UNIVERSITY OF RUHUNA

Faculty of Engineering

Semester 8 Examination in Engineering: August 2022

Module Number: CE8251 **Module Name:** Bridge Design Engineering

[Three Hours]

[Answer **all questions,** Marks are given as indicated]

Note: Code of practice BS EN 1991-1-5: 2003 and BS EN 1991-2: 2003 are provided separately.

Q 1. Figure Q1 shows a diagram of a bridge. Several structural elements are labeled with numbers in this diagram. In your answer sheet, provide the names of these nine structural elements.

[4.0 Marks]

a) Explain the following terms in your own word and describe their importance in the design of bridges.

i) Approach Slab

ii) Scoring Depth

iii) Freeboard

[6.0 Marks]

Q 2. A senior structural engineer wants your support to determine the required temperature values to design expansion joints for a long span concrete bridge located in a hilly area. The concrete deck slab of this bridge is rested on post tensioned concrete girders.

a) As per the isotherm given by the client of the bridge, the characteristic value of the maximum shade air temperature (T_{max}) and the minimum shade air temperature (T_{min}) are 32^oC and -2^oC, respectively. Determine the maximum uniform bridge temperature ($T_{e,max}$) and minimum uniform bridge temperature ($T_{e,min}$) at this location. [2.0 Marks]

b) The senior structural engineer mentioned that the initial bridge temperature (T_0) at the time that the structure is restrained is expected as 14^oC. Determine the characteristic values of the maximum contraction range($\Delta T_{N,\,con}$) and the

maximum expansion range ($\Delta T_{N,exp}$) of the uniform bridge temperature components. [2.0 Marks]

c) Determine the **design values** of the maximum contraction range $(\Delta T_{N,con})_{design}$ and maximum expansion range $(\Delta T_{N,exp})_{design}$ of the uniform bridge temperature components. [2.0 Marks]

d) Determine the overall range of the uniform bridge temperature component (ΔT_N). [1.0 Mark]

e) The concrete deck (thickness of 250mm) of this bridge is rested on 1000mm high post tensioned girders. Further, 120mm thick surfacing layer is proposed to apply on this bridge deck as shown in Figure Q2. Determine the vertical linear temperature components (Approach 1) for a bridge (heating $\Delta T_{M,heat}$ and cooling $\Delta T_{M,cool}$). [4.0 Marks]

f) Determine simultaneity uniform and temperature difference components (Approach 1) of this bridge. [4.0 Marks]

Q 3. A bridge design company is planning to estimate the design and detailing cost of a rural bridge project which contains 6 bridges in different areas in Sri Lanka. In order to quantify the design work load, the quantity surveyor of the company has summarized the deck geometrical feathers of these six bridges in Table Q3 a. However, the information Table Q3a is not sufficient for the accurate quantification of the design work load. Fill out the notional lane information of these six bridges in the Table Q 3b. (You may copy the Table Q 3b to your answer sheet and fill its blank cells). [10 Marks]

Q 4. Assume that you are a junior structural engineer of a bridge design company. This company received a design report of a small bridge to check and verify the design and analysis. In order to obtain a rough idea of the analysis results of the bridge, your senior structural engineer asks you to carry out the manual calculations with reasonable approximations. He also advises you to consider only the self-weight of the deck slab and vehicle load for this manual analysis. This bridge has 9m long and 5m wide reinforced concrete deck rested on two steel I girders as shown in Figure Q4. (Note: The partial safety factor for both the permanent load and variable load are equal to $\gamma_G = \gamma_Q = 1.35$.)

a) In order to apply traffic loads, determine the:

   i) Carriageway width

   ii) Number of notional lanes

iii) Notional lane width and the width of remaining area

[3.0 Marks]

b) Explain the possible notional lane and remaining area combinations over the carriageway, where the vehicle live load can be applied so that to obtain critical reactions on the deck slab (bending moments and shear forces). [3.0 Marks]

c) As per the client's requirements, this bridge was designed for the load modal LM1. As per the Euro code the LM1 has three lane numbers with three different Tandem systems and UDLs. Explain the lane number, Tandem system and UDL system applicable to this specific bridge deck. [3.0 Marks]

d) The senior structural engineer wants you to determine approximate design bending moments and shear forces of the deck slab in the transverse direction. For the simplification, he instructs you to consider a one meter wide strip of deck slab with one axial load of LM1 for this analysis.

i) Draw sketch of one meter wide strip to determine the maximum hogging bending moment. In your sketch, clearly show the lengths, supports and loadings.

ii) Using above sketch, determine the maximum hogging bending moments.

iii) Determine the mid sagging bending moment and maximum shear force using the load arrangement in section d i).

[8.0 Marks]

e) The senior structural engineer also wants you to approximately determine the maximum bending moment of a supporting steel I girder. He advice you to consider LM1 vehicle at midspan (in longitudinal direction) of the bridge for this analysis. You also can neglect the self-weight of the I girder for this analysis. (Hint: reaction of the transverse deck strip can be considered as UDL or point loads on the steel I girder) [4.0 Marks]

f) It was observed that the breaking and acceleration load was not applied in the Finite Element model of this bridge. Since this load is important in the design of abutments, you are assigned to determine the breaking and acceleration load for this bridge. Please present your answer as the load per unit length of (kN/m) the bridge. [4.0 Marks]

