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Parametric Study on Effect of Curvature on Steel-Concrete Composite Bridge

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Abstract— ***One of the most common bridge construction technologies in the current world is steel concrete composite bridges. It has these following advantages over RCC bridges i.e. economic nature, speedy construction and low construction and maintenance cost. Owing to these factors a lot of research is being done by engineers and designers on steel-concrete composite bridges. Therefore we are interested to dive into this research. For the purpose of parametric study one straight steel-concrete composite bridge and 4 curved in plan bridges having different radius of curvatures are modelled in MIDAS Civil software. The span length, number of steel I-girders, cross section and material properties all remain unchanged for parametric study purpose. The only parameter that changes is the radius of curvature of the bridge. The cross-section of the bridge consists of six steel I-girders and a concrete deck. All the models are subjected to self-weight, moving load of vehicles as per IRC 6 and their combinations. The parameters such as deflection, bending moment, shear force and torsion for different loads and load combinations are thus obtained for each positions for all the models. These responses are further used for the parametric study of the behaviour of curved bridge with respect to that of a straight bridge.***

Keywords— ***Composite bridge, MIDAS Civil, curved bridge, bending moment, deflection, torsion.***

I. INTRODUCTION

Due to rapid advancement in construction techniques and the increased maintenance cost of the reinforced concrete bridges there is a need to find an alternative cost effective methods of bridge design and construction which will not only make the bridge economical at the same time will also reduce its maintenance cost and the maintenance period considerably and will also make the bridge construction faster. In recent years due to the above mentioned reasons a lot of research has been done in this field to develop new and more durable bridge design and construction techniques and materials.

Steel is a well-controlled material in terms of production, fabrication, construction and durability. It has long history with regards to its uses in bridge construction. Because of these advantages of steel together as a material, a new and advanced construction technology called *composite construction* has been developed.

By the use of composites we get better advantages such as high strength-to-weight ratio, corrosion resistance, design flexibility, extended service life and low maintenance cost. The main advantage of steel-concrete composite bridge is that it utilizes the tensile strength of steel in the main girders and the compressive strength of concrete in the slab and because of the combination of both these materials the bending resistance of the entire bridge is greatly increased and therefore lager span bridges can be made possible.

Horizontally curved bridges make up a significant portion of the bridge population in our country. Horizontally curved bridges are much in demand due to problems like space constraints in urban areas, sudden change of road alignment, when there is a complex intersection where traffic is coming from all sides, to avoid traffic congestion and to increase the aesthetics of the bridge. However due to the curvature effect, the behaviour of such bridges changes and is more complicated than a straight bridge. Moreover the design and analysis of such bridge is much more difficult than that of a straight bridge, ultimately creating challenges for engineers.

II. PROBLEM DESCRIPTION

In the present work, a straight bridge is considered having constant span length of 40m and width 12 m. Concrete is used as deck material and the girders are made of steel I section.

The design data for the steel concrete composite bridge considered is as follows:

Super dead load calculation is given below:

Anti-crash barrier:
Height of barrier = 1m
Thickness of barrier = 0.5m
Weight density = 24 kN/m³

Wearing coat:
Weight of wearing coat = 20 kN/m³
Thickness of wearing coat = 0.1m
Total area load = 20*0.1= 2kN/m²

Live load data:

- Vehicular live load are applied as per IRC 6
- Class 70R and Class A wheeled vehicles and their combination for three lanes are applied in all models

- In case of curved bridges there will be an additional centrifugal force acting on the vehicle which will tend to push the vehicle away from the centre of the curve.
- As per clause 212.2 of IRC 6 the centrifugal force is given by the equation:
  $C = (W*V^2)/(127*R)$

III. FORMULATION OF MODEL

The straight steel concrete composite bridge and all curved bridge are modelled in MIDAS Civil software. For the above problem all the models are modelled using steel composite girder bridge wizard in which the entire deck is supported on six I girders, slab is spanning one way for 2 meters between the girders and cantilevered on two sides. For parametric study 4 curved in plan bridges modelled having different radius of curvature (100m, 200m, 300m and 400m). The loading, material properties, sectional properties and analysis method will be same for all the models. The load due to deck of the slab is considered as element load for main longitudinal beams. One way distribution is considered along the length of the girders. Vehicular live loads are applied as per IRC 6. Class A and class 70R vehicles and their combinations as per IRC 6 are considered. These vehicles are positioned in the transverse direction for worst loading conditions. These are then moved along the span using moving load concept. The parameters like deflection due to dead load, deflection due to live load, shear force and bending moments due to dead load, live loads and SLS combinations and torsion in straight bridge will be compared to that of the curved bridge models. The cross-section of the model is shown in Fig.1.

