Master of Mechanical Engineering Examination, 2017

(2^{nd} semester)

Design of Structural Elements

Time – 3 hours Full marks: 100

(Answer any five questions)

Data if missing may be assumed reasonably

1a. Prove that centroidal axis is not the neutral axis for a curved beam and hence find locations of the neutral axes for circular and rectangular section beams.

b. Determine the ratio of bending and shear deflections of a circular section cantilever beam under uniform transverse loading and show it's variation with slenderness ratio of the beam.

10 + 10

2a. Locate the shear centre of the thin walled (h>>t) channel section cantilever beam, as shown in figure 1a, with reference to the origin point of the coordinate system.

b. Derive equations for the induced stresses at the corner point 'A' of the clamped end of the beam, as shown in figure 1b, if force 'P' acts along line 'L-L', making an angle θ with +ve x-axis.

10 + 10

3a. Determine the stress function associated with pure bending of a slender beam. Show that the stress boundary conditions are satisfied at the two ends and at the top and bottom surfaces of the beam. Also derive the displacement fields from the stress function and discuss about their physical significance.

b. Repeat the problem of question 3(a) if the beam is simply supported and under uniformly distributed loading.

10 + 10

4a. Explain the concept of limit load of a structural element and hence define limit load factor (LLF).

b. Determine the LLF of a thick walled pressure vessel, assuming 'linearly elastic – perfectly plastic' material behaviour. State the assumptions needed to carry out the analysis and show the dependence of LLF on radii ratio.

c. Determine the LLF for a high speed rotating steel disk of uniform thickness and also show its dependence on radii ratio.

d. Compare the LLFs of the above two cases and state your observations.

3+7+7+3

5a. State the assumptions of the classical thin plate theory (CPT) and mention their applicability and limitations.

b. State the boundary conditions of the free edge of a plate and state how the fallacy of three boundary conditions was resolved by Kirchhoff in this connection.

c. Determine the strain energy stored in a thin rectangular plate following CPT and discuss the significance of the Gaussian curvature term in the energy expression.

d. State the various other plate theories, indicating their differences with CPT.

5+4+7+4

[Turn over

6. State and derive Von Karman's equations for large displacement non-linear analysis of rectangular plates. Express the final equations in uncoupled form and discuss about the in-plane boundary conditions. Explain how the same problem can be framed by using three unknown displacement fields?

8+7+5

7. Explain how the dynamic problem of thick beams is analyzed by using Timoshenko beam theory and extend the method for the solution of thick plate vibration problems following Mindlin plate theory.

20

8a. Determine the critical load of a thin rectangular simply-supported plate (a x b x t), subjected to unidirectional uniform compressive load. Make a plot of the buckling coefficients showing its variation with the aspect ratio of the plate and indicating the first four transition values where buckling modes change.

b. Draw the interaction diagram (plot of the buckling coefficients) for the first five buckling modes of a square simply-supported plate under bi-directional compressive load.

14+6

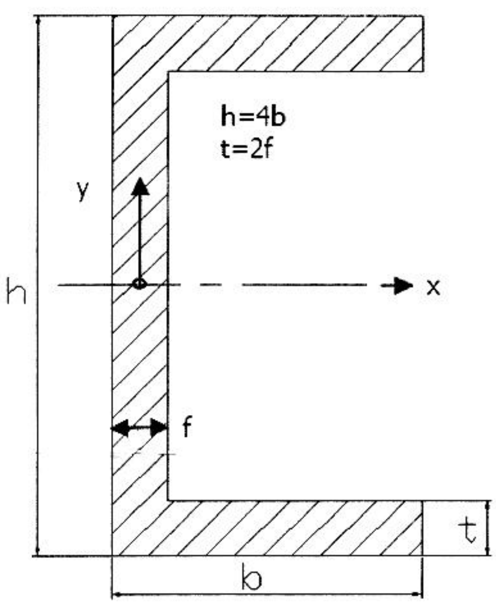

Fig. 1a.

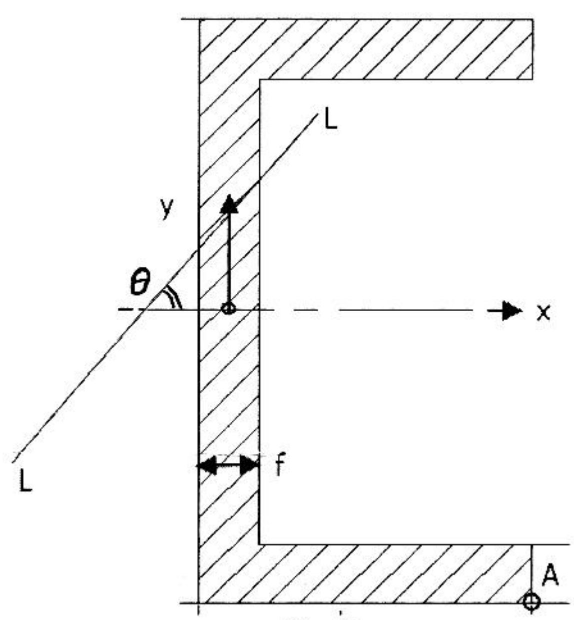

Fig. 1b.