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Comparative Study of the Analysis and Design of T-Beam Girder and Box Girder Superstructure

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Abstract: The purpose of present study is the design of bridge structure for 25 m of span. The most obvious choice of this span is T- Beam and Box Girder. They have their own characteristics and limitations as T-Beam has easy construction mythology, where as Box girder has sophisticated and costly formwork. In present study a two lane simply supported RCC T- Beam Girder and RCC Box Girder Bridge was analyse for dead load and IRC moving load. The dead load calculation has been done manually and for live load linear analysis is done on Staad Pro.

The goal of study is to determine most favourable option from above two. The decisions based on obvious element of engineering that are safety, serviceability and economy. Following these aspect a design for both T-Beam and Box Girder has been performed. After calculation two basics material consumption steel and concrete the most economical has been selected. This study is on the basis of moment of resistance of section, shear capacity of section and cost effective solution from both T-Beam and Box Girder Bridge. The study gives the solution based on the prevailing rates of construction cost to be adopted by design Engineer.

***Keywords*— T-Beam Girder, Box Girder, Staad-Pro**

I. Introduction

Bridge is life line of road network, both in urban and rural areas. With rapid technology growth the conventional bridge has been replaced by innovative cost effective structural system. One of these solution present two structural RCC systems that are T-Beam Girder and box Girder Bridge.

Box girders, have gained wide acceptance in freeway and bridge systems due to their structural efficiency, better stability, serviceability, economy of construction and pleasing aesthetics. Box girder design is more complicated as structure is more complex as well as needed sophisticated from work. In the place of Box Girder if we talk about T-Beam Girder geometry is simple and does not have sophisticated in construction.

Bridge design is an important as well as complex approach of structural engineer. As in case of bridge design, span length and live load are always important factor. These factors affect the conceptualization stage of design. The effect of live load for various span are varied. In shorter spans track load govern whereas on larger span wheel load govern. Selection of structural system for span is always a scope for research. Structure systems adopted are influence by factor like economy and complexity in construction. The 25 m span as selected for this study, these two factor are important aspects. In 25 m span, codal provision allows as to choose two structural systems i.e. T-Beam Girder and Box Girder. This study investigates these two structural systems for span 25 m and detail design has been carried out with IRC loadings. The choice of economical and constructible structural system is depending on the result.

II. Literature Review

Design of difference structural system for different span has been the subject of considerable, experimental and analytical research.

A important research has been published for Box Girder Bridge by Chu, K. H. (1971) [1] analysed simply supported curved box girder bridges by using finite element method. Schlaich, J. (1982), [2] describe the Concrete Box-Girder Bridges. Sami M. Fereig (1994), [3] has been carried out a Preliminary design of precast prestressed Concrete Box Girder Bridge. M. Qaqish (2008),[4] presents the analysis of two continuous spans Box Girder Bridge. The first method based on one dimensional model according to AASHTO specifications 2002 and the second method is based on three dimensional finite element analyses. M. Qaqish (2008), presents the Comparison between Computed Bending Moments by AASHTO Specifications and Finite Element Method of Two Continuous Spans of Voided Slab Bridge. Gokhan Pekcan (2008), presents Seismic Response of Skewed RC Box-Girder Bridges.

Many methods are used in designing T-Beam Girder Bridge such as AASHTO specifications, grillage and finite element methods. Chan and O'Connor (1990 a),[5] describe further field studies on the bridge referred to above and reported values for the impact fraction I, consistent with the values obtained previously. In a companion paper, the same authors Chan and O'Connor (1990 b), [6] present a vehicle model in which each axle load includes a dynamic load component that varies sinusoidally at the first natural frequency of the bridge. Wang and Huang (1992), [7] studied the dynamic and impact characteristics of continuous

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steel beam bridge decks and slant-legged rigid frame bridges. Dr. Maher Qaqish (2008),[8] was analysed a simple span T-beam bridge by using AASHTO specifications and Loadings as a one dimensional structure, then a three-dimensional structure. N. K. Paul (2011), [9] is developed three dimensional finite element model and tested under two point loading system to examine structural behaviour of the longitudinal girder of a reinforced concrete T-beam bridge

