International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 3 Issue: 7 4926 - 4928

Design Development & Analysis of Structural Bearings for Torsional Forces

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Abstract:- All over the world; development of roadways, infrastructure is increasing. All the latest large span bridges require Structural bearing for their better performance, durability, life & low cost. These structural bearing enables freedom of movement between a superstructure and substructure, while transmitting vertical loads and rotation caused by the effect of operating loads, temperature variations, wind or earthquakes. These standard structural bearings are designed & manufactured as per well known international standards like BS: 5400, EN-1337, AASTHO, IRC 83, Indian Railway, etc.
In the latest designed bridges, in addition to standard forces, torsional forces also occurs in the Bridges when high wind causes the suspended roadway to rotate and twist like a rolling wave & these are also generated at the time of turning of fast moving trains. This report is development of New Structural bearings suitable for torsional forces in addition to all standard features of bearings. This new development of structural bearing suitable for torsional forces will help to reduce the cost of structure & cost of bearings.

Keywords:- *Bridge bearings, Knuckle leaf bearings, torsional bearing, New bridge bearing, Bearing suitable for high wind load, Uplift restraint Bearings.*

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I. Introduction

The structural bearing is the key element that enables freedom of movement between a superstructure and substructure, while transmitting vertical loads and rotation caused by the effect of operating loads, temperature variations, wind or earthquakes.
Bearing is an element of superstructure which provides an interface between superstructure & substructure. This interface is vital because superstructure goes into dimensional changes & deformation because of following factors,

- Thermal expansion/contraction
- Elastic deformation under live load
- Seismic/wind forces
- Creep & shrinkage of concrete
- Settlement of concrete
- Tractive breaking force

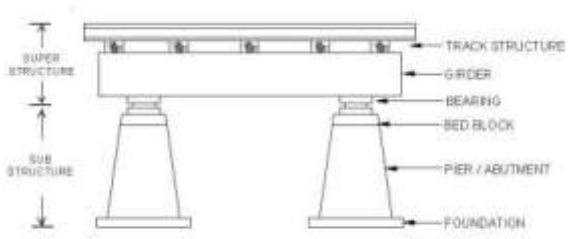


FIG. 1.1 PARTS OF BRIDGE

Structural bearings are designed & manufactured according to well-known international standard as EN-1337, BS:5400, AASTHO, IRC:83.

Advantages of Structural Bearings:-

- Very low sliding friction
- Unlimited movement capability
- High load carrying capacity
- Self-alignment capability
- Compact in size
- No maintenance required
- Easy Removability
- Easy installation

Most common type of Structural Bearing used in Bridges is **POT CUM PTFE BEARING,** which further classified as follows,

- **Pot cum PTFE Free sliding bearing/ Pot cum PTFE Bi-directional sliding bearing:-** Pot cum PTFE free sliding bearing bears and transmit vertical force & allows movement in any direction in the horizontal plane and allows rotation about any axis in horizontal plane.
- **Pot cum PTFE guided bearing/ Pot cum PTFE Uni-directional sliding bearing:-** Pot cum PTFE guided bearing along with vertical force bears and transmits horizontal force in one direction only & allows movement perpendicular to that direction and allows rotation about any axis in horizontal plane.
- **Pot fixed bearing:-** Pot fixed bearing along with the vertical force, bears & transmits horizontal force in any direction and allows rotation about any axis in horizontal plane.

II. Literature Survey

Other than Vertical, Breaking & horizontal forces **torsional forces** also occurs in the Bridges when high wind causes the suspended roadway to rotate and twist like a rolling wave & these are also generated at the time of turning of fast moving trains.

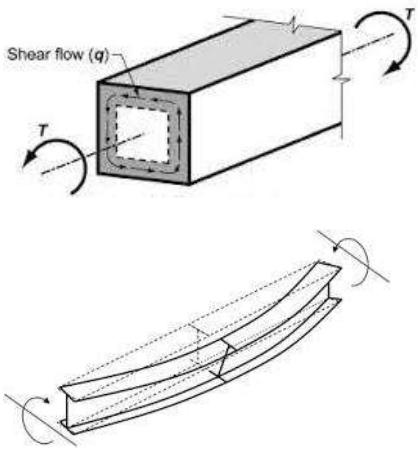


Fig. 2.1 & 2.2 Torsional forces in Bridge Girder

Fig. 2.3 & 2.4 Images of Bridge with fast moving train

Current Methods for absorbing torsional forces:-

- Engineers conduct wind tunnel tests on models to determine the bridge's resistance to torsional movements. Armed with this data, they employ aerodynamic truss structures and diagonal suspender cables to mitigate the effects of torsion.
- Suitable arrangement in the Bridge itself.
- POT PTFE Bearings are used with 2/4 no's of POT with larger diameter of rubber part

Problems Faced in Current Methods:-

When POT Bearings are subjected to torsional Forces it is observed that PTFE Sheet & rubber Will Subjected to highly edge stressing which is not Permitted in the design codes.

