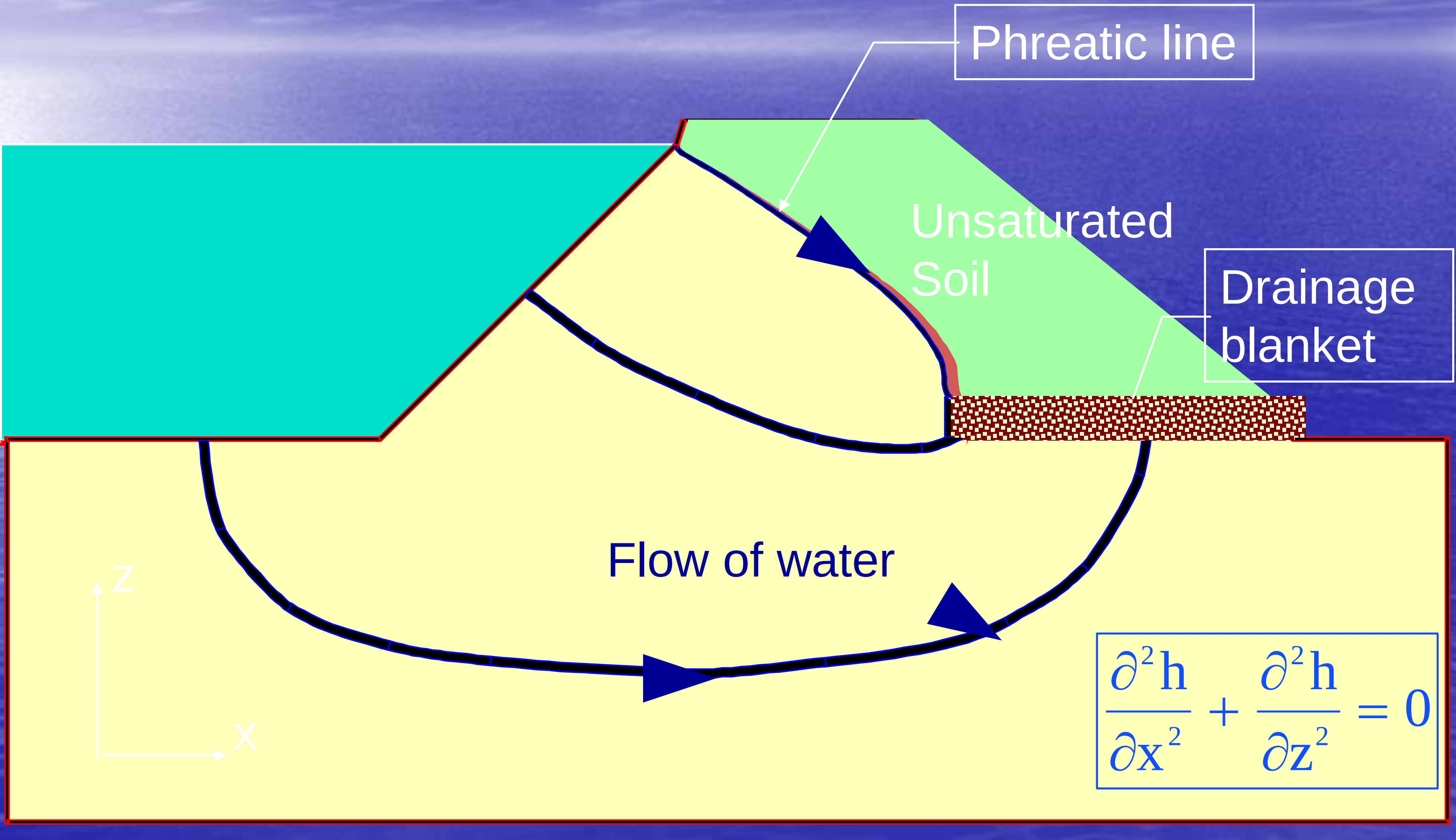
# Water in Soil ( Seepage)