III. DESCRIPTION OF BRIDGE SUPER STRUCTURE

The structure considered in this case study is 25 m simply supported. The deck slab is 250 mm in both the cases. The thickness of T-Beam girder and two cell Box Bridge has been selected on appropriate design consideration and shows below:

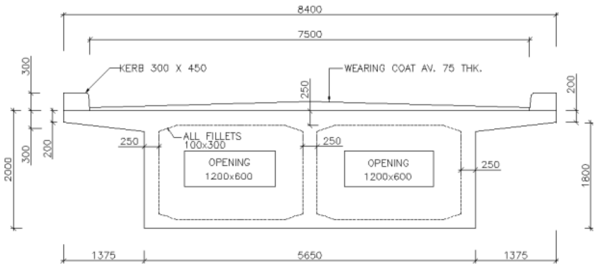

Fig. 1 Cross section of two-cell Box Girder Bridge Deck

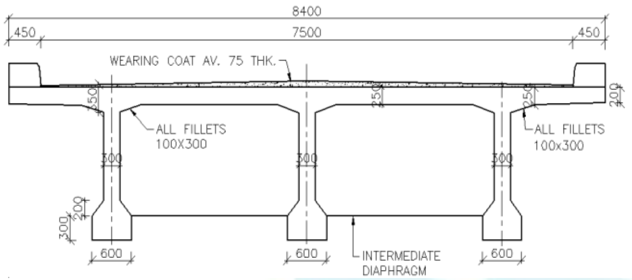

Fig. 2 Cross section of T-Beam Girder Bridge Deck

IV. DESIGN ANALYSIS

Detail design of bridge Superstructure for Dead load and Live load has been performed. Calculation of Dead load evaluated manually where as for Live load consideration linear model has been created is Staad-Pro, as show

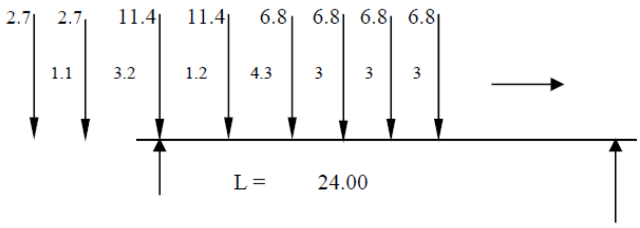

Fig. 3 Schematic diagram for Class A (T) along centreline of Deck

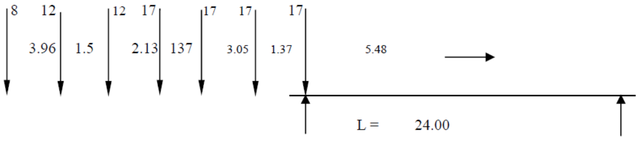

Fig. 4 Schematic diagram for Class 70-R (T) along centreline of Deck

Then Live load Shear force and Bending moment has been modified for both impact effect and lateral distribution. For lateral distribution the morice little has been adopted.

V. COST ANALYSIS

Two structural system adopted has been detail estimated Steel and concrete quantity has been calculated as per design requirement and consider local SOR rates the cost has been consider.

Structure	Concrete (Cum)	Rate (Per Cum)	Amount (Rs.)
T-Beam Girder	125.13	4454	557329
Box Girder	126.67	4454	564188

Table 1 Cost of Concrete

Structure	Steel (Kg)	Rate (Per Kg)	Amount (Rs.)
T-Beam Girder	19744	55	1085920
Box Girder	20619	55	1134045

Table 2 Cost of Steel

Structure	Amount of Concrete (Rs.)	Amount of Steel (Rs.)	Total Amount (Rs.)
T-Beam Girder	557329	1085920	1643249
Box Girder	564188	113405	1698233

