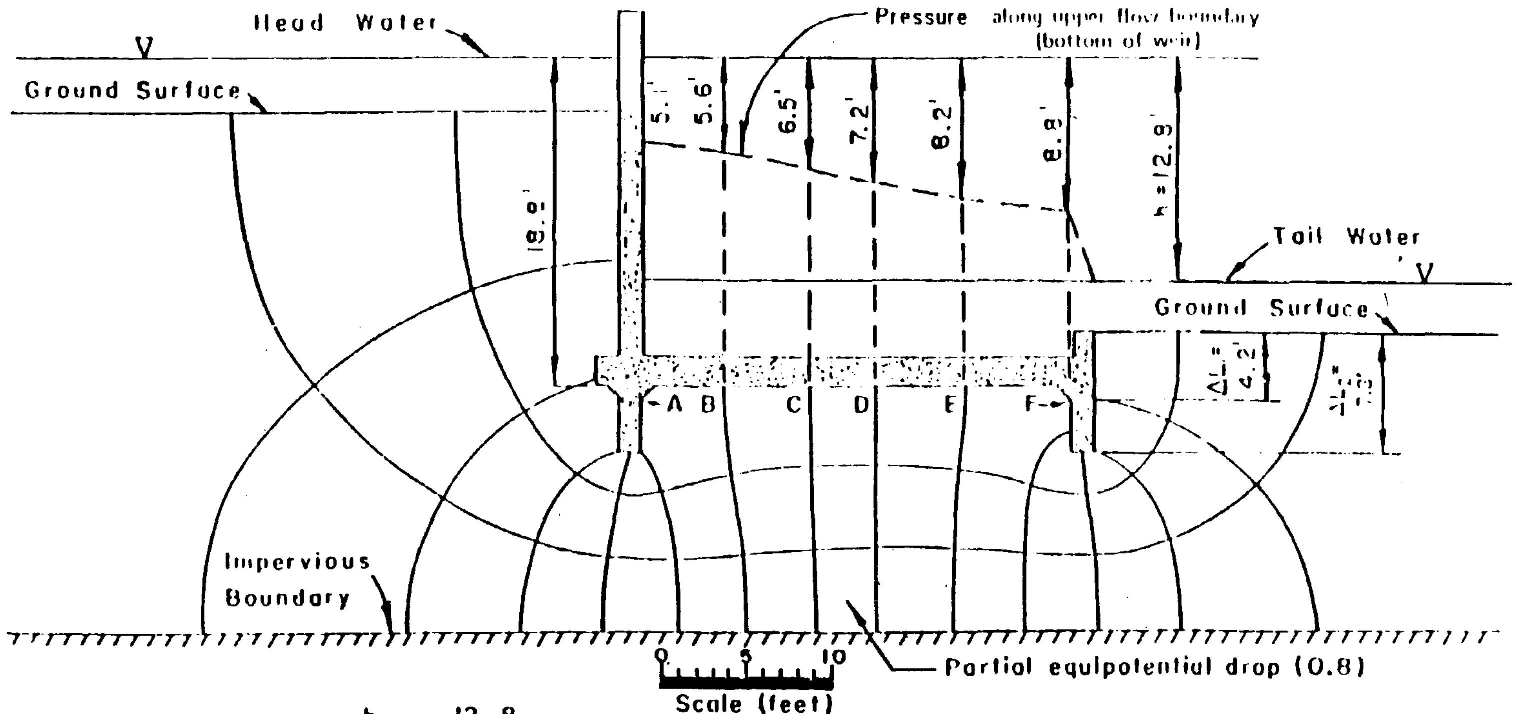
CHAPTER 5
CONFINED FLOW PROBLEMS

5-1. General Considerations. As explained in Chapter 4, confined flow exists when the saturated pervious soil mass does not have a line of seepage boundary. Impervious weirs or gravity dams on pervious soil or rock are typical projects which have confined flow conditions. This chapter will consider two of these cases. While examples of this chapter use flow nets, other methods for determining uplift and gradient such as the Method of Fragments may be used.

5-2. Gravity Dam on Pervious Foundation of Finite Depth. Figure 5-1, a copy of figure 4-15, provides an example of an impervious structure on a pervious foundation of finite depth with calculation of uplift and escape gradient. Figure 4-12 illustrates a gravity dam on a composite pervious foundation of finite depth and figure 4-10 shows an example of an impervious dam (though not a gravity dam) on a finite anisotropic foundation. A cross section of a classical gravity dam/weir, figure 5-2 indicates the effect of a partially penetrating cutoff placed beneath the upstream portion of the dam. Comparing figure 4-10(b) with figures 5-1 and 5-2 will show the reduction in gradient at the downstream toe caused by embedment of the structure in the pervious foundation. Embedment provides a longer upper flow line for a given structure width and reduces the gradient at the downstream toe of the structure. Other measures to reduce uplift and/or high gradients at the downstream toe include cutoffs beneath the downstream portion of the dam and placement of drains beneath the downstream portion of the dam.