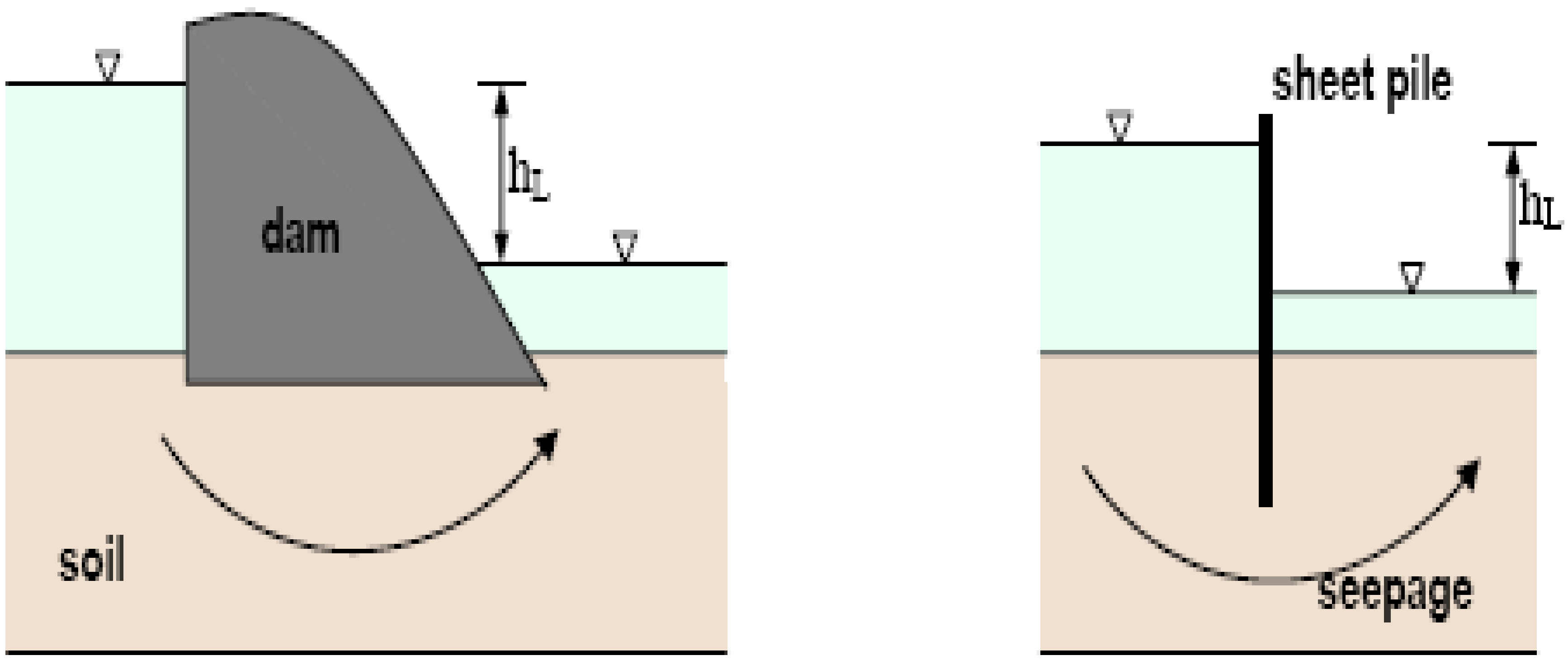
# Seepage

- Flow of water through soils is called *seepage*
- Movement of water is from upstream to downstream
- The rate of seepage can be estimated after measuring the coefficient of permeability
- When seepage velocity is great enough, erosion can occur
- Erosion of the soil (‘piping”) can lead to failure of the structure.
- Therefore detecting, positioning and mapping the seepage flownet is important.

