Comparison of Simply Supported and Continuous Box Girders

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Abstract- ‘Nation’s development depends on the Infrastructure growth’. In the current trend a lot of importance is being given to the infrastructure development by the central and state governments. Currently, a lot of National Highways are being proposed, upgraded by the National Highways Authority of India and the State Highways are being developed by respective State governments.

Bridges / Flyovers / Road Over Bridges / Road under Bridges play vital role in the planning and construction of Highways. Box girder type of Bridge is the most advanced type of Bridge superstructure and it provides the best features of aesthetics, comfort & economy over the other types of superstructure for longer spans.

But as per the design trend a lot of simply supported box girders were proposed against the same span compared to that of continuous box girders even though the continuous box girder superstructures are more economical.

In this project the effort was made to compare the analysis (Shear force and Bending moments) of simply supported and continuous box girders and to enable the option of choosing the best type of Highway structure to meet the comfort, safety and economic considerations of the Highways.

Keywords: Bridge, Superstructure, Box Girder.

I. INTRODUCTION
The continuing expansion of highway network throughout the world is largely due to the result of great increase in traffic, population and extensive growth of metropolitan urban areas. This expansion has lead to many changes in the use and development of various kinds of bridges. The bridge type is related to providing maximum efficiency of use of material and construction technique, for particular span, and applications. As Span increases, dead load is an important increasing factor. To reduce the dead load, unnecessary material, which is not utilized to its full capacity, is removed out of section, this results in the shape of box girder or cellular structures, depending upon whether the shear deformations can be neglected or not. Span range is more for box bridge girder as compare to T-beamGirderBridge resulting in comparatively lesser number of piers for the same valley width and hence results in economy.

A box girder is formed when two web plates are joined by a common flange at both the top and the bottom. The closed cell which is formed has a much greater torsional stiffness and strength than an open section and it is this feature which is the usual reason for choosing a box girder configuration.

Box girders are rarely used in buildings (box columns are sometimes used but these are axially loaded rather than in bending). They may be used in special circumstances, such as when loads are carried eccentrically to the beam axis.

“When tension flanges of longitudinal girders are connected together, the resulting structure is called a box girder bridge”.

Box girders can be universally applied from the point of view of load carrying, to their indifference as to whether the bending moments are positive or negative and to their torsional stiffness; from the point of view of economy.
1.1 Historical development and description of box girder:

The first box girder cross section possessed deck slabs that cantilevered out only slightly from the box portion shown in figs a to e. With the prestressed concrete the length of cantilever could be increased. The high form work costs caused a reduction in the number of cells fig 1.1 (f, g, h). In order to reduce the construction loads to minimum possible extent or to require only one longitudinal girder in working states even with multiple traffic lanes.

It was only with the development of high strength prestressing steel that it became possible to span longer distances. The first prestressed concrete bridges, most of I-cross sections were built towards the end of the 1920’s. The great breakthrough was achieved only after 1945. “THE SCLAYN” bridge over the river Maas, which was built by Magnel in 1948, was the first continuous prestressed concrete box-girder bridge with 2 spans of 62.70m. In following years the ratio of wages to material costs climbed sharply. This thereby shifted the emphasis of development of construction method. The box girder cross-section evolved structurally from the hollow cell-deck bridge or T-beam Bridge. The widening of the compression zone that began as a structural requirement at the central piers was extended throughout the entire length of bridge because of advantages transverse load-carrying characteristics.

![Fig.1: Different types of Bridge Superstructures](image)

II. THEORITICAL ANALYSIS

2.1 Loads:

The various loads & combinations (with conformance to RC 6: 2000) are considered in the analysis of simply supported and continuous box girders are as under.

2.1.1 Dead loads:

Dead load of the structure is estimated based on unit weight of 24.525 KN/ m³ for pre stressed concrete. The appropriate loads based on the cross sectional areas shall be estimated.

2.1.2 Super imposed dead load:

2.1.2.1 Wearing coat:

Wearing coat shall be 65 mm-thick comprising 25mm-mastic asphalt layer overlaid by 40mm bituminous concrete. Load intensity works out as follows.

Density of Asphalt = 22 kN/m³

Intensity of asphalt layer = 0.065 x 22 = 1.43 kN/m²

2.1.2.2 Crash barrier & parapet:

Crash barriers shall be provided on the bridge as per details given in IRC: 5. The crash barrier will be designed as per Table 3 of IRC: 6 – 2000 under P-1 category.

The cross sectional area of the crash barrier works out to be 0.335m².

