IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

OPTIMIZING BOX GIRDER DESIGN ACROSS THE VARIABLE SPANS THROUGH SOFTWARE ANALYSIS

Dipika A. Khirade[1], Prof. S .S Zambani[2], Prof. A. S. Gadewar[3]

[1]PG Student, Department of Civil Engineering BNCOE Pusad, Maharastra, India
[2]Associate Professor, Department of Civil Engineering, BNCOE Pusad, Maharastra, India
[3]Assistant Professor, Department of Civil Engineering, BNCOE Pusad, Maharastra, India

ABSTRACT

In the realm of structural engineering, the analysis and design of box girder superstructures for both highway and railway bridges stand as a global endeavour. Various countries, responding to the unique challenges posed by their natural surroundings, have formulated their own sets of codes, accounting for factors such as seismic activity, extreme weather conditions, topography, and vehicular diversity. In the context of India, bridge engineers turn to the standards outlined by the Indian Road Congress (IRC), specifically IRC: 112-2011, as their guiding light.

This study delves into the realm of box girders, focusing on two distinct cross-sectional configurations. The contemporary landscape of bridge construction has magnified the significance of these box girder bridges, especially within modern highway systems and urban interchanges. Their appeal lies in their structural efficiency, serviceability, stability, aesthetic appeal, and cost-effectiveness. Box girders achieve the remarkable feat of minimizing weight while optimizing flexural strength, making them an exemplary choice for bridge construction.

Keywords: Prestressed Concrete, Box Girder, IRC Loading, Superstructure

I.INTRODUCTION

Bridges stand as architectural marvels, spanning gaps to facilitate the passage of railways, roadways, footpaths, and even fluid conveyance. The selection of a bridge site is a delicate task, driven by the pursuit of maximum commercial and societal benefits, efficiency, effectiveness, and equality. Within the world of bridge engineering, the box girder takes centre stage—a structural marvel comprising two web plates interconnected by a common flange at both top and bottom.

Box girders, versatile in form and function, find classification based on construction method, purpose, and shape. Three commonly encountered configurations are single-cell, multiple-cell, and multi cell box girders. These hollow, channel-shaped beams are crafted from materials such as pre-stressed concrete, structural steel, or reinforced concrete, depending on the specific requirements of the project. Shapes may vary, with box girders taking on rectangular, trapezoidal, or circular forms, particularly suited for spans ranging from 20 to 40 meters.

Bridge construction, an integral facet of communication infrastructure, stands as a testament to the craftsmanship of civil engineers. Girders, the robust beams that support the bridge deck, play a pivotal role in this endeavor. For the majority of bridges, the box girder, with its distinctive hollow construction, boasting two or more side webs and two flanges, represents an optimal choice, combining structural integrity with efficient material usage. Thus, bridges, in their diverse forms and materials, epitomize human ingenuity and engineering process.

II. LITRATURE REVIEW

Khaled M. [1] Based on the published literature on the elastic analysis of straight and curved box-girder bridges, the following comments, pertaining to box-girder bridges, are made.

- The finite-element method is presumably the most used and time consuming, among there fined methods. Whereas for static and dynamic analysis it is still the most involves and comprehensive technique, capturing all aspects affecting the structural response. The other methods are identified to be sufficient but limited in scope and applicability.
- The cumulative analysis of bridge structures through the construction, service, and ultimate phases time-dependent analysis software's survey would be beneficial for designers. This would also apply to the design of new bridges and rating of existing bridges, especially when the software can be converted from analysis to design-oriented programs.
- The effects of various used support conditions unrestrained and restrained with respect to temperature effects can be represented only by the 3D finite-element method. These factors need further experimentation, because they affect the flexibility of the bridge structure and, then, its static and dynamic responses.

