Bengal Engineering and Science University, Shibpur
M.E. (Civil) First Semester Examination, 2012
Flow Through Porous Media (CE-910)

Full Marks : 70 **Time : 3 hours**

Answer any *FIVE* Questions
The questions are of Equal Value

1(a) Discuss the nature of fluid flow in soils.
(b) With reference to Reynolds' findings based on his classical experiments on flow of water, discuss the relationship between velocity and gradient.
(c) In this context, state Darcy's law and discuss its range of validity. (3+8+3)

2.(a) Using Poiseuille's law, Taylor (1948) developed an equation based on considering flow through porous media similar to flow through a bundle of capillary tubes. Stating this equation, outline and discuss the factors affecting soil permeability under the sub-headings: (i) the factors related to the permeant characteristics, and (ii) the factors related to the soil characteristics.
(b) For a stratified deposit of n number of homogeneous and isotropic strata, derive expressions for equivalent coefficient of permeability (i) parallel to the bedding plane and (ii) perpendicular to the bedding plane.
(c) Show that the square root of the directional coefficient of permeability for an homogeneous and anisotropic layer, when plotted from a point, generates an ellipse. (4+2x5)

3.(a) Starting from fundamentals, derive the basic equation (Laplace equation) for steady flow in soils. Clearly state the assumptions involved.
(b) Show that in the above equation, the effects of anisotropy can be taken into account by a simple transformation of spatial co-ordinates.
(c) Derive an expression for the equivalent coefficient of permeability for an homogeneous and anisotropic section. (8+2x3)

4. (a) Enumerate the methods of solving flow problems in soil mechanics.
(b) With a neat sketch describe the method of flow-net sketching and derive an expression for the quantity of seepage in an homogeneous and isotropic flow domain.
(c) When using the above method, demonstrate how the flow lines change directions across an interface between soils of different permeabilities. (4+6+4)

5.(a) Show that the stream function as well as the velocity potential satisfies Laplace equation.
(b) Show that existence of velocity potential implies irrotational flow.
(c) Prove analytically that flow lines cut the equipotential lines orthogonally. (2x5+4)

6.(a) Show that $\phi+ky$ = const. represents both (i) line of seepage and (ii) surface of seepage. Are then (a) and (b) the same?
(b) Show how an impervious boundary is represented by ψ = const. and a reservoir boundary by ϕ = const.
(c) Give the step-by-step procedure for obtaining the solution of a flow problem using numerical method (2x4+6)

PTO

7.(a) A 50m high homogeneous earth dam on an impervious foundation having a top width of 15m, u/s slope of 1V:2.5H, and a d/s slope of 1V:3H retains an impounding reservoir of height 40m. The dam is composed of a soil of $k_z = 1x10^{-5}$ cm/sec and $k_x = 10\ k_z$. Calculate the quantity of seepage through the dam.
(b) What will be the side slopes of a model dam to be constructed to study the seepage characteristics of the above prototype if the soil to be used in the model has $k_x = 16\ k_z$.? (10+4)

8. With the help of Schwarz-Christoffel transformation, derive the equations for the families of the streamlines and the equipotential lines, and, also draw the pattern of flownet for flow around a sheetpiling wall having head water level at h_1 and tail water level h_2 above the dredge level; and a depth of embedment of d. (14)