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REVIEW ARTICLE OPEN ACCESS

Optimization and Comparative Study of Balance Cantilever Bridge and Extradosed Bridge for Various Spans: A Review Paper

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Abstract:

Now a days, in India Balance Cantilever bridges are widely used in north region were supporting from the bottom is difficult. The name Balance Cantilever Bridge is arrived due to the application of construction methodology which balances out the cantilever portion. It is one of the most efficient methods of building bridges without the need of false work. Balanced cantilever bridges are used for special requirements like construction over traffic, short lead time compared to steel and use local labour and materials. Extradosed bridge is a novel idea bridge between Girder Bridge and cable-stayed bridge.

As most of the literature covers either balance cantilever bridge or extradosed bridge, this paper introduces and attempt to summaries comparative study of balance cantilever and extra dose bridge with its span arrangement,span by depth ratio, prestressing steel etc.

Keywords **—Cantilever construction, Extradosedbridges,Prestressing.**

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I. INTRODUCTION

Mathivat Jacques is France engineer who is recognized as the inventor of extradosed bridge type. According to Mathivat in recent new type bridges which are transacted to Cable stayed Bridges from conventional post tensioned balance cantilever bridges. Extradosed Bridge are combination of posttensioned balance cantilever bridge and cable stayed bridge. Conventional post tensioned balance cantilever bridges and cable stayed bridges have their own specific structural behaviour like construction methodology, economic advantages and span limitation.

For conventional balance cantilever bridges economical span ranges between 50m to 150m and on other side for cable stayed bridge span ranges above 200m. Now a day economical span ranges are now increased due to advancement in construction material, design and construction methodology.

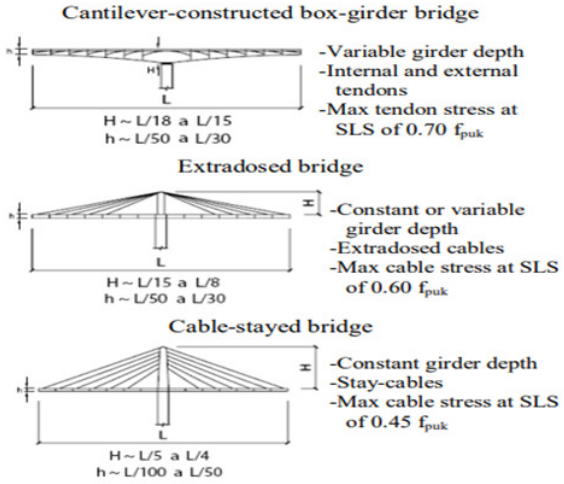

Fig 1.1 Comparison among prestressed bridges, extradosed and cable-stayed bridges

It is suggested that economical span ranges for Extradosed bridge is between 60 m (200 ft.) to 275 m (900 ft.) Cantilevering construction method for a long span bridge either post-tensioned box girder balanced cantilever method bridges or cable stayed bridge is still the dominance construction method.

India's first extradosed bridge was built by Larsen & Toubro Ltd. for the Second Vivekananda Bridge Toll Corporation (figure1.2) over river Hooghly, Kolkata. This bridge is 880 meters long, with a span of 110 meters. A new bridge that bears a similarity to the famous Golden Ears Bridge in Vancouver, Canada, will soon be constructed across Narmada River in Bharuch. This will be the first "extradosed bridge" to be built in Gujarat and the "longest" in the country. This will be the first extradosed bridge in Gujarat. Presently, three such structures exist in India. But the span of 144m for the Extradosed Bridge in Gujarat on Narmada will be the longest in India.

Fig 1.2 Second Vivekanand bridge

LITERATURE REVIEW

[2]This paper present, how to determine the suitable cable forces for extradosed bridge. Author develops a methos combined with stiffness of girder in extradosed bridge, it used linear programming to resolve the cable force with section moment.

Also, comparative analysis is done under different constraints to obtain cable force after that analysis is done with consideration of different objective functions like 1. If Linear addition pattern used cable force appears uneven, 2. If constraint condition set inappropriate then cable results may give negative force, 3. If sum of square pattern used, cable have uniform distribution. From above three consideration square pattern gives more realistic and uniform results.

[3]This literature represents comparative analysis of girder bridges and extra dosed bridges based onconstruction methodology, design and other parameter like minimum span to depth ratio and aesthetic. In this paper details of Balason Girder bridge at Darjeeling and Siddapur Extra dosed bridge are explained.

Some advantages over cantilever construction mentioned in paper are as follow.

