National Exams December 2011

04-Agric-B2, Structural Design for Agricultural, Biosystems, and Food Industries

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 an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Some questions require an answer in essay format. Clarity and organization of the answer are important.

1. Define the following terms and explain how they relate to the structural design of agricultural structures; use examples to illustrate your answers.

a. live load (LL)
b. dead load (DL)
c. limit states design (LSD)
d. load factor
e. strength factor
f. low human occupancy
g. matrix structural analysis
h. hoop stress

2. A reinforced concrete floor covers and is supported by a below-ground rectangular concrete liquid manure tank with a centre wall. Thus, the floor has two equal spans continuous over the centre support; each span is 5.0 m clear span. All wall thicknesses are 0.25 m. Select the appropriate concrete (strength, max. water/cement ratio) for this corrosive environment, and adequate reinforcing steel and slab thickness for the floor to support cattle in loose housing (LL. 5.0 kPa) and light farm machinery for cleaning and maintenance (LL. 7.0 kPa) Table 1 provides areas of reinforcement, A_s, per one-metre strip.

3. Analyze the beam in Figure 1 for reactions at A and B, shear forces and bending moments. Identify the maximum positive and negative bending moments and their location. Draw shear force and bending moment diagrams. Assuming that the beam cross section is rectangular in shape, what is the neutral axis and where is it located? If the beam width is b and the depth d, what is the maximum shear stress and where would this stress occur?

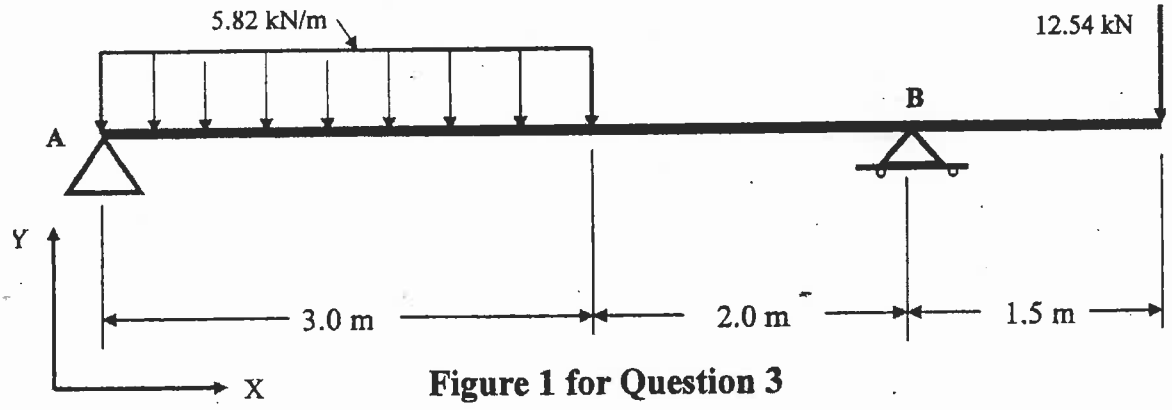

Figure 1 for Question 3

4. A horizontal or bunker silo for the storage of animal feed is simply a paved area surrounded on three sides by near-vertical retaining walls to contain the animal feed. The feed, mostly whole-plant corn silage or alfalfa forage, is deposited in the silo by dump trucks and consolidated by a tractor or a tracked vehicle, and then covered with plastic to keep the rain and snow out.
The 1995 (latest) National Farm Building Code specifies a silage pressure perpendicular to the wall L = 3.5+3.5H kPa where L is the lateral pressure and H is the depth from top of wall, in m.
Design a precast concrete wall that can be used for a silo wall 4.0 m high measured from the top of the footing. Do not design the reinforcing steel. It is intended that the precast unit includes the wall and an appropriate footing. Design the geometry of a stable, adequate retaining wall and recommend the length of individual sections bearing in mind that they have to be transported by road. The wall will not typically be backfilled with soil except to provide frost protection for the footing.

