UNIVERSITI SAINS MALAYSIA

KSCP Examination
2016/2017 Academic Session

August 2017

EAS665 – Bridge Engineering

Duration : 2 hours

Please check that this examination paper consists of **SEVEN (7)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **FIVE (5)** questions. Answer **ALL** questions.

1. [a] An arch bridge is a bridge with abutments at both sides and connected through end shaped of curved arch. The bridges work by transferring the weight of the bridge and its load partially into a horizontal thrust restrained by the abutments in cooperation at sides. Traditionally, arch bridges were built from stone or brick owing to their great natural strength. However, even today arch bridges remain in use, and with the introduction of new materials, their arches can be build on much longer spans and smaller size of structural member. Explain the basic principle of arch bridge.

[10 marks]

[b] In order to ensure the functionality, safety and maximizing the life of bridge, it is important to avoid catastrophic failure. Therefore, bridge maintenance, repair and rehabilitation, it often has been reactive activities. It will alarming the relevance authorities to carry out such investigation or assessments of bridge performance and conditions rather than visual inspections and condition ratings. Prescribe the proactive strategies to ensure the effective and safety life-cycle of the bridge.

[i] Girder bridge
[ii] Moveable bridge
[iii] Scour and settlement
[iv] Concrete members
[v] Steel members

[10 marks]

2. The purpose of bridge deck joints is to protect the interior edges of concrete decks from vehicle loads, seal the joint openings, and accommodate movements due to temperature changes, creep and shrinkage of concrete structures. Describe several types of joints available for use on concrete bridge decks. With the aid of illustration, discuss the performance characteristics of each type, including primary functions and movement ranges.

[20 marks]

3. Bearing is designed and chosen based on its ability to take appropriate load and movement capabilities. With regards to dimensional changes and deformation of superstructure or substructure i.e. concrete material due to short-term and long-term deformation the bearing should be able to accommodate those movement. With the aid of illustration, discuss **FIVE (5)** types of bearing which are normally used for concrete bridges.

[20 marks]

4. [a] Briefly discuss the mechanics of a pier with a fixed support and the method to achieve the fixity.

[6 marks]

[b] A seat-type reinforced concrete abutment has been selected for a bridge project. The proposed abutment is supported by four vertical piles and three raked piles as shown in Figure 1. The forces acting on the abutment are shown in Table 1. If the pile working capacity is set to be 800 kN, evaluate the proposed pile arrangement. Take positive moment as acting in clockwise direction.

[14 marks]

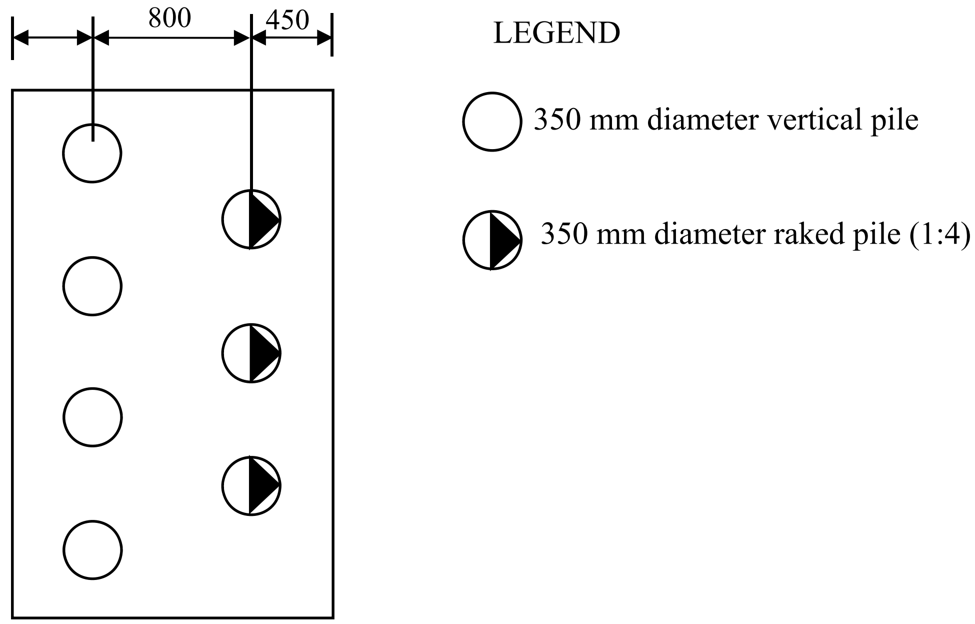


Figure 1: Pile arrangement for abutment (all dimensions in mm)

Table 1: Forces acting on abutment

Item	Force (kN)	Lever Arm (m)
Surcharge (active)	80	0.84
Surcharge (approach slab)	40	0.84
Soil (active)	120	0.56
Wind	20	1.2
Traction	200	1.2
Temperature	40	1.2
Shrinkage and Creep	80	1.2
Dead Load	1000	-0.12
Abnormal Load	1300	-0.12
Curtain Wall	10	0.3
Abutment (seating)	300	0.03
Ballast Wall	60	-0.5
Approach Slab	70	-0.6
Wing Wall	20	-1.3

