EFFECT OF CHANGE IN RADIUS OF CURVATURE IN PLAN ON BRIDGE BEARING REACTIONS

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Abstract— Bearing is very small part of bridge compared to all other components. Though it is small part requires more attention as entire load is transmitted from super-structure to sub-structure through bearings. Bearing not only helps to transfer the force of super-structure to sub-structure but also resist or transfer the deformations of super-structure with respect to sub-structure which were unavoidable in case of high altitude and large span bridges. This study includes effect of geometry of a bridge on selection of bearing. To demonstrate effect of geometry on variation in reactions combination of simply supported spans and curved spans with and without curvature in plan where considered.

Keywords— Bearing, Super-Structure, Sub-Structure.

I. INTRODUCTION

Any structure which made to cross an obstacle is known as 'Bridge'. Bridge components are mainly divided in to two parts. One is Super-structure includes deck, girder and bearing, and other is sub-structure includes bed block, pier or abutment and foundation of bridge. Bearing is on verge of super-structure and sub-structure. Bearing is the component whichconnects one structural part to another. Bearings may also have to perform functions like support, guide and reduce friction and allow movement between two components.

Super-structure of bridge under goes dimensional change due to thermal expansion of deck, Elastic deformation, Seismic force, Wind force, Creep and shrinkage of concrete, Settlement of supports, Longitudinal forces and bearing has to take care of all this deformation also has to transfer the force to sub-structure. If these movements are not allowed then large amount of force may develop in girder and sub-structure due to which the design sections will be large which leads to uneconomical design of super-structure and sub-structure. Bearings are connecting component for super-structure and sub-structure and it has to perform the function like allowing permitted amount of movement and transfer vertical and horizontal load form super-structure to sub-structure. Bearing movement includes translation and rotation with respect to the span. In current paper simply supported and curved bridge with single span, two span continuous and three span continuous are analysed and effect of curvature in plan on reaction of bearing were studied.

The portion of horizontal load with respect to vertical load is now days increased by 10-20% than level of some year ago. This increase in horizontal load is due to current trend of continuous, joint free, redundant structure. Engineers avoid expansion joints as they require maintenance, which results in long-joint free structure which has very few horizontal load carrying bearings. In case of continuous span portion of horizontal to vertical load increases with continuity.

II. PROBLEM STATEMENT

For analysis of bridge span 27m were taken. The span is effective distance betweenthe bearings centrepoint. Span divided into 3 main cases those are simply supported, twospans continuous and threespans continuous bridge. With variation in radius of curve in plan from infinity to 1000m, 750m, 500m, 250m and 100m.

Cross section details of the span to be considered are the cross section of PSC boxgirder having deck width of 9.8m. Soffit is of width 3.6m. Contains 4 cables per web, post tensioningcables used is 19k – 15 systems. Sections were made up of M-45 grade concreteand steel used is of grade Fe500. Centre to centre distance between the bearings is 2.4m.

The reaction when bridge is subjected to DL of 13t/m, SIDL of 2t/m and train of vehicle of class 70R rolledalong the centre of the span and along the respective eccentricity to the centre line of thespan were observed and discussed.

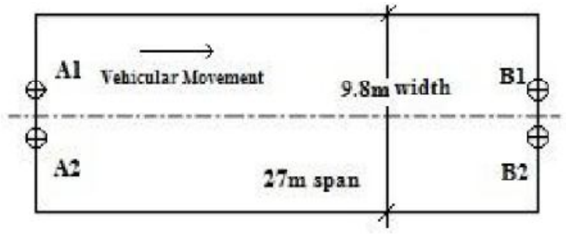

Fig.1. Plan view of Simply supported 1 span straight bridge.

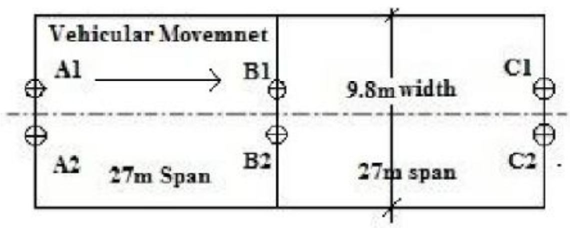

Fig.2. Plan view of 2 span continuous straight bridge.

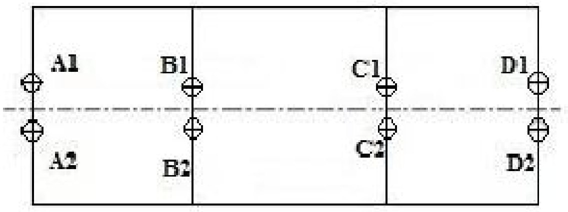

Fig.3. Plan view of 3 span continuous straight bridge.

