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Time and Cost Comparison of PSC Superstructure with RCC for River Bridge

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Abstract: ***Bridges are the key component of the highway infrastructure supporting transport system of India. The design of river bridges are mainly depend on the navigational flow, available waterway, velocity of water current etc. Executions of such bridges is always a challenging job. Though the engineers feel the foundation of River Bridge is critical, the construction of superstructure is also not easy. It depends on various site constraints like land available for construction, resources available, water intensity etc.. The superstructure type shall be selected considering the river flow and suitability of execution as well as durability of the structure. The use of advance construction methods will help for faster completion of the projects reducing overall cost and time of project. The proper selection of superstructure will help to complete the bridge as per schedule which finally saves cost of the project. In the present study, two superstructure types (RCC/PSC) are studied to review its suitability for bridge having span length of 21.50m. The cost and time component for both types are evaluated to work out the economical option for superstructure. It is observed that the RCC T Beam is the economical superstructure type in construction point of view but it is having some limitations for durability of structure.***

Keywords: bridge, river, design, method, execution, durability, cost, time

1. Introduction

Bridges are basic and important components in the highway networks. But in spite of this known importance, bridges continue to receive lesser attention during construction as well as maintenance. Many of the bridges serve for many years even after their design life overs only if they are constructed properly. The routine maintenance of Bridges is also essential activity for a Highway Engineer. The timely and keen supervision during construction along with good maintenance monitoring system post construction always gives best results. This will lead to save cost of the project and this will support economical growth of India.

The bridges mainly consist three parts: foundation, substructure and superstructure. The foundation and substructure are being cast in situ as well superstructure can be in situ or precast. Superstructure is everything from bearing up to finished deck and is the most visible part of the bridge. Its basic design, in the most simplified form, can be compared to a log ranging from one side to the other across a river or creek.

The present study suggests the selection of superstructure suitable for bridge based on cost comparison. Here the feasibility of PSC I girder superstructure in lieu of RCC T Beam type is reviewed. The cost will be compared for same span for RCC T Beam type superstructure with PSC I Girder type. The superstructure work is proposed for a river bridge for a specific span length of 21.50m to observe its impact. The basic factors affecting selection of superstructure are generally site conditions, geometrical features, availability of resources like man, material, machinery etc.

2. Literature Review

The various research appears were studied to know the various factors affecting the selection of superstructure type. Few of them are narrated here, Natraj Singh, N.P. Devgan and A. M. Kalra (2015) presented the study which will facilitate as a hand on tool for selection of economical superstructure type for 20m span bridges. Keeping in view the fund constraints faced by infrastructure organizations, the present study aims to develop an economic solution for construction of superstructure for 20m span bridge under Indian Road Congress (IRC) loading. The effects of placement of span in normal conditions and launching above the railway line have different cost implications because cost associated with the Traffic block has a substantial cost share in launching process. An attempt is made to quantify the cost associated with the traffic block and the speed restriction. Another important aspect is the use of sacrificial shuttering in combination with conventional shuttering and its effects are explored from the economy point of view. The study selected most economical section for four types of super structures. The effects of the placement of span are also studied for different site conditions.

Anuja Rajguru and Parag Mahatme (2016) presented that in the construction project, time and cost are the most important factors to be considered in the planning of every project. It is a difficult task undertaken by project managers in practice, which include evaluation of plans, corrective actions and constantly measuring progress should be taken whenever required. Cost optimization is an important issue in construction project management. It is mostly used by contractors and needs to carry out throughout the life of a construction project. The cost optimization method in a construction project is used to identify the problem faced by the contractor in optimizing the costs on site. The availability of qualified expertise is the main problem faced by contractor in optimizing the costs on site. The duration of the project and ever changing environment are the least problem faced by contractor in optimizing the costs on site. The study is able to state that, "The problem of cost optimization is actually the lack of knowledge and inadequate planning for

the implementation coupled with the poor management of construction resources

3. Objective

1) To analyze RCC and PSC Type bridge superstructure for span length of 21.50m.
2) To compare the cost and time incurred for execution of both types of superstructure
3) To check the economic feasibility of best sup[restructure among both.

