Cost Comparison of Superstructure for Bridges: A Review

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Abstract:- A bridge project from its conception to completion involves various stages such as planning, design, approval/sanction, tendering and execution. Also inspections, maintenance & repairs are continuing activities for enhancing the service life of the structure. The selection of superstructure type for bridges plays a vital role to execute the project. The time and cost factor for completion of the bridges shall have great impact on finalization of the superstructure type. The type of superstructure has numbers of aspects in line with the design constraints, geometrical aspects, existing features of old bridges, etc. The standard specifications for design also play a key role to freeze the type of superstructure. The basic idea of study is to increase the cost-effectiveness of bridges by increasing their durability (i.e., useful life). There may be many ways to achieve more durable, less expensive and rapidly constructed structures, however, the methods for execution matters, in cost point of view. A proper method selected will help to save in time and cost of the work. Recently, there has been increased interest in constructing bridges that last longer, are less expensive, and take less time to construct. The results of the study are evaluated for different effective spans by considering support conditions, constituent materials, casting/fabrication methodologies etc. to reach at best economical option for superstructure of the river bridge.

Keywords: *bridge, planning, design, tender, execution, maintenance, lifecycle.*

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I. INTRODUCTION

Bridges are the part of highway project, a transport facility which helps for economic growth of India. The bridges are the key component in the infrastructure development of India, specifically for transport sector. The improvised methods if used in construction of bridges helps for faster completion of the projects helps to reduce the overall cost and time with saving in money. The delay in construction of the structures like bridges/flyovers/underpasses/overpasses will lead to delay in highway projects affecting the construction productivity. Hence it is important to know the present methods adopted by various contractors for bridge construction, specially the superstructure methods.

The present study suggests the selection of superstructure type suitable for bridge based on cost comparison. The study reviews present methods adopted for superstructure works for three bridges (two river bridges and one ROB), the factors affecting the selection method, the site conditions, geometrical features, availability of man, material, machinery (resources) etc. The superstructure types considered for study are RCC T-Beam, PSC I-Girder (In-situ & Precast) and Steel Composite Girder.

II. COST OPTIMIZATION

Optimization is an act of obtaining the best results under given circumstances. In design, construction and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate aim of all such decisions is either to minimize the efforts required or to maximize the desired benefit.

Our main objective function is to minimize the total cost of the bridge system considering the cost of materials. The cost of structural element covers cost of material and labour for reinforcement, concrete and formwork. The design constraints for the optimization are always considered according to Standard Specifications for road bridges. To achieve these goals the aim of any project engineer is to select proper superstructure type and methodology so as to construct the bridge with economy resulting saving in time and cost.

Cost Reduction Techniques being used at site:
The general methods used by the contractors for optimizing the cost at site are described as:
i) Comparison with a cost standard
ii) Subdivision by detail
iii) Integration with other functions
From above all the working of cost comparison by using the third method, integration with other functions, is more effective

to analyze the costing by considering various factors governing the activity.

III. BASIC PARAMETERS

To select the superstructure type there are various parameters needs to be considered. The important parameters are discussed here,

A. Design criteria

The basis considered for design of bridge superstructures are, the span arrangement of proposed bridge, whether it is in line with the existing bridge or not (In case of river bridges), vertical clearance required (River Bridges/Flyovers/ROB), contractual obligations for selection of superstructure (if any), project scope, approach work ,etc. For a particular type of superstructure such as girder, a large number of parameters control the design of the bridge such as girder spacing, cross sectional dimensions of girder, deck slab thickness, deck slab reinforcement, concrete strength, materials of construction, design codal restrictions, reinforcement in cross girder and intermediate girders etc.

B. Site constraints

The site condition is also one of the important aspect needs to be considered for finalization of superstructure type. The various site constraints are generally as listed below,

- Geological features of project location
- Frequency of existing traffic
- Limitation of work space & site set up
- Obstructions of existing Structures
- Obstructions of Utilities

C. Availability of Resources

The main resources required for the bridge execution are basically material, manpower, machinery and money. At the planning stage, we need to check the requirement of all these sources based on the detail approved drawings. The other factors like proposed work methodology, fund requirements, machineries and equipments in hand/need to purchase, manpower availability (Skilled/Unskilled) for the bridge work, etc. also have major impact on selection of superstructure type.

