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# Investigation and Analysis of Bridge Pot Bearing

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## ABSTRACT

The paper present describes the investigation and analysis of bridge pot bearing. A technical solution to the problem of unavoidable movements in bridge structures is the use of bridge bearing. The road engineering consists of three major structure, road embankments, bridges, and tunnels. In consideration of the cost of land acquisition in urban areas, the trend of road engineering migrating to hilly or mountain areas has been developed. Pot bearing has many advantages the extremely long service year in addition to the correct installation the routine inspection and maintained of pot bearing in the service time are necessary for them to fully function. Current domestic research mainly concentrates of rubber bearing and has only few discussion and analysis on pot bearing.

***Keywords: Bridges, Pot bearing, Elastomeric bearing, Finite element modeling, POT PFET bearing.***

## 1. INTRODUCTION

In the early days of bridge construction, masonry was the prime construction materials and the arch was the predominant structural form. But the fact is that, no bridges will last forever and that proper managements contains design, material and construction, preventive and curative nature to ensure that, bridge will perform properly at least for the period of 100 to 120 years nominal life. In order to have better bridge for longer duration it is necessary to coordinate and implements the following task associated with the care of bridges. Bearings can term as the mechanical part of a bridge structure. The earliest bridges were built of high mass of stones, bricks or timber material. A bearing which carries vertical load by compression on an elastomeric disc confined in a steel cylinder and which accommodates rotations by deformations of the disc. A bridge structure can be divided into two main bodies, the superstructures and the substructures; the superstructure bears its own weight and the traffic load, and the sub structure bears the load from the superstructures. Pot bearing was first used on Germany's bridge in 1958; after years of development, it has gradually become the most widely used metal bearing in the world's bridges. Pot bearings places an elastomeric inside a steel pot and press the top of the elastomeric by using a steel plate; the elastomeric functions like a viscous fluid inside a hydraulic jack and the top steel plate behaves like the piston. Inside the pot of elastomeric is to be laterally restricted, is not able to be compressed, and not able to horizontally lengthen. The bearing can hold substantially high pressure and enable slight rotations under homogeneous compression stress; these aforementioned items are the principle of a pot bearing.

## LITRATURE REVIEW

**Ankit gupta, Diwakar prakash verma (2014)** has reviewed about the Suitability of POT PTFE bearing in Bridges. Design of Pot-PTFE bearing is governed by the minimum average stress on the PTFE disc, elastomeric Pad and the top plate at which all the system is fixed .It is evident from the figure and mathematical model that maximum stress developed in the PTFE disc, elastomeric Pad and the top plate is considerable as a safe design. It is also evident from the figure the stress developed in the POT PTFE bearing is also under the critical stress as per the design consideration. It can be concluded the POT PTFE bearing is very useful where the heavy load is under consideration. It is also remarkable that it is the best replacement of roller bearings which is widely used in bridges. . It is also observed from the literature that the design of Pot-PTFE bearing is restricted due to the stimulated minimum average stress and can be feasible for railway bridge girders of spans 61.0 m and above.

**Vinodkumar Ishwaral Jangid (2014)** discussed design development and analysis of structural bearings for torsion forces. By analytical calculation sizes of bearing parts are selected and 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 calculations and it is observed that stresses are almost similar to analytical results and main objective of the project i.e., edge stressing of PTFE part is eliminated. To reduce the large bearing size and ease to handle. For this study we can conclude that knuckle leaf bearings are most suitable for torsion forces along with all standard features of bridge bearings.