Weight of crash barrier = 0.335x 24 = 7.5 kN/m

2.1.3 Live loads

- One lane of 70 R Wheeled vehicle or One lane of 70 R W+ Class A or 3 lanes of Class A is taken for the analysis and governing of all these is considered in the design.

- Impact factor shall be considered for the longitudinal design of superstructure as per clause 211.2 of IRC: 6-2000.

- Reduction in longitudinal effect on the bridge is considered as per clause 208 of IRC6 – 2000.

- For continuous box girder superstructure for 70 R W case the tail to nose distance of successive vehicles is taken as 30 m and in the case of class A it is 18.4 m as per IRC: 6 : 2000

III. NUMERICAL ANALYSIS - STRUCTURAL ANALYSIS

- The superstructure is analyzed by Grillage analysis using STAAD-Pro 2008 software by forming grillage members along the centre of the girder.

- For the analysis of Box girder the cross section of the Box girder is assumed as a node and the length of the superstructure is divided into number of nodes which are joined together to form number of members. Here the entire box girder is idealized as a single line model and the properties of the box girder at various cross sections are assigned to the respective members.

- The analysis is carried out for the above mentioned load combinations comprising of
Dead Load (DL), Super Imposed Dead Load (SIDL), Live Load viz. 70 R Wheeled ecc, 70 R Wheeled + Class A and 3 lanes of Class A loading.

- From the analysis bending moment and shear force at critical locations for different load combinations are computed.

IV. RESULTS & DISCUSSION

4.1 Results:
The typical Bending Moment & Shear Force diagrams for Simply Supported and Continuous Box Girders are presented below:

![Fig.2: Typical Bending Moment Diagram of Simply Supported Box girder](image1)

![Fig.3: Typical Shear Force Diagram of Simply Supported Box girder](image2)

![Fig.4: Typical Bending Moment Diagram of Continuous Box girder](image3)

![Fig.5: Typical Shear Force Diagram of Continuous Box girder](image4)

4.2 Discussion:
From the above results the following observations can be made:

1. The % variation of max sagging BM of simply supported and 3 span continuous box girders for the span 40m is 32.3 %
2. The % variation of max sagging BM of simply supported and 3 span continuous box girders for the span 45m is 33.1 %
3. The % variation of max sagging BM of simply supported and 3 span continuous box girders for the span 50m is 33.6 %
4. The % variation of max SF of simply supported and 3 span continuous box girders for the span 40m is -19.5 %
5. The % variation of max SF of simply supported and 3 span continuous box girders for the span 45m is -21.9 %
6. The % variation of max SF of simply supported and 3 span continuous box girders for the span 50m is -23.9 %
7. The % variation of max sagging BM of simply supported and max hogging BM of 3 span continuous box girders for the span 40m is 16.3 %
8. The % variation of max sagging BM of simply supported and max hogging BM of 3 span continuous box girders for the span 45m is 16.6 %
9. The % variation of max sagging BM of simply supported and max hogging BM of 3 span continuous box girders for the span 50m is 16.7 %
10. The Mid span Sagging moment in simply supported box girder is always considerably higher than the corresponding maximum sagging moment in the respective continuous box girder span.
11. The Mid span Sagging moment in simply supported box girder is also higher than the corresponding maximum hogging moment in the respective continuous box girder span at support.
12. On the contrary the max shear force in simply supported box girder is considerably lesser than the max shear force of corresponding 3 span continuous box girders.

V. CONCLUSIONS
From the results and discussion the following conclusions can be made:

1. As per the present comparative study in the thesis is limited to the comparative analysis of shear force and bending moments continuous bridges are at an advantage compared to the simply supported box girder bridges because,
i) The % variation of mid span Sagging moment in simply supported box girder & corresponding maximum sagging moment in the respective continuous box girder span for the spans 40, 45 & 50 m are 32.3 %, 33.1% & 33.6% respectively.

ii) The % variation of mid span Sagging moment in simply supported box girder & corresponding maximum Hogging moment in the respective continuous box girder span for the spans 40, 45 & 50 m are 16.3 %, 16.6 % & 16.7 % respectively.

2. Hence it can be concluded that the effect of continuity not only improves the functionality (riding quality since the expansion gaps will be reduced) but also reduces the governing BM which in turn reduces the cost of the superstructure.

3. The depth of the superstructure can be varied because of the large difference in the sagging and hogging moments in the case of continuous box girders (Sagging at mid span and hogging at pier locations) the cost of superstructure can be further reduced.

4. Based on the above it can be finally concluded that the continuous box girders are superior to the simply supported box girders wrt. the structural performance, riding quality and cost of the overall bridge (Super structure and substructure)

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