ZHANG[2017] In this paper a non-linear finite-element method has been adopted to track the PC box bridge girder under the exposure of fire conditions. It has been found that the degree of prestressing has a considerable impact on fire resistance of PC box girder bridge. Prestressed concrete box bridge girders exposed to fire with higher degree of prestressing have lower ductility than that with less prestress degree. It has been seen that temperature variation along the girder depth is almost same and mean temperature increases significantly with fire exposure time. When the time of the girder exposed to fire is120 min, the temperature in bottom slab and web surpasses 450℃ and prestressing strands is also in high temperature, and this can lead to deterioration of mechanical properties in prestressing strands., during first 10 min of fire exposure, mid-span deflection increased linearly, this is mainly due to significant thermal gradients that lead to high thermal stress and curvature along the girder section. The developed curvature at this stage of fire exposure is independent of structural loading on the girder due to the fact that this curvature results mostly from the coupled effect of thermal gradient.

AHMED [2017] In this paper the value of the acceleration coefficient, base shear, velocity and displacement have been determined at the joints of the bridge structure. The results were shown in the form of a comparative diagram. According to the results below mentioned inference could be made.

- The values, displacement, acceleration, velocity and base shear with respect to the time in the y-direction the value of the acceleration, is lesser than the displacement, velocity and base shear with respect to the time in the x-direction. Acceleration response of the bridge deck dependence on the characteristics of the bridge and applied ground motion.
- Results show that the seismic response of the super structure good agreements with recorded ground motion data in the term of the acceleration, baseshear, velocity and displacement in both directions.
- It also the indication that the baseshear has played an important role in the seismic response of the bridge deck. It provides resistance to lateral load.

RAZAQPUR AG [2017] The nonlinear finite element method is used to analyze the scaled models of single-cell and two-cell box girder bridges tested to destruction at McGill University. Extensive comparison between the analytical and experimentally measured values for deflections, concrete and steel stresses, and ultimate strength are presented. Based on the favorable agreement between the two sets of results, it is concluded that (1)then on linear finite element method is capable of predicting the full response of single- and two-cell prestressed concrete box girder bridges over the complete loading range, and (2) the flexural strength of the bridge models can be predicted with reasonable accuracy using the conventional rectangular stress block and strain compatibility procedure; this method cannot, however, predict the full response of the structure.

E. SAUMYA [2017] This study focused on the parametric variations such as radius of curvature of the deck, span lengths, and span/depth ratio. Girder was subjected to IRC class A loading and the responses of the structure were obtained using the response spectrum analysis. The study was conducted on the software of ANSYS. The frequency of vibration, bending moment and reactions and the deflection in the longitudinal direction is obtained. The following results are obtained for response spectrum analysis. The results which were attained were analyzed. Those were the longitudinal deflection, the bending moments, shape of the girder, stresses maxima, and their suitability was evaluated and compared in this study as mentioned.
The trapezoidal shape was considered most efficient from the deflection and maximum bending moment, stresses point of view

III. METHODOLOGY

3.1 General

Significant improvements have been seen in the field of structural engineering from the past decades. From the design point of view, drastic improvements have been made which can help to reduce the cost of the structure without compromising with the serviceability limits, in fact, it has been enhanced proportionally. Developing countries like India have been spending a lot to improve the infrastructure of the country, and reduction in the expenses by providing a safe and economical design helps in the reduction of fiscal burden. Improvements in the field of structural design, construction techniques, materials help in this feat. Bridge engineering being an important part of structural engineering, in this chapter, various design parameters have been mentioned which are taken in the analysis of the deck of the bridge, and different loading conditions are mentioned to which the bridge is subjected.

There are a lot of parameters that control the design of a bridge structure, such as the span-to-depth ratio of the bridge, span length, cross-section, prestressing cables, material properties, location, etc.

The major components that affect the cost of the bridge were selected on the basis of a parametric study performed on all variables. The major variables were selected for their effect on cost and performance of reinforced concrete box girder bridges for a parametric study.

This thesis considers the important aspects related to cost optimization of box girder bridge structure. In here, a box girder of different spans such as 30m, 40m, and 50m is considered. In general, a box girder which has a span of more than 50m, prestressing is used. Box girder can be inconsiderably used for various types of loading, any type of bending moment whether positive or negative, and it has high stiffness in terms of torsion and provides a very economic structure. It has been concluded from the previous studies that the most economical structure is in which the cost of the foundations and the substructure are equivalent to the cost of the superstructure that has been provided.

In this study, dead load and the live load effects have been taken into consideration according to the latest IRC6:2016 recommendation.