The Architect / Structural Designer / Planner or Execution engineer cannot overcome all these problems by working in isolation. A complete 'Team Work' is essential to solve these problems and to converge to an effective solution. But, from the failures of many ambitious bridge projects, it can be observed the there is absence of the team work (except in few cases). Typical failure of bridge may happen in case the designer doesn't know how the contractor is going to construct the particular structure, and on the other hand, sometimes the contractor does not know how that bridge is designed.

IV. COST COMPARISON

In the present case study, we have analyzed the actual cost of the superstructure of bridge for three types of superstructure (RCC T Beam, PSC I Girder & Steel Composite Structure) from the ongoing project of construction of 2L/4L major bridges on Mumbai-Goa highway (NH-66). The cost is worked out for a typical span based on the design data available. The span lengths varies as 21.50m, 36.60m & 43.00m respectively. As the span lengths are different for these three types of superstructure, the cost per sqm is worked out for clear understanding. For PSC I Girder bridge, the cost for In situ and precast method of erection for superstructure are worked where only cost of launching/staging will differ and material cost will remain same in both case.

The cost analysis include following components,

i. Basic cost of the material involved in Construction/Fabrication of the structure including labour cost
ii. Placement/ launching of Structure element at designated location

The cost of finishing and maintenance are not considered here as the effect of these costs have no impact on the comparison. The cost component for all three types will be proportionately same for finishing and maintenance items.

The sectional properties of superstructure in all three cases have been studied from the approved drawings. The cross section details of superstructure elements are summarized and the details are represented in Table I. From the sectional properties and other detail drawings, the quantity of materials like Concrete, Reinforcement Steel, Prestressing Steel and Structural Steel is calculated. Also the quantum of shuttering (Formwork) required to execute the superstructure is figured out because generally the contractors considers shuttering cost separately in their project budget. The shuttering charges include the labour charges and shuttering material hire charges. The quantities of these materials for different types of superstructure are summarized in below table (Table II).

The placement/launching of the girder is the process of final placement of the girders on the piers at required position. The cost associated with the placement/launching is greatly affected by the prevailing site conditions. Greater the restriction in the free movement of the cranes greater the cost involved with the placement of the girder. Considering the type of ground condition the placement type can be broadly divided in two categories; one is normal ground condition and another is above the railway line (For ROB case).

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353 – 356

Table I
Sectional Properties of Concrete Structure

Sr. No.	Description	Unit	RCC T Beam	PSC I Girder	Steel Composite Girder
1	Name of Bridge		Janavali	Vasisthi Bridge	ROB at Khed
2	Span Length	M	21.50	36.60	43.00
3	Depth of deck slab	M	0.20	0.20	0.25
4	Web depth (excluding deck slab)	M	1.55	2.14	2.60
5	Top width (at end span)	M	0.35	1.40	0.85
6	Bottom width (at end span)	M	0.35	0.60	1.00
7	Web width (at Support)	M	0.35	0.60	0.018
8	Top width (at mid span)	M	0.35	1.40	0.85
9	Web width (at mid span)	M	0.35	0.30	0.018
10	Bottom width (at mid span)	M	0.35	0.60	1.00

Table II
Quantities of Materials

Sr. No.	Description	Unit	Type of Superstructure		
			RCC T Beam	PSC I Girder (In – situ/ Precast)	Steel Composite Girder
1	Span length	m	21.50	36.60	43.0
2	Concrete	Cum	120.00	254.00	124.00
3	Reinforcement	MT	18.00	28.20	15.50
4	Shuttering	Sqm	548.00	1071.00	370.00
5	Pre-Stressing Steel	MT	-	8.30	-
6	Structural Steel	MT	-	-	245.00

A. In Normal Ground Condition

In this type, the launching/placement cost directly depends on the weight of the superstructure member. In our case only PSC girders are to be launched in normal ground condition. It is important to mention that RCC T-beam is cast-in-situ and does not require any launching/placement. In lieu of that the cost of erection of temporary structure for staging work of RCC T beam type is considered. The launching of Steel composite structure comes under second type and described below. The launching methodology was freezed at initial stage only.