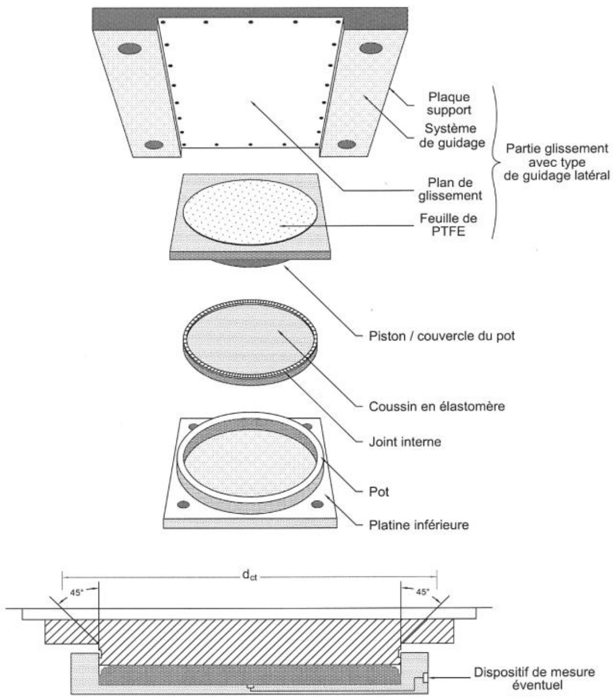
**Young Jin Kim, Sung yong park (2013)** discussed load measuring pot bearing with built in load cell. The measurement of the vertical transmitted from the superstructure to the substructure by the bridge bearing can have multiple applications for the structural health monitoring of the bridge. The paper presented the performance test results performed on load measuring pot bearings with built in small size load cells inserted to the base plate of the bearing. The method determining the details for the insertion of the load cell in the base plate of the bearing was proposed and the test results for pot bearings with different capacities were presented. The results revealed that inserting one load cell at the center of the pot bearings base plate is more advantageous than inserting several load cells.

**Cem Topkaya (2004)** discussed analysis of specimen size effects in inclined compression test on laminated elastomeric bearings. Specimen size effects in inclined compression test were presented. Experiments performed to date were not sufficient to draw firm conclusions on the specimen size effects. An approximate analytical technique, Haring shear weak column theory, was employed to explain the reduction in apparent shear modulus due to p-$\Delta$ effects. Based on the parameters identified, a finite element study has been conducted. Finite element analysis offered the modeling of geometric and material non linear ties. For the elastomeric material grade that is in the range of interest could be independent of the shear modulus of full size bearing.

## POTBEARING

A bearing which carries vertical load by compression on an elastomeric disc confined in a steel cylinder and which accommodates rotations by deformations of the disc. A bridge structure can be divided into two main bodies, the superstructures and the substructures; the superstructures bear its own weight and the traffic load, and the sub structures bear the load from the superstructures. Pot bearing was first used on Germany's bridge in 1958; after years of development, it has gradually become the most widely used metal bearing in the world's bridges.

## LAYOUT OF POT BEARING




## TYPES OF POT BEARING

**Fixed Type bearings:** Along with vertical load, it bears and transmits horizontal force in any direction and allows rotation about permitting any movements in horizontal plane.

**Free Sliding Type Pot cum PTFE bearing:** It bears and transmits vertical load and horizontal plane and accommodated rotation about any axis in horizontal plane.

**Guided Sliding Type POT Cum PITE Bearings:** Along with vertical load, it bears and transmits horizontal force in one direction only and allows movements perpendicular to that direction and allows rotation about any axis in horizontal plane.

### Approximate Load Carrying Capacity

The approximate load carrying capacity is shown in figure.

| **Bearing Type** | **Min Reaction (KN)** | **Max Reaction (KN)** | **Max Displacement (mm)** | **Max Rotation (rad)** |
|---|---|---|---|---|
| Unreinforced continuous Elastomeric Sheet | 0 | 450 | ±15 | ±0.02 |
| Steel Reinforced elastomeric Pad | 200 | 3000 | ±25 | ±0.04 |
| Pot Bearing | 1500 | 12000 | No limit with slider plates | ±0.025 |
| Fixed steel Plate Rocker | 1000 | 4000 | 0 | No practical limit |

## DESIGN OF POT BEARING

The pot bearing consists of circular, non -reinforced natural rubber elastomeric pad, totally enclosed in a steel pot with the load applied to the elastomeric via a piston attached to the upper bearing plate. A seal is used to prevent rubber extruding between piston and pot. As the elastomeric is fully confined within a metal cylinder, it provides a load carrying capacity medium whilst at the same time providing the bearing with a multidirectional rotational capacity. By them, pot bearing do not permit translation.