1. Reduction in the superstructure girder depth where a girder solution may not provide the necessary clearance requirements
2. Reduced tower height in situations whereas the traditional cable-stayed bridge towers require very high towers and stricter super vision is necessary during construction.
3. Higher permissible stresses in cables due to reduced fatigue stress levels.
4. More efficient tower and cable anchorage designs – providing cost and inspect ability advantages
5. Signature bridge form that provides an enhanced level of driver experience due to the tower & cable elements than a cantilever girder solution

Bridge Type	Girder Height		Tower Height
	Middle Support	Mid Span	
Girder Bridge	Span/20-Span/18	Span/40-Span/35	-
Extra-dosed Bridge	Span/36	Span/55	Span/13 – Span/12
Cable Stayed Bridge	Span/80 – Span/100		Span/5 – Span/4
Balason Bridge (Girder Proposal)	Span/15 (10 m)	Span/40 (3.25 m)	
Balason Bridge (Extra-dosed proposal)	Span/34 (4.5 m)	Span/46 (2.8 m)	Span/11 (14 m)
Sidhapura Bridge (Girder Proposal)	Span/18 (3.15 m)	Span/35 (2.0 m min)	
Sidhapura Bridge (Extra-dosed Proposal)	Span/28 (2.0 m)	Span/35 (2.0 m min)	Span/11.5 (4.975 m)

Table 1 : Giving main aspects of extra-dosedand Cantilever bridge

However, following aspects need to be taken care during design and execution:

1. Though the prestressing cables reduce considerably, the larger eccentricity of cables

produce higher magnitude of moment as well vertical reaction near support. When the extra-dosed cables are placed in multiple planes, the prestressing from one plane only create uneven vertical force and create high magnitude of unbalanced moment in cross section, i.e., torsion in the deck, temporarily although can be catastrophic. This requires simultaneous stressing of prestressing of extra-dosed cables from both sides of support and all planes in together.

2. The prestressing of extra-dosed cables even after extreme precaution and see-saw stressing generate unsymmetrical cable forces on either side of support and needs to be taken care during design. 15% to 20 % variation in cable forces on either side must be taken while designing the pylon.

3. The saddle for the passage of prestressing of cables in the pylon requires stricter quality and smooth profiling, the FIB requirement have been followed and are adequate.

Balason Bridge Quantities Comparison				
System	Concrete M^3	Prestress Steel Mton	Concrete depth per m^2 area	Prestress steel Mton per m^3
Girder System	2460	140	0.8	57
Extra-dosed	2145	80	0.7	38
Sidhapura Extra-dosed Bridge Quantities				
System	Concrete M^3	Prestress Steel Mton	Concrete depth per m^2 area	Prestress steel Mton per m^3
Extra-dosed	765	17.25	0.8	23

Table 2: showing quantity comparison

Above table outlines quantities of Balason Bridge with prestressed girder system and extra-dosed, also Sidhapura Bridge which is designed as extra-dosed bridge. The common other elements for the two options are not shown in the table for clarity.

With this case study we understand, the savings in the prestressed steel for extra-dosed option is higher for lesser span and reduces for the higher span. The extra-dosed option appears to be the more cost-effective option up to span of 150 m based on the results of this study.

[9] The According to this research literature on the extradosed bridge at present stage, it can be seen that the theoretical research on the bridge type has emerged in recent years, and the research results and engineering practice are mainly focused on the following aspects: the alignment of the main beam, the construction control technology, and the mechanical behaviour research

They also summarized the extradosed bridge to help the understand the span range across the world.

Bridge Name	Country	Span combination	Bridge Name	Country	Span combination
Sunniberg Bridge	Switzerland	59+128+140+134 +65	Pakse Bridge	Laos	70+102+9×123 +143+91.5
Odawara Port Bridge	Japan	74+122+74	Pyung—Ye02Gyo	Korea	65+120+65
Yashiro Bridge	Japan	64.5+2×105+64.2	Miyalkoda River Bridge	Japan	133+133
Shinkawa	Japan	90+130+80.5	Keong—An	Korea	70+1 30+70
Kiso River	Japan	160+2×275+160	Gum-Ga Grand	Korea	85+5×125+85
Kani sawa Bridge	Japan	99.3+180+99.3	Brazil Peru Unicom Bridge	Brazil	65+110+65
Saj ika Bridge	Japan	60.8+105+60.8	Home Bridge	Croatia	72+120+72
Golden Ears Bridge	Canada	121+3×242+121	New Pearl Harbor Memorial Bridge	America	75.9+157+75.9
Ganter Bridge	Switzerland	127+174+127	Palau KB bridge	Palau	82+247+82
Viaduc de la ravine des Trois-bassins	France	43+75+105+126	The Second Vivekananda Bridge Tollway	India	55+7×110+55
Ibi River	Japan	154+4×271.5+157	Sh i nkawa	Japan	94+3×140+94
Karato Bridge	Japan	66.1+120+72.1	Tsukuhara Bridge	Japan	65.4+180+76.4