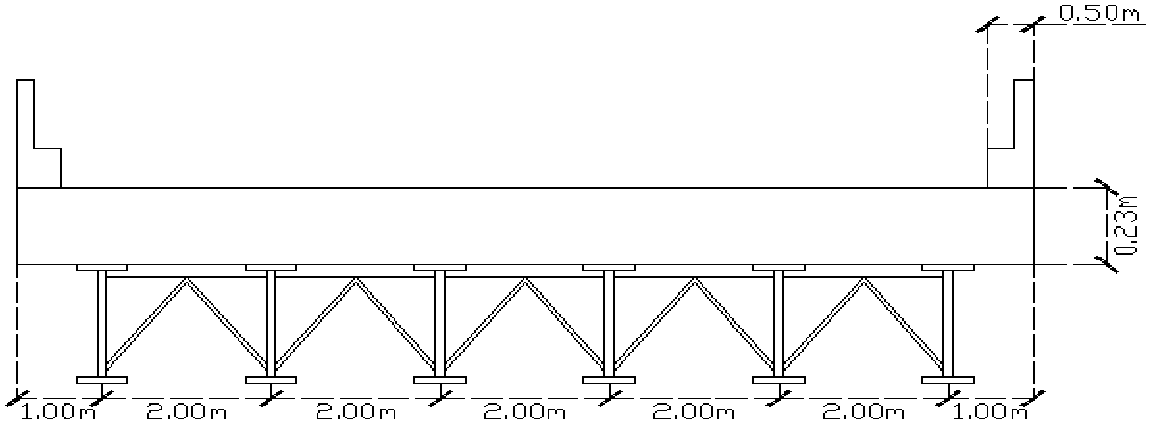

Fig.1 Cross-section of the steel-concrete composite bridge

The girder cross-section for the bridge model is shown in Fig.2.

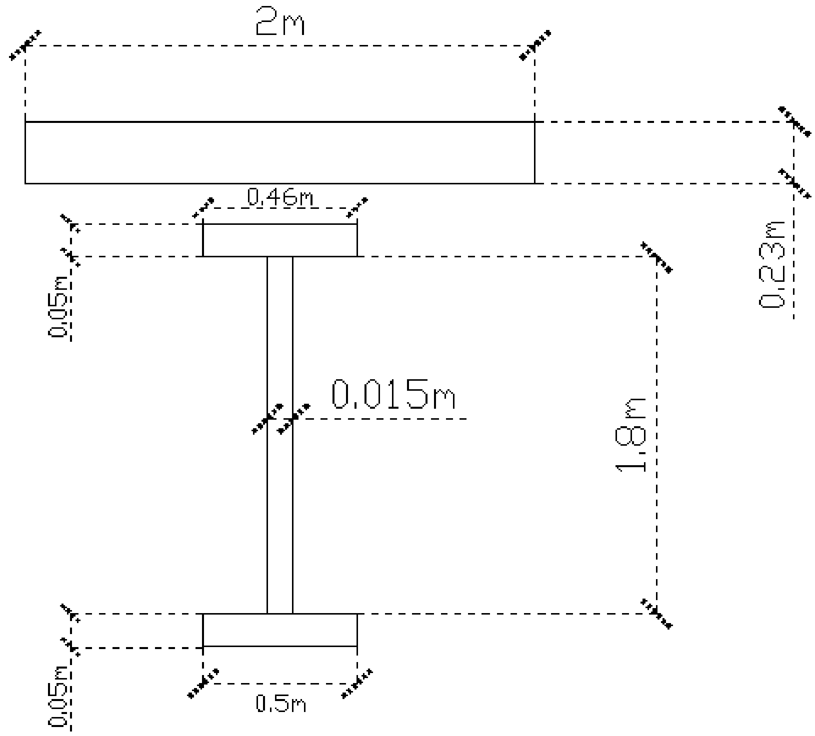

Fig.2 Girder Section

IV. RESULTS

The deflection of the girder due to self-weight and moving load Class A- 3 lanes is shown in Fig.3.

