Bengal Engineering and Science University, Shibpur
M.E. (Civil) First Semester Examination, 2011
Flow Through Porous Media (CE-910)

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

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

1.(a) Enumerate the conditions that are required to specify completely the flow of fluids under any circumstances.
(b) Define superficial velocity of flow and seepage velocity and derive a relation between them.
(c) Effects of which three forces are combined in the Navier-Stokes equations?
(c) In Soil Mechanics, which law is analogous to the general Navier-Stokes equations? State the generalized form of this law in three dimensions and discuss its range of validity.
(d) On what factors does the coefficient of permeability depend? (3x4+2)

2.(a) Derive the governing equation of flow through soils.
(b) Hence deduce the Laplace equation in three dimensions. (8+6)

3.(a) Show that the stream function (ψ) as well as the velocity potential (ϕ) satisfies Laplace equation.
(b) Show also that the streamlines and the equipotential lines are mutually orthogonal.
(c) Show how an impervious boundary is represented by ψ = const. and a reservoir boundary by ϕ = const.
(d) $\phi+ky$ = const. represents both (i) line of seepage and (ii) surface of seepage. Are then (a) and (b) the same? (3x4+2)

4.(a) Show that a stratified medium of thin homogeneous and isotropic layers can be converted into an equivalent single homogeneous and anisotropic layer. Show also that the coefficient of permeability is greater in the direction of stratification.
(b) Show that the square root of the directional coefficient of permeability for an homogeneous and anisotropic layer when plotted from a point will generate an ellipse.
(c) Show that the effects of anisotropy can be taken into account by a suitable transformation of spatial co-ordinates. (8+2x3)

5.(a) Calculate the quantity of seepage through the homogeneous and anisotropic earth dam founded on an impervious base, having the following dimensions and soil permeabilities:
(i) Dam height = 50m, (ii) Top width = 15m, (iii) U/S side slope = 1V: 2.5 H; (iv) D/S side slope = 1V: 3H; Height of reservoir water level = 40m; (v) Vertical permeability $k_z = 1x10^{-5}$ cm/sec, Horizontal permeability, $k_x = 10\ k_z$.
(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 a horizontal permeability 16 times that in the vertical direction? (8+6)

6. (a) Obtain an analytical solution of Laplace equation for the one dimensional rectilinear flow through tube occupied by two soils of permeabilities k_1 and k_2 and taking up lengths L_1 and L_2 along the tube axis.

(b) For the above situation, show that the seepage force per unit volume is given by $i.\gamma_w$ where I is the hydraulic gradient. For the particular case in which the tube axis is vertical, show that the critical gradient is given by

$$i_c = (G-1)/(1+e) \qquad (8+6)$$

7. (a) Considering the simple case of two-dimensional confined flow under a concrete dam of width 2b founded at the surface of an infinite, permeable medium, obtain a solution of the Laplace equation using Schwarz-Christoffel transformation. Derive the equations for the families of the streamlines and the equipotential lines, and, also draw the pattern of flownet.

(b) Also derive an expression for the exit gradient. (11+3)

8. (a) Explain in detail the modifications needed for flownet diagram when flowing water moves from one medium to another of different coefficient of permeability.

(b) Derive an expression for the height of capillary rise in soils and state the factors on which it depends.

(c) Show that from a flow net drawn on a transformed section in the case of an anisotropic soil having horizontal and vertical permeabilities k_x and k_z respectively, the flow quantity can be obtained by taking the coefficient of permeability $k' = (k_x k_z)^{0.5}$

(d) Describe exit correction from the parabolic shape of top flow line for dams without an underdrain. (3x4+2)