STUDY OF EXTRADOSED BRIDGE AND INFLUENCE OF DIFFERENT TOWER HEIGHT ON IT

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Abstract*: Bridges are one of the most important source of transportation therefore they keep on evolving.Extradosed bridges are the advanced version of cable stayed bridge. Extradosed bridge, a concept introduced by J.Mathivat in 1988, is still not much researched. Extra dosed bridges have shallow cables which add to the prestress in the deck. In this paper five models have been created and analysed by software CSI BRIDGE.All sections and dimensions are kept same except the tower height .In this paper we will also study the impact of tower height and angle of the cables of Extradosed bridge.Tower height and angle of cables lead to the demonstration of other important factors like deflection of cable and girder, compressive and tensile forces of girder etcStudy shows that optimum height of Extradosed Bridges lie under the range of 20m -30m.*

Keywords: *Axial force, deflection, extradosed bridge,, prestress, tower height.*

1.INTRODUCTION

The Extradosed bridges are the bridges having characteristic similar to cable stayed bridge and prestressed girder bridge. It could be said that they are the improved version of cable stayed bridge as they encounter many short comings of cable stayed bridge by keeping the height of the bridge about half the height as that of cable stayed bridge. In other words they are advantageous in terms of structural functions, architecture and economy too. Extradosed bridge is although a new concept but it is prevalent since a long time as first bridge of this kind was built in 1980 in Switzerland. Until now more than 70 such bridges have been constructed through out the world among which 5 are constructed in India itself.

The main objective of this paper is to diversify the knowledge of Extradosed bridge and perform analysis on tower height, cable angle, deck section . In the analysis change in cable angle with respect to the deflection in girder and cable is studied along with girder and cable axial forces and stresses.

1.2 Structural Behaviour of Extradosed Bridge

- An Extradosed bridge shows structural behaviour similar to girder and cable stayed bridge.
- Extradosed bridges rely about 20%-50% of their load on cables and the remaining portion is carried by the girder.
- Tower height of Extradoesd bridge is about half the height of cable stayed bridge.
- The deck of Extradsoed bridge is stiffer and stronger as the bridge decks are prestressed internally.

2. MODELLING AND ANALYSIS

Five different models of the bridge has been created and analysed through the help of CSI BRIDGE.
Model is divided into four parts girder, cables, pier and tower. Pier and cable section are circular whereas girder and tower are rectangular. For modelling roller supports are used at two ends of Bridge, as only gravitational loads are considered and lateral loads are ignored for the analysis. Fixed support is used below the pier and the portion below the pile cap is ignored. Self weight is considered as main load for modelling and lane load is considered to be uniformly distributed load. Self weight is assigned by selecting whole

section and uniformly distributed load is assigned to girder only.

S.No.	STRUCTURAL PART	DIMENSIONS
1.	Bridge type	Extradosed bridge
2.	Length of bridge	200m
3.	Width of carriageway	7.5m
4.	Depth of deck	400mm
5.	Height of Pylon	Five models with varying height (20m,23m, 25m, 27m ,30m)
6.	Pylon type	Circular
7.	Longitudinal cross girder	600mm*120mm
8.	Cross girder	500mm
9.	Spacing of cables	6m
10.	Cable arrangements	Fan type
11.	Loading as per IRC 6:2017	Class 70R(wheeled) and class A for two-lane
12.	River discharge	30cum
13.	Concrete (Bridge,Deck,Pylon)	Grade M45
14.	Steel reinforcement	Grade Fe500
15.	Cables	200 N/mm^2

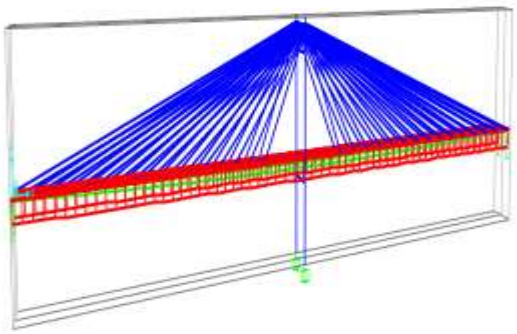

Fig.1. Extradosed bridge model by CSI BRIDGE SOFTWARE

2.3 Analysis of the Model

The models are generated on same span and girder section. Study on different parameters like tower height, cable angle, axial force and stress of girder and cable is performed. Girder and Cable deflection is also observed from these models. All five models have variable tower height. Analysis of the models helps us to meet the purpose of this research.

3. RESULT AND DISCUSSIONS

The following paper represents the results found from the analysis done by the software. Table-1 and Table-2 represents the results of the models.

