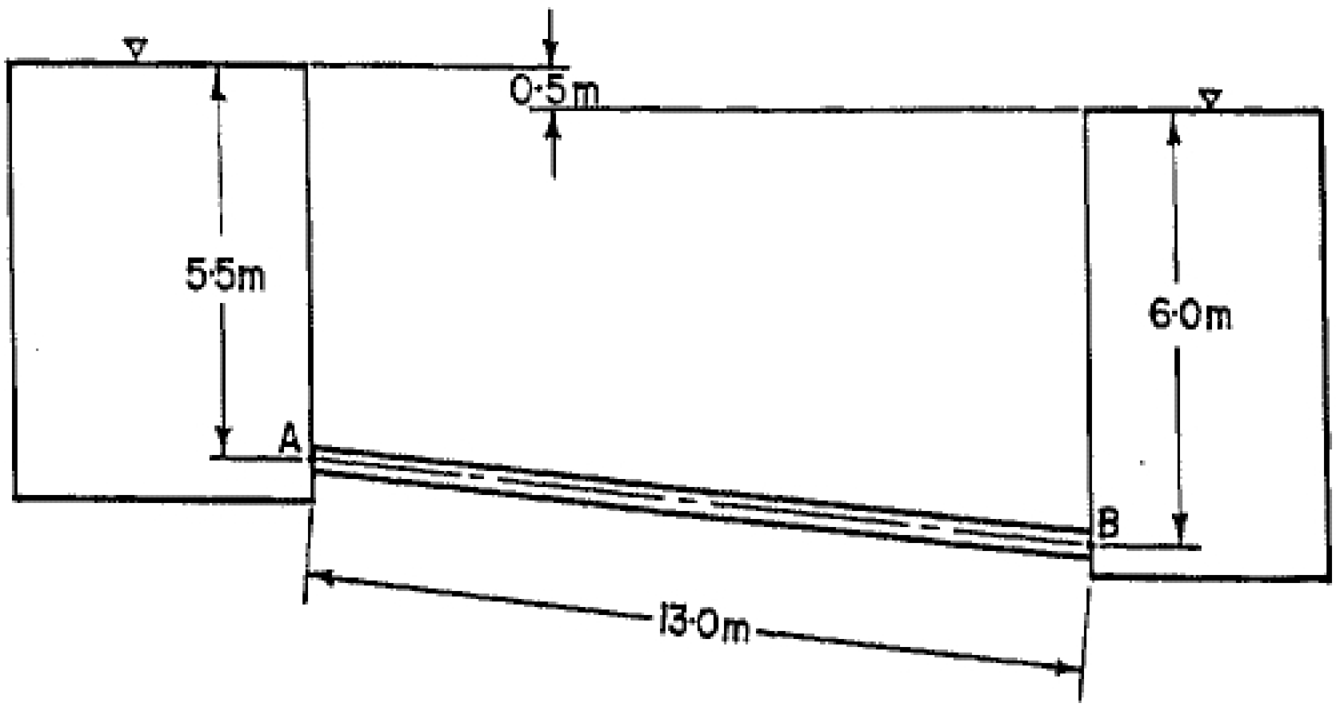

Fig. 5.6

5.5 PORE PRESSURE IN THE SOIL

The pressure head h_p is a measure (in units of length) of the pore pressure of the water in the soil. Again referring to Fig. 4.5 the pressure head at any point P may be found by measuring the vertical distance (h_p) between point P and the total head line ABCD. In other words if a piezometric tube was inserted into the soil at point P and suspended upwards with the end of the tube open to atmospheric pressure the water would rise in the tube a distance h_p above point P.

The pore pressure (u) may be calculated from the pressure head (h_p) by means of the expression

$$u = \rho_w g\, h_p \qquad (5.13)$$

where ρ_w = density of water

g = acceleration due to gravity

EXAMPLE

Referring to Fig. 5.6, a pipe (AB) 13.0m long connects two reservoirs. The pipe, which is filled with sand has a gross internal cross sectional area of $0.2m^2$. The permeability of the sand is 10^{-6}m/sec. Determine the amount of seepage that occurs under steady state flow conditions and calculate the pore pressure at the mid point of the pipe.

Firstly, an arbitrary datum must be selected. Suppose that this is set at a distance of 2.0m below the centreline of the pipe outlet (point B).

Then elevation head at B

$$h_{eB} = 2.0m$$

pressure head at B

$$h_{pB} = 6.0m$$

therefore total head at B

$$h_{tB} = 2.0 + 6.0 = 8.0m$$

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Similarly,

$$h_{eA} = 3.0m$$

$$h_{pA} = 5.5m$$

$$h_{tA} = 3.0 + 5.5 = 8.5m$$

Loss in total head between points A and B

$$\Delta h = h_{tA} - h_{tB}$$

$$= 8.5 - 8.0 = 0.5m$$

Note that this loss of total head is equal to the difference in elevations of the reservoir water levels.