- Distribution of the shear stress and the bending moments have been analyzed with the help of CAD software.
- Design and analyses of the box girder.
- The quantity of concrete in every section is to be estimated such as deck slab, web, soffit, and diaphragms, as well as quantities of the steel reinforcement.
- A spreadsheet is then prepared which calculates performance in terms of deflection. This sheet was then used to perform a parametric study by varying each parameter and calculating the performance indices and cost of the bridge superstructure.

3.2 Span Length

The span length is termed as the distance between the two consecutive supports of the bridge structure. The bridge is generally categorized based on span length. Span Length is one of the most important and deciding criteria for the selection of the bridge design. Spans are sometimes preferred because they have the tendency to reduce the disruption in the flow of the traffic as the number of piers reduces. Different spans length uses a different type of selection of the bridge and the type of construction methodology.

- For the bridges with smaller spans (less than 60 feet), concrete with timber reinforcement, or prestressed concrete or steel girder bridges are generally used.
- For the medium span bridges (span length more than 60 feet but less than 120 feet), steel or prestressed bridges are used.

- For the bridges with larger spans (span length more than 120 feet and less than 300 feet), Higher performance steel, composite girders, and steel trusses can be used.
- Very large span bridges (greater than 300 feet and less than 600 feet), segment bridges, extra dosed bridges, and cable-stayed bridges could be used.

The span length is a governing factor for the expenses to be attained in the construction of the bridge; therefore, in the designing process, various spans are considered, and the feasible outcome is often selected. The various factors that affect the span length are the site conditions, navigation, pier height, geotechnical conditions, and economy. The other important factor nowadays is the aesthetic requirements. The bridges with long spans provide good visual appearances and reduce obstacles. The box girder bridge is economical for the bridges with span length between 30 meters to 50 meters; above that, balanced cantilever or trusses are often used.

From past studies, it has been established that the economic structure comes out to be in which the expenses involved in the superstructure are equal to the cost of the substructure. The design and the functioning of a structure mainly depend upon the site locations, topography, and the substructure.

As the span length of the bridges increases, the number of intermediate piers decreases, and therefore the cost per unit length reduces. Although the span length of a bridge structure depends on other factors such as the foundation depth, soffit level from the ground. Therefore, the cost of the superstructure is variable depending upon such factors. Box girder bridges are widely used for medium span bridges because of the ease of construction and economy. Therefore, in this study different spans are taken into consideration such as 30m, 40m, and 50m to evaluate the structural behaviour and optimization of the cost.

With the increase in span length, the dead load also increases, therefore it is needed to reduce the dead load of the structure. To do so, the excess material which is redundant should be removed, when it is done a box girder or hollow section is formed.

The span length of a bridge is also dependent on other factors such as the launching cost and the expenses incurred on the erection of the superstructure. Therefore, the site conditions and the topography are also to be kept in mind based upon the complications which can occur in the launching process. It is, however, possible that the higher span can reduce the cost of the structure but with a larger span, the erection can be tough resulting in higher erection cost. So, it is evident that the span length is selected by considering all the factors and then choosing an optimum result.

Here in this study, different span lengths are taken into consideration which are used in practical purposes and they are mentioned here below.

- Span of 30m - Span of 40m - Span of 50m

3.3 Span to Depth Ratio

The designing of a box girder is a very complicated design, and there are various parameters that affect the design process, of which span-to-depth ratio is one of the most important parameters. Span depth ratio, which is termed as the slenderness ratio, is one of the important and deciding parameters of the behavior of the bridge. This ratio is used to calculate the required depth of the superstructure and plays a crucial part. It is selected during the preliminary or conceptual designing process. Span-to-depth ratio is generally selected from the previous experiences or the values used in the bridges constructed in the past. Therefore, there has been a case of the possibility of the erroneous part, and hence this study is being conducted to provide a more efficient solution.

It has been observed from previous studies that the ratios of span to depth have not changed for many decades. The recent developments in terms of material and the introduction of high-strength concrete have allowed for better structural behaviour even with more Slender components.