5. The truss in Figure 2 will be constructed of structural steel. It is simply supported at joints 1 and 3. The applied force at joint 5 is sloped 3 horizontal to 4 vertical, as shown. Determine the forces in all seven members of the truss and indicate tension or compression. Make a sketch of what the connection at joint 2 might look like. Discuss your choice of connection. All truss joints may be assumed pinned.

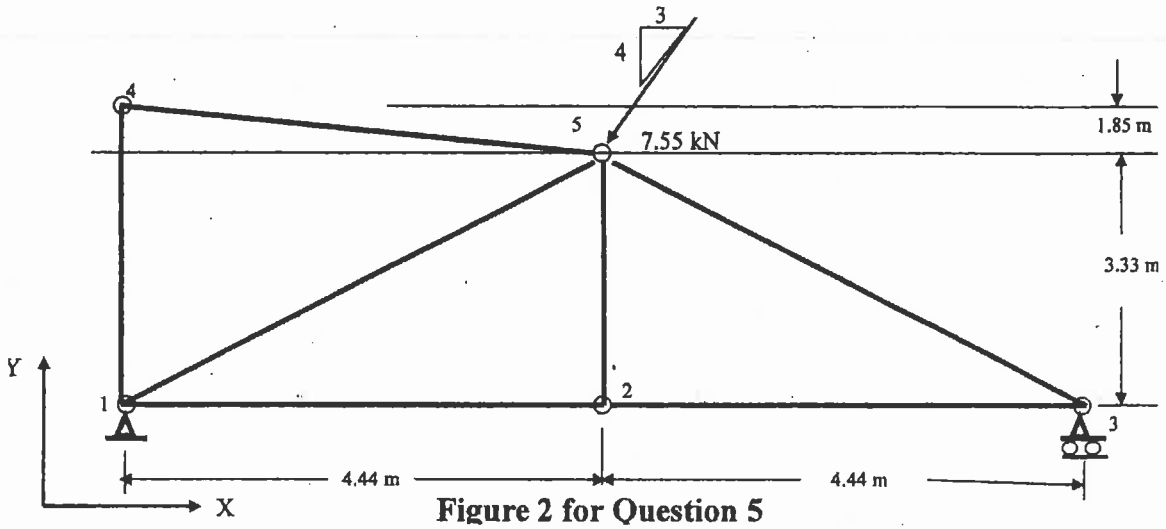

Figure 2 for Question 5

6a. Explain your understanding of prestressed concrete construction, including advantages and disadvantages, Draw a typical stress diagram across the depth at the centre of a simply supported prestressed concrete beam loaded with a uniformly distributed load, a) fully loaded, b) loaded with dead load only. What is meant by post-tensioned; and by pre-tensioned. Provide some typical examples of post-tensioned and pre-tensioned concrete applications.
6b. Many farm and food industry structures are in corrosive environments because of high moisture levels, manure in animal housings and acidity of silages. Discuss the measures that should be taken to reduce corrosion to a minimum of concrete components of buildings. Do the same for metal components of buildings. In your discussion pay close attention to and comment on the cost of any measures that you recommend.

Table for Question 2
Area of Reinforcing Steel, A_s in mm^2,
Per One-Metre Strip

Bar Spacing mm	Bar Size (No.)				
	10	15	20	25	30
50	2000	4000	6000	10000	14000
80	1250	2500	3750	6250	8750
100	1000	2000	3000	5000	7000
120	833	1667	2500	4167	5833
150	667	1333	2000	3333	4667
180	556	1111	1667	2778	3889
200	500	1000	1500	2500	3500
220	455	909	1364	2273	3182
240	417	833	1250	2083	2917
250	400	800	1200	2000	2800
260	385	769	1154	1923	2692
280	357	714	1071	1786	2500
300	333	667	1000	1667	2333
320	313	625	938	1563	2188
340	294	588	882	1471	2059
360	278	556	833	1389	1944
380	263	526	789	1316	1842
400	250	500	750	1250	1750
420	238	476	714	1190	1667
440	227	455	682	1136	1591
460	217	435	652	1087	1522