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A Study on Bridge Pot Bearing by Using ANSYS

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Abstract:
A technical solution to the problem of unavoidable movements in bridge structures is the use of bridge bearings. Bridge bearings are small integral part of the entire bridge structures serving several purpose, such as connection, transfer of forces allowing movements force damping etc. Bridge bearings are important components of modern bridge system and plays a key role to attenuate the vehicular traffic loads on piers. Though many developments have taken place in design and materials technology, still it requires a better understanding with respect to experimental verifications of bearings and their knowledge for proper designing, manufacturing, detailing, installing and maintaining the bridge time to time. The elastomeric bearings are sensitive components and vulnerable to wear to tear and deterioration due to its function of movement. The result of bridge pot bearing by using ANSYS.

Keywords: *Bridges, Pot bearings, Elastomeric bearings, Finite Element Method, POT PTFE bearing.*

1. Introduction

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. 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. Pot bearings places an elastomer inside a steel pot and press the top of the elastomer 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 elastomer 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 bearings.

Bearings are used to 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 are restricted and the horizontal force will be transferred through the bearings to the lower structures. The purpose of bridge bearings is to support the superstructure at the elevation to carry all forces from super structure into sub structure and to allow necessary super structure motions to take place. Layout of pot bearing is shown in Figure. 1.

