Seepage

Seepage (change in head)

$$q_{in} = q_{out}$$

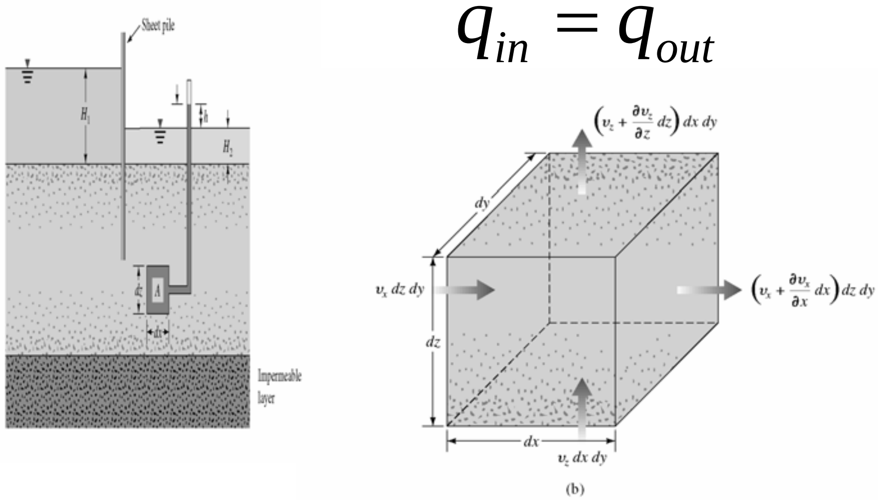


Figure 5.11 (a) Single-row sheet piles driven into a permeable layer; (b) flow at *A*

Laplace's Flow Equation

Assumptions:

Sr = 100%

e= constant (no compression of medium)

$K_v = K_h$ (isotropic)

Darcy's law is valid

$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial z^2} = 0$$

Flow Net Solution:

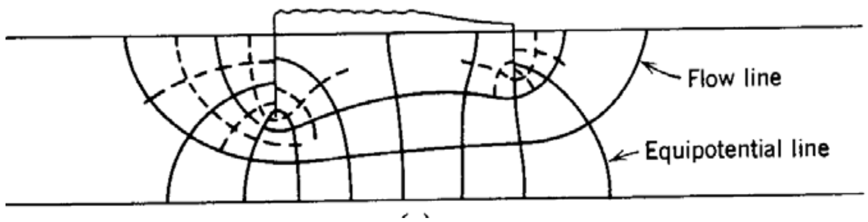
Flow Lines and Equipotential Lines

Flow-nets Requirements

Any flow net must meet certain requirements, of which the following are basic:

1. Flow lines and equipotential lines must intersect at right angles to form areas that are basically squares.
2. Certain entrance and exit requirements must be met.
3. A basic deflection rule must be followed in passing from a soil of one permeability to a soil of a different permeability.
4. Adjacent equipotentials have equal head losses.
5. The same quantity of seepage flows between adjacent pairs of flow lines.

Flow & Equipotential Lines



Flow & Equipotential Lines

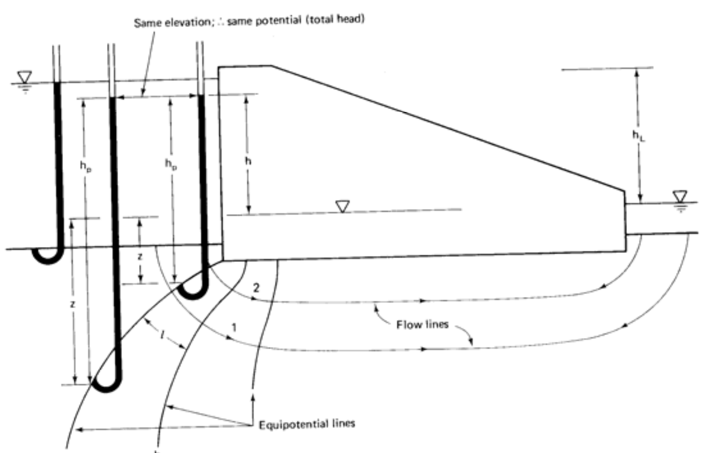


Fig. 7.15 Equipotential and flow lines (only a few shown).