The optimization of span-to-depth can be done by selecting some values and making suitable combinations and plotting them against the different spans by the process of an iteration. By this process, it is beneficial as it can provide a cost-efficient solution. The other benefit that can be obtained is good aesthetics, as it is always preferred to select a slender component as possible. The selection of an optimum span-depth ratio is always a critical and important part as it can help to save a lot of expenses involved in the project because the quantity of materials that are to be mobilized and the cost of construction of the superstructure are directly affected by the span-depth ratio. For instance, if a higher span-to-depth ratio is used, it will require a high amount of pre-stressing, the superstructure would be light, and as the cost of the bridges is generally determined by the proportion of the superstructure, in this case, with lesser volume, the cost would come out to be lesser.

Based on the structure in terms of deflection, different span-to-depth ratios are considered in this study for spans of 30m, 40m, and 50m, and the material consumption in terms of concrete and steel is evaluated. Results demonstrate the total cost of material for specific span and span-depth ratio cases and are formulated in the form of a graph. The permissible deflection and the deflection obtained are evaluated, and the percentage variation is observed.

3.4 Number of Cells

The box girder can be categorized into single cell or multi-cell depending on the arrangement between the web connection between the top and the bottom slabs. Generally, in case if the depth is more than one-sixth to one-fifth of the width of the deck, then the single-cell girder is considered, whereas if the depth is less than one-sixth to one-fifth of the width of the deck, then the multi-cell or twin-cell box girder is preferred.

- Single-cell box girder segment is a type of bridge segment in which the number of cells is only two.
- In double or multi-cell box girders, the no. of webs is more than two, where the thickness of the inner and outer web can vary.
- The type of segment depends on several structural aspects such as economy, structural stability, stiffness, and the cost of construction.

3.4 Loading

Loading on Box Girder Bridge :

The various types of loads, forces, and stresses to be considered in the analysis and design of the various components of the bridge are given in IRC 6:2000 (Section II). But the common forces are considered to design the model are as follows:

3.4.1 Dead Load (DL): The dead load carried by the girder or the member consists of its own weight and the portions of the weight of the superstructure and any fixed loads supported by the member. The dead load can be estimated fairly accurately during design and can be controlled during construction and service.

The dead weight of the structure is the total weight of the components in a bridge. It includes the weight of the superstructure plus the weight of the substructure components. The dead load of a structure can be calculated to the precise and accurate level and it plays an important role in the design of the structure and selection of the bridge type as it can be controlled in the process of construction. The dead load can be calculated by the material properties enabled in a structure.

3.4.2 Superimposed Dead Load (SIDL): The weight of superimposed dead load includes footpaths, earth-fills, wearing course, stay-in-place forms, ballast, waterproofing, signs, architectural ornamentation, pipes, conduits, cables, and any other immovable appurtenances installed on the structure.

3.4.3 IRC Standard Live Loads

In a structure, Live loads are the vehicular loads that travel on the bridge and are moving loads. A designer doesn’t have much control over them and are very dynamic in nature. These loads are very hard to estimate accurately. Live loads are those caused by vehicles which pass over the bridge and are transient in nature. There have been efforts to estimate and consider the live loads reasonably so that they can give a true picture of the behaviour of the structure that is occurring over them.

In the designing of the bridges, the live loads which are considered shall consist of vehicles which are wheeled or tracked and are classified in the clause of 201.1 of IRC 6:2016 and the other special vehicle loading for other purposes such as military or transient purposes is as per the clause 204.5 if needed. It is to be noted that the trailers which are attached are not detachable.

Live loads are those caused by vehicles which pass over the bridge and are transient in nature. These loads cannot be estimated precisely, and the designer has very little control over them once the bridge is opened to traffic. However, hypothetical loadings which are reasonably realistic need to be evolved and specified to serve as design criteria. There are four types of standard loadings for which road bridges are designed.

i. IRC Class 70R loading ii. IRC Class AA loading iii.IRC Class A loading iv. IRC Class B loading

There are four types of standard loadings for which road bridges are designed.

a) IRC class AA Loading: This loading consists of either a tracked vehicle of 700kN or a wheeled vehicle of 400kN with dimensions of 3.05m by 5.5m. It has a live load intensity of $24kN/m^2$. The live load is applied to the entire area.

