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Optimized Solution on Curvature Problem in Flyovers

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ABSTRACT

In order to address concerns regarding the superstructure behavior, this research experimentally and analytically investigated four in-service, horizontally curved, steel I-girder bridges with integral and semi-integral abutments.. For the research, a monitoring system was installed on the bridges using an array of strain gauges. The implications of the critical data that the monitoring system produced will enable further development of design specifications for similar bridge types, particularly with respect to thermal effects. In addition to the measured field data, an analytical model for one of the instrumented bridges was established using a commercial finite element analysis software package. Several conclusions were formed from both of the experimental and analytical results. First, the short term experimental results produced moment distribution factors that were most heavily influenced by the degree of curvature. More importantly, bridges with increased curvature and skew may require special attention in future practice as lateral bending stresses may increase due to temperature loads.

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I. INTRODUCTION

Around 25% of the Nation's steel girder bridges are designed with horizontal curvature. Deformations are directed along the line defined by the section from the given direction bearing to the fixed bearing. Depending on the bearing, the values of the internal forces from all effects will be different. Thermal and rheological effects as well as the compression of tightly curved, multi-span superstructure, cause that it experiences displacements and deformations in the plan. Top plate of sliding bearings displace mutually. Lack of detailed analysis of these interactions at the design stage may result in the adoption of too small freedom of movements in the bearings hitch can appear during the operation in the form of emergency situations involving the excessive sliding or even fall of the bearing from the axle support.The FEM replicated a continuous three-span horizontally curved I-girder bridge comparing dynamic and static loading responses. Dynamic loading concentrated on free vibrations. FEM found that plate elements adequately represented plate bending behavior and interactions in the cross framing. Refined meshing is more critical along the longitudinal direction of the bridge versus the transverse direction at a particular cross-section. Modeling the haunch with plate elements provided negligible differences compared to using rigid links.

Methodology:-The re-alignment of the intersection of Interstates of curved bridge.

Develop preliminary instrumentation schemes
The bridges will be monitored over a period of approximately 15 months for assessing the long-term thermal behavior. During this period, the strains, temperatures, and displacements were recorded once per hour under varying thermal conditions
Using the collected data, simple analytical models and observations were formulated. The goal was to relate the results to several design conditions (e.g., geometry, boundary conditions, etc.) that may provide information on other hypothetical situations

II. LITERATURE REVIEW

Miller et al. (2009) state that curved beams create twisting effects which result in warping out of plane similar to torsion. This phenomenon is referred to as a bimoment, a product of combined bending and torsional shear. In addition, negligible secondary effects occur when the curved compression flange bows outwards, increasing the degree of curvature. When secondary effects are introduced, lateral bending in the flange results in a variation of bending stresses across the flange width.

Lydzinski et al. (2008) further explain additional complications that arise when analyzing and designing I-girders in curved bridges. Complications range from the individual plates to the constructed girder as a whole. Compared to straight girders, horizontally-curved I-girders are significantly different in the following ways:

- Flange local buckling may differ from the outer to the inner side of the web.
- Local buckling is possible on the inner half of the tension flange.
- S-shaped bending occurs in the web, causing an increase of stress at the web-flange connection.
- Bending and torsion stresses are not decoupled, resulting in lateral bending behavior.

Twisting can occur under individual girder self-weight, causing construction issues in framing.

Curved bridges and their most common problems

a) Bearing failure problem

Multi-span bridges on connecting roads on motorways intersections are usually made of reinforced or prestressed concrete. These are usually the structures of girder, beam or box girder cross section. Despite many years of experience in design of such structures, unfortunately, there are still cases in which there have been negative and not anticipated by the designer or contractor incidents and issues; especially, if we are dealing with a statically not determinable prestressed structure. The most common issues are: detachment of the top plates from the outermost bearings and their overload, excessive mutual displacements of the bearing plates in the plan and the change in the geometry of the superstructure as well as the change in slope of the cross-section, which may also be associated with reaching the allowable rotation angle of the bearings.