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The gradient of total head

$$i = \frac{\Delta h}{L} = \frac{0.5}{13.0}$$

Using Darcy's law, the rate of seepage flow

$$Q = k\,i\,A$$

$$= 10^{-6} \text{ x } \frac{0.5}{13.0} \text{ x } 0.2$$

$$= 0.77 \text{ x } 10^{-8} \text{ m}^3/\text{sec}$$

As the total heads at points A and B are 8.5m and 8.0m respectively the total head at the mid point of the pipe is 8.25m. The elevation head at the mid point of the pipe is 2.5m

∴ pressure head at mid point of pipe	=	8.25 - 2.5 = 5.75m
pore pressure	=	$\rho_w g\, h_p$
where ρ_w	=	1000 kg/m^3
g	=	9.81 m/sec^2
∴ pore pressure	=	1000 x 9.81 x 5.75 N/m^2
	=	56.4 kN/m^2

EXAMPLE

Fig. 5.7 (a) represents a steady state one dimensional seepage situation in which the upstream and down stream water levels are maintained constant. The container in which the soil (permeability $k = 1.2 \text{ x } 10^{-5}$ m/sec, and porosity $n = 0.2$) has been placed consists of two sections having different diameters. The areas of the upper (A_U) and lower (A_L) sections are 28cm^2 and 14cm^2 respectively.

(a) Determine the rate of seepage flow through the soil.
(b) Calculate the actual velocity of flow through the upper section of soil.
(c) Sketch the distribution of pore water pressure throughout the soil.

Firstly it is necessary to establish an arbitrary datum from which the elevation head may

Firstly it is necessary to establish an arbitrary datum from which the elevation head may be measured. Let this datum be located a distance of 4cm below the lower boundary of the soil.