Table 3 Total Cost

VI. RESULTS

i. Dead Load

Comparison of Dead load has been presented

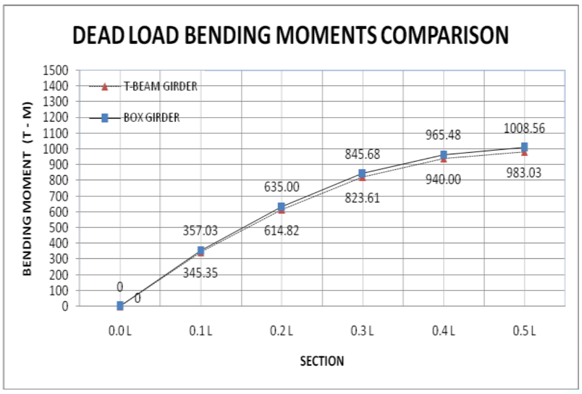

Fig. 5 Dead load bending moments comparison

Dead load moment due to assumed adequate section has been calculated and studied with graph. The analysis shows T-Beam Girder has produced less moment than Box Girder units. This means T-Beam Girder has less heavier section than two cell box Girder.

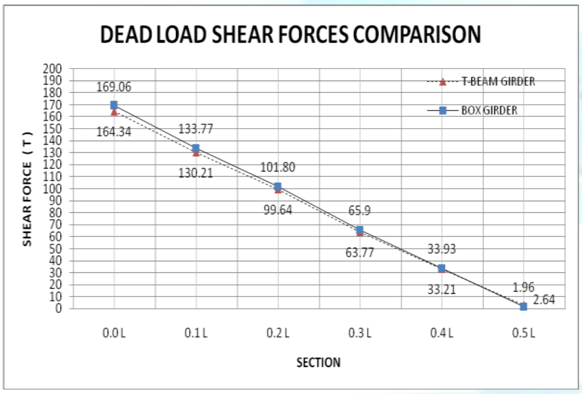

Fig. 6 Dead load shear forces comparison

The representation of shear force due to assumed adequate section for assumed span varies higher in the structural system as represented by graph. The analysis shows T-Beam Girder has produced less shear than Box Girder units because of cross section area of concrete.

ii. Live Load

Live load bending moment and shear force on section is same for both T-Beam Girder and Box Girder. But major difference carries after application of load distribution factor due to Morrice and little method. The final bending moment and shear force after applying Morrice little co-efficient has been computed in subsequent graph.

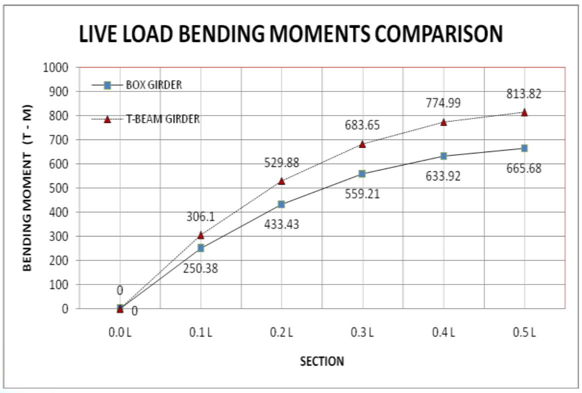

Fig. 7 Live load bending moments comparison

The bending moment on T-Beam Girder for standard arrangements of beams formed more.

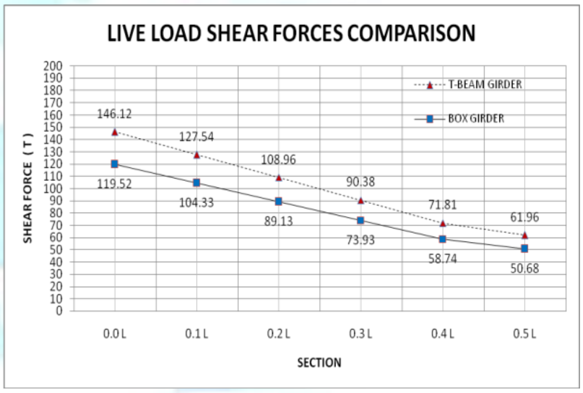

Fig. 8 Live load shear forces comparison

Live load shear forces for Box Girder are less after applying distribution factor due to its symmetry.

iii. Live Load and Dead Load

Combined effect of live load and dead load has been presented with graph.