Flow & Equipotential Lines

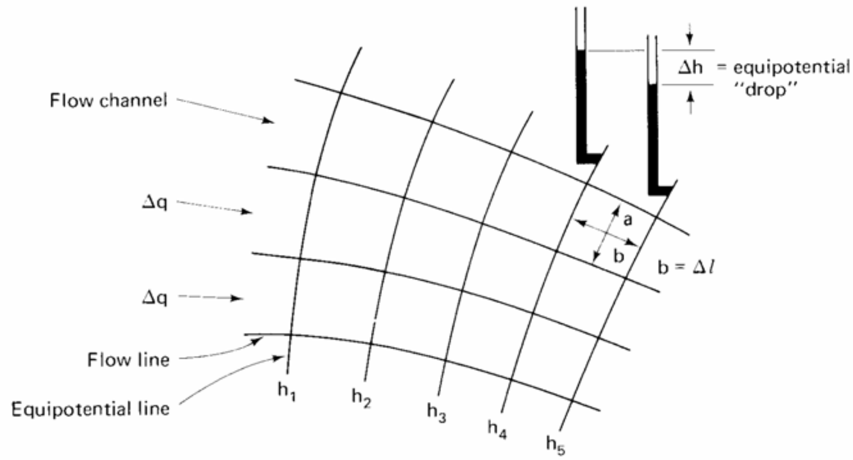


Fig. 7.16 Flow net illustrating some definitions.

Porewater Pressure Determination

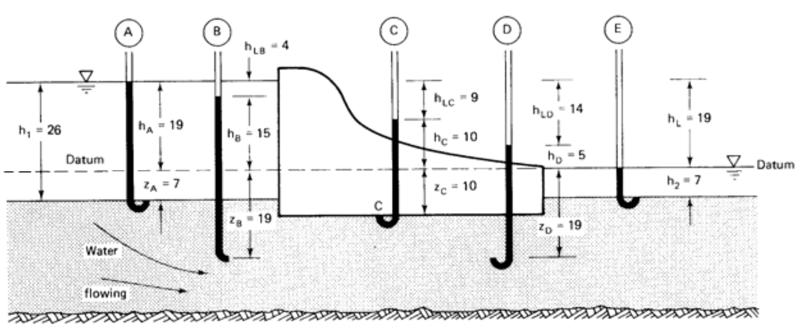


Fig. 7.14 Example of piezometric heads and head loss due to seepage under a dam. All dimensions in m.

Flow & Equipotential Lines

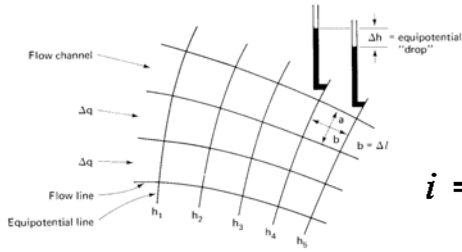


Fig. 7.16 Flow net illustrating some definitions.

$$i = \frac{\Delta h}{\Delta l} = \frac{\Delta h}{b} = \frac{h_L/N_d}{b}$$

where the length of the flow path in one square is $b = \Delta l$. The equipotential drop between two flow lines is $\Delta h = h_L/N_d$, where N_d is the total number of potential drops, and h_L is the total head lost in the system.

Flow & Equipotential Lines

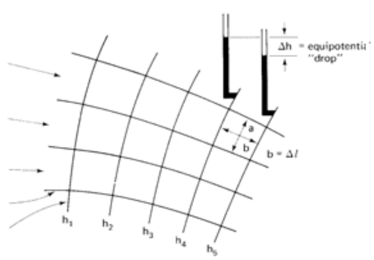


Fig. 7.16 Flow net illustrating some definitions.

$$\Delta q = k\frac{\Delta h}{\Delta l}A = k\left(\frac{h_L/N_d}{b}\right)a$$

$$q = \Delta q N_f = kh_L\left(\frac{a}{b}\right)\left(\frac{N_f}{N_d}\right)$$

: N_f is the total number of flow channels in the flow net.