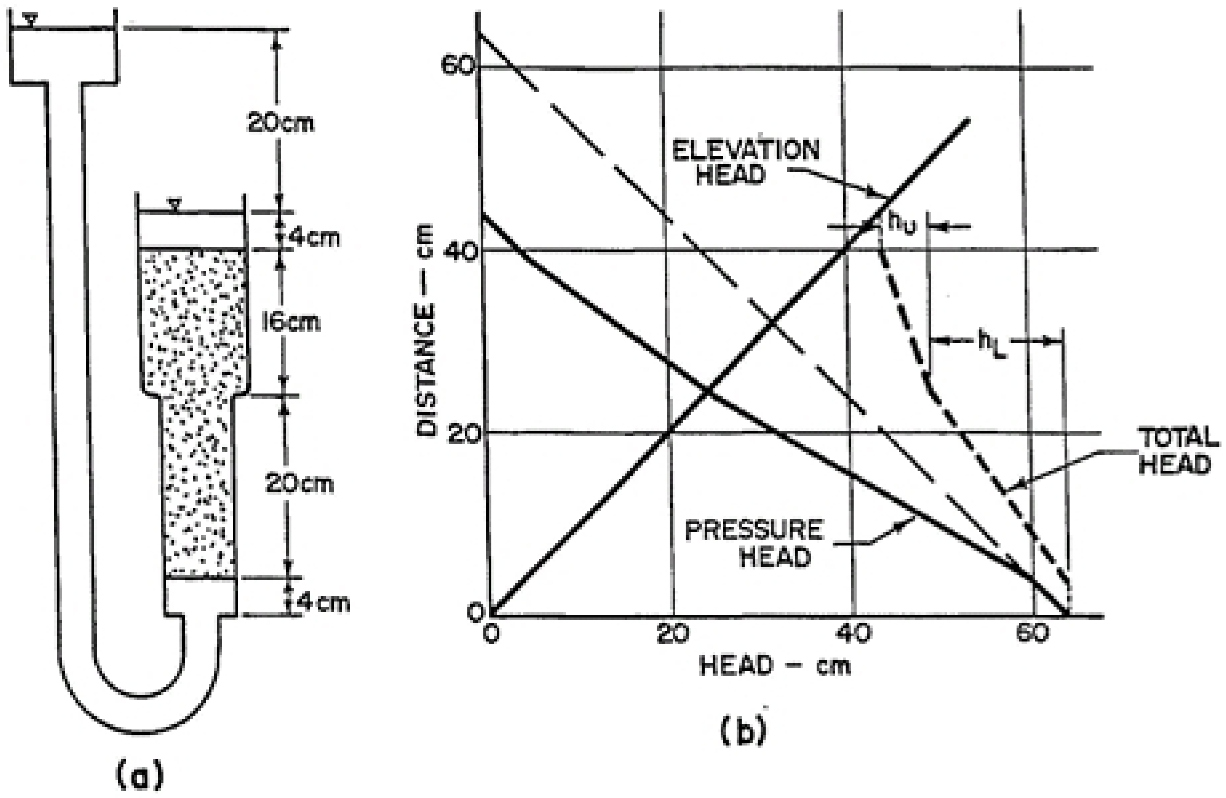

Fig. 5.7

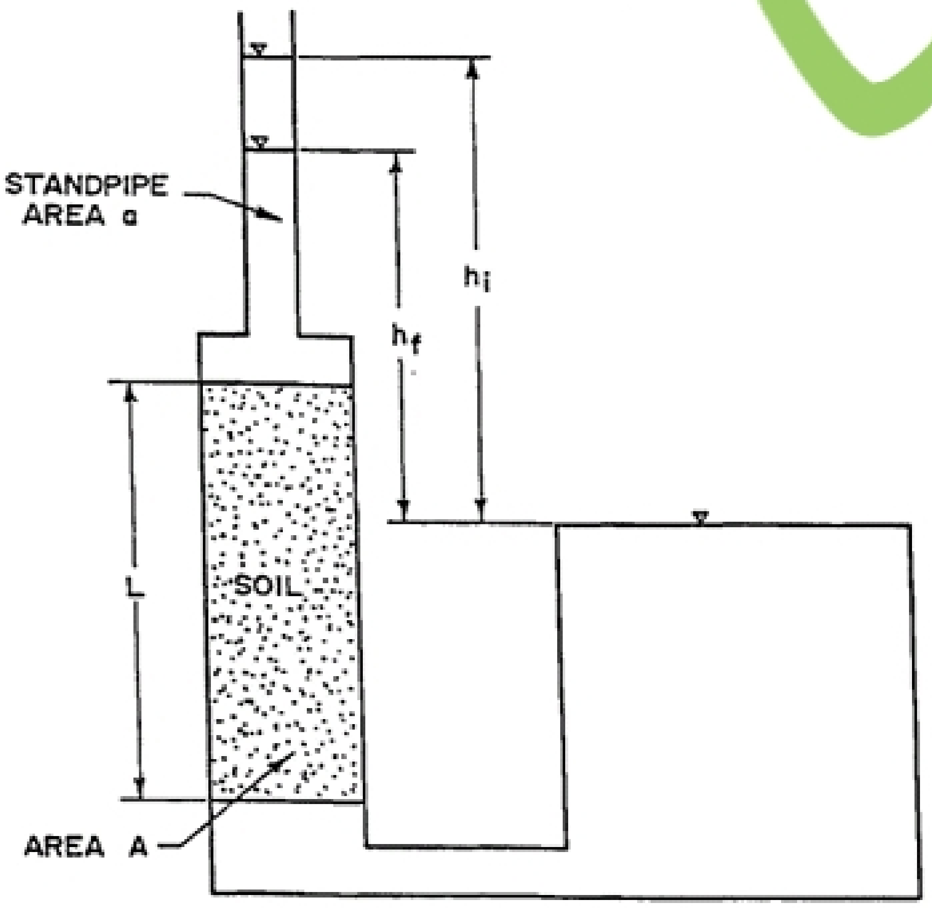

Fig. 5.8 Falling Head Permeability Test

The elevation head line can now be drawn on a plot of head against distance above the datum as illustrated in Fig. 5.7 (b).

Fig. 5.8 Falling Head Permeability Test

The elevation head line can now be drawn on a plot of head against distance above the datum as illustrated in Fig. 5.7 (b).

The pressure head lines can now be drawn for the water on the upstream and downstream sides of the soil. The pressure head for the upstream (lower) side of the soil is determined by the distance below the upstream water level (left tube in Fig. 5.7 (a)). The distribution of pressure head throughout the soil cannot be drawn at this stage.

The total head lines can now be found for the water on the upstream and downstream sides of the soil by addition (represented horizontally in Fig. 5.7 (b)) of the pressure and elevation head lines. As shown in Fig. 5.7 (b) the total heads on the upstream and downstream sides of the soil are 64.0cm and 44.0cm respectively. This means that the loss in total head through the soil is 20.0cm (the same value as the elevation difference between the upstream and downstream water levels).

$$h_L - h_U = 20.0$$

where h_L and h_U are the total head losses in the lower and upper sections of soil respectively.

Since the rate of flow through the upper and lower section must be equal

$$Q = k\, i_L\, A_L = k\, i_U\, A_U$$

or

$$\frac{h_L}{L_L} \cdot A_L = \frac{h_U}{L_U} \cdot A_U$$

$$\frac{h_L}{20.0} \cdot 14.0 = \frac{h_U}{16.0} \cdot 28.0$$

$\therefore$

$$2h_L = 5h_U$$

The two equations involving h_L and h_U can now be solved to yield

$$h_L = 14.29\text{cm and } h_U = 5.71\text{cm}$$

and the total head line can now be completed as shown in Fig.5.7 (b).

The rate of seepage flow can now be found

$$Q \quad = \quad k\, i_L\, A_L$$