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Parametric Study of Box Girder Using IRC 112:2011

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Abstract:
As box girders forms one of the suitable & popular choices over the years for the superstructure of bridges a detailed study is carried out in this paper. Span-to-depth ratio is an important bridge design parameter that affects the structural behaviour, construction cost and aesthetics. In this paper a parametric study is carried out between different span to depth models and for each model bending moments and shear force as per IRC 112:2000 will be extracted and compared. Commercially available software Midas-Civil has been used for modelling and to carry out linear analysis of box girder for balanced cantilever bridges. The linear analysis has been carried out for dead load, live load as per IRC 6:2000, Class 70R loading. The obtained results will form a thumb rule and can provide guidance to the bridge designers.

Keywords — **Box girder, IRC 112:2000, Midas-Civil, Bending moments, Shear force**

I. INTRODUCTION

Standards have to be laid down for guidance of engineer to design the structure so that uniformity is maintained in designing the same. In India, these standards for prestressed concrete bridges are laid down by the Indian Road Congress (IRC), a statutory body formed by the government of India. Earlier prestressed concrete bridges were designed using the code IRC18 which is based on the working stress method. With rapid technology growth and the new development in the material it becomes imperative to adopt a rational design philosophy to meet the changing needs. In limit state approach the material strength is utilized to its maximum value during its lifespan whereas in working stress method the structure during its whole lifespan may experience the stresses which are far below the ultimate state. Hence IRC 18 has been refined and revised to be replaced by IRC112:2011 which is based on semi probabilistic limit state approach.

II. OBEJCTIVE OF THE STUDY

The overall objective of the study is as follows:

1. To carry out the parametric study and longitudinal analysis of the box girder, forming the superstructure of balanced cantilever bridge using conventional method.
2. The member response investigated for this study examines explicitly the effects of moments and shear due to the force effect of dead load, live load, super-imposed dead loads by using both the codes IRC112:2011.
3. To carry out the same study using F.E.M software like Midas-Civil and then, compare with the conventional method and comment.
4. Carry out the span-depth study for different depths of girders.
5. Plot the graphs for various span-depth for box girder sections carried out then, compare and comment.

6. By performing the parametric study finding the ideal depth required at the root section for different span v/s depth values.

III. METHODOLOGY

As the balanced cantilever bridges forms one of the suitable choice for wide range of spans the depth at support & at mid-span becomes crucial for the moment and shear check. In this research each of the four different spans i.e. 60m, 70m,80m, 90m, will be tried for depths of box section ranging from 5m, 6m, 7m, 8m&10m at the support. The depth that will be within the parametric check according to IRC 112:2011 that are tried for different spans will form the thumb rule. The cross section selected for the bridge is pre-cast single celled PSC box girder with depths of the box cross section tried for each span at the support:. The depth of the box cross section considered at the mid-span 2.5m & clear carriageway width 7.5m is kept constant. The bridge is subjected to loads such as dead load, super-imposed dead load, live load & the load combination selected is: One lane of class 70R for every two lanes with one lane of class A or three lanes of class A. The models will be created in the MIDAS-civil software and for each model bending moments and shear force at the support will be extracted. This bending moment and shear values will be checked with the corresponding values which are manually calculated according to IRC 112:2011.

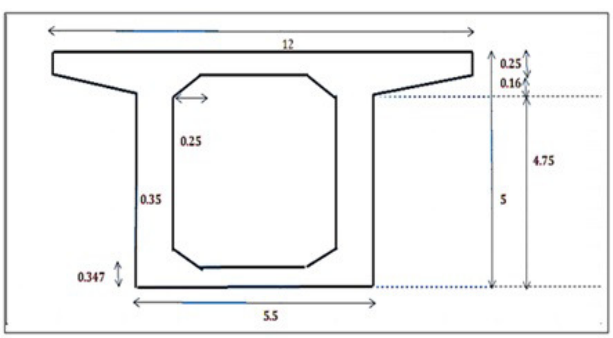

Fig.1Box Cross-Section of- 5m Depth

IV. MODELLING AND MATERIAL PROPERTIES

The step by step elements will be created to form the geometry of the entire span of the bridge in Midas-Civil. The typical prospective view of the bridge is as shown in the **Fig. 2.**

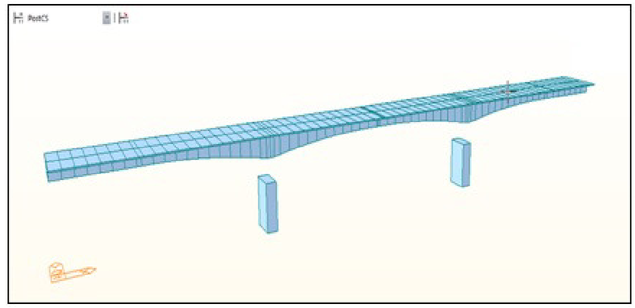

Fig.2Prospective view of the bridge modelled in Midas-Civil

TABLE I
PROPERTIES OF THE MATERIAL

Properties	Value
Grade of Concrete	M50
Modulus of Elasticity	35355 N/mm^2
Poisson's Ratio	0.3
Ultimate tensile strength	1860N/mm^2