# Flow through a Dam

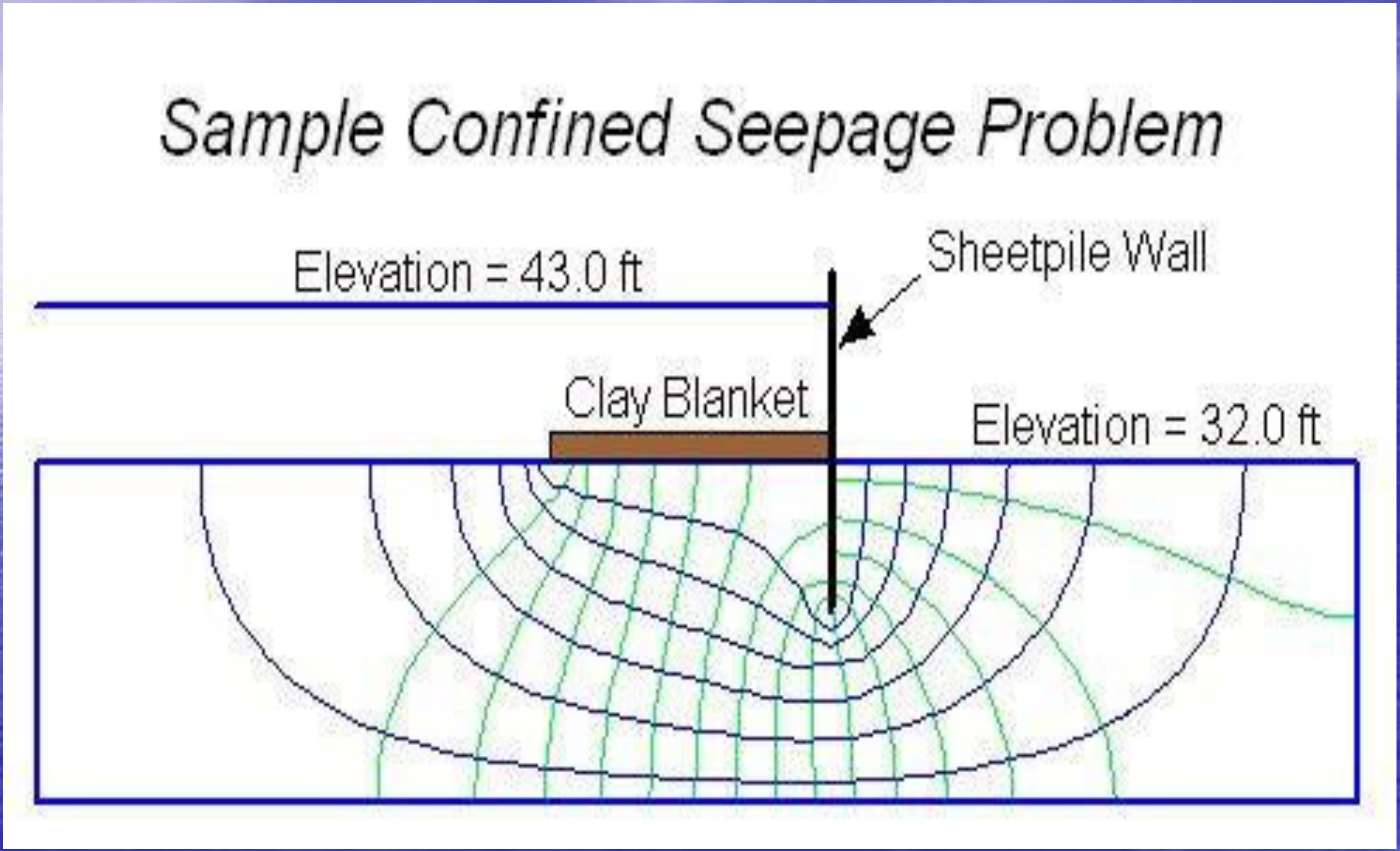



$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial z^2} = 0$$

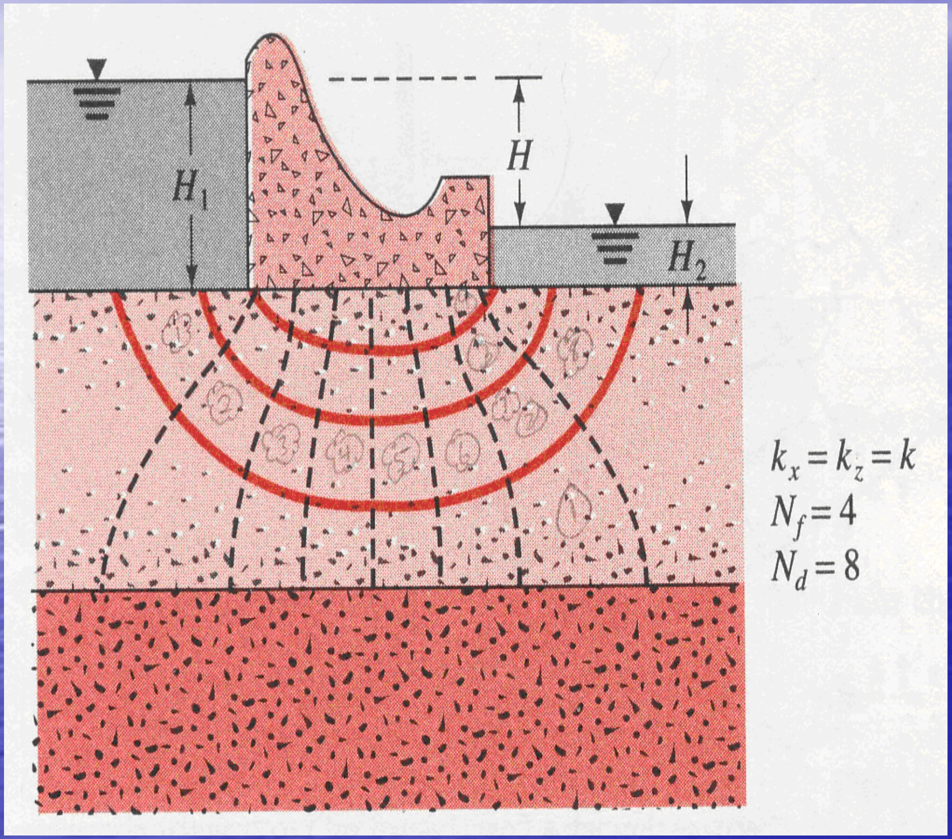