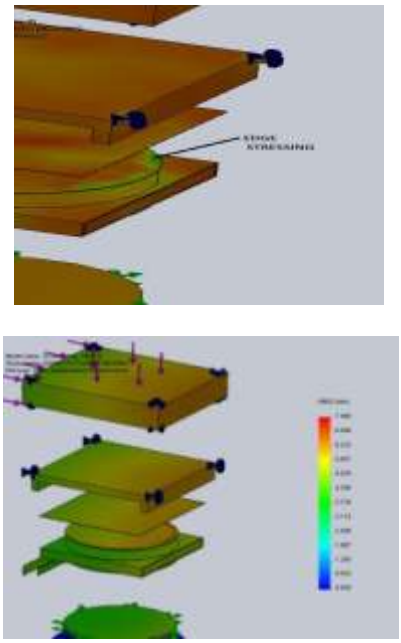


Fig. 2.5 & 2.6 High Edge Stressing in PTFE Part & High deformation in rubber part.

As per Bearings design concern limitation are as follows,

- High Edge stressing of PTFE & Rubber Parts
- Large Bearing Size
- Require more area for fixing bottom & top part of Bearings
- Handling is not easy because heavy weight
- Requires large size machines for manufacturing
- High Cost

All above mentioned problems can be overcome by Design of Knuckle Leaf Bearings suitable for torsional forces.

III. Problem Formulation

Why Knuckle leaf bearings designed?

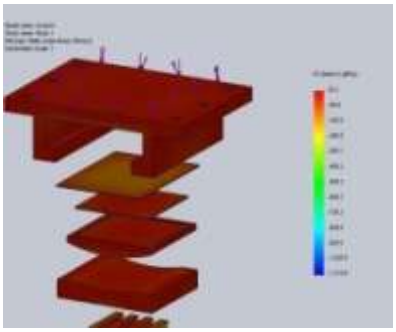
As discussed in literature survey if POT PTFE Bearings are used in Bridges for torsional forces we face problems like High Edge stressing of PTFE & Rubber Parts, Large Bearing Size, Require more area for fixing bottom & top part of Bearings, Handling is not easy because heavy

 ISSN: 2321-8169
4926 - 4928

weight, Requires large size machines for manufacturing, High Cost.

Whereas when Knuckle Bearings will subject to torsional force few parts of bearings will rotate & direct forces & developed forces due to torsion will act perpendicular to the PTFE part & thus leads no edge stressing of PTFE Component.

By analytical calculation sizes of bearing parts are selected & 3D model of the same is created. Static analysis of the same model is done in latest simulation software. Results of stress analysis are compared with analytical calculation & it is observed that stresses are almost similar to analytical results & main objective of the project i.e. Edge stressing of PTFE part is eliminated. Refer Fig. 3.1 & 3.2 shows no edge stressing observed in PTFE. In knuckle leaf bearing rubber part is removed & knuckle leafs are used for rotation.



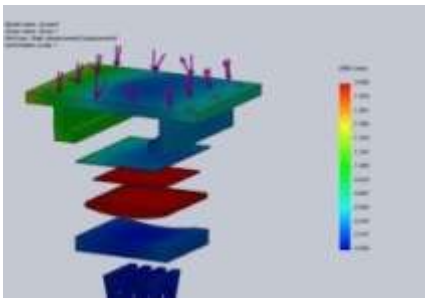
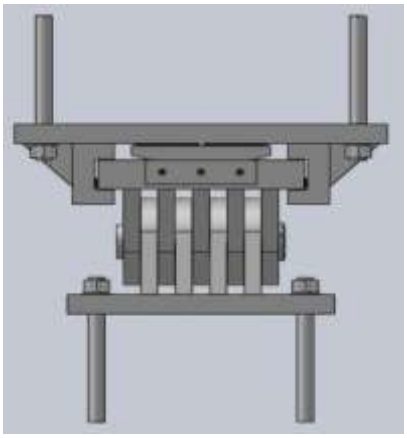


Fig. 3.1 & 3.2 No Edge Stressing in PTFE Part



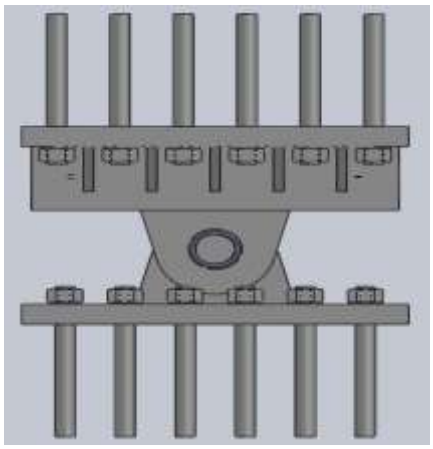


Fig. 3.3 & 3.4 Front view & side view of Knuckle leaf suitable for torsional bearing

IV. Objective& Conclusion

The main objective of "Design, Development & analysis of Structural Bearings for torsional forces" is to eliminate High Edge stressing of PTFE & Rubber Parts. By the use of knuckle leaf bearings following factors are eliminated &

- To eliminate High Edge stressing of PTFE & Rubber Parts
- To reduce Large Bearing Size
- To reduce area require for fixing bottom & top part of Beairngs
- Ease to handle.
- To Reduce Cost.

From this study, we can conclude that **Knuckle Leaf Bearings** are most suitable for **torsional forces** along with all standard features of standard Bridge bearings.

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