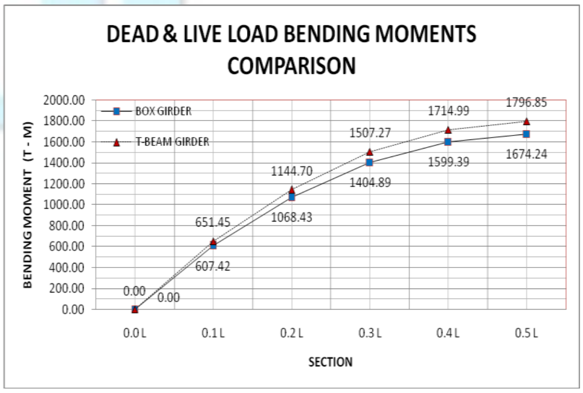

Fig. 9 Dead load & Live load bending moments comparison

Here bending moment for chosen span has been plotted.

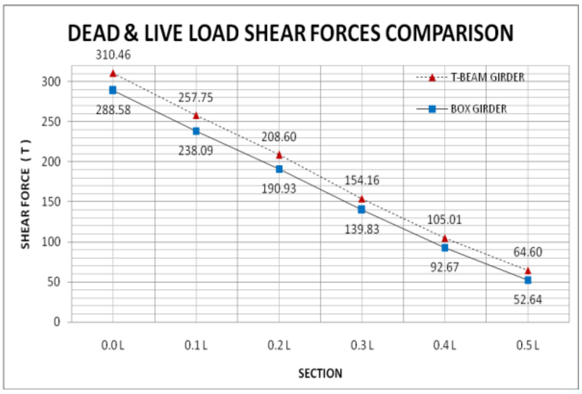

Fig. 10 Dead load & Live load shear forces comparison

iv. Moment capacity and Shear resistance

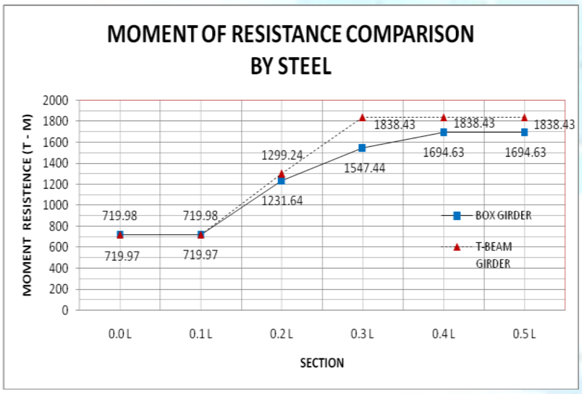

Fig. 11 Comparison of moment of resistance (By Steel)

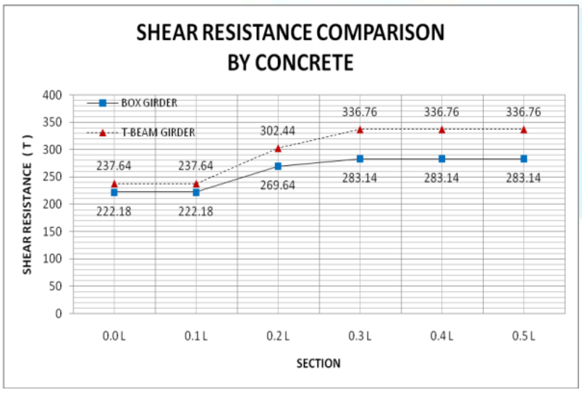

Fig. 12 Comparison of shear resistance (By Concrete)

As per above graph it has been concluded that the T-Beam girder are more resistance capacity of moment and shear for 25 m span. Considering same shear reinforcement in both T-Beam Girder and Box Girder. T-Beam capacities to resist the shear are more.