b) IRC class A Loading: This loading consists of either a tracked vehicle of 310kN or a wheeled vehicle of 180kN with dimensions of 2.7m by 4.9m. It has a live load intensity of $20kN/m^2$. The live load is applied to the entire area.

c) IRC class B Loading: This loading consists of either a tracked vehicle of 175kN or a wheeled vehicle of 100kN with dimensions of 2.3m by 4.2m. It has a live load intensity of $17kN/m^2$. The live load is applied to the entire area.

d) IRC class 70R Loading: This loading consists of either a tracked vehicle of 70kN or a wheeled vehicle of 40kN with dimensions of 2m by 3.2m. It has a live load intensity of $12kN/m^2$. The live load is applied to the entire area.

3.5 Geometry of the box Girder

In this study the variables are span and the depth of the single cell and double cell box girder bridge. Thevariablesdepthaspertheselectedspantodepthratiohasbeencalculated and the modelling has been done accordingly. The different depths of the box girder pertaining to particular span length is mentioned in the table below. The other cross-sectional properties such as the thickness and the spacing between the outer webs is 5.6 meters. The other portion is cantilever part and the length of the cantilever is 3.25 meters on each side. The cantilever portion has foot path over it which is of 1.5 meters on each side. The thickness ofouterwebis200mm.

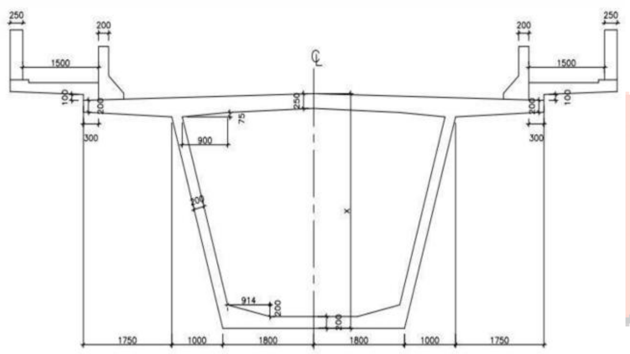

Fig.1.1 : Cross Section of single Cell box girder

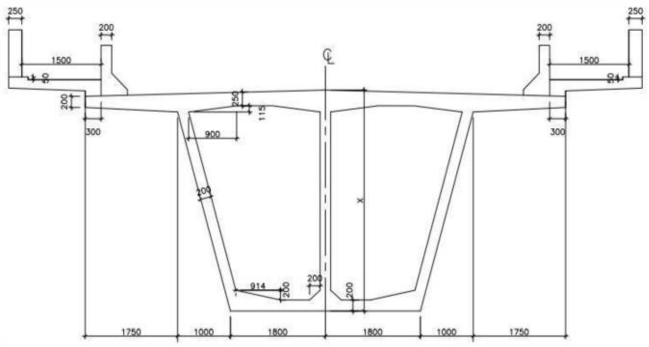

Fig.3.9: Cross section of multi cell box girder

Table 3.2: The Depth pertaining to each case of span length and the span/depth

Span (m)	Span to depth ratio	Depth 'x' (m)
30	15	2.00
	20	1.50
	25	1.20
40	15	2.67
	20	2.00
	25	1.60
50	15	3.33
	20	2.50
	25	2.00

3.4 Material and Section Properties

From the section selected for the study, sectional properties for each varying span and span depth ratio and for the number of cells are calculated. The calculations for the same has been shown in the appendix ii. The properties which are calculated are the area and the moment of inertia of the section. These properties are very vital for the calculation of the deflection and the maximum bending moment and the maximum shear force induces into the section. The moment of inertia plays an important role as it is the property of the material to resist the deformations due to the loads applied.

The material properties are also inputted to files during analyses and these are the grade of the concrete and the steel. The grade of concrete used is M40 and the grade of the steel is Fe 415 HYSD.

3.5 Design Analysis

The software used for dissertation work is STAAD pro. All the analysis of bridge superstructure is done using this software by taking account of effect of earlier mentioned vehicle on bridge superstructure by generating influence surface. Structural behavior in terms of deflection in both the directions that is longitudinal as well as transverse is obtained using this procedure.