Table -1. Summary of the results of models

Model	Tower height (m)	Angle of cable (degree)	Max. Compressive force of Girder (KN)	Max. Tensile force of cable (KN)
M1	20	20.79	65127.34	16527.3
M2	23	22.03	62529.87	15119.6
M3	25	24.67	60341.87	14185.2
M4	27	26.34	58013.16	13295.6
M5	30	28.54	54495.11	12975.7

Table- 2 Continuation of Table 1

Model	Deflection of Girder (mm)	Deflection of Cable (mm)	Stress of Girder(KN/m^2)	Stress of Cable(KN/ m^2)
M1.	430.52	2576.2	3338.85	330566.2
M2.	426.28	2734.2	3205.65	302402.7
M3.	387.79	2827.9	3093.43	283723.1
M4.	352.56	2995.6	2974.31	265931.1
M5.	312.91	3228.4	2792.54	241534.4

The difference in various parameters with respect to change in Tower height and Angle of Cable is illustrated by plotting various curves.

The graph shown below is Angle of Cable vs. Tower height graph. It shows the variation of Angle of Cable with the Tower height models.

As the tower height increases the angle of the cable with girder also increases. Maximum Cable angle is found to be 28.54 degree for the tower height 30m. The curve is linear.

4. RESULT AND DISCUSSIONS

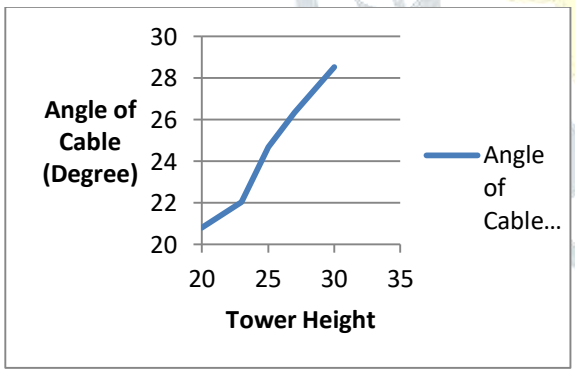

Fig. 2. Variation of Angle of Cable with respect to Tower Height

By the change in angle of cable the compressive force of girder and tensile force of cable also changes. Maximum compressive force curve shows that as the angle of cable increases, compressive force of girder decreases. Maximum compressive force of the girder is 65127.34KN at an angle of 20.79 degree and tower height 20m. Maximum compressive force curve found for different tower height is a linear curve.

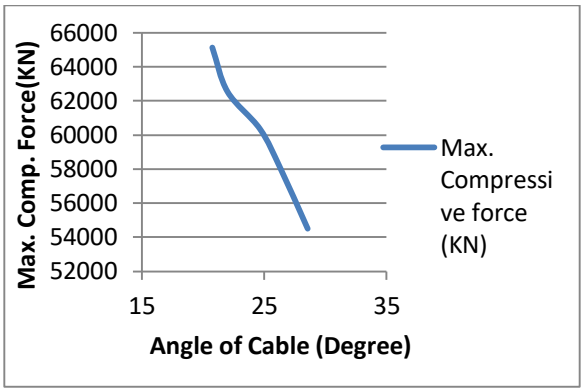

Fig 3.Variation Of Max. Compressive Force (of girder) with respect to Angle of Cable

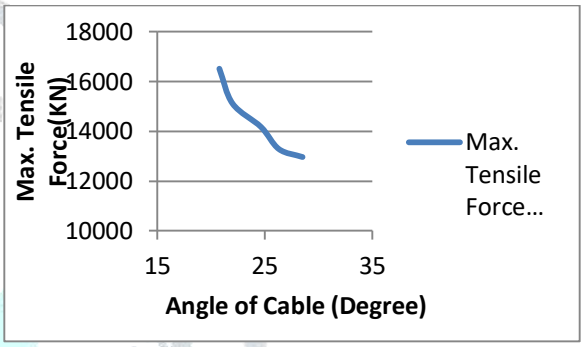

Fig. 4 Variation of Max. Tensile Force (of cable) with respect to Angle of Cable

Maximum tensile force curve of cables indicates same behaviour as Maximum compressive force curve. As cable angle increases the cable tensile force decreases. The maximum tensile force of cable is 16527.3 KN for the same cable angle 20.79 degree.

This is inferred that deflection of girder decreases with increase in height of the tower whereas deflection of cables increases with increase in tower height.

