ANALYSIS AND DESIGN OF STEEL BOX GIRDER BRIDGE USING TEKLA STRUCTURES

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Abstract – *The immense importance of Highway Bridge in a modern transportation system would imply set of rigorous design and specification. This paper deals with the study of four different cross section of same loading. The design standard of India, IRC is used in the design of steel box Girder Bridge, which is subjected to IRC Class AA loading. Analysis is done on four different models to show the optimized cross section. As a result it is found that resulted bending moment and stress will vary for different cross section. The cross section with lesser value of bending moment requires less steel also give most economical cross section. This shows that the muiltcell steel box girder are costlier than compared to single cell box girder, when loading and the supporting conditions were kept same for all the four different models of different cross section. Analysis and design are carried out using Tekla structures.*

Key words: Steel box girder, IRC loading, Tekla structures.

1. INTRODUCTION

Bridge is a structure built to span a physical obstacle, such as body of water, valley, and road without closing the way underneath. It is constructed for the purpose providing passage over the obstacles, usually something that can be detrimental to cross otherwise. There are many different designs that each serve particular purpose and apply to different situation. Designs of bridges vary depending on the function of bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and fund available to build it. Bridges are first analysed, the bending moment and shear force distribution are calculated due to the applied loads. For this, the finite element method is the most popular and the analysis can be one, two or three dimensional. This paper is about the making a steel box girder bridge to find most efficient section by using Tekla structures software.

1.2 BOX GIRDER BRIDGE

A box girder bridge (also known as a Box Section Bridge) is a bridge in which the main beams comprise girders in the shape of a hollow box. The box girder normally comprises either prestressed concrete, structural steel, or a composite of steel and reinforced concrete. The box is typically rectangular or trapezoidal in cross-section. Box girder bridges are commonly used for highway flyovers and for modern elevated structures of light rail transport. Although normally the box girder bridge is a form of Beam Bridge, box girders may also be used on cable-stayed bridges and other forms. Steel bridges when compared with concrete girders, have an advantage of offsite prefabrication of steel components that causes construction time on site, often in hostile environments, is minimised. The speed of bridge construction made possible by steel allows the disruption to road and rail users to be kept to a minimum. The low self-weight allows of steel permits the option of longer spans and faster erection by different ways. After the girder is erected the slab has to be casted over it using the formwork and hence until the wet concrete dries the girder has to take the concrete weight. But, once the concrete hardens there is composite action taking place due to the interference of two different materials with the help of shear connectors that are provided in the form of steel studs or channels at required spacing and are welded to the flange of the girder section. Steel also has greater efficiency than concrete structures in resisting seismic forces and blast loading and also has greater life.

2. AIMS AND OBJECTIVE

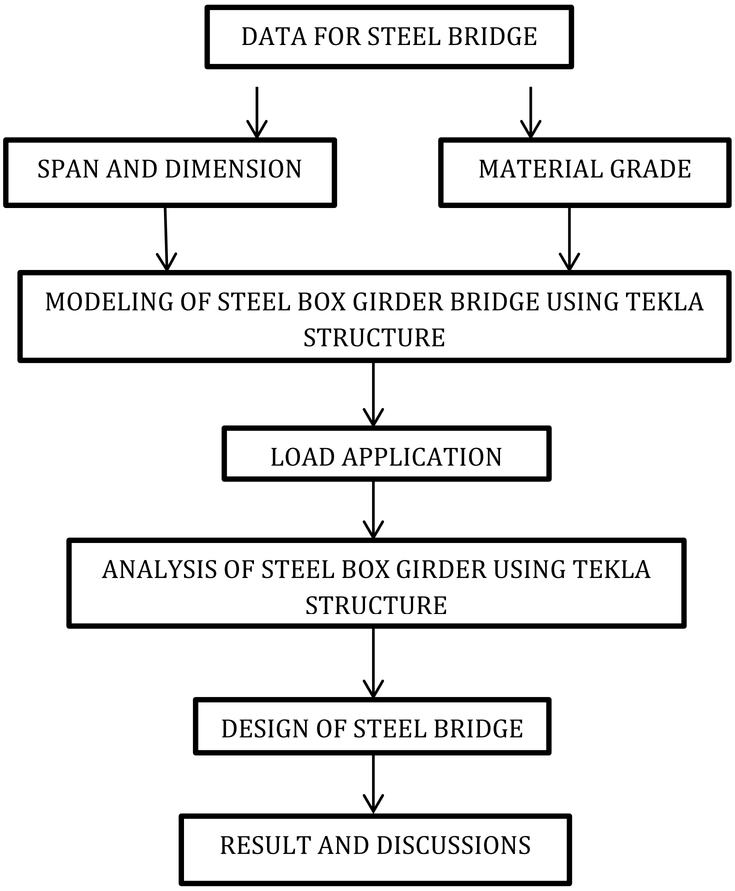
The main aim is to provide a steel box girder bridge for Highway purpose.