## MATERIAL SPECIFICATIONS

| | | | |
|---|---|---|---|
| i) | Mild Steel | : | IS : 2062 grade-B |
| ii) | Stainless Steel | : | IS : 6911 |
| iii) | Cast Steel | : | IS: 1030 grade 280-520W. |
| iv) | Elastomeric Pad | : | a) IRC: 83 (Part-II) Standard specifications and code of practice for Road Bridges- Elastomeric Bearings.<br><br>b) IRC : 83 (Part III) Properties of confined Elastomeric. |
| v) | PTFE | : | a) BS: 3784 grade 'A'. Specification for poly tetrafluroethylene (PTFE) sheet.<br>b) IRC : 83 (Part-III) for permissible pressure on confines PTFE |

### Design of Elastomeric Pad Diameter and Thickness

- Average stress in confined elastomeric pressure pad of pot bearing shall not exceed 35 Mpa.
- And extreme fiber pressure shall not exceed 40 Mpa.
- The minimum thickness of the confined elastomeric pressure pad shall not be less than 1/15th of its diameter or 16mm, whichever is higher and the diameter shall not be less than 180mm.
- Minimum average stress confined elastomeric pressure pad of pot bearing, under any critical combination of loads and forces than can coexists, shall in no case be less than 5 Mpa.

### Design of Pot Wall

The design of pot wall is done with respect to the hoop tensile stress in the cross section of the cylinder wall. Hoop tensile stress in the cross section of cylinder wall due to:

i) Fluid Pressure, $\sigma_{at1}$ = (di x he x $\sigma_{Ce}$) / (2 x bp x hc)

ii) Horizontal Force, $\sigma_{at2}$ = H / (2 x bp x hc)

Where,

di = Diameter of confined elastomeric pressure pad in mm

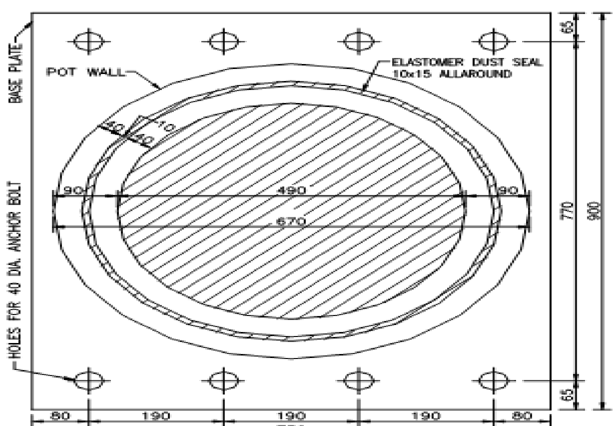
| | | |
|---|---|---|
| He | = | Thickness of confined elastomeric pressure pad in mm |
| $\sigma_{ce}$ | = | Fluid pressure in confined elastomeric pressure pad due to vertical load in Mpa. |
| Bp | = | Thickness of cylinder wall in mm |
| Hc | = | Height of cylinder wall in mm |

**Design of Sealing Ring**

For brass sealing ring type internal seal, 2mm thick and 20mm wide split rings made of metallic brass shall be provided in layers with staggered split positions. Minimum two layers of rings shall be provided for elastomeric pressure pad of diameter up to 480mm and minimum three layers of rings shall be provided for elastomeric pressure pad of diameters more than 480mm.

**Design of Pot-PTFE Bearings For Railway Bridges**

The design of Pot-PTFE bearings has been done for large railway bridges based on above codal provisions and provisional drawings have been issued. The sectional elevation and plan of typical sliding bearing for 76.2 m span railway bridge girder. The values of critical design parameters in respect of minimum average stress, average stress and extreme fiber stress are tabulated for different spans. The typical sectional elevation and plan of sliding bearing for 76.2 m span railway open web girder for H.M loading.




PLAN

**COMPONENTS OF BRIDGE STRUCTURE**

**Wearing course:** It is the portion of the deck cross section which resists traffic wear. It is generally made of separate layers of bituminous materials having the thickness between 50 & 100mm.

**Deck:** It is physical extension of the roadway across the obstruction to be bridged. It can be a reinforced concrete slab or stiffened steel plate depends upon the type of bridge.

**Abutment**: Abutments are earth – retaining structures, which support the super structure and over pass roadway at end of the bridge.

**Piers**: Piers are structures, which support the supper structure at intermediate point between the end supports (Abutment).

**Bearings**: Bearings are mechanical system, which transmit the vertical load of super structure to the sub structure. The use and function of the bearings are depending on the size and configuration of the bridge.

**Back wall:** A back wall, sometimes called as dirt wall or stem is a primary component of the abutment acting as a retaining structure at each approach.

**Wing wall**: A wing wall is side wall to the abutment back wall are stem designed to assist in confining earth behind the abutment.

