH-26	66' (20m)	N. 784404m	E. 2904680m
BH-27	66' (20m)	N. 784332m	E. 2904743m
BH-28	66' (20m)	N. 784328m	E. 2904649m
BH-29	66' (20m)	N. 784412m	E. 2904545m
BH-30	66' (20m)	N. 784326m	E. 2904588m
BH-31	66' (20m)	N. 784378m	E. 2904541m
BH-32	66' (20m)	N. 784325m	E. 2904540m
BH-33	66' (20m)	N. 784221m	E. 2904563m
BH-34	66' (20m)	N. 784238m	E. 2904677m
BH-35	66' (20m)	N. 784181m	E. 2904708m

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Observation of Water Table

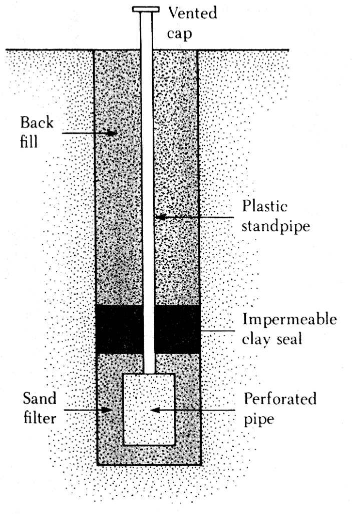
The presence of a water table near a foundation significantly affects a foundation's load-bearing capacity and settlement, among other things. The water level will change seasonally. In many cases, establishing the highest and lowest possible levels of water during the life of a project may become necessary.

If water is encountered in a borehole during a field exploration, that fact should be recorded. In soils with high hydraulic conductivity, the level of water in a borehole will stabilize about 24 hours after completion of the boring. The depth of the water table can then be recorded by lowering a chain or tape into the borehole.

In highly impermeable layers, the water level in a borehole may not stabilize for several weeks. In such cases, if accurate water level measurements are required, a *piezometer* can be used. A piezometer basically consists of a porous stone or a perforated pipe with a plastic standpipe attached to it. Figure 2.21 shows the general placement of a piezometer in a borehole.

See Fig. on next page

Das/PFE/p.108



▼ FIGURE 2.21 Casagrande-type porous stone piezometer

Das/PFE/p.108

L3/P18

For silty soils, Hvorslev (1949) proposed a technique to determine the water level (see Figure 2.22) involving the following steps:

1. Bail water out of the borehole to a level below the estimated water table.
2. Observe the water levels in the borehole at times

   $t = 0$

   $t = t_1$

   $t = t_2$

   $t = t_3$

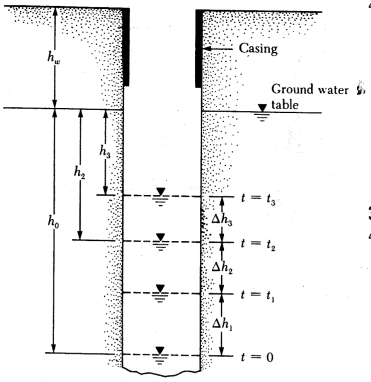
   Note that $t_1 - 0 = t_1 - t_2 = t_2 - t_3 = \Delta t$.
3. Calculate Δh_1, Δh_2, and Δh_3 (see Figure 2.22).
4. Calculate

$$h_0 = \frac{\Delta h_1^2}{\Delta h_1 - \Delta h_2} \tag{2.12a}$$

$$h_2 = \frac{\Delta h_2^2}{\Delta h_1 - \Delta h_2} \tag{2.12b}$$

$$h_3 = \frac{\Delta h_3^2}{\Delta h_2 - \Delta h_3} \tag{2.12c}$$

5. Plot h_0, h_2, and h_3 above the water levels observed at times $t = 0$, t_2, and t_3, respectively, to determine the final water level in the borehole.



▼ FIGURE 2.22 Determination of water levels [Eq. (2.12)]

Das/PFE/pp.108-109

EXAMPLE 2.1

Refer to Figure 2.22. For a borehole, $h_w + h_0 = 9.5$ m

$\Delta t = 24$ hr

$\Delta h_1 = 0.9$ m

$\Delta h_2 = 0.70$ m

$\Delta h_3 = 0.54$ m

Make the necessary calculations and locate the water level.

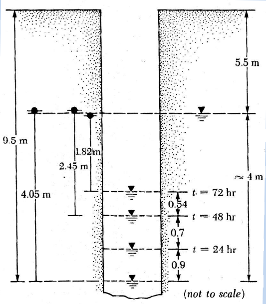
Solution Using Eq. (2.12),

$$h_0 = \frac{\Delta h_1^2}{\Delta h_1 - \Delta h_2} = \frac{0.9^2}{0.9 - 0.70} = 4.05 \text{ m}$$

$$h_2 = \frac{\Delta h_2^2}{\Delta h_1 - \Delta h_2} = \frac{0.7^2}{0.9 - 0.7} = 2.45 \text{ m}$$

$$h_3 = \frac{\Delta h_3^2}{\Delta h_2 - \Delta h_3} = \frac{0.54^2}{0.7 - 0.54} = 1.82 \text{ m}$$

Figure 2.23 shows a plot of the preceding calculations and the estimated water levels. Note that $h_w = 5.5$ m. ▲



▼ FIGURE 2.23

Das/PFE/pp.110