The objectives are as follows:

1. To model and analyze the steel box girder using Tekla structures software.
2. To design steel box girder as per IRC codal provision.
3. To validate a comparative result for multi cell steel box girder bridge.
4. To develop a method of structural idealization for steel box girder bridge.

3. METHODOLOGY

The following flow chart represents the methodology of the steel box girder bridge,



3. MODELLING

The composite girder bridge is modelled in Tekla structure using the Steel composite bridge wizard, which is used to create a three dimensional model of four different box girder of different cross section. The cross section of single box cell is mentioned here. The height girder column is 2m (ISSC 250), Grade Fe590. A length of girder beam is 6m (ISMB 500), Grade Fe490. The braced frame of equal angle section of ISA 100*100*6 of Grade Fe 290 is taken for model.

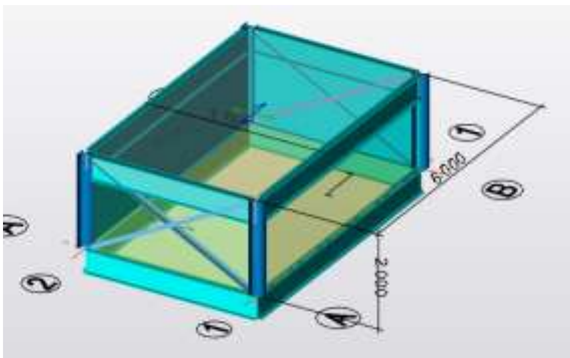


Fig 3.1: General section for steel box girder

3.2 STRUCTURAL DATA OF BRIDGE

The single span of 144m is taken from reference paper and existing bridges with different width of carriageway are taken, for single lane with single cell steel box girder having carriageway of 3.75m, two lane with double cell steel box girder having carriageway of 7.5m, two lane with triple cell steel box girder having a carriageway of 11.25m, muilt lane pavements with muilt cell steel box girder of carriage way of 15m with 0.5 for kerbs are taken. It is a general composite section as the concrete deck slab is casted over the steel girder. The thickness of the slab is taken as 500mm and wearing course as 80mm. A pier of normal concrete of 9m in height with cross section 2*2m is taken. The foundation of isolated pile cap of depth 750mm, 2 no of piles are taken. All concrete section are provided with a Grade of M35 and Fe415.