4. Cost Comparison

In the present study, the actual cost of RCC T Beam superstructure from the ongoing project of construction of 2L/4L major bridges on Mumbai-Goa highway (NH-66) is worked. The data of RCC T Beam superstructure is collected from approved drawings. The quantum of PSC I girder is analyzed in line with the quantum of RCC T Beam. The sectional properties of PSC I Girder superstructure for span of 21.50m have been studied from the design drawings. The design and drawings for PSC I Girder for 21.50m is specially worked out for comparison only. In the proposed project of construction of Janavali Bridge, on LHS, the RCC T Beam superstructure type is being executed; RCC T Beam and deck slab both are cast in-situ only. For proposed bridge on RHS, the viability of PSC I Girder will be checked by designing it for same span length, ie. 21.50m and its costing will be reviewed. The feasibility of PSC I Girder will be checked for in situ as well as for precast girder as only erection methodology will vary here and material cost will remain same in both cases, i.e. in-situ and precast type. For PSC I Girder bridge, the cost for In-situ erection method and for precast method of erection for superstructure are worked because here only cost of launching / staging will differ and material cost will remain same in both case.

The cost analysis covers following components,

i. Basic cost of material incurred for construction of the structure including all labour cost
ii. Erection/ Placement/ launching of structure element at designated location including all lead lift, labour, all types of equipment hire charges, overheads etc.

The cost of finishing is not considered for analysis as the effect of finishing cost has no impact for cost comparison of superstructure type.

a) Material Cost

The sectional properties of superstructure in both types are studied. The sectional properties of superstructure elements are brought out, summarized and are represented in Table I.

Table 1: Sectional Properties of RCC/PSC Superstructure

Sr. No.	Description	Unit	RCC T Beam	PSC I Girder
1	2	3	4	5
1	Name of Bridge	M	Janavali	Janavali
2	Span Length	M	21.50	21.50
3	Depth of deck slab	M	0.20	0.25
4	Web depth (excluding deck slab)	M	1.55	1.30
5	Top width (at Support)	M	0.35	1.10
6	Bottom width (at Support)	M	0.35	0.70
7	Web width (at Support)	M	0.35	0.70
8	Top width (at mid span)	M	0.35	1.10
9	Bottom width (at mid span)	M	0.35	0.70
10	Web width (at mid span)	M	0.35	0.30

Based on sectional properties and detail drawings, the quantity of materials like Concrete, Reinforcement Steel, and Prestressing Steel is calculated. Also the quantum of shuttering (Formwork) required to execute the said superstructures are figured out. The shuttering charges are including of labour charges and material hire charges. The quantities of materials for both types of superstructure are tabulated in table (Table II).

b) Placement / Launching / Erection Cost

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 surrounding site conditions. The free movement of cranes is being restricted many times due to less land width available for crane erection. Greater the restriction greater the cost involved for placement of the girder. The cost of launching / placement depends on the weight of the superstructure member being launched. In our case only PSC I Girder girders will be launched. It is important to mention that RCC T-beam is cast-in-situ and does not require any launching / placement. Hence for RCC T Beam case the cost of erection of temporary structure for staging work is considered for analysis. The work methodology for erection of both types of structures needs to be freezed before start of the work. The approval of the methodology is also required to be taken from concerned authority before actual work starts. The launching cost includes the operating cost of casting and stacking yard, hire charges for crane and trailer, labour, safety arrangement expenses, etc.

c) Finishing Cost

In case of reinforced or prestressed concrete bridges work generally does not require any finishing. The surfaces of cast structures are smooth due to quality concrete work and an only need in case of any honeycombing is observed post concreting. Hence the cost will not have any major impact on total cost. Due to this, the impact of finishing cost is not considered.

d) Maintenance Cost

The maintenance cost is not considered here for comparison of PSC I Girder with RCC T Beam superstructure type and same will be reviewed separately at later stage.

e) Total Cost

The final cost of the finished structure including cost of material along with cost of launching will be as shown in Table III.

Table 2: Quantities of Materials of RCC/PSC Superstructure

Sr. No.	Description	Unit	Type of Superstructure	
			RCC T Beam	PSC I Girder (In – situ)
1	2	3	4	5
1	Span length	M	21.50	21.50
2	Concrete	Cum	120.00	142.00
3	Reinforcement	MT	18.00	12.80
4	Shuttering	Sqm	548.00	520.00
5	Pre-Stressing Steel	MT	-	2.90

Table 3: Cost of Superstructure of RCC/PSC Superstructure

Sr. No.	Description	Type of Superstructure		
		RCC T Beam	PSC I Girder (In-situ)	PSC I Girder (Precast)
1	2	3	4	5
1	Material	20,11,640.00	23,15,200.00	23,15,200.00
2	Transportation, Placement / Launching cost	1,38,000.00	1,80,000.00	4,70,000.00
3	Total Cost (in Rs)	21,49,640.00	24,95,200.00	27,85,200.00
4	Deck area Sqm (For width 12m)	258.00	258.00	258.00
5	Cost per Sqm (Rs.)	8,332.00	9,671.00	10,795.00