Flow-Net Construction

1. Draw the cross section to be studied on good tracing paper; turn the sheet over and construct the flow net on the reverse side. After the flow net has been completed by freehand sketching trace it on the front side or on fresh paper. Use French curves if a smooth finished product is desired for illustrative purposes. *Freehand lines do not detract from the accuracy or usefulness of a flow net if the basic rules have been properly followed.*

2. Be practical in the number of lines drawn. Do not clutter up the drawing with too many lines, but do not use so few that essential features are lost. Remember that parts of a flow net can be subdivided to any degree that is required to emphasize detail (Fig. 3.5 and Fig. 4.2*d*).

Flow-Net Construction

3. Be practical in selecting a scale for the drawing. A scale that is too large wastes time and erasers. An 8½-by-11-in. sheet is a good size for many flow nets, although a sheet several feet wide may sometimes be needed for the analysis of a levee or dam with a wide berm or a wide upstream blanket and for groundwater studies of wide cross sections.
4. Before starting to sketch a flow net look for important boundary conditions and for prefixed flow net lines (Figs. 4.2*a* and 4.3*a*). In every flow net some flow lines and some equipotentials are established by the boundary conditions before the flow net is started. *Noting the prefixed lines helps one to get the general shape somewhat correct in the beginning.*

Flow-Net Construction

5. In drawing flow nets for composite sections (those having more than one permeability) look for dominating parts of a cross section. Highly pervious or highly impervious parts sometimes have a major influence on flow patterns (Figs. 4.7 and 4.8).
6. Do not overlook the overall shape while working on details and never refine a small portion of a flow net before other parts have been fairly well developed. Corrections made in one part have some influence on every other part.
7. Study the basic rules that must be carried out and follow them (Sec. 3.3).

Flow-Net Construction

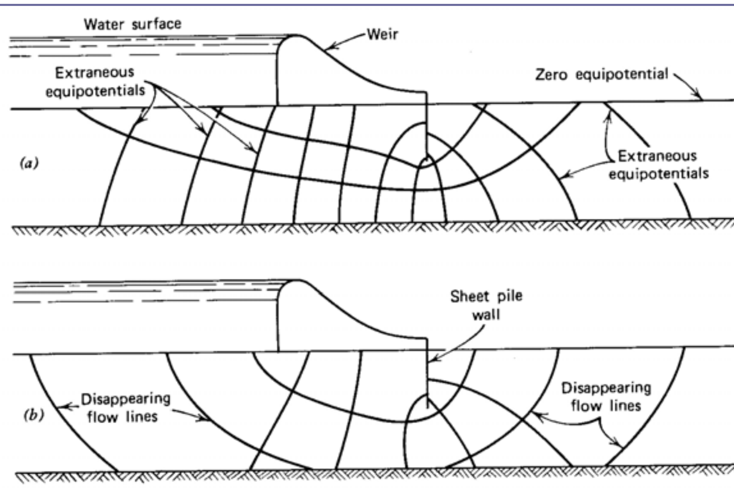
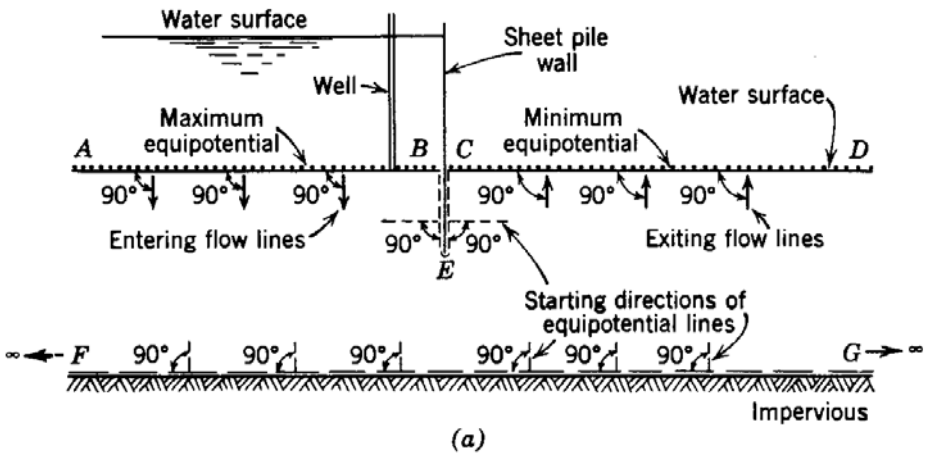
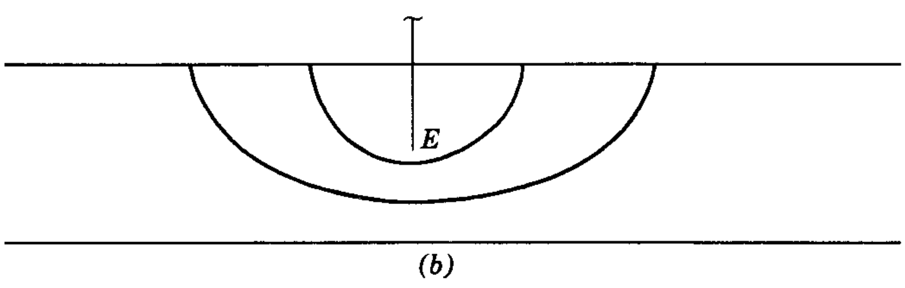