**Seepage beneath (a) a concrete dam (b) a sheet pile**

# Flow Nets

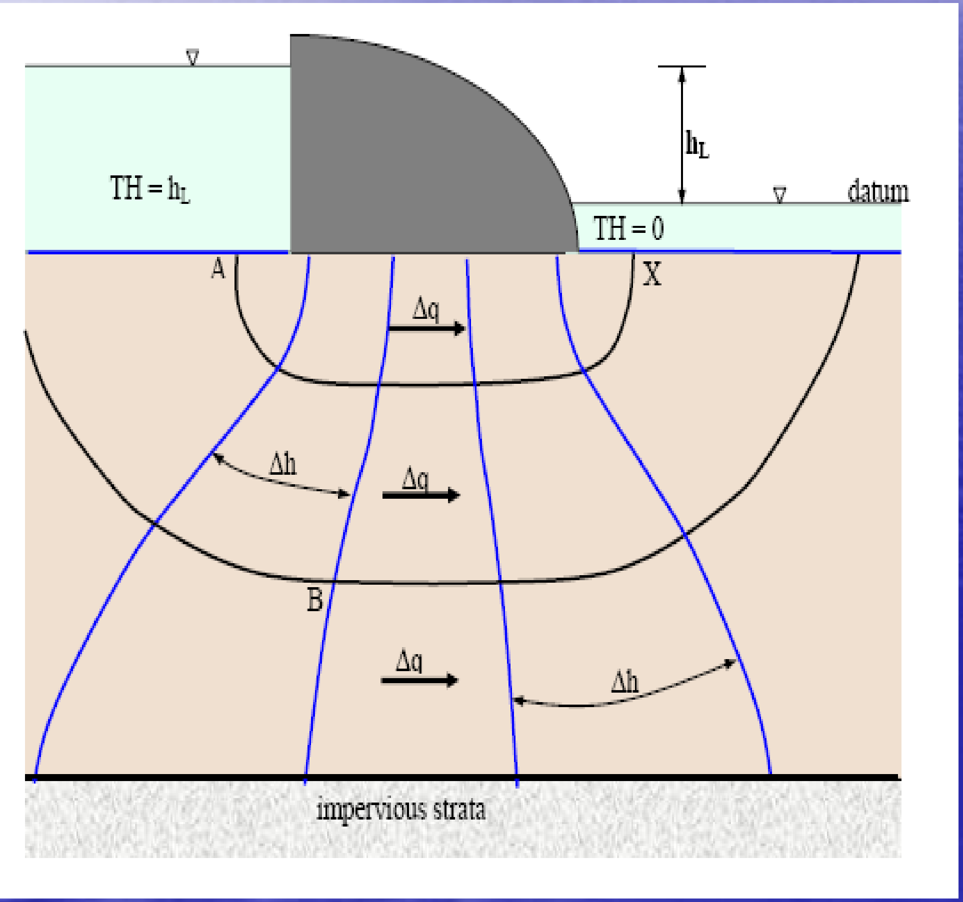

Sample Confined Seepage Problem
Elevation = 43.0 ft
Sheetpile Wall
Clay Blanket
Elevation = 32.0 ft