Detachment of the top plates on the outermost bearings is associated with the uneven load distribution on the bearing couples lying on the same support. This is due to the presence of much greater torsional moments than in simple structures. Mostly concerning the bearings located on the abutments where, due to obvious reasons, reactions are often less than half of the reactions at the intermediate supports. Distribution of the dead load at high curvature is the reason why there is significantly more material at the exterior side of the connecting road. As a result, the reaction at the internal bearing may be small, so that, due to pretension effect or adverse distribution of live load, the reaction will decrease and the top plate will elevate Typical bridge bearings are not designed for this type of work. There must be minimum pressure, so the bearings fulfill its function and the damage or accelerated wear does not occur. The under load of the internal bearing is usually associated with the overloading of the adjacent external bearing. If this was not foreseen by the designer, then an unexpected excess of the carrying capacity may lead to permanent damages of the bearing structure and, consequently, to the need to replace it

An appropriate support of the structure requires bearings, which provide the greatest flexibility in terms of the superstructure deformation while satisfying the overall stability condition. In structures with large curvatures, it is extremely difficult to provide a freedom of deformation. Among many possible ways to support a span on the bearings, there are two most commonly methods, so called: at the tangent and at the radius. The first method – at the tangent, is about the orientation of deformations from thermal effects along the axis of the girder. Such layout usually results in additional stresses in areas where the structure is not free from deformation. The second method – at the radius, induces smaller additional internal forces resulting from the extra links in the plan and allows for the greatest possible freedom of displacements.

Fig. 3.1 Bearing positions

The cases described above occurred in the connecting road described in [2] at the Lipce junction in Southern Bypass of Gdansk Detachment of the superstructure over the bearing at the outermost support reached several centimeters Fig. Superstructure displaced unpredictably due to not taking the curvature of the span into consideration when modeling the pretension. Displacements at the intermediate supports reached up to tens of centimeters (Fig.), causing an overload of certain bearings

b) Uplift force problem: Anti-lifting bearings , also known as Uplift restrained, negative load or double acting' bearings, the special anti lifting bearings are also capable of resisting negative loads, commonly denominated uplift forces, this additional feature can be added to virtually all types of bearings.

- The most common application of special anti lifting bearings is in flyovers characterized by a long central span via two lateral spans.
- While constructing curvature part of any flyovers negative forces is developed in longer span. To anchor this superstructure we need negative bearing, which are not easily available in India and periodical maintenance cost is more.

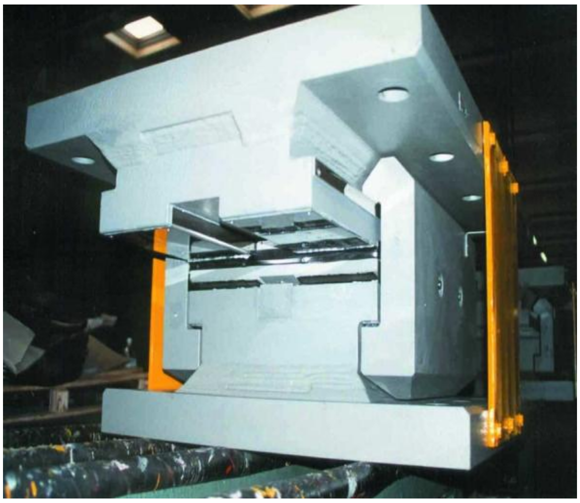

Fig. 3.2 Negative Bearing

Problems of HTS Cables on curvature portion of flyover: Prestressing is a method of inducing known permanent stresses in a structure or member before the full or live load is applied. These stresses are induced by tensioning the High Tensile Strands, wires or rods, and then anchored to the member being Prestressed, by mechanical means. The Prestressing counteracts the stresses, produced by subsequent loading on the structures, thereby extending the range of stresses to which a structural member can safely be subjected. This also improves the behavior of the material of which the member or structure is composed. For Example; The Concrete which has relatively a low Tensile strength, shall behave like a member having high tensile strength, after Prestressing. The High Tensile wires/strands, when bunched together are called Cables. These cables are generally placed inside a cylindrical duct made out of either metallic or HDPE material. The Anchorages, one of the main components of the Prestressing activity, are used to anchor the H.T. Cable after inducing the Load. The whole assembly of the Anchorage and the H.T. Cable is named as 'TENDON'.

III.CONCLUSION

As it seems, it is hard to predict the strength using simple hand calculations and since the results vary in a wide interval it will never be possible. It will not be possible to do any type of optimization of the shear key as the results vary too much and the most important thing is to construct them to work safely.However, the test-results show that the bridge could take the design load of 300 kN until breaking. So for Ultimate Limit State (ULS) the shear key seems sufficient.The negative bearing is also a important part to be considered in design.

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