A Cost Analysis of Bridge Construction across the Railway Line in Sri Lanka

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1. INTRODUCTION

In the world, most of the railway lines are across public roads, as well as in Sri Lanka also most of the Railway lines are across public roads and highways. As a result, the road network was expanded all over the country. Most of the Railway lines around the world including Sri Lanka are across public roads, which resulted in the expansion of road networks as a whole. With this expansion, the need for providing railway-level crossings was also increased. And this led to problems related to traffic congestion, alienation, aggressive driving behaviour, and also time delay [1].

Providing an overhead bridge to minimize the delay and maximize safety seems better compared to other available options. Minimal steps have been taken so far to eliminate the delay at level crossings [2]. People's expectation is to cross over the railway lines comfortably with minimal delay and also with safety assurance. So, an overhead bridge across the railway line is the best technique to overcome this problem in a cost-effective way manner. Therefore, Sri Lanka needs to overhead a bridge across the railway line.

Environmental impact, investment cost, safety, quantity, and material requirement should be decisive factors for the selection of structural solutions [3]. The design of the rail over a bridge based on effectively could result in a good solution, but can't guarantee the cost and feasible structure in Sri Lanka. To do so, several different solutions should be considered and compared in order to choose the optimal one. Thus, structural optimizations concerning geotechnical impact and cost have become of major interest in the last decades [4].

In Sri Lanka, the critical issue is the delay. When addressing this issue whatever the solution proposed should be practical and affordable for relevant organizations and acceptable for society for implementation [5]. Therefore, this study focuses on finding the most appropriate structurally stable and economic overhead bridge structure across the railway line in Sri Lanka.

2. MATERIALS AND METHODS

2.1 Geometric model

This method produces a completely optimal solution including the number of spans, piers, deck, piers cross-section, the cross-section of the bridge, and suitable designs of the bridge and layout.

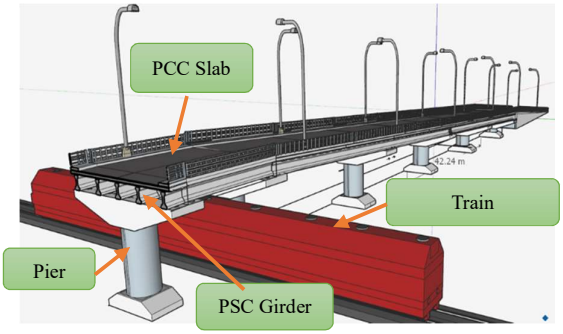

Figure 1:- Typical overhead bridge across the railway line

After the design of the bridge elements, two types of geometry models are carried out. One is piers with bridge elements and the other is abutment with bridge elements.

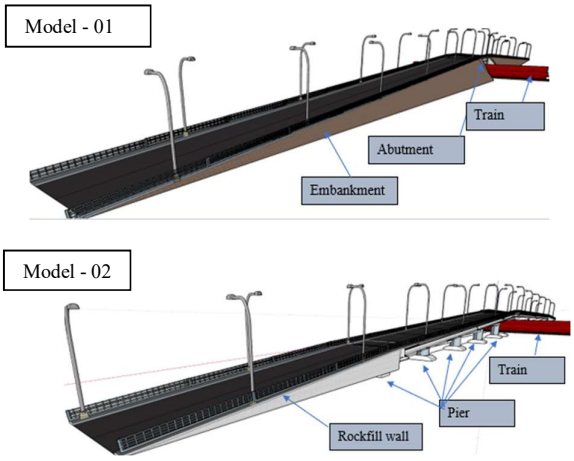

Figure 2:- Different types of the bridge model

2.2. Cost of bridges

The overall outcome of the cost analysis is given in Table 1 with the consideration of different types of bridge models. From the cost analysis, it can be summarized that case 2 (Pier & PCC slab with PSC girder bridge) is a more economical bridge type across the railway line.

Table 1: Cost for various cases of bridges

cases	Different types of the structural element	total cost (millions)
case1	Abutment with rock fill embankment & PCC slab with PSC girder bridge	283.26
case2	Pier & PCC slab with PSC girder bridge	105.99
case3	Pier & orthotropic steel deck with steel plate girder bridge	2,215.66
case4	Pier & PCC slab with steel plate girder	1,377.88
Case5	Abutment & PCC slab, Steel plate girder	405.07
Case6	Piers & steel plate deck, PSC girder	685.96
Case7	Piers & steel plate deck, Steel plate girder	1,836.13

2.3 Total cost estimation

Based on the study, summarized that the following types of cost are highly influencing on the cost comparisons of the bridge structures. These are material cost (MCe) and Labor cost (LCe).

$$IC_e = (MC_e) + LC_e = \sum m \, MC_m^e = \sum m \, LC_m^e \quad (1)$$

Where: MC_m^e = Material cost for specific material (m) and bridge component/element(e)

LC_m^e = Labour cost for specific material (m) and bridge component/element (e)

Material cost is purely dependent on the national and international market and its fluctuation and on the amount of material. Considering a specific material (m) and element (e), calculated as in Eq. (2)

$$MC_m^e = C_m \times q_m^e. \quad (2)$$

Where:

C_m = unit price of material

q_m^e = amount of material m in the considered element

Table 2: Unit prices for materials which are used in this study

Material		Unit price
Concrete C25 1:1:2	m^3	LKR 18,356.00
Concrete mid-steel deck	8×1^{ft}	LKR 600,000.00
Asphalt	m^3	LKR 7,356.32
Rock fill	m^3	LKR 3,750.00
PCC girder	m^3	LKR 25,500.00
Backfill	m^3	LKR 6,950.00
Reinforcement D32mm	kg	LKR 5,700.00
Reinforcement D20mm	kg	LKR 3,750.00
Reinforcement D16mm	kg	LKR 2,375.00

3. RESULTS AND DISCUSSION

Cost comparison study shows that, Pier with PSC Girder Bridge is one of the best type of overhead bridge to overcome the level crossing issues across the railway line. Also, this model is the low cost due to the utilization of the local materials for the construction and locally available soil and rock have been considered for the earthworks and backfilling. It is described in Figure 3.

Figure 3: Cost analysis of the bridge model

4. CONCLUSION

Based on the cost analysis study conducted, it could be concluded that a prestressed concrete girder is more economical than a steel plate girder. Also, concluded that the following bridge model is strongly recommended for the following criteria.

- Durability of the girder- Prestressed concrete girder is more than a steel plate girder.
- Cost effective- Precast concrete bridge is most effective than other cases.
- Easy construction- Precast concrete bridge elements are an easy way to construct.
- Availability of material- Concrete materials are more available in Sri Lanka comparing long-span girders and orthotropic girders.

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