Table 3 : A list of Extradosed bridges (Main span > 100 m) built across the world

Cantilever bridges in abroad	Cantilever bridges in India
Hikoshima ohashi bridge main span 236 m	Siang bridge, Arunachal Pradesh 162 m span
Beaucaire bridge 81.2 x 5 span	Barak bridge, Silchar 122 m span
Savines bridge 77 x 7 + 38.5 x 2	Deopani bridge, Arunachal Pradesh 50 + 100 x 2 + 50
Worms bridge over Rhine river 28 + 101 + 114 + 104	Toong bridge Sikkim 20 + 90 + 20
Coblenz bridge over the Moselle 23.6 + 102 + 114 + 123+34.3	Dikchu bridge, Sikkim 145 m
Calix viaduct in caen, 1880 m long center span 156 m	B III bridge 30 + 60 x 2 + 30
Urato bridge, Japan 55 + 130 + 230 + 130 + 55	Bagchal bridge, Himachal Pradesh 185 x 2

Table 4 : Balance cantilever bridges built in abroad and India

[1] This paper presents a detailed study of the current state of knowledge on bridges with extradosed prestressing. Considered a relatively new typology (most existing extracted bridges were built in the last 20 years), and although there are several works in this regard, there is a hesitation in the bibliography regarding the extradosed bridges conceived following the concept of rigid tower-flexible board. The structural behaviour of these extradosed bridges presents characteristics and differs from the behaviour of classic cable-stayed bridges. Through a parametric study, the influence of the different variables on the structural behaviour is analysed, such as the rigidity of the board, the rigidity of the pylons and the amount of extradosed prestressing. He provides guidelines on basis of cost effectiveness.

[4] The purpose of this thesis is to provide insight into how different geometric parameters such as tower height, girder depth, and pier dimensions influence the structural behaviour, cost, and feasibility of an extradosed bridge. A study of 51 extradosed bridges shows the variability in proportions and use of extradosed bridges and compares their material quantities and structural characteristics to girder and cable-stayed bridges. The strategies and factors that must be considered in the design of an extradosed bridge are discussed. Two cantilever constructed girder bridges, an extradosed bridge with stiff girder, and an extradosed bridge with stiff tower are designed for a three-span bridge with central span of 140 m. The structural behaviour, materials utilization, and costs of each bridge are compared. Providing stiffness either in the girder or in the piers of an extradosed bridge are both found to be effective strategies that lead to competitive designs

[5] This paper presented the study of extradosed prestressed concrete bridges. The influence of geometrical parameters, such as the height of towers, girders depth and size of piers in the structural behaviour and in the design and construction of an extradosed bridges were also analysed it is intended to get a critical sense of how each component of an extradosed bridge affects its structural behaviour. The paper also discusses the main factors that define the design of an extradosed bridge. From its setting in vast world of bridge with different solutions to some critical details that must be considered in the final design.

[6]This paper present, how to determine the suitable cable forces for extradosed bridge. Author develops a methos combined with stiffness of girder in extradosed bridge, it used linear programming to resolve the cable force with section moment.

Also, comparative analysis is done under different constraints to obtain cable force after that analysis is done with consideration of different objective functionslike

1. If Linear addition pattern used, cable force appears uneven,

2. If constraint condition set inappropriate then cable results may give negative force,

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[8]In this paper, author evaluated extradosed bridge and cable stay bridge on the basis of structural parameter like bending moments, shear force, depth of girder at mid span and pylon height etc. As the shear transferred through web to pylon, the girder depth near pier is more for extradosed bridge, while cable staycan be provided with constant depth of girder. Paper concludes that lower height of pylon provides ease of construction than cable stay bridge&Stay cable requiredmore numbers of cable than extradosed for same span.

II. CONCLUSIONS

Extradosed Bridge are combination of post-tensioned balance cantilever bridge and cable stayed bridge. Conventional post tensioned balance cantilever bridges and cable stayed bridges have their own specific structural behaviour like construction methodology, economical advantages, and span limitation. From literature review it seems that balance cantilever mainly used for 50m to 150m and extradosed bridges used for 100m to 275m. As it is review paper, detailed work over the analysis of bridges of various spans and concluding results will be discussed in the final paper.

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