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Reinforced Concrete Box-Section Bridges in Developing Country

Ponts à poutre-caisson en béton armé dans un pays en développement

Stahlbeton-Hohlkastenbrücken in einem Entwicklungsland

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1. INTRODUCTION

The advantages of the standard (i.e. the M and I beams) precast prestressed concrete beam-reinforced concrete slab composites are well known. The implementation of the major highway projects in Malaysia recently has resulted in the extensive use of such structural system along the highway such that the advantages of possible alternatives have sometime been overlooked, even for bridges built away from the highway. A classical case is the design of the Kangkar Tebrau Bridge in Johor, Malaysia. This bridge was originally designed as a precast-prestressed I beam-reinforced concrete deck slab composite, and the concept was accepted by the client and authorities. Just prior to tender, an r.c. box section alternative was proposed, and much convincing was necessary for the authority who was rather sceptical about its advantages and the capability of local contractors in constructing the box-section bridge. After completion, however, it was agreed that the construction was much simpler that anticipated, and cost comparisons showed that it was cheaper than the estimated cost of the prestressed I beam-rc slab composite. Following this, two other similar bridges have been designed, namely the Templer Park and the Klang Bridge, of which the Templer Park Bridge has only been recently constructed. The features of these bridges are briefly discussed in the following.

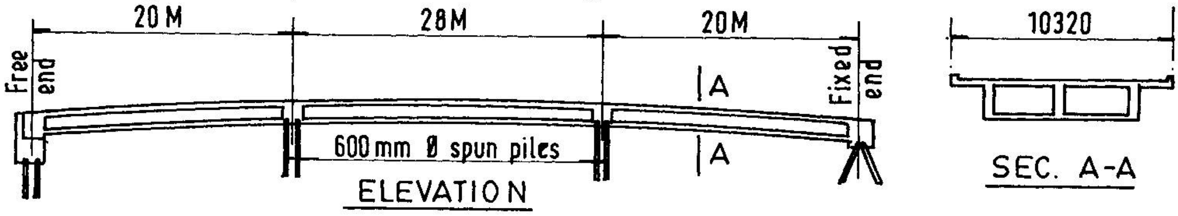

Figure 1. Kangkar Tebrau Bridge

2. KANGKAR TEBRAU BRIDGE

The Kangkar Tebrau Bridge is a three continuous span rc box section bridge, as shown in Figure 1. Some of the advantageous features of the bridge are as follows:

- i. The normal reinforced concrete construction, as opposed to the precast prestressed concrete construction can be handled by the main contractor without requiring the support of specialist subcontractors for prestressing.
- ii. The cast-in situ construction do not require special transportation or launching equipment.
- iii. Lower grade concrete (fcu = 30 N/mm^2) as opposed to the higher grade (45 N/mm^2) concrete required for prestressed beams is easier to make. Although this may not be an acceptable reason for not using high strength concrete, experience does show that contractors do faced problems in this regard from time to time.
- iv. The continuous spans result in lower overall maximum bending moment, and hence a shallower section may be used.
- v. The bottom flange of the concrete box can be utilised to resist the compressive stresses in the section over the supports due to hogging moments.
- vi. The continuous deck (except at the ends of the bridge) means that the number of joints, which are common sources of deterioration, is minimised.
- vii. Driven precast concrete piles were used for the foundation support. At each pier position, the piles were built up to the soffit of the deck, thus acting as the pier without requiring cast-in-situ pier columns, which may be difficult to build in the water.
- viii. The cast in-situ construction enabled the box-section to be cast homogeneously with the top of the piles. At such locations no pile-cap or pier head and bearings are required. The cost of bearing maintenance may therefore be reduced or eliminated.
- ix. The abutments were built far enough from the banks, avoiding the need of using retaining-wall type abutments. Only simple bank seats were used.
- x. At one abutment, the bridge deck is fixed against horizontal movement but allowed to

rotate about the axis perpendicular to the bridge span, whilst at the other it is allowed some horizontal movement subject to the restraint provided by the shear stiffness of the bearing used. Hence mechanical joint is required only at one abutment.

xi. It is anticipated that due to the simple support at the fixed abutment, crack will occur due to rotation of the deck under load. To minimise deterioration of the concrete due to the ingress of water into this crack a water stop is used as shown in Figure 1.