Fig.4. Plan view of 1 span curved bridge.

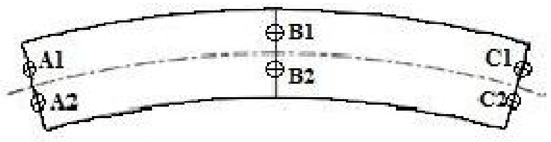

Fig.5. Plan view of 2 span continuous curved bridge.

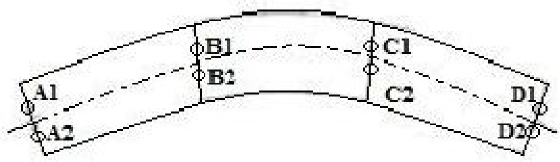

Fig.6. Plan view of 3 span continuous curved bridge.

III. ESTIMATION OF REACTION

Reactions at each bearing location were calculated manually and same were verified using STAAD Pro and Midas software's. For manual calculation in case of continuous span concept of ILD were used. The change in reaction is mainly due to geometry and another is the eccentricity of the load with respect to centre line of the bridge.

Dead load is uniformly distributed along the span. Hence it was assumed that whole deadload is to be concentred at CG of the section in plan. In case of straight span CG is lie oncentre line of the bridge. As dead load is uniformly distributed the reaction on each bearing incase of straight span will be same on specific support, whereas in case of curve bridges CG ofthe section did not lie on the centre line of the span. In present case study the CG will lie onouter side of thechord joining centre of different bearing supports. Because of which thebearings on inner side of the curve will experience the uplift. This uplift is due to torsionalmoment known as torsion due to geometry orgeometric torsion.

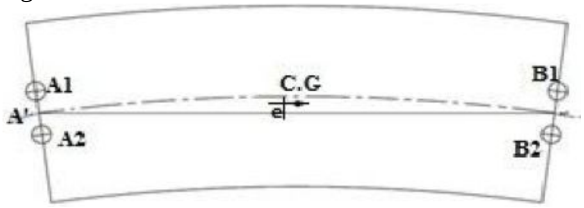

Fig.7. Geometric torsion eccentricity.

In case of live load when it roll along the centre line of the straight span bridge theload gets equally distributed on support and hence on bearings. In case of eccentric loading the torsion due to eccentricity will get induced which depends on the position of load with respect to centre line of the span and consequently the reaction or force acting on bearing will affect. In case of curve in plan span bridge though load is running along the centre line of thebridge eccentricity develop and it varies along the span this eccentricity is with respect to chord joining two supports and centre line of the bridge. Due to this eccentricity the bearing will subject to addition torsion.

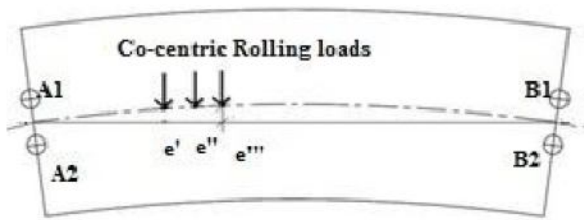

Fig.8. Eccentricity of vehicle due to rolling along centre line of curve.

IV. RESULT AND DISCUSSION

The maximum and minimum reaction on bearing is important for selection of various types of bearing and their size. For above mentioned problem statement the graphs for maximum reaction are plotted as maximum reaction will govern in case of bearing selection and are discus below:

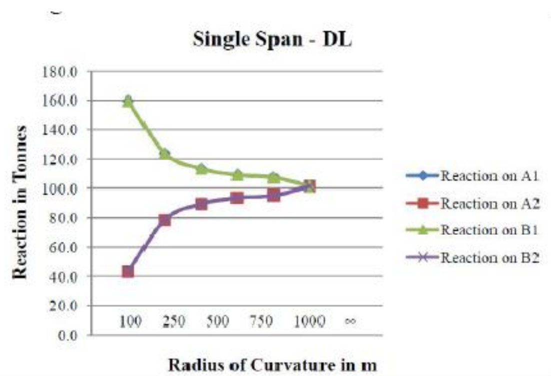

Fig.9. Single Span – DL

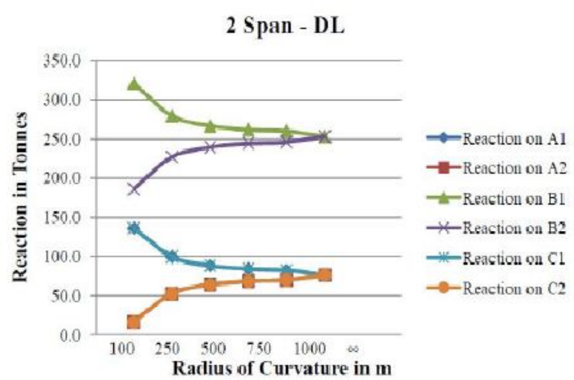

Fig.10. Two Span – DL

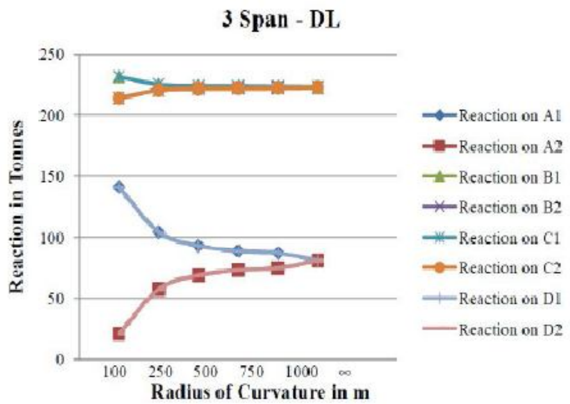

Fig.11. Three Span – DL

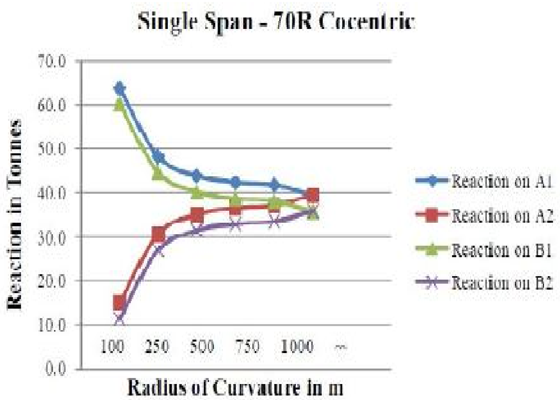

Fig.12. Single Span - 70R Co-centric

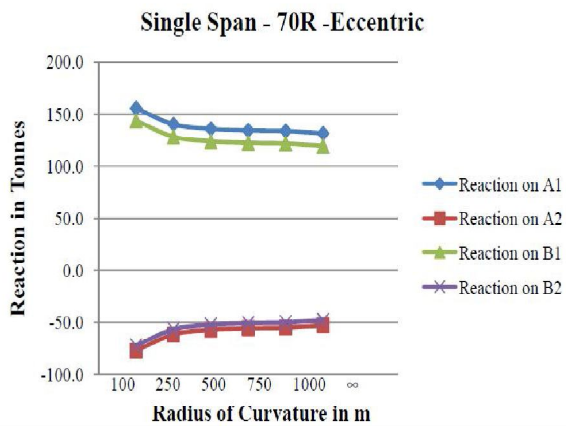

Fig.13. Single Span - 70R –Eccentric

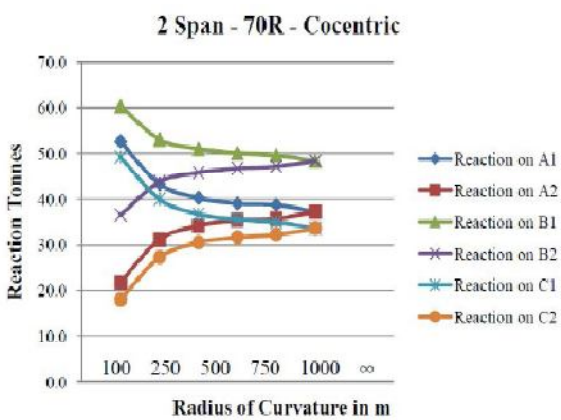

Fig.14. Two Span - 70R – Co-centric

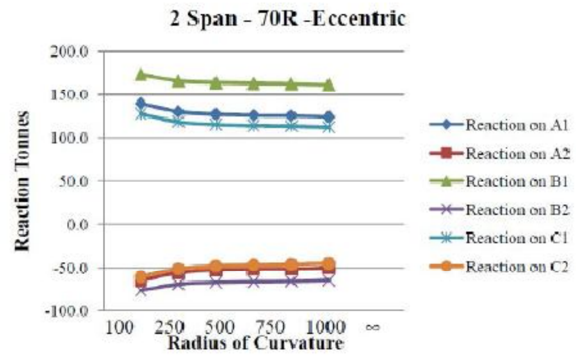

Fig.15. Two Span - 70R –Eccentric

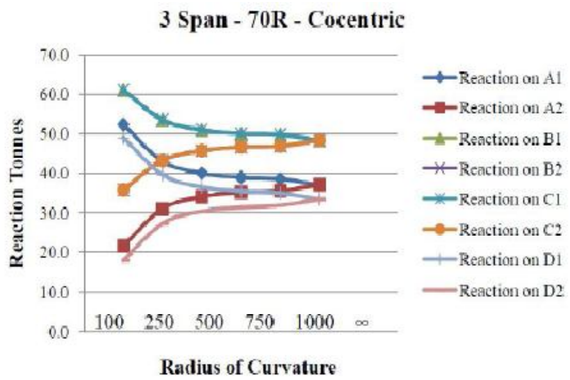

Fig.16. Three Span - 70R – Co-centric

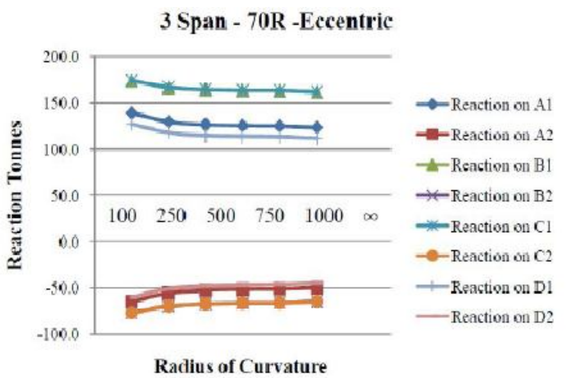

Fig.17. Three Span - 70R –Eccentric

1. As radius of curvature in plan goes on increasing Centre of gravity of curve shift towards the centre line of the straight span and because of which eccentricity between centre of gravity and chord of the curve goes on decreases which results in decrease in reaction of outer curve bearing and increase in reaction of inner curve bearings.
2. Percentage increase in reaction of outer support is same as percentage decrease of inner support and this percentage with respect to decrease in radius of curve in plan goes on increasing for outer bearings and decreasing for inner bearing, which indicates that there are chances of uplift for inner bearings of small radius of curve are more than higher radius of curve inner bearings.
3. Due to continuous span load on outer support bearing goes on decreasing while increases on inner support bearings. This help to provide economical bearing with respect to load.

4. If number of continuous span increases then load on inner support bearings increases at smaller rate as compared to the outer support bearings.
5. In case of straight span at any support location DL contribution is almost 70% and30% due to LL. This is in case of concrete box girder where as in case of steel girders the contribution may change.