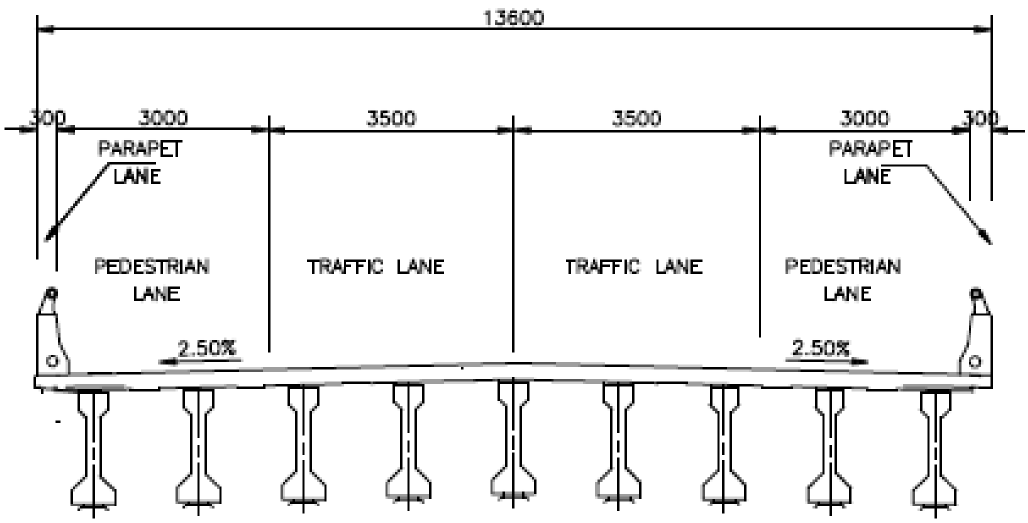
5. [a] Explain the characteristics of HA and HB loading types that are specified in the code.

[5 marks]

[b] A bridge deck of the beam-slab type is to be analyzed for design purposes. The cross sections of the proposed beam-slab bridge are shown in **Figure 2(a)** and **(b)**. Basic data of the proposed bridge are listed in the **Table 2(a)**. And, the requirement of loading computation is given in **Table 2(b)** and **(c)**.

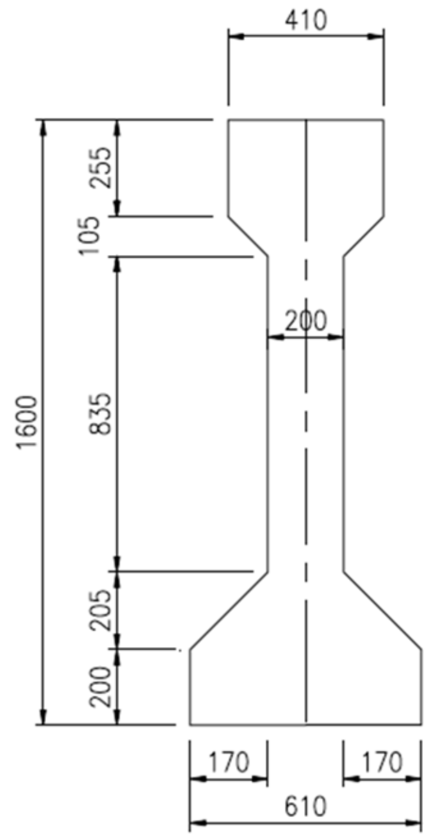
Perform loading computation for the live loads acting on the proposed deck by considering the combination of type HA and HB highway loading. Analyze the critical bending moment on beam and maximum shear force acting on abutments. For maximum sagging moment, position leading axle of the HB vehicle at 18.30 m from the left end abutment. The maximum moment occurs under the third axle. The HB vehicle with the 6.0 m inner axle spacing will give the critical sagging moment.

[15 marks]



9 nos. of I-beam post tensioned beam. Beam depth is 1600 mm and spacing is 1500 mm c/c

Figure 2(a)



Unit: mm

Figure 2(b)

Table 2(a)