# Flow Nets

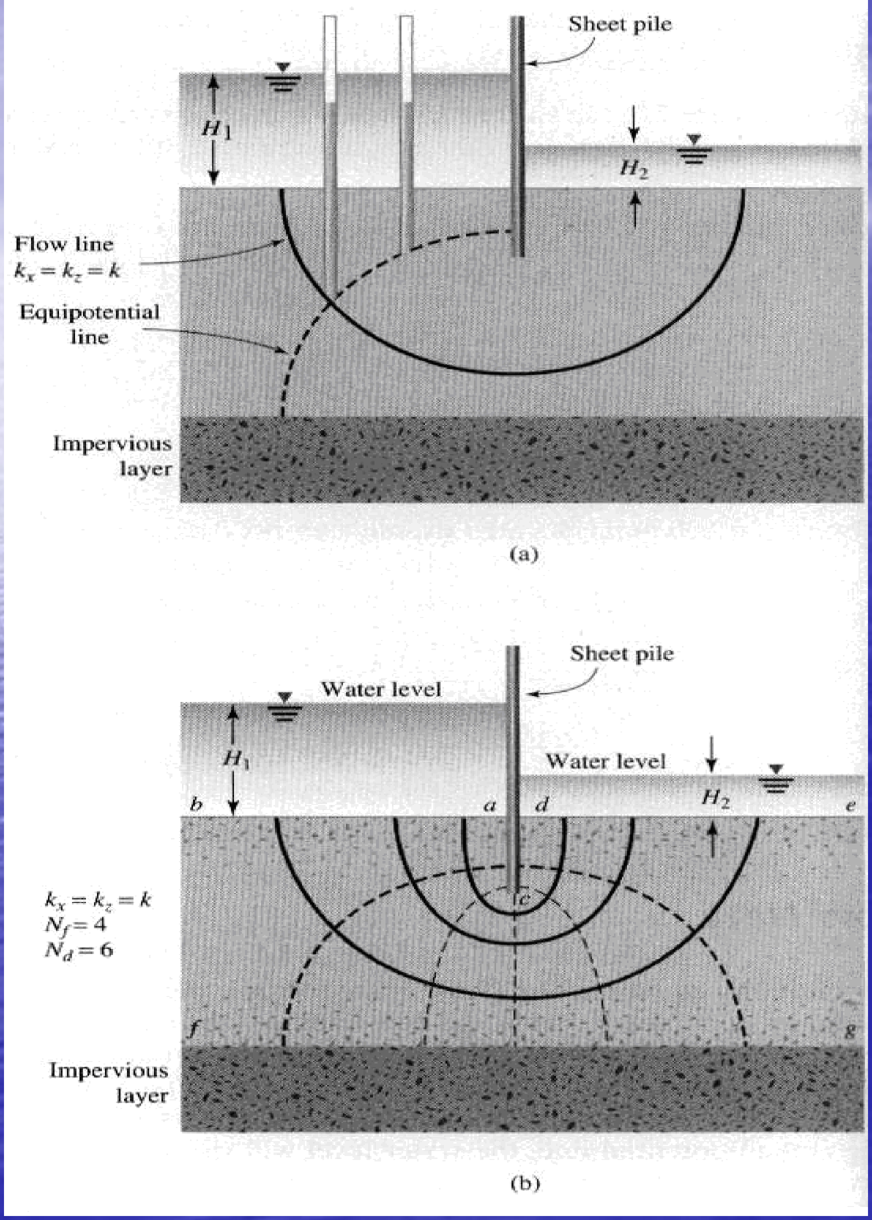



- Flow net can represent the seepage
- The quantity of seepage under dams and sheet piling can be estimated using the graphhical construction known as a flownet.
- Flow net is a concept that illustrates graphically how the head of energy lost as water flows through a porous medium

# Flow Nets




- Water seeps through the permeable stratum beneath the dam from u/s (left) to the d/s side (right).
- The flownet represent the network of **flow lines**( black line) and **equipotential lines** (blue line).




- **Flowlines** represent the flow of water through the foundation under the dam,the sheetpile wall and etc.
- **Equipotential line** represent the energy of flow. An equipotential line is a line along which the potential head at all points is equal.
- To complete the graphic construction of a flow net, one must draw the flow and equipontential lines in such a way that:

1. The equipontential lines intersect the flow lines at right angles.
2. The flow elements formed are approximate squares.