FIG. 4.1 Some common errors in flow nets by beginners.(*a*) Extraneous equipotentials. (*b*) Disappearing flow lines.

Example

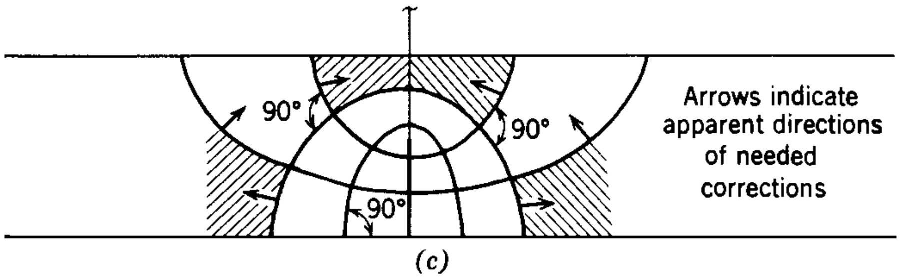


Example



Draw a few flow lines

Example



Add a few equipotential lines

Example

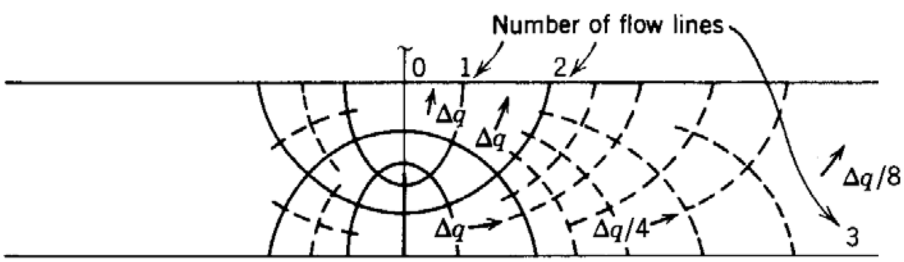


FIG. 4.2 Example of the construction of a flow net for confined flow in single permeability section (Example 1). (*a*) Identify prefixed conditions, noting starting directions of lines. (*b*) Draw trial family of flow lines (or equipotentials) consistent with prefixed conditions. (*c*) Keeping the lines drawn in (*b*), sketch first trial flow net. Make all lines intersect other set of lines at 90°. (*d*) Erase and redraw lines until all figures are square. Subdivided as desired for detail and accuracy.