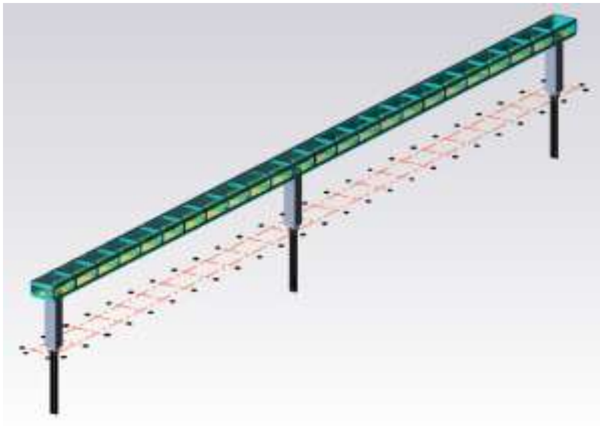


Fig 3.2: Perspective view of single cell steel box girder

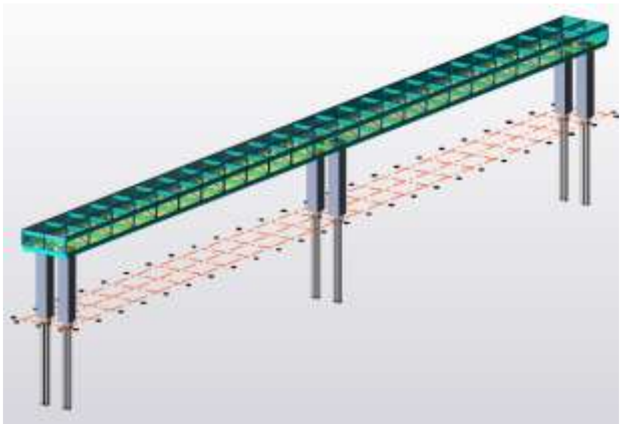


Fig 3.3: Perspective view of double cell steel box girder

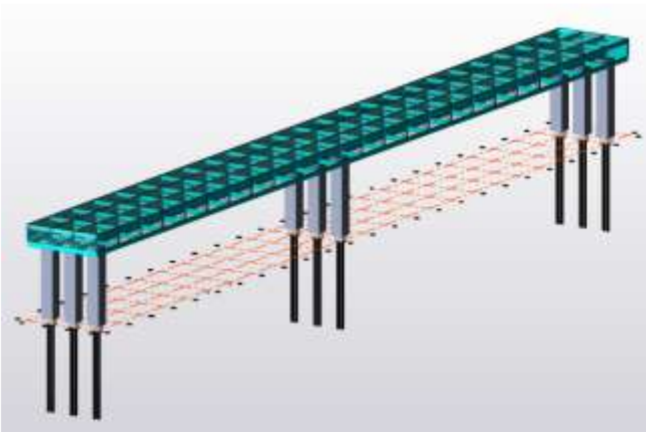


Fig 3.4: Perspective view of triple cell steel box girder

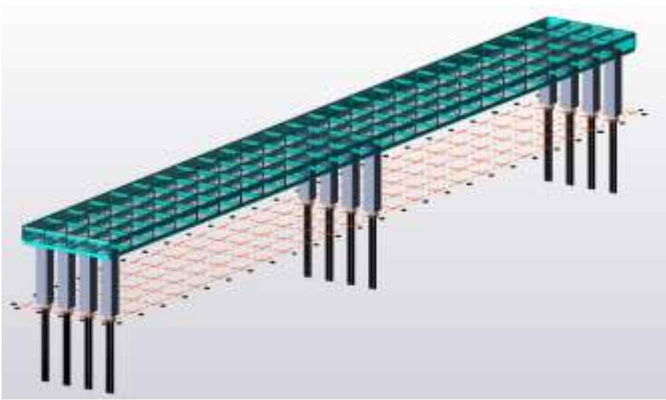


Fig 3.5: Perspective view of muilt cell steel box girder

3.3 LOADING

The steel bridges are assumed to function as Highway Bridge and therefore the loading are taken as per IRC 6: 2017 (IRC Class AA Tracked vehicle loading) is considered as live load. The live load case is defined as rolling load case in which the software will place the loads at various points within the defined lane width and the maximum effect is taken as critical. The other loads that are applied on the models include the dead load, wind load etc. All these loads are applied uniform throughout the carriage width. The load combination is also generated. Since the bridge is considered as a highway purpose and the loads are applied on the models for the analysis.

4. ANALYSIS

The model is analysed with moving load analysis along with dead loads and other additional components. The stresses, bending moments and deflections are obtained at critical points and interpreted for different load cases. Comparison between the four type of bridges as well as variations in their cross sections is discussed under the results. Since the four different models of steel box girder bridges are analysed and the results are obtained as follows.

4.1 INFLUENCE LINE DIAGRAM

The moving load tracer can be used to find the placing of the vehicle load for the most critical output of an element.

