NATIONAL EXAMS – May 2009

98-Civ-B2, Advanced Structural Design

3 Hours Duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a **"CLOSED BOOK"** examination. Handbooks and textbooks are permitted. **NO** notes or sheets are allowed. Candidates may use one of two calculators, the Casio or Sharp approved models. You must indicate the type of calculator being used, i.e. write the name and model designation of your calculator on the first inside left-hand sheet of the exam workbook.

3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer will be marked.

4. All questions are of equal value.

5. **All loads shown are unfactored.**

USE THE FOLLOWING DESIGN DATA

Design in   SI

Concrete	$f'_c = 30$ MPa
Structural Steel	$f_y = 350$ MPa
Rebar	$f_y = 400$ MPa

Prestressed Concrete	f_c (at transfer) = 35 MPa
	$f'_c = 50$ MPa
	$n = 6$
	$f_{ult.} = 1750$ MPa
	$f_y = 1450$ MPa
	$f_{initial} = 1200$ MPa
	Losses in prestress = 240 MPa

1. Figure 1 shows a <u>steel rigid frame</u> to be designed using the <u>Plastic Method of Design</u>. The plastic moment capacities of the members are given.

(15)   (a) Design the members of the frame.

(5)   (b) Determine the size of the concrete footing at base D, using 300 kPa for the soil bearing capacity.

[Assume lateral support is provided at all joints and load locations.]

(12) 2.   (a) Check whether the steel section chosen in Question 1 is satisfactory for the <u>beam-column AB.</u>

(8)   (b) Design a welded connection for the joint at B.

[Assume adequate lateral support at all joints and load locations; neglect the effect of axial and shear deformations.]

(12+6+2) 3.   The continuous <u>welded steel-plate girder</u>, Figure 2, is simply supported at A and rigidly embedded into rock at C. Choose a suitable cross-section to satisfy:

(a) Flexure; (b) Shear, and (c) their interaction.

[Assume adequate size for the load base plates.]

(12+6+2) 4.   A <u>post-tensioned prestressed concrete</u> girder is to be designed to carry the live load shown in Figure 3:

(a) Design an adequate section for the girder, allowing no tension.

(b) Calculate the area and profile of the post-tensioned steel strands.

[Moment of inertia can be based on the gross cross section.]

5. A simply supported bridge is to be designed in <u>composite steel-concrete construction</u>. The bridge has a span of 16 m, a width of 20 m and a concrete deck slab 230 mm deep. The steel beams are to be spaced at 2.5 m.

Using unshored construction:

(15)   (a) Design the cross-section of the bridge, ignoring the self-weight of the steel beam. Assume 100% interaction between the steel beams and the concrete deck slab.

(5)   (b) Determine the number of shear connectors required.

[Assume the steel beams have adequate lateral bracings.]

(14+6)   6. Use the Limit States Design Method to design the continuous 3-span reinforced concrete beam, ABCD, in Figure 4. The requirements for both flexure and shear must be satisfied.

(14+6)   7. The rigid frame ABCD, loaded as shown in Figure 5, is to be designed in reinforced concrete.

(a) Design an adequate section for the beam-column AB.

(b) Estimate the long term deflection at C.
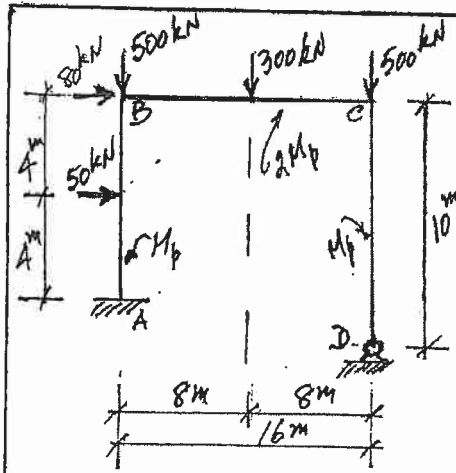
[Assume that the structure is braced at all joints.]
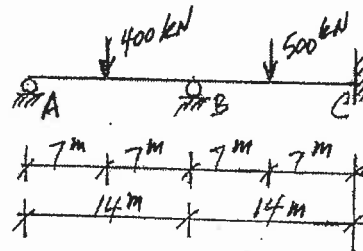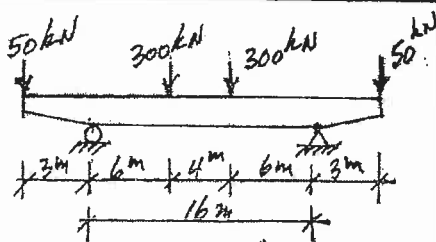
FIGURE 1

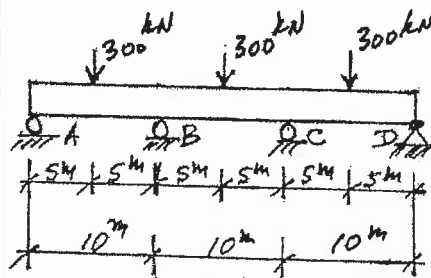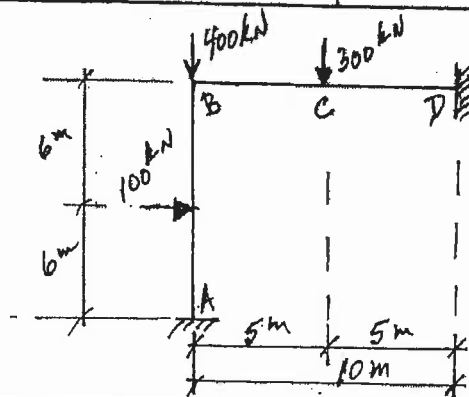NOTE: Lateral Support Provided @ 2m intervals

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5