Master of Mechanical Engineering Examination, 2019

(1st year, 2nd 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 Euler – Bernoulli theory for beam bending is valid only where induced bending moment is constant or varies linearly along the axis of the beam.

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

10+10

2a. Determine the ratio of bending and shear deflections of a circular section cantilever beam under a concentrated transverse load at the free end, and show it's variation with slenderness ratio of the beam.

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

10+10

3. Explain the concept of limit load of a structural element and hence determine the limit load factors of the following structural elements, assuming 'linearly elastic – perfectly plastic' material behaviour.

a) Thick walled pressure vessel

b) High speed rotating steel disk of uniform thickness

2+8+10

4a. Derive the moment-curvature relation for the deflected surface of a simply-supported rectangular plate, subjected to pure bending.

b. Derive the equation of deflected surface once again when the plate is under distributed transverse loading and explain the different classical boundary conditions.

c. State how the fallacy of redundant boundary condition of free edge was resolved by Kirchoff.

7+8+5

5a. Obtain the deflected shape $w(x,y)$ for large deflection of a thin rectangular plate, simply-supported along each of its four edges, by using energy functionals. The plate is acted upon by a uniformly applied load of magnitude q_0.

b. Repeat the problem if the plate is clamped along each of its four edges.

10+10

6a. Solve the combined bending-stretching problem of a clamped–clamped beam, subjected to uniform transverse loading, by using energy method. State the appropriate coordinate functions to be used.

b. Derive von Karman's equations for large displacement analysis of rectangular plates. Express the non-linear equations in uncoupled form and discuss about the 'in-plane' boundary conditions.

10 + 10

7. Explain how the dynamic problem of thick beam 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. Plot the buckling coefficients showing its variation with the aspect ratio of the plate. Also indicate the first four transition values of aspect ratios where buckling modes change.

b. How the buckling coefficients will change if the plate is subjected to bidirectional uniform compressive load.

12+8

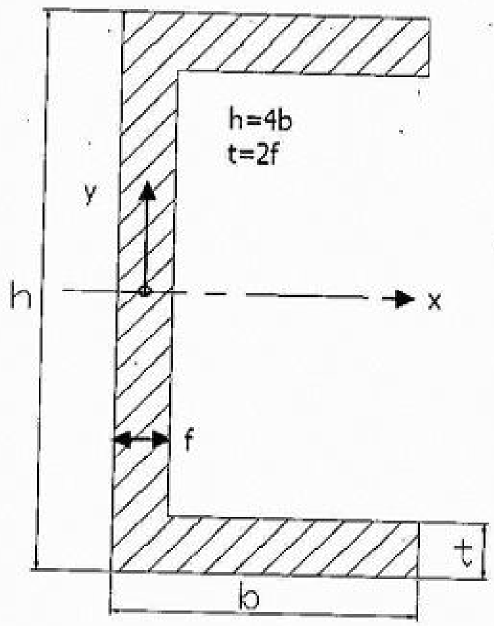

Figure 2b