B. Placement/launching Above Railway Line

The launching above the railway line mainly consists of two cost components. One cost component is attributed to the launching/placement operations due to restriction in term of space & time and another cost component is attributed to the indirect cost implication in terms of Speed restriction on movement of trains & the block periods.

Table III
Cost of Superstructure for Typical Span

Sr. No.	Description	Type of Superstructure			
		RCC T Beam	PSC I Girder (In-situ)	PSC I Girder (Precast)	Steel Composite Girder
1	Material	20,11,640.00	46,61,930.00	46,61,930.00	2,87,83,100.00
2	Transportation, Placement / Launching cost	1,38,000.00	3,00,000.00	8,00,000.00	12,25,000.00
3	Total Cost (in Rs)	21,49,640.00	49,61,930.00	54,61,930.00	3,00,08,100.00
4	Deck area Sqm (For width 12m)	258.00	439.20	439.20	516.00
5	Cost per Sqm (Rs.)	8,332.00	11,298.00	12,436.00	58,155.00

The design grade of concrete for RCC T Beam, PSC I Girder and Deck Slab are M30, M40 and M35 respectively and Reinforcement Steel Grade used for above structures was Fe500.

The budgeted rates are considered to calculate the cost of material. The final cost of the finished product including cost of material along with cost of launching would be as shown in Table III. From table, we can say that RCC T Beam type

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353 – 356

superstructure is economical among all three types. The total composite cost of superstructure in normal conditions (launching cost) is nil for RCC T-beam. However, among other two options where launching is involved, PSC I-section is having lower cost if compared with steel composite type.

But if we consider the durability of structure and for large projects, expert's opinion that PSC I-girder will remain most beneficial. From the cost comparison graph (fig 1), the cost per sqm of RCC T Beam superstructure is economical among all four options. There is marginal difference in the Precast and In Situ type of PSC I Girder superstructure which indicates that for small quantum of work the type of methodology (Precast/In situ) will not have major impact on the cost of the project.

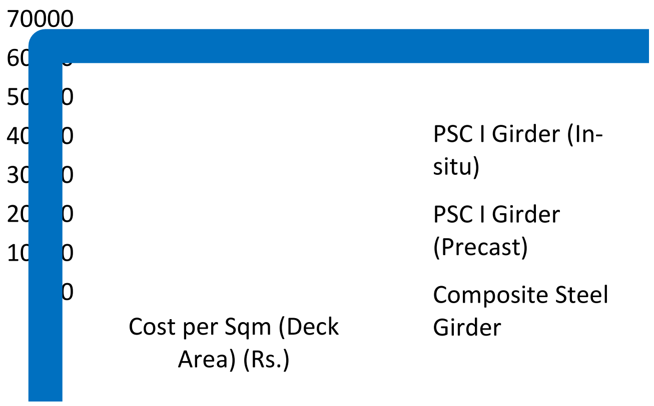

Fig 1 Cost per Sqm of Deck Area of Superstructure

V. CONCLUSION

We have compared the costs for different spans as 21.50m, 36.60m and 43.00m respectively. Due to variation in span length, to conclude the economical method, the rate per sqm of deck area is worked out. The rate of deck area for RCC T Beam superstructure type is worked out as Rs.8332/- per Sqm while the rate per sqm of PSC I Girder is Rs. 11298/- for In situ type and Rs. 12436/- for precast type superstructure. The rate per sqm for Steel Composite Girder type superstructure is Rs.58155/- which is drastically high as compared with the other three types. Hence the RCC T Beam superstructure is found economical in above case. The decision regarding consideration of PSC I Girder type (Precast/In Situ) needs more research to check its cost effective benefits.

We may learn that if such analysis is carried out in advance for finalization of superstructure type for a specific bridge work, will help to reduce the cost of construction as well as time. The various aspects as discussed above will guide to select the proper superstructure type for bridges. The effective use of advance construction methods available in the market and the study on availability of resources will definitely guide to freeze the superstructure type of bridges. It is necessary to submit that ii is very difficult to provide the perfect policy measures to suggest the superstructure type for any bridge based on above study as each bridge construction locations are differs in end users aspects and other important features.

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