3. TEMPLER PARK BRIDGE

Although one of main the advantages of the box section is its ability to resist hogging moment at the supports between the continuous spans (as is true for the Kangkar Tebrau Bridge), it may still be economical for single span bridges, as in the case of the Templer Park Bridge shown in Figure 2. This bridge consist of two independent simple spans, i.e. a 22 m span of rc box section deck and a shorter span of rc slab. The features found in this bridge are very similar to the first bridge, except that bored piles were used and cast in situ concrete columns were built for the middle pier. In this case, the river bed is very shallow and usually dry at the location of the pier.

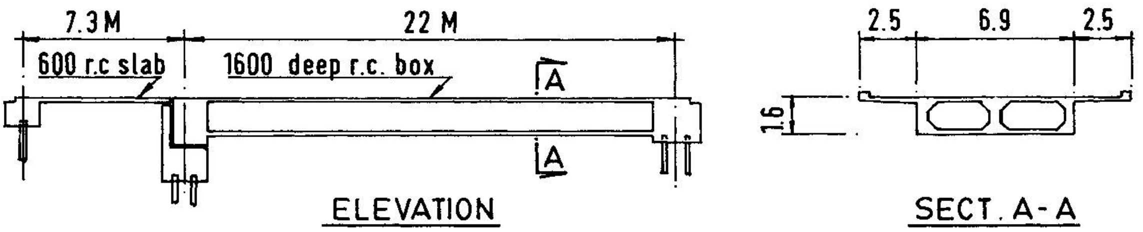

Figure 2. Templer Park Bridge

4. KLANG BRIDGE

The Klang Bridge consists of 9 spans, as shown in Figure 3. To minimise shrinkage and temperature effects, the bridge is broken into three sections of three spans each. The first section consists of three continuous spans of rc-box section of 1800 mm total depth. The second section consist of three unequal spans (31 m - 40 m - 35 m) of rc box section of 2500 mm total depth. The relatively long middle span is due to the required clearance for the passage of railway lines below. The third section consists of three simple spans of steel beam-concrete deck composite structure with a total depth of 1775 mm. The steel beams were used in response to the client's request to use steel as a construction material wherever possible and practicable. Homogeneous pier-deck construction were used at all continuous supports. At the discontinuities between the different sections, pier heads were used. Bearings were therefore required at these points and the abutments.

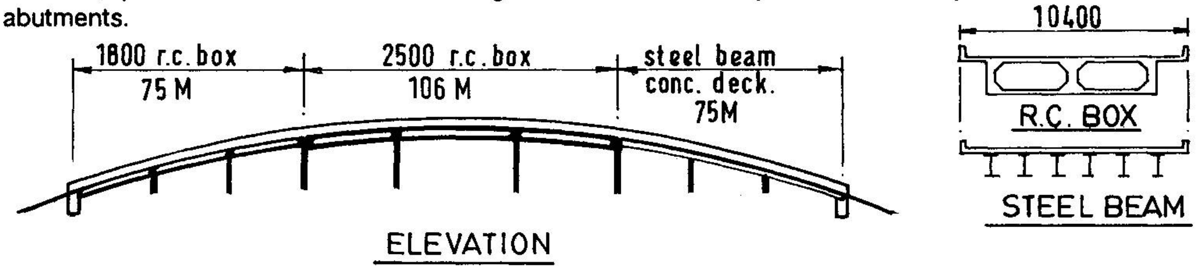

Figure 3. Klang Bridge

5. CONCLUSION

RC box section is a viable alternative to the popular precast prestressed beam-rc slab composites, especially for isolated bridges where mass production and speed are not the most important considerations. Several questions must be asked when considering the best structural form, including the following. (i) What are the conditions of the crossing? Can falsework be supported at the base of the crossing? (ii) Is it going to be a continuous multispan structure? (iii) Is access easy for the transportation of factory manufactured standard beams? (iv) Can expansion joints be avoided? (v) Can simple bank seats be used? (vi) Can piles be built up as pier columns?.

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