v. Cost Comparison

The cost of superstructure is the sum of deck & girder concrete and reinforcement cost. In this section the cost of the T-Beam Girder and Box Girder is compared. The quantity of steel and concrete has been calculated as per mentioned sections. The bar chart considering quantities has been presented below-

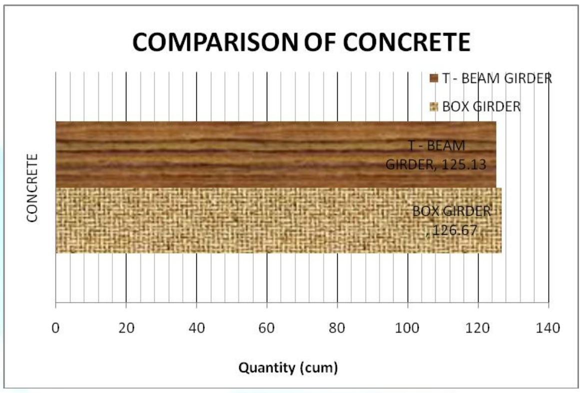

Fig. 13 Comparison of Concrete

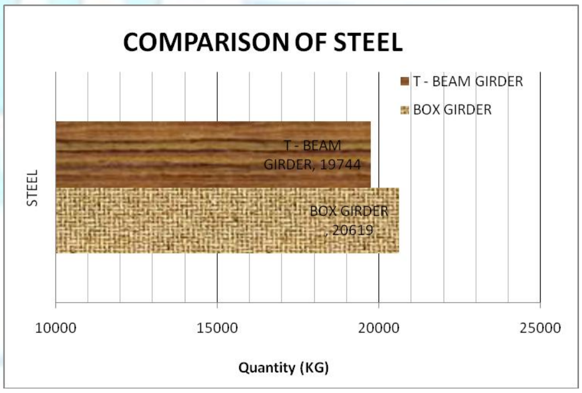

Fig. 14 Comparison of Steel

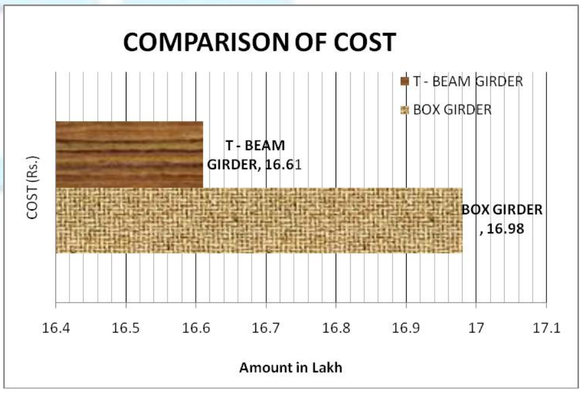

Fig. 15 Comparison of Cost

Concrete and reinforcements which are used in T-Beam Girder and Box Girder are shows by above bar chart. We see that, the quantity of concrete is almost same but the quantity of steel has more in Box Girder Bridge.

As per above result it has been concluded that the T-Beam girder are obvious choice for designer for 25 m span. It has two advantage, they didn't need more sophisticated formwork as well as it is economically sounded.

VII. CONCLUSION

The following conclusion are drawn upon -

1. Service Dead load bending moments and Shear force for T-beam girder are lesser than two cell Box Girder Bridge. Which allow designer to have lesser heavier section for T-Beam Girder than Box Girder for 25 m span.
2. Moment of resistance of steel for both has been evaluated and conclusions drawn that T-Beam Girder has more capacity for 25 m span.
3. Shear force resistance of T-Beam Girder is more compared to two cell Box Girder for 25 m span.
4. Cost of concrete for T-Beam Girder is less than two cell Box Girder as quantity required by T-beam Girder.
5. Quantity of steel for T-beam Girder is less so cost of steel in T-Beam is less as compared to two cells Box Girder Bridge.

For 25 m span, T-Beam Girder is more economical but if span is more than 25 m, so Box Girder is always suitable. This type of Bridge lies in the high torsional rigidity available because of closed box section.

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