5-3. Gravity Dam on Infinitely Deep Pervious Foundations. This case, illustrated by figure 5-3, is symmetrical (if there are no asymmetrical cutoffs or drains beneath the dam) and at large distances becomes a series of half circle arcs for flow lines and radial lines for equipotential lines. Since the upstream (entrance) and downstream (exit) boundaries extend to infinity and the foundation depth is infinite, the flow quantity is infinite. Obviously the analyst must decide the limits of the problem and calculate flow quantity based on those limits. The same manipulations and effects of embedment, cutoff, and drain described for the previous case will apply to this case.



$N_d = 13.8; \quad \Delta h = \frac{h}{N_d} = \frac{12.8}{13.8} = 0.93'$

Point designation	No. of drops to point	Head loss = (Δh x No drops) (ft.)	Uplift pressure (18.8'- hd. loss) γ_w (p.s.f.)
A	5.5	5.1	855
B	6	5.6	824
C	7	6.5	768
D	7.8	7.2	724
E	8.8	8.2	661
F	9.5	8.8	624

Escape gradient at toewall and transverse sill:

$$i_{e_1} = \frac{\Delta h}{\Delta L_1} = \frac{0.93}{4.2} = 0.22$$

$$i_{e_2} = \frac{2\Delta h}{\Delta L_2} = \frac{1.86}{7.3} = 0.25$$

Figure 5-1. Base uplift and escape gradient for concrete drop spillway (from U. S. Department of Agriculture[123])

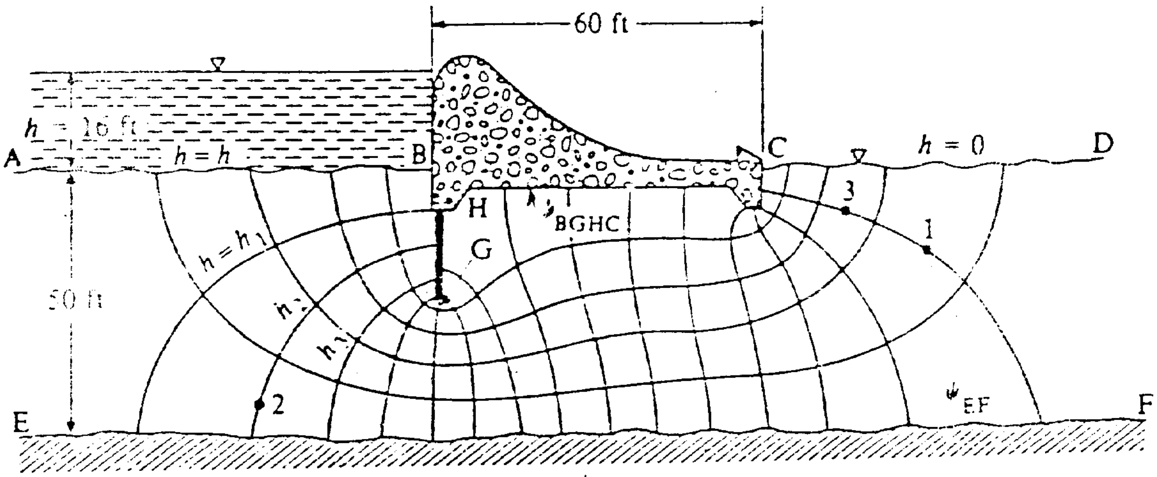


Figure 5-2. Gravity dam on pervious foundation of finite depth (courtesy of McGraw-Hill Book Company[181])

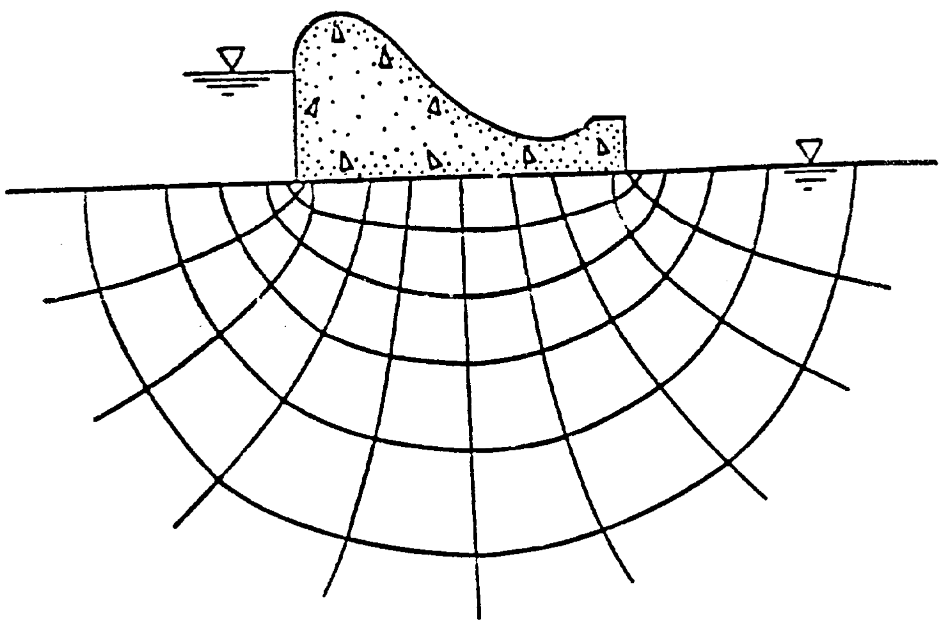


Figure 5-3. Gravity dam on an infinitely deep pervious foundation (prepared by WES)