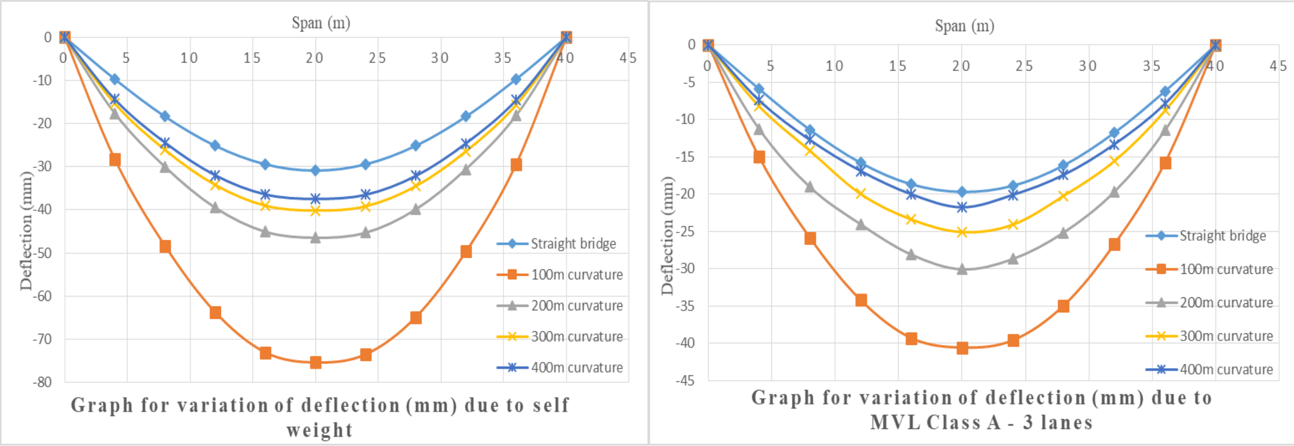

Fig.3 Deflection of the girder due to self-weight and moving load Class A- 3 lanes

The deflection of the girder due to moving load Class A + Class 70R and SLS combination is shown in Fig.4.

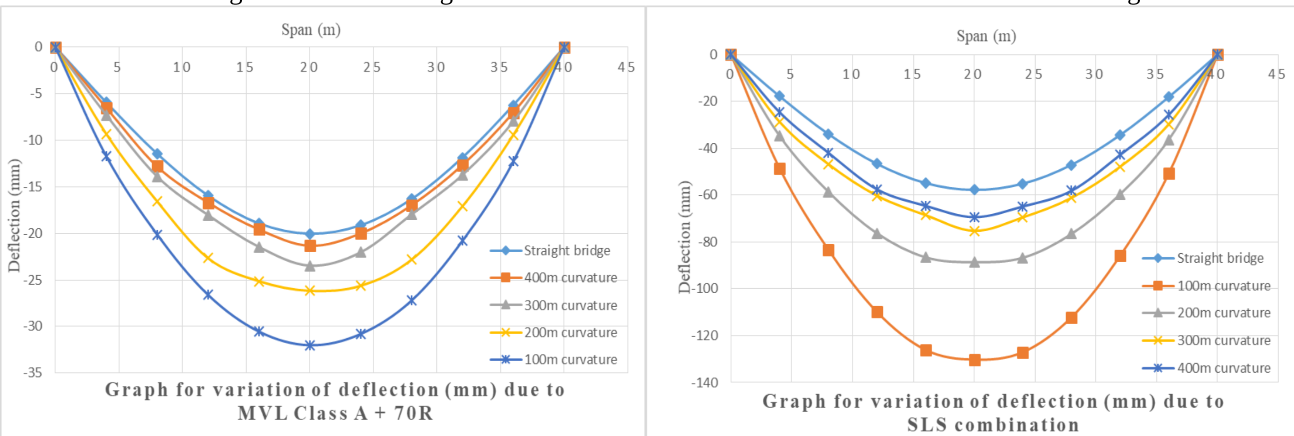

Fig.4 Deflection of the girder due to moving load Class A + Class 70R and SLS combination

The shear force of the girder due to self-weight and moving load Class A- 3 lanes is shown in Fig.5.