6. Eccentric loading of only LL on curve shows the actual load on support may be greater than that of only due to DL. That is in case of eccentric loading of LL the reaction under any bearing may be greater than that of reaction due to DL.

CONCLUSIONS

1. In case of continuous span end support reactions are less as compared to simply supported single span.
2. Due to continuity of bridge reaction on intermediate support increased but that reaction value is decreases with increase in number of continuous span.
3. Reaction is get affected and hence selection of bearing also get influenced.
4. Decrease in radius of curvature increase the chances of uplift of inner bearing of the curvature.
5. The span with curvature in plan when compared with straight span the reactionon outer bearing increases which is due to effect of geometric torsion. Innerbearing experiences uplift in certain cases. The reaction value further increasesdue to eccentricity of the vehicle which is more in case of curve bridges ascompared to straight bridges.
6. In case of straight span roller- rocker bearings or elastomeric bearings or pot bearings are suitable depending on the value of reaction. In case of curve span in plan bridges we have to provide Pot bearings only. Elastomeric bearings are also suitable but they have limit of movement to allow which depends on the height of the bearing. Negative reaction at support indicates uplift. In case of uplift pot PTFE and Elastomeric bearings are infective and hence disc bearings are provided in such cases. Hence we have to provide disk bearing to resist the uplift.
7. In present work the negative reactions at support is very less this is due to DL and LL combination. In reaction contribution of the DL is 60% whereas that of LL is about 40% but in case if steel girders are provided the case become reverse, the DL contribution will be 45% that of LL is 55% hence more chances of uplift in case of steel bridges. That is one of the reason for which elastomeric bearings are not preferred for steel bridges.

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