# Construction of flownet

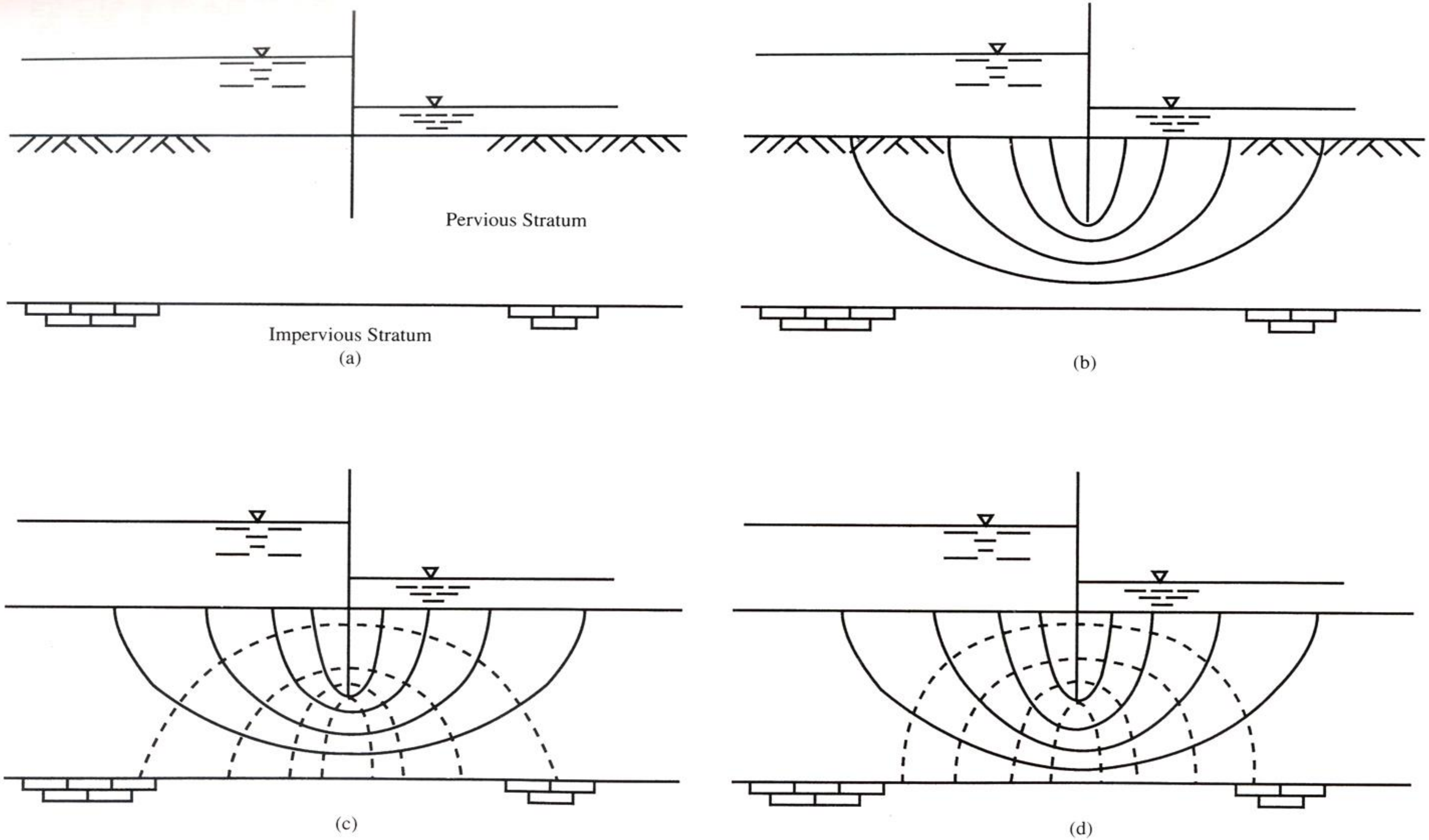


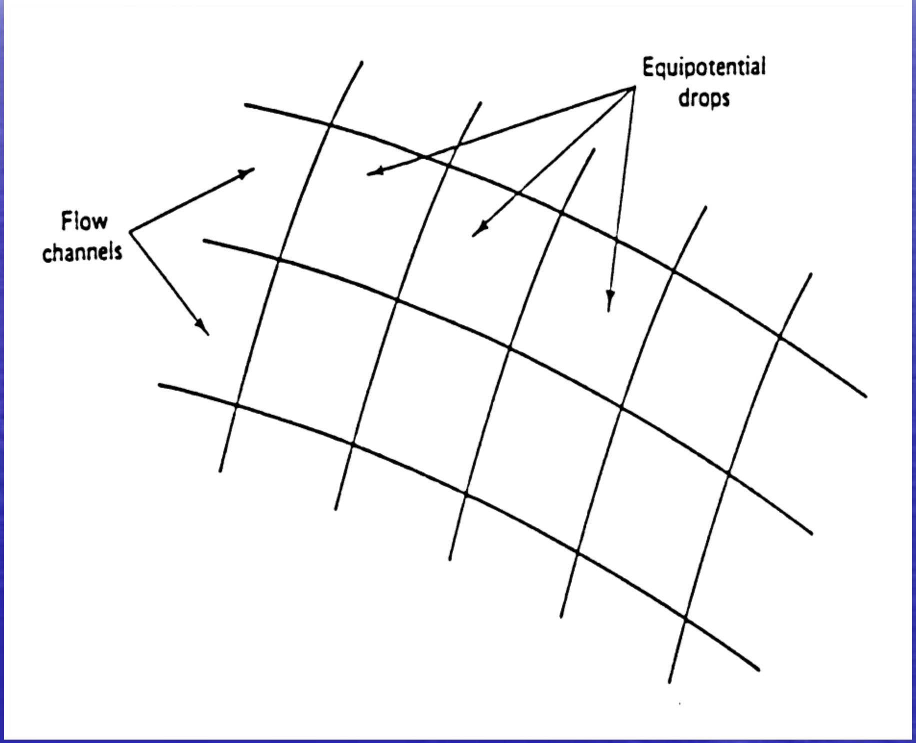

**FIGURE 5–11** Construction of flow net: (a) scale drawing showing pervious and impervious boundaries; (b) flow lines; (c) equipotential lines; (d) final flow net.

# How to Sketch Flow Net

- For 2D problem, simply draw the medium with its boundaries to some convenient scale.

- By trial & error, sketch a network of flowlines and equipotential lines so that the enclosed figures resemble squares.