A. Moment & Shear values from Midas Civil

Variation of bending moment and shear force in full span for different loading cases is carried out from MIDAS software. The longitudinal analysis of the cantilever span will be carried out for different combination such as dead load, live load, super-imposed dead load and prestressing force. The cantilever span of the bridge will be analysed, where the maximum moment will be at the support that is section that is just above the pier and the minimum moment will be at the mid-span. The ultimate bending moment extracted from the software for the above considered loading is checked against the moment capacity calculated as per the code. The ultimate moment and moment capacity is plotted for span versus depth value

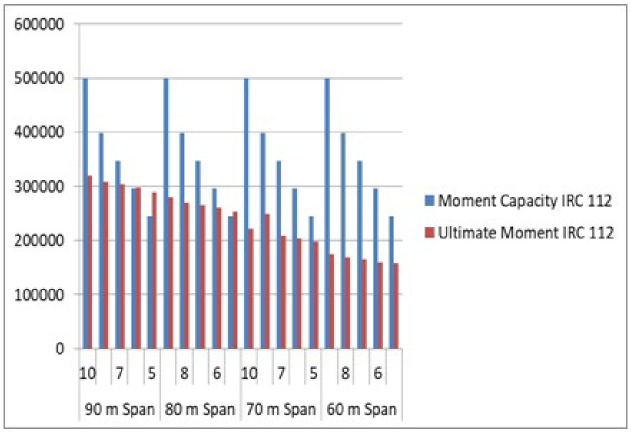

Fig.3Ultimate moment & Moment capacity according to IRC112:2011

Similarly the shear forces for the prestressed concrete span for same loading conditions are calculated and are plotted to find the adequacy of the section.

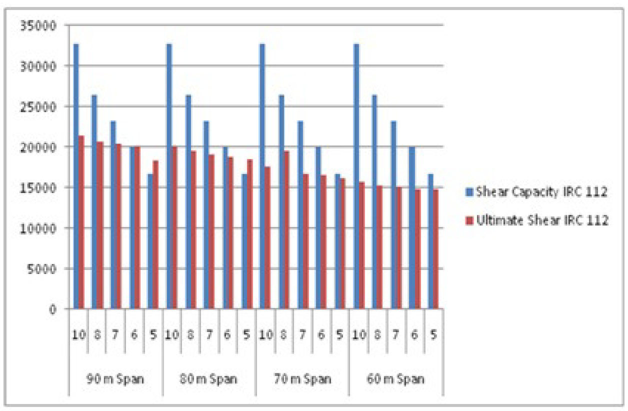

Fig.4Ultimate Shear & Shear capacity according to IRC112:2011

B. Stresses

Stresses due to self-weight of box girder, live load and pre-stressing force is combined to get final stress and these results are finally combined for temporary & service stress stages. The permissible limit at construction and service stage are as follows:

1. Compressive stress at construction stage shall not exceed $0.5f_{ck}$
2. Tensile stress at construction stage shall not exceed $1/10_{th}$ permissible temporary compressive stress
3. Compressive stress at service stage shall not exceed $0.33f_{ck}$
4. Tensile stress at service stage shall not be less than 0.

The stresses for each of the span to depth case is calculated for both temporary and service stage and plotted**.**

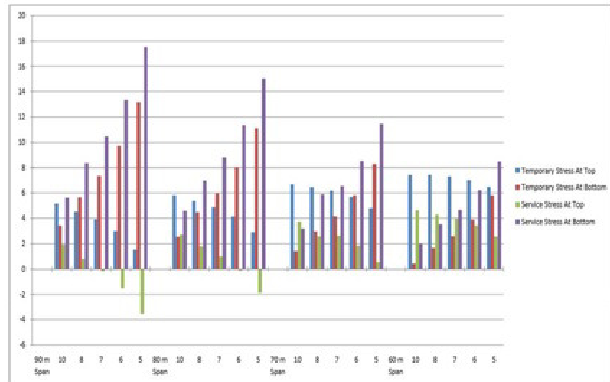

Fig.5Graphical Representation of Stresses v/s Span &Depth

From the stress analysis it is clear that top stresses for smaller depth are less compared to bottom stresses. As the span increases i.e is for span above 70m the depth of the box girder should be increased to bring the stresses within the permissible limit.

V. CONCLUSION

1. From the bending moment and shear force analysis it is clear that upto 80m span the different depth considered the ultimate moment and shear force are within the capacity check according to IRC112. However, for 90m span the depth above 7m have to be adopted.
2. In our analysis all the stresses are well within the permissible limit except for 80m- 5m depth and 90m-5m,6m depth.
3. Thus from the analysis it can be concluded that**:**

TABLE II
THUMB RULE FOR SPAN V/S DEPTH AT SUPPORT

Span	Depth at support
60m, 70m	5m
80m	6m
90m	7m

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