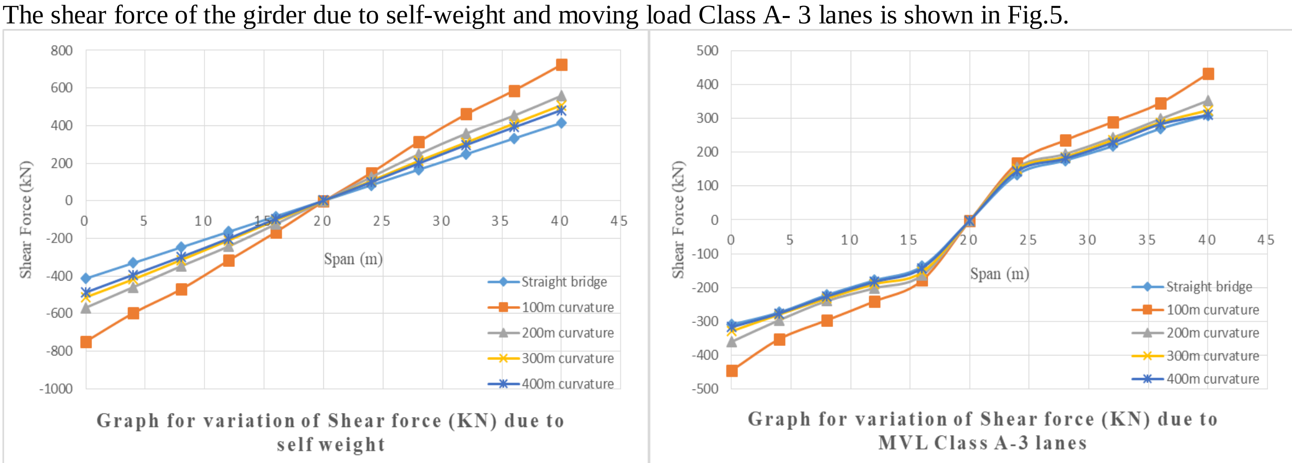

Fig.5 Shear force of the girder due to self-weight and moving load Class A- 3 lanes

The shear force of the girder due to moving load Class A + Class 70R and SLS combination is shown in Fig.6.

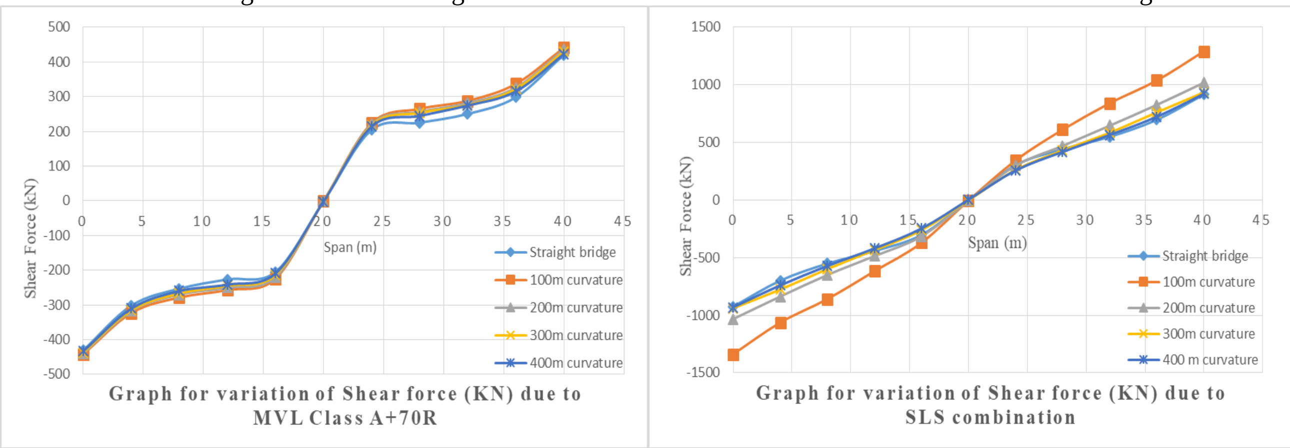

Fig.6 Shear force of the girder due to moving load Class A + Class 70R and SLS combination

The bending moment of the girder due to self-weight and moving load Class A- 3 lanes is shown in Fig.7