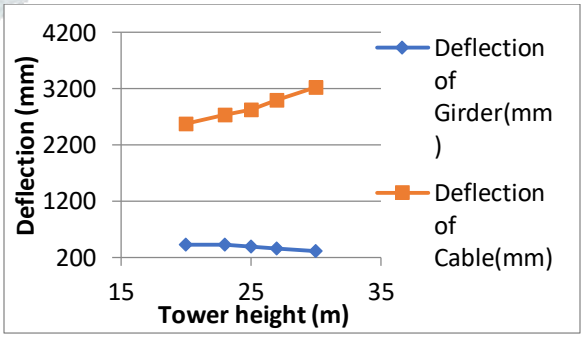

Fig. 5. Relation between Deflection of Girder and Cables and Tower Height of models.

From the analysis, Maximum deflection of girder is 430.52 m at tower height 20 m and minimum

deflection of girder is 312.91 m at tower height 30 m. Conversely maximum deflection of cable is 3228.4 mm at tower height 30 m and minimum deflection of cable takes place at tower height 20 m.

5. CONCLUSIONS

The structural behaviour of the Extradosed Bridge is concluded as follows by the analysis

- Prestressing source of prestressed box girder bridge is maintained by cables anchored in the box girder.
- In the Extradosed bridge optimum tower height plays an important role. From the analysis it was observed that when the tower height rises from 20 m to 25 m the Compressive force of girder decreases from 65127.34 mm to 60341.87 mm which indicates 25% increase in tower height leads to 7.35% reduction of Compressive force of Girder. Tensile force of cable decreases from 16527.3 mm to 14185.2 mm which indicates that for same amount of increase in tower height reduces 14.17% tensile force of Cable.
- From the observation optimum tower height is taken between 20 m – 25 m.

According to the concept of Extradosed bridge it is desired that the cables should have much tensile force which will give a higher compressive force in girder. From the analysis it is observed that maximum compressive force of girder occurs when the cables are in higher tensile force.

6. ACKNOWLEDGEMENT

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7. REFERENCES

- S. Ikeda, A. Kasuga, 2000, “Development of Extradosed Structures in The Bridge Construction” 25th Conference on Our World In Concrete and Structures in the Bridge Construction.
- Kasuga, Akio, 2006, Extradosed Bridges in Japan, Structural Concrete, Thomas Telford and fib No. 3, pp 91-103.
- Pengzhen Lin, Shijun Zhou, Fengkui Liu, 2006, ”Study on Dynamic Characteristics Parameters of an Extradosed Bridge with Single Cable Plane” Journal of Vibration and Shock, Vol. 25, pp 150-153.
- Congchun Chen, Haizhi Zhou, Rucheng Xiao, 2006, “Advancement of Extradosed Bridges in World” Vol. 1, pp 70-73.
- Dookie Kim, 2008, “Earthquake Risk Assessment of Seismically Isolated Extradosed Bridges with Lead Rubber Bearings”, Vol. 29, issue no. 6, pp 689-707.
- M.S. Chowdhury, 2015, “Study on Extradosed Bridge and It’s Structural Behaviour” IICSD.
- Erik Mellier, 2015, “State of the art Extra dosed Cable Technology”
- M.S. Chowdhury, 2015, “Study on Extradosed Bridge and It’s Structural Behaviour” IICSD.
- Yohan Peyrani and Zhi Sun, 2015, “Progressive Cable Yielding of a Cable Stayed Bridge Considering Geometric Nonlinearities and Uncertainities of Loads” IABSE Conference.
- Y.K.R. Gunawardena, H. Ohashi, Y. Yamahana and T. Nohmi, 2015, “Design of the new Extra dosed Bridge over Kelani River” , Vol.4, issue, pp 16-20.
- Jing-Xian Shi, Zhi-Hong RAN, 2017, “Effect of concrete creep pnExtradosed Bridge” , ICEESE.
- Garima Malik, Sumit Saini & Anjali Malik, 2018, “Application of Extradosed Prestressing”, Vol.8, issue no. 5, pp 17429-17431.
- Heemika Upadhyay, Pradeep Pandey, 2018, “Comparative Study of Super Structure of Box Girder and Extradosed Bridge”, Vol.7, issue no. 5, pp 21-26.
- N.K.Sinha, Gautam Chattopadhyay, Malay Dasgupta, 2018, “Extradosed Bridges for Major River on Vadodara Mumbai Expressway ”.
- Yogesh B Jankar, Suresh M R, 2018,”Time History Analysis of an Extradosed Bridge for Various Spans and Pylon Height”. Vol.5, issue no. 10, pp 166-172, IRJET.