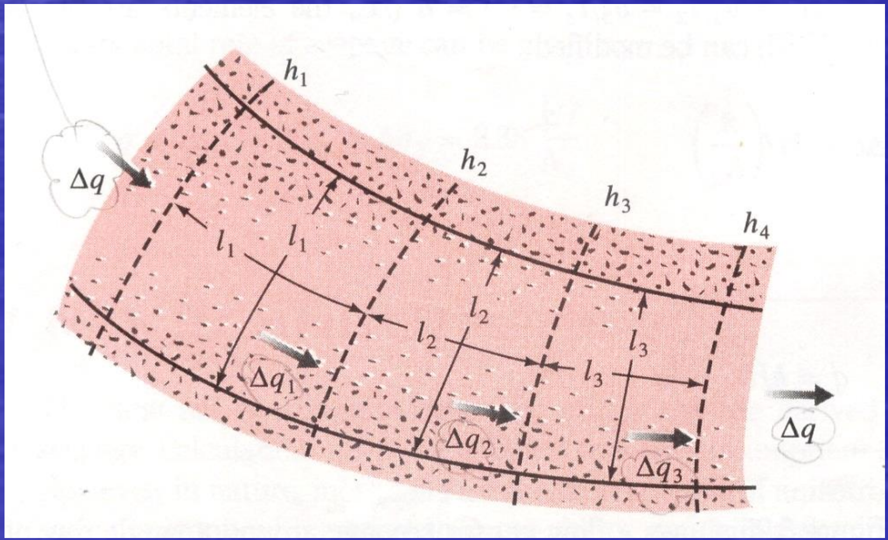
- Flow lines can't intersect on impervious boundaries. In fact, impervious boundaries is a flow line!



# Seepage Calculation From A Flow Net ( isotrophic soil )

- In any flow net, the strip between any two adjacent flow lines is called flow channel.
- Figure shows a flow channel with the equapontential line forming square elements. Let h1, h2, h3……hn be the piezometric levels corresponding to the equipontential lines.
- Rate of seepage through the flow channel per unit length (perpendicular to the vertical section through the permeable layer) can be calculated as follows: Because there is no flow across the flow lines,

$$\Delta q1 = \Delta q2 = \Delta q3 = \Delta qv$$



- From Darcy law, flow rate is equal to kiA. So equation above can written

$$\Delta q = \frac{k(h_1 - h_2)l_1}{l_1} = \frac{k(h_2 - h_3)l_2}{l_2} = \frac{k(h_3 - h_4)l_3}{l_3}$$

- From equation above shows that if the flow elements are drawn approximate squares, the drop in piezometric level between any two adjacent equipontential lines is the same. This is called the *potential drop*. Thus,