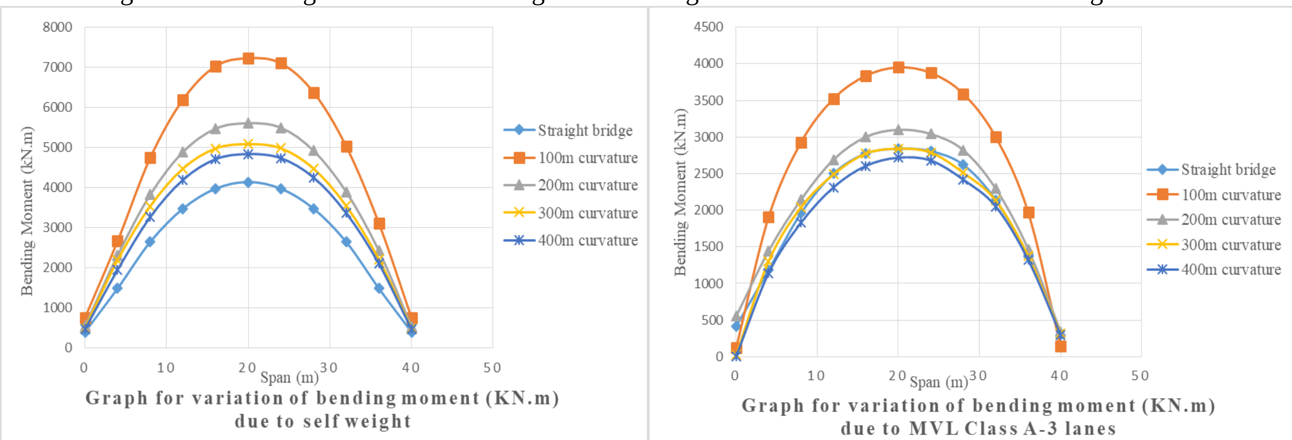

Fig.7 Bending moment of the girder due to self-weight and moving load Class A- 3 lanes

The bending moment of the girder due to moving load Class A + Class 70R and SLS combination is shown in Fig.8.

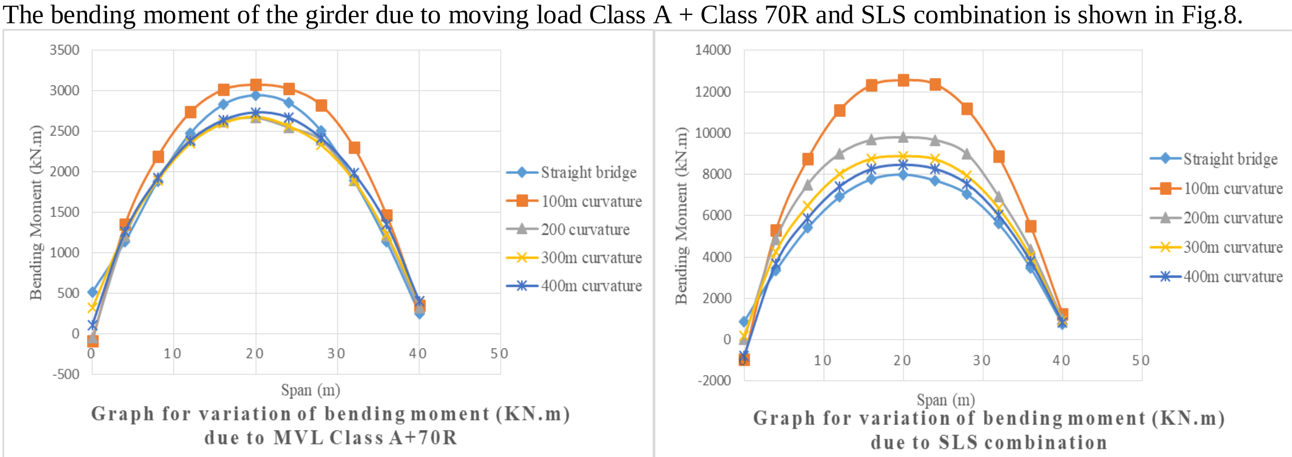

Fig.8 Bending moment of the girder due to moving load Class A + Class 70R and SLS combination

V. CONCLUSIONS

Following conclusions can be drawn from the results shown above:

- As the radius of curvature goes on reducing the value of maximum deflection goes on increasing for all dead load, live load and SLS combination.
- The value of maximum deflection occurs near the centre of the convex end of the curved bridges.
- The values of maximum bending all occurred at the convex end of the curved bridge for all loading cases.

- The value of absolute maximum bending moment goes on increasing for all dead load, live load and SLS combination as the radius of curvature reduces.
- The maximum shear force value also goes on increasing as the curvature reduces for dead load and SLS combination.
- Whereas the maximum value of shear for live load combinations increases by a very small amount.

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