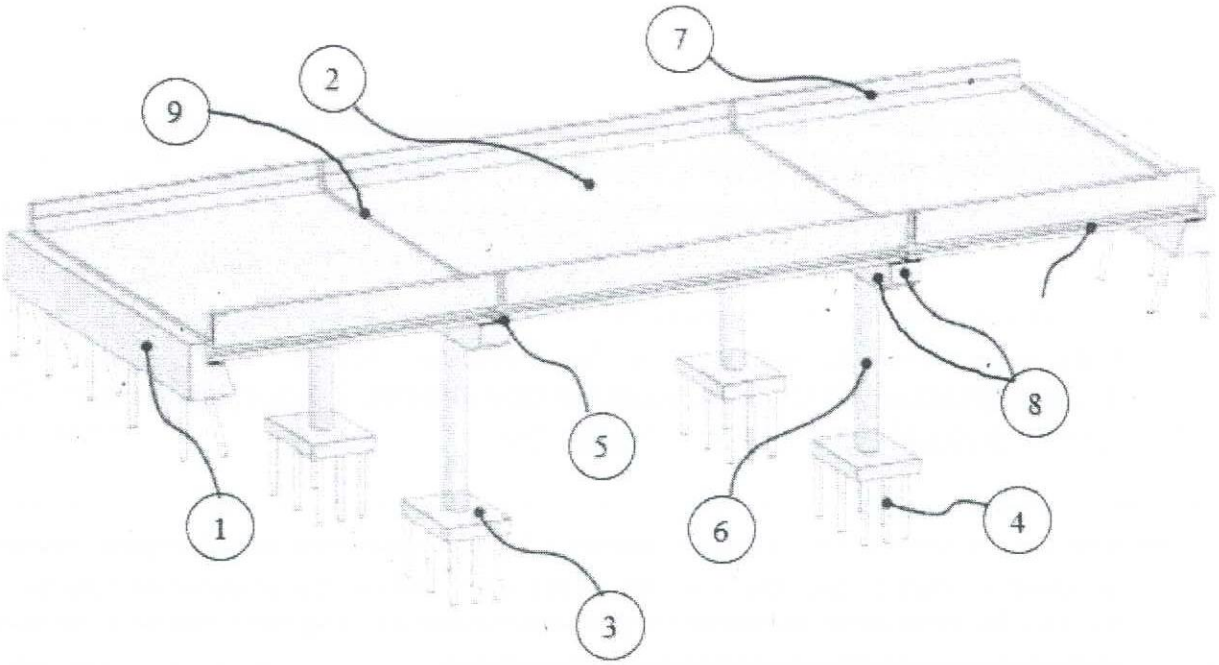


Figure Q1 Bridge Diagram

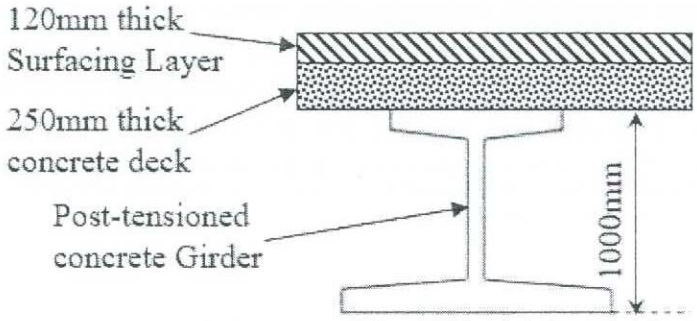


Figure Q 2 Cross section of the bridge through a post tensioned girder

Table Q3 a. Gematrical information of the bridge deck cross sections

Bridge Number	a (m)	b (m)	c (m)	d (m)
1	0.9	3.5	0.9	0.15
2	0.9	3.5	0.9	0.075
3	0.9	4	0.9	0.15
4	0.9	4	0.9	0.075
5	0.9	8	0.9	0.15
6	0.9	8	0.9	0.075

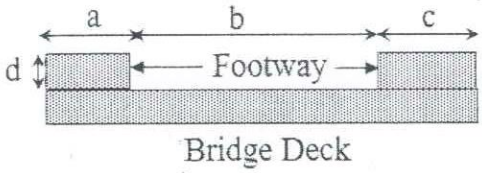
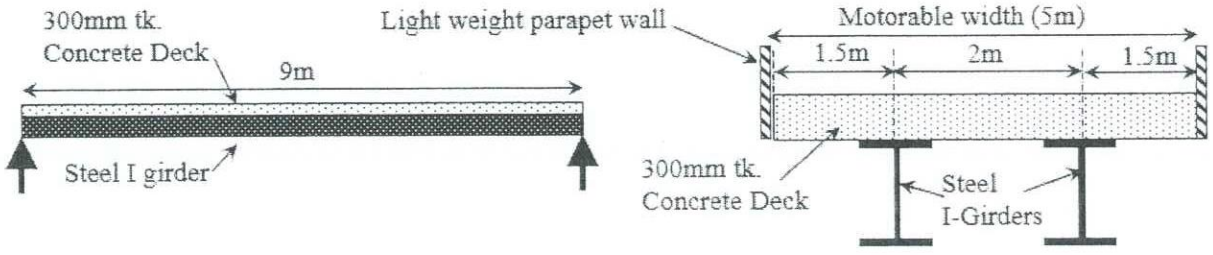


Table Q3 b. Notional Lane information of the bridge deck cross sections

Bridge Number	Carriageway width-w(m)	Number notional lanes (n_1)	Width of notional lane (m)	Width of Remaining area (m)
1				
2				
3				
4				
5				
6				



(a) Longitudinal sketch

(a) Transverse Cross sectional sketch

Figure Q 4. Sketch of the simply supported Bridge with RC deck