## CAUSES OF MOVEMENT IN BRIDGES

- Movements due to shrinkage and creep
- Movements due to traffic loads
- Movements due to dead load of the bridge structure
- Movements due to lateral forces acting on the bridge structure as wind loads
- Movements due to temperature changes

## BRIDGE BEARING

Bearings are used bridge structure forces from one structural member to another. They are also required to restrict or permit linear or rotational movement in the vertical plane, where horizontal movements is restricted and the horizontal forces will be transferred through the bearings to the lower structure.

| Bearings | Translation | | Rotation | | | Load | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | L | T | L | T | P | V | L | T | X – Not | L- |
| Roller | | X | | X | X | | X | S | Suitable | Longitudinal |
| Rocker | X | X | | X | X | | | S | | |
| Knuckle | X | X | | X | X | | | S | | |
| Sliding | | | X | X | | | S | S | | |
| Elastomeric | | | | | | | | | | |
| Pot | X | X | | | S | | | | | |
| Guide – L | | X | | S | X | X | X | | S- | T- plan |
| Guide – T | X | | S | | X | X | | X | Suitable Can be considered | V- Vertical |

### Types of Bridge Bearings

There are many type of bearings used in bridge structure depending upon the requirements of load transmission to the sub structure and translation movements and rotation or the super structures. The common bearings are roller bearings, rocker bearings, knuckle pin bearing, leaf bearing, link bearing, sliding – bearings, elastomeric bearing and pot – cum – PTFT bearing.

### Selection of Bridge Bearings

The following factors are to be considered while selection the bearings

- Vertical load capacity
- movements capability
- Effect of bearings due to longitudinal forces and width of cap beam.

- Const aspect including initial cost and cost of maintenance.
- Unique factors to the particular bridge.

## MERITS OF POT BEARING

- They can support considerable high vertical load with little space required, higher capacities can also be obtained depending on the design.
- It is satisfactory in safety and operation.
- The design is simple hence production can be rationalized.
- Generates less force in elasticity in comparison to other types of bearing.

## BRIDGE BEARING DESIGN CONSIDERATION

The primary design consideration for the bearings.

- Vertical and Horizontal forces acting on the bearing.
- Translation and Rotational requirements.
- Attachment details and strength of the supporting concrete member.

The secondary design considerations for the bearings are:

- Method of attachment
- Preset / offset requirements to cat irreversible translations.
- Corrosion protection requirements.

### Bridge Bearings Reactions

- Maximum vertical force and the adjacent maximum horizontal force.
- Minimum vertical force and the adjacent maximum horizontal force.
- Maximum horizontal force and the adjacent maximum vertical force.
- Maximum horizontal force and the adjacent minimum vertical force.

## EXPERIMENTAL INVESTIGATION

**Vertical Test:** The bearing was placed centrally and aligned well under a compression testing machine. Initially the load was applied up to 1.25 times the design vertical load (Test load) under a compression testing machine. The corresponding deflection was noted.

**Rotation Test**: The rotation test was performed on the bearings for design rotation under design vertical load. The vertical load was applied under a compression testing machine till it reaches the design vertical load.

**Friction Test:** A pair of bearing samples was tested under each category. The samples were oriented such that the top plate was free to move in the direction of horizontal force applied using a hydraulic jack.

**Horizontal Test:** The Design horizontal force to be considered shall be the resultant of the coexisting active horizontal force, determined from global analysis, and included horizontal force, Generated due to friction at sliding interface.

## FINITE ELEMENT MODELLING

He finite element method translates partial differential equation problems into a set of linear algebraic equation.