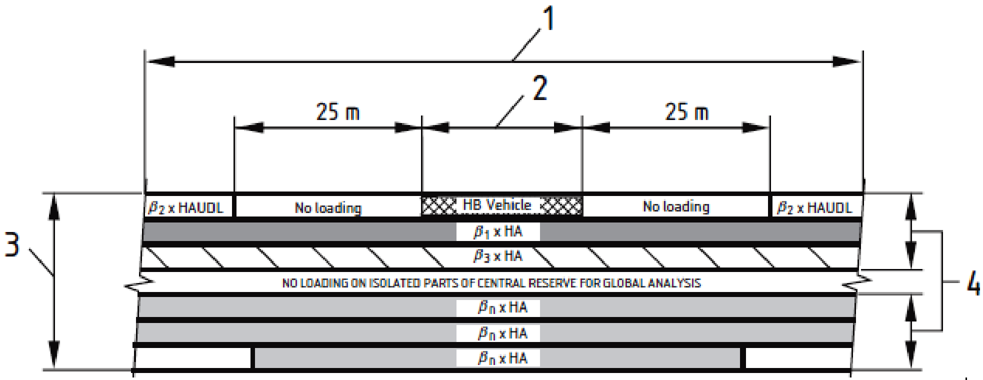
Span	30.0 m
Skew	0^0
Width	13.6 m
Thickness (slab)	200 mm
Location	PLUS Highway
Live loads	HA loading (UDL = $336\left(\frac{1}{L}\right)^{0.67}$) HB loading (30 units) (use inner axle spacing of 6.0 m)
Unit weight	In-situ concrete: 24 kN/m^3 Premix: 22.6 kN/m^3 Pre-cast concrete: 25 kN/m^3
Formwork	0.5 kN/m^2 allowance for possible permanent formwork
Temperature: Min. shade air temperature	20^{o}C
Wind: Max. mean hourly wind	32 m/s
Concrete grade	f_{st} =40 N/mm^2
Reinforcement	f_y =460 N/mm^2

Table 2(b)

Carriageway width, b_L (m)	**No. of notional lane**
$5.00 \leq b_L \leq 7.50$	2
$7.50 \leq b_L \leq 10.95$	3
$10.95 \leq b_L \leq 14.60$	4
$14.60 \leq b_L \leq 18.25$	5
$18.25 \leq b_L \leq 21.90$	6
Lane no.	**Lane factor**
1	$\beta_1 = \alpha_2 = 0.0137[b_L(40 - L) + 3.65(L - 20)]$
2	$\beta_1 = \alpha_2 = 0.0137[b_L(40 - L) + 3.65(L - 20)]$
3	0.6
4 and above	$0.6\alpha_2$

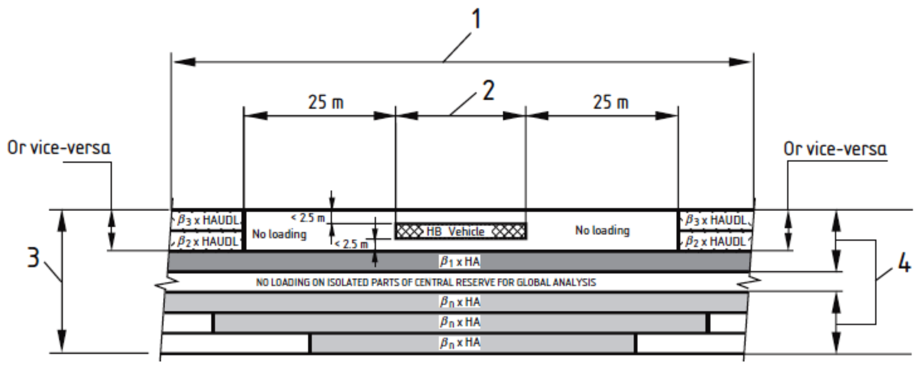
Table 2(c)

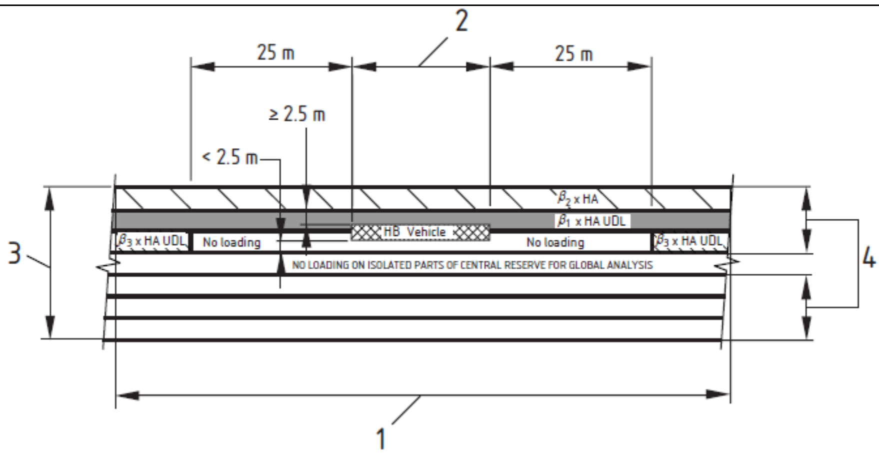
1) HB vehicle within one notional lane



2) HB vehicle straddling two notional lanes

(a)





(b)

Key

1 Loaded length for intensity of HA UDl in lane containing HB vehicle

2 Overall vehicle length for axle spacing having most severe effect

3 Lane loadings are interchangeable for most severe effect

4 Notional lanes in each carriageway

NOTE 1 See **6.4.1.1** for the value of the HA lane factor (β) to be taken for each lane.

NOTE 2 The overall length and width of the HB vehicle shall be as specified in **6.3.1**.

NOTE 3 Unless otherwise stated, type HA loading includes both uniformly distributed loading (UDL) and knife edge loading (KEL).

NOTE 4 See **6.4.1** for loaded length to be taken in each lane.

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