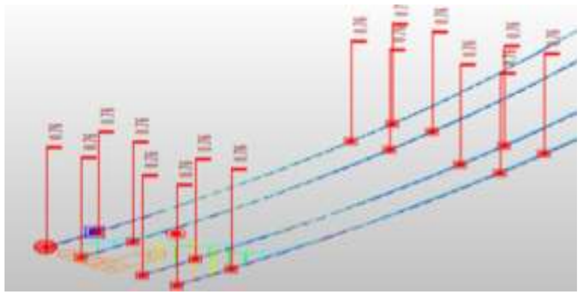


Fig 4.1: Position of Live load for Rolling load analysis

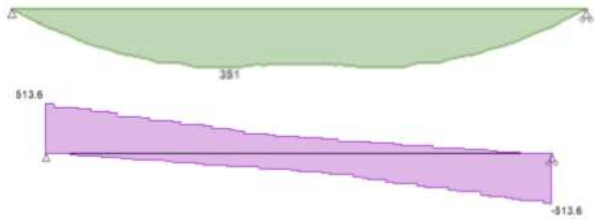


Fig 4.2: Bending moment and shear force for single cell steel box girder

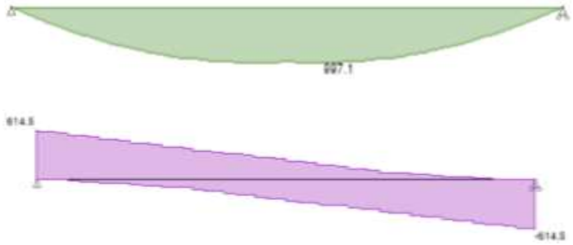


Fig 4.3: Bending moment and shear force for double cell steel box girder

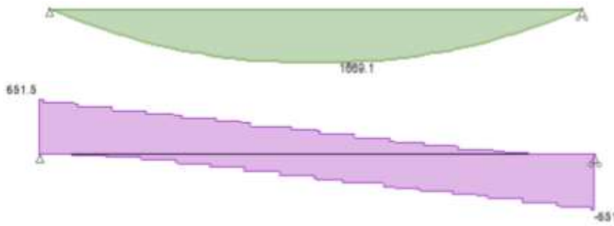


Fig 4.4: Bending moment and shear force for triple cell steel box girder

Fig 4.5: Bending moment and shear force for muilt cell steel box girder

5. DESIGN OF STEEL BOX GIRDER BRIDGE

Design Bending moment = 351 kNm

Effective depth = √ (M/QB) = 263mm

'd' Provided = 410mm

Hence ok.

Ast = 1833.41 mm^2

Spacing = 105mm c/c.

Provide 20mm φ at 150mm c/c spacing as main reinforcement.

Distribution reinforcement:

0.3 ML+ 0.2 MD = 12.43 kNm

Ast = 355.05 mm^2

Spacing =315mm c/c.

Provide 10mm φ at 300mm c/c as distribution reinforcement.

Check for Shear:

Ʈv= 0.24 N/mm^2, Ʈc = 0.32 N/mm^2.

Ʈv < Ʈc

Hence safe.

Table 1: The table shows comparison between four different models of cell

S.NO	BENDING MOMENT kNm	SHEAR FORCE kN	DEFLECTION mm
Single cell	351	513.6	1.2
Double cell	997.1	614.5	13.9
Triple cell	1669.1	651.5	24.9
Muilt cell	2354.9	672.6	122

6. CONCLUSION

The analysis and design of steel box Girder Bridge using Tekla structures is carried out and the following results are obtained. This paper presents the most economical cross-section of steel box girder for the IRC Class AA loading and comparative analysis of four different cell is summarized. By comparison of the result it is clear that single cell or the one celled cross-section steel box girder is most effective for IRC class AA loading. This section counters fewer amount of steel, reinforcement bar and more suitable for single lane road. For two lane road, double or two cell steel box girders is recommended. Because three and muilt cell girder occupies more space and is not more economical for highway bridges.

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