$[k]\{q\} = \{f\}$

Where k = Stiffness matrix

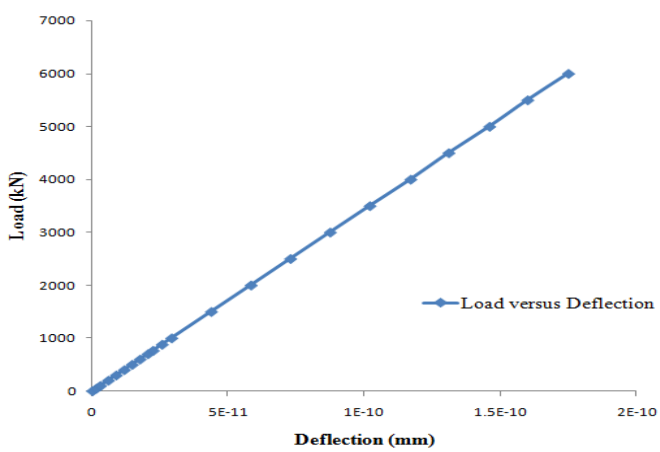
q = Nodal displacement vector

f = Nodal vector force

## EXPERIMENTAL RESULT

| Sl. No | Vertical Load (kN) | Experimental Pressure |
|---|---|---|
| 1 | 50 | 28 |
| 2 | 100 | 55 |
| 3 | 200 | 111 |
| 4 | 300 | 166 |
| 5 | 400 | 221 |
| 6 | 500 | 276 |
| 7 | 600 | 332 |
| 8 | 700 | 387 |
| 9 | 765 | 423 |
| 10 | 880 | 574 |

## ANALYTICAL RESULT




## Load versus Deflection

| Sl .No | Load(kN) | Deflection(mm) |
|---|---|---|
| 1 | 50 | 0.146E-11 |

| | | |
|---|---|---|
| 2 | 100 | 0.291E-11 |
| 3 | 200 | 0.583E-11 |
| 4 | 300 | 0.874E-11 |
| 5 | 400 | 0.117E-10 |
| 6 | 500 | 0.146E-10 |
| 7 | 600 | 0.175E-10 |
| 8 | 700 | 0.204E-10 |
| 9 | 765 | 0.223E-10 |
| 10 | 880 | 0.256E-10 |
| 11 | 1000 | 0.291E-10 |

## COMPARISON OF EXPERIMENTAL AND ANALYTICAL PRESSURE

It is clear that material property for the different type of materials involved in making pot bearing has been taken for FEM analysis (ANSYS). A von mises criterion is chosen for the decision of failure analysis. The sectional elevation of PTFE bearing in which all the dimension has been shown after taken the load capacity 6000 KN in the vertical direction which is acting at the top plate of PTFE bearing and 500 KN in the horizontal direction

| Sl.No | Vertical Load (kN) | Experiment Pressure | Analytical Pressure Result | % of Error |
|---|---|---|---|---|
| 1 | 50 | 28 | 24.01 | 16.61 |
| 2 | 100 | 55 | 48.24 | 14.07 |
| 3 | 200 | 111 | 98.23 | 13.01 |
| 4 | 300 | 166 | 145.42 | 14.15 |
| 5 | 400 | 221 | 198.93 | 11.09 |
| 6 | 500 | 276 | 249.93 | 10.43 |
| 7 | 600 | 332 | 296.13 | 12.11 |
| 8 | 700 | 387 | 342.25 | 13.09 |
| 9 | 765 | 423 | 369.07 | 14.61 |
| 10 | 880 | 574 | 494.18 | 16.15 |

## RESULT AND DISCUSSION

The design of Pot-PTFE bearings has been done for large railway bridges based on above codal provisional and provisional drawings have been issued. The bearings should normally be designed to serve for the full lifetime of the bridge. The materials used in their manufacture and the method adopted for protection against corrosion should be such as to ensure that the bearings function properly throughout their life.

## COCLUSION

In practical where the bearing is supposed to take heavy loads, there would be a lot of vibration which have to be taken into consideration. In the design of PTFE bearing the analysis has been done considering the above condition. Design of Pot-PTFE bearing is governed by the minimum average stress on the PTFE disc, elastomeric Pad and the top plate at which all the system is fixed .It is evident from the figure and mathematical model that maximum stresses developed in the PTFE disc elastomeric Pad and the top plate are considered for safe design. It is also evident from the figure the stress developed in the POT PTFE bearing is also under the critical stress as per the design consideration.

## REFERENCE

1. Ankit Gupta, Diwakar Prakash Verma, Girija Shanker (2014) Suitability of POT PTFE bearing in bridges, International Journal, 2, 47-53.

2. Cem Topkaya (2004) Analysis of specimen size effects in inclined compression test on laminated elastomeric bearings, Journal of Engineering structures, 26, 1071-1080.

3. European Committee for Standardization Structural Bearings- Part 5 Pot bearings, 2005

4.IRC 83 (Part-II) -1987 Standard Specifications and code of Practice for Road Bridges – Section IX Bearings – Part II Elastomeric Bearings.

5. Pugazhenthi and Kumaran, G. Experimental study on pot bearing used for railway metro project, Master of Engineering, Department of Civil and Structural Engineering, Annamalai University, Annamalai Nagar, 2014.

### Conflict of Interest

None of the authors have any conflicts of interest to declare.

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