The design grade of concrete for PSC I Girder superstructure and Deck Slab is M45 while for RCC T Beam type, the concrete grade is M30. Reinforcement Steel of Grade Fe500 is proposed in both types. High Tensile Steel of 12.7mm diameter will be used as per design drawing for PSC I Girders. The bridge superstructure is analysed and compared for RCC T Beam and PSC I Girder (In situ/Precast). The cost is compared based on the deck area covered. The cost per sqm worked out in Table III is represented through chart (Fig 1).

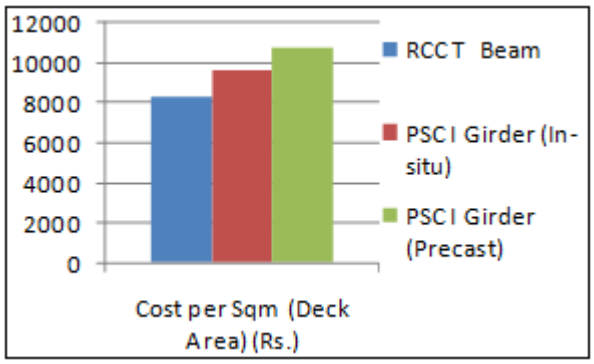

Figure 1: Cost per Sqm of Deck Area of Superstructure

5. Time Duration and Manpower

Along with the cost comparison analysis, the manpower consumed and the time required to execute the superstructure work at said bridge are analyzed. The data collected suggests that the manpower required for execution of RCC T Beam is about 23% less as compared with the PSC I Girder (In-situ) type of superstructure and is less than 40% when it compared with PSC I Girder (Precast) type.

Table 4: Time Duration and Manpower of RCC/PSC Superstructure

Sr. No.	Description	Type of Superstructure		
		RCC T Beam	PSC I Girder (In-situ)	PSC I Girder (Precast)
1	2	3	4	5
1	Workers (Nos)	30	32	40
2	Supervisory Staff (Nos)	6	8	8
3	Time required for Execution (Days)			
a	Staging	10	10	36
b	Girder Casting	10	16	
c	Deck Slab Casting	6	15	21
d	De-Staging	22	18	10
	Total	48	59	67
4	Total Man days (Workers)	1440	1888	2680
5	Total Man days (Supervisor)	288	472	536

6. Results and Discussion

The cost is worked out for bridge superstructure for two types having same span arrangement. The costs are measured for basic material cost, shifting and launching cost, staging cost and all other indirect costs incurred for actual construction and for planned work based on the budget rates. To evaluate correctly, the superstructure costs are converted in to deck area to form a standard basis for comparison.

1) Based on the cost comparison, it is observed that the RCC T beam type superstructure is economical among two. But the superstructure type, PSC I Girder (In –situ) can be considered based on important aspects like durability, aesthetic point, etc.
2) 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. 9671/- for In-situ type and Rs. 10795/- for precast type PSC I Girder superstructure. Hence the RCC T Beam superstructure is found economical among all above. The decision regarding consideration of PSC I Girder type (Precast/In Situ) needs more research to check its cost effective benefits.
3) There is saving in time duration of 11 days when RCC T Beam superstructure is proposed instead of PSC I Girder for 21.50m span bridge.

The RCC T Beam type superstructure basically saves construction cost only. But if we consider the working life of both type of superstructure (PSC/RCC), the PSC I Girder type superstructure is having more life than RCC T Beam. The PSC structure is also stronger than RCC structure. The RCC type superstructure is susceptible for corrosion, tensile cracks, etc. Due to heavy reinforcement steel at tensile zone there are chances of honeycombing during concrete. Placing of concrete gets more difficult in RCC T beam type while in

PSC I Girder type, concrete placing is more easier as congestion of reinforcement steel is avoided. The segregation of aggregates does not occur and chances of honeycombing are less in PSC I Girder type.

We may conclude that the cost analysis will help to finalize superstructure type well in advance for a specific bridge work and it will help to reduce the construction cost and required time duration. The availability of resources will definitely guide to finalize the type of superstructure. It is important to state that ii is very difficult to provide the perfect policy measures to suggest the superstructure type for a bridge based on above study as every bridge construction locations are differs in end users aspects and other important features.

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