$$h1 - h2 = h2 - h3 = h3 - h4 = \ldots\ldots = H/ Nd$$

and

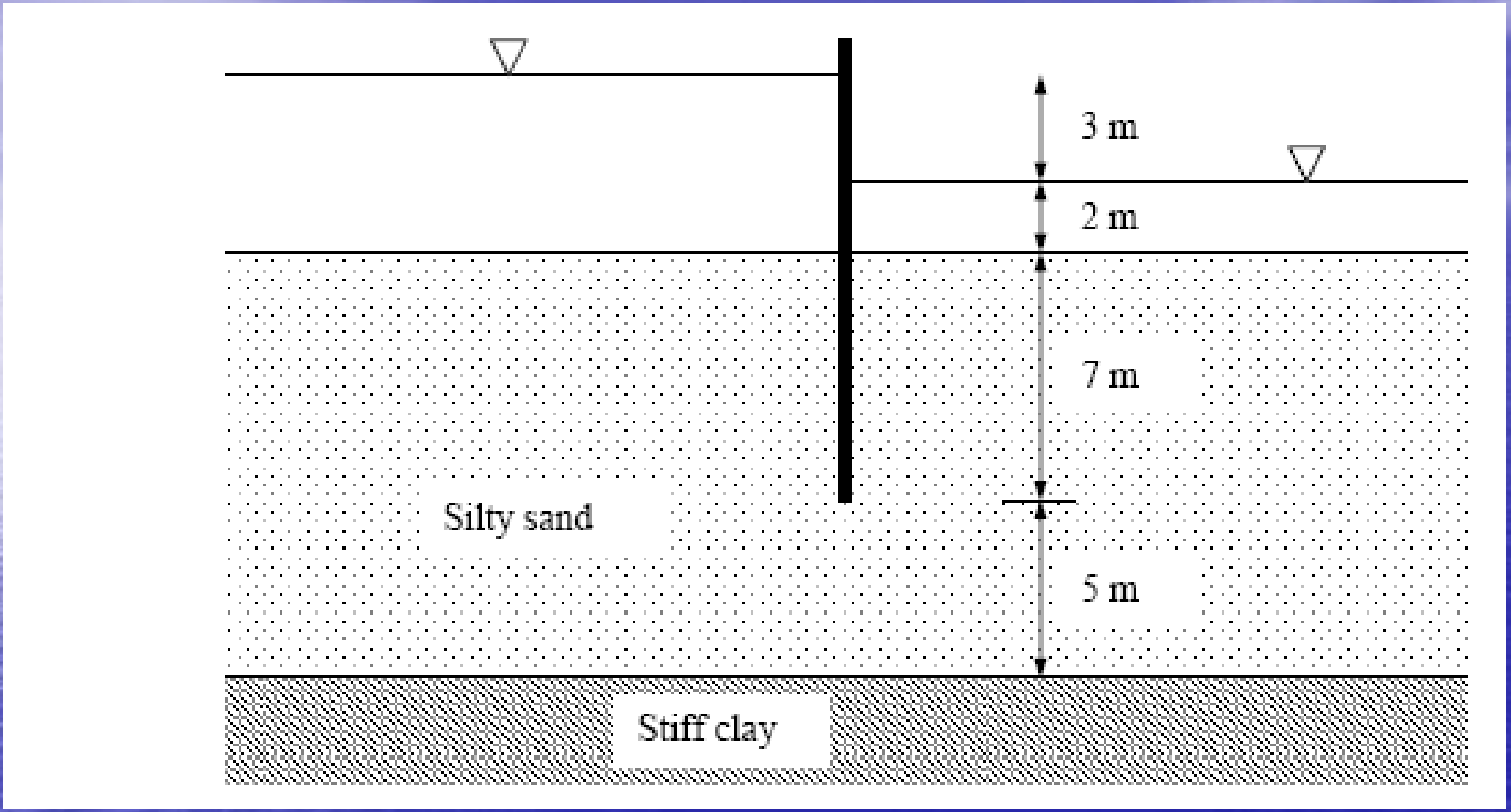
$$\Delta q = k \frac{H}{N_d}$$

where H = head difference between the upstream and downstream sides
Nd = number of drops

If the number of flow channels in a flow channel is equal to Nf, the total rate of flow through all the channels per unit length can be given by

$$q = k \frac{HN_f}{N_d}$$

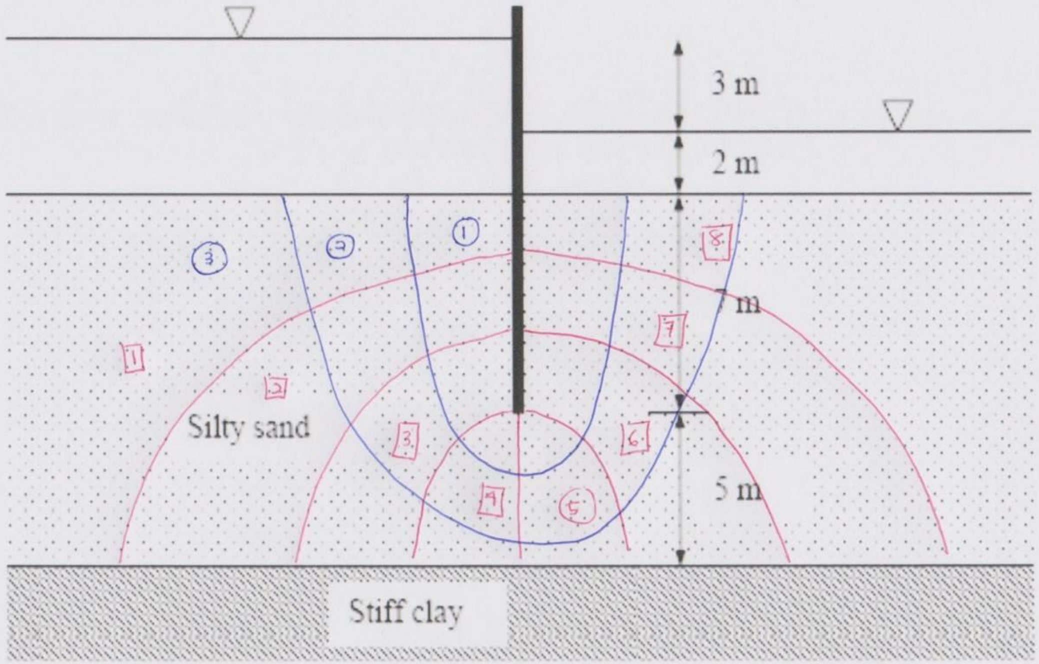
# Example




**A stiff clay layer underlies a 12 m thick silty sand deposit. A sheet pile is driven into the sand to a depth of 7 m, and the upstream and downstream water levels are as shown in the figure. Permeability of the silty sand is 8.6 × 10-4 cm/s. The stiff clay can be assumed to be impervious. The void ratio of the silty sand is 0.72 and the specific gravity of the grains is 2.65.**

**Draw a flow net and estimate the seepage beneath the sheet pile in m3/day per metre.**

# Solution




$H_L = 3$

$N_f = 3$

$N_d = 8$

$$q = k\frac{HN_f}{N_d}$$

= 0.836 $m^3$/day per metre