The sectional properties have been calculated manually using excel spreadsheet, and are inputted in the staad to calculate the required factors. From the STAAD analysis the bending moments and the shear forces which are occurring in the transverse and the longitudinal direction are observed and taken into the account.

After STAAD analysis, the designing of box girder bridge deck is carried out manually and the excel spreadsheet is prepared for the purpose.

A spreadsheet for the design of 50m span box girder bridge deck is attached in the appendix. In the design, required area of the steel for each individual span and corresponding span depth ratio is calculated. From the area, requisite quantity of steel is taken out and the cost estimation is performed. The quantity of steel for each individual case is represented in the units of metric tons. Then from the sectional properties of the box girder, volume of concrete to be used is find out from which the cost analysis of concrete is performed. From this cost analysis of the material quantity detailed study is performed and the optimum values are identified for each case of span depth ratio and the number of cells.

Deflection is an important criterion which not only monitors the bridge behavior due to various forces but also plays an important role in the overall cost of the bridge structure. Due to emergence of new construction materials and other construction techniques, deflection of the structure can be controlled to an extent. Now a days there is an urgent need to reduce the costing of the structure than the same bridges constructed in past decades. Therefore, efforts are made to make the box girder as slender as possible. But this possibility is available only up to an extent as the deflection cannot be more than an certain permissible value. In this analysis, for various spans, and span depth ratios, induced deflection due to vehicle loads, super imposed dead loads, foot path live loads have been considered and accordingly the variation in the costs has been evaluated. The concerning factor in the design of RCC box girder bridge is the induced deflection in both longitudinal and the transverse directions.

It is therefore this parameter is selected for the study. In this study deflection due to vehicles loads, SIDL and the dead weight of the superstructure is calculated. The bridge is subjected to three different types of vehicles loads as per IRC 6:2016, and the case in which maximum moments occur is considered further for the analysis. The cases which are considered were IRC class 70 R tracked vehicle class 70R tracked vehicle and IRC class A loading. The maximum moments were reorder in IRC class 70R wheeled loading. Hence the deflection for such case is considered. The total deflection is the sum of the deflection due to vehicle loads, SIDL, and dead load of the box girder. It is then compared with the maximum permissible deflection according to IRC which is mentioned as maximum up to (span length/220). There is also a theoretical expression for the deflection which is:

$$\text{Deflection, } \delta = 5\,W\,L^4 / 384\,EI$$

Where ‘L’ is the span lengths ’W’ is the total load on the structure, ‘E’ is the young’s modulus of elasticity and ‘I’ is the maximum moment of inertial

3.5 Cost Analysis

Cost analysis has been performed of the structural element to analyze the variation in the costs for different selections of span depth ratios and number of cell and to study the trend of the cost vis a vis changes in span length. Cost analysis is conducted after detailed analysis and the design of the box girder of particular parameters.

It is done by calculating the exact quantities of steel and concrete which is required in the structure.

The quantities are calculated from the designs performed. The rates of the quantities are as per Current schedule of rates. The rate specified are Rs 4699 for the concrete of grade M40. The rate of steel is Rs 51,600 Per metric tons of quantity and also the binding cost of steel of Rs 4000 per metric ton is also added as specifies in the book.

IV. RESULTS AND DISCUSSION

4.1 General

In this study, detailed analysis is carried out for different span length of a box girder bridge with respect to selected span to depth ratios. The two-lane carriageway is analyzed the appropriate dimensions were considered. The carriageway width of the box girder is kept to be 7.8metres and the total width of 8.2 meters including the width of the kerb. The bridge deck is analyzed for various type of live loads as per IRC 6:2016. The live loads taken into consideration are IRC Class 70R wheeled load, IRC Class 70R Tracked vehicle, IRC Class A vehicle. The load combinations are then applied as per table 6A of IRC 6:2016. The other loads considered were dead load, superimposed dead loads and footpath live. Then the analysis of the structure was carried out.

The spans to depth ratio of 15,20 and 25 is selected for the spans of 30m,40m and 50m and accordingly the section properties were accounted. The box girder considered were single cell and double cell and the results in terms of deflection were analyzed output in terms of deflection is evaluated in the form of Bar graphs and Curves. After the detailed analyze cost estimate for each observed case is carried out and the cost optimization for the most optimum values in terms of quantity of concrete and steel is done taking the most efficient geometrics of the structure in terms of deflection into consideration.

The results are discussed here below

4.2 Result Analysis

4.2.1variation in Span Length and its Effects

Here the effects of span length in terms of deflection is discussed, also the results are then computed by evaluating the cost of material quantity in box girders. The spans are of 30 meters, 40 meters and 50 meters analyzed for single cell and double cell box girder.

4.2.1.1 Deflection

The observed deflection for the respective span lengths and permissible deflection according to IRC is reported for both single cell and double cell box girder

Table 4.1 : Showing The deflection for different values of span length of single cell boxgirder.

Span (m)	Span to depth ratio	Max. deflection (mm)	Permissible deflection (mm)	% variation of max.deflection w.r.t permissible deflection
30	15	43.3	136	-68
	20	88.8		-35
	25	155.9		15
40	15	67.6	182	-63
	20	129.8		-29
	25	226.3		24
50	15	91.4	227	-60
	20	180.1		-21
	25	305.3		34

Table 4.2 : Showing Deflection for different values of span length for double cell box girder.

span (m)	Span/depth ratio	Max Deflection (in mm)	Permissible Deflection (in mm)	% variation of max. deflection w.r.t permissibledeflection
30	15	41.5	136	-69
	20	86.5		-36
	25	153.5		13
40	15	64.8	182	-64
	20	121.4		-33
	25	222.7		22
50	15	91.9	227	-60
	20	187		-18
	25	293.7		29

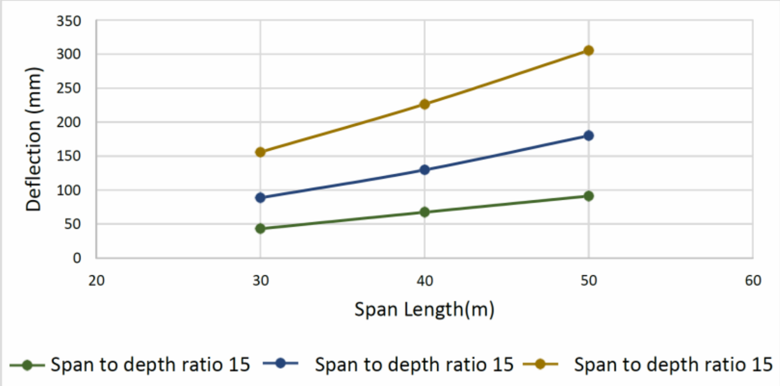

Fig.4.1 : Graph depicting the variation of deflection with respect to span length of single cell Box Girder

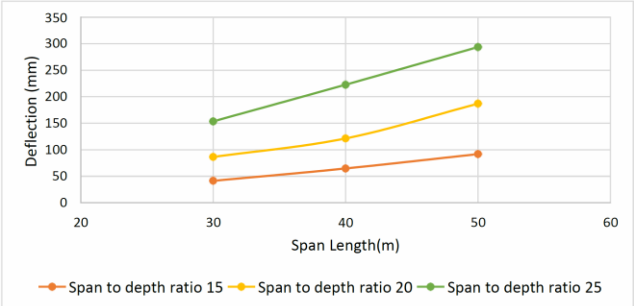

Fig. 4.2 : Graph depicting the variation of deflection with respect to span length of Double cell Box Girder

The deflection indices for different spans have been calculated and are compared with respect to the allowable deflection in each case. It is then represented in the form of graph. From the graphs plotted and the values mentioned, it can be observed that the deflection in each case of span increases with the increase in span to depth ratio. For the span depth ratio of 25, deflection is maximum in all the cases, but it shall be noted that thedeflection in that case is more than the maximum permissible deflection and hence that case is not feasible.

It is observed that the percent variation of the deflection that is the difference of the deflection observed to the maximum permissible deflection decreases with the increase of span depth ratio. i.e., the variation is more when moved to span depth ratio of 15 to 20 thenthe 20 to 25.

The deflection for single cell box girder is more than the deflection in double cell box girderwhile keeping all the other parameters constant.

V. CONCLUSION

In the comprehensive analysis of single and multi-cell box girder bridges subjected to IRC Class AA loading conditions, several important findings and observations were made:

1. Bending Moment: The analysis revealed that single-cell box girder bridges experienced the highest bending moments compared to their multi-cell counterparts. This indicates that single-cell designs are subjected to greater structural forces under the specified loading conditions.
2. Span-to-Depth Ratios: Various span-to-depth ratios were examined in the study of beam bridges. In all cases, it was reassuring to note that deflection and stresses remained well within permissible limits. This compliance with established standards underscores the structural integrity of the bridge designs.
3. Deflection: The research demonstrated that deflections resulting from different loading conditions and during service were consistently within permissible limits as per IRC guidelines. Notably, the maximum vertical deflection occurred near the mid-span location of the bridge, aligning with anticipated structural behaviour.
4. Load Types: Results indicated that bending moments and stress levels were similar for self-weight and superimposed weight scenarios. However, significant differences were observed when considering moving loads. These disparities arise from the specific provisions within IRC codes, which address the effects of dynamic and transient loads in a distinct manner.
5. Literature Review: A concise review of existing literature highlighted a wealth of research on box girder bridges. These studies explored diverse variations in parameters, including shape, span, depth, construction materials, construction methods, cell configurations, curvature, and more. This body of work underscores the continuous evolution and innovation in bridge engineering.
6. L/D Ratio Trials: The study conducted various trials of the span-to-depth ratio (L/D) for box girder bridges. It was consistently found that deflection and stress criteria were well within permissible limits. Interestingly, as the depth of the girder increased, the prestressing force decreased, and the number of cables required decreased as well. This observation underscores the effectiveness of prestressing in optimizing concrete strength and ensuring serviceability while keeping construction costs manageable.

In this conclusion, the analysis provides valuable insights into the performance of single and multi-cell box girder bridges under IRC Class AA loading conditions. The findings can inform future bridge design decisions and contribute to the continued development of safe, efficient, and cost-effective bridge structures.

Load (self-weight) for simply supported span and the continuous span were analyzed on the box girder. The bending moment and the longitudinal bending stress in the bottom and top flange have been carried out along the span for different cross-sections' following conclusions can been drawn from the based study.

i. The Bending moment also increases with the increase in the depth of box girder
ii. The longitudinal bending stress in bottom flange and top flange along the span decreases with the increase in depth of box girder.
iii. Of the rectangular and trapezoidal cross section of box girders for different depths, the trapezoidal girder has the highest bending moment under the load combination of live load and dead load, live load placed (centrally) and minimum in rectangular girder. Therefore, it can be drawn that the rectangular box girder section is the stiffest section among these two.

REFERENCES

[1] Khaled M. Sennah, John B. Kennedy, (2002), "Literature Review in Analysis of Box-Girder Bridges", American Society of Civil Engineers, Journal of Bridge Engineering, Volume 7 • Issue 2 • March 2002, Pages: 134 – 143.

[2] Gang Zhang, Venkatesh Kodur, Jincheng Xie, Shuanhai He, Wei Hou, (2017), "

[3] Behavior of prestressed concrete box bridge girders Under hydrocarbon fire condition", ELSVIER Procedia Engineering, Vol. 210, pp 449–455.

[4] Ahmed Abdelraheem Farghaly, (2017), "Seismic analysis of adjacent buildings subjected to double pounding considering soil–structure interaction", Int J Adv Struct Eng. Vol. 9, pp 51–62.

[5] A.G. Razaqpur, M. Lamberti, F. Ascione, (2020), "A nonlinear semi-analytical model for predicting debonding of FRP laminates from RC beams subjected to uniform or concentrated load", ELSVIER, Construction and Building Materials, Volume 233, 10 February 2020,

[6] Saumya E, Biby Aleyas, (2017), "Analytical and Parametric Study of Double Box Girder", International Research Journal of Advanced Engineering and Science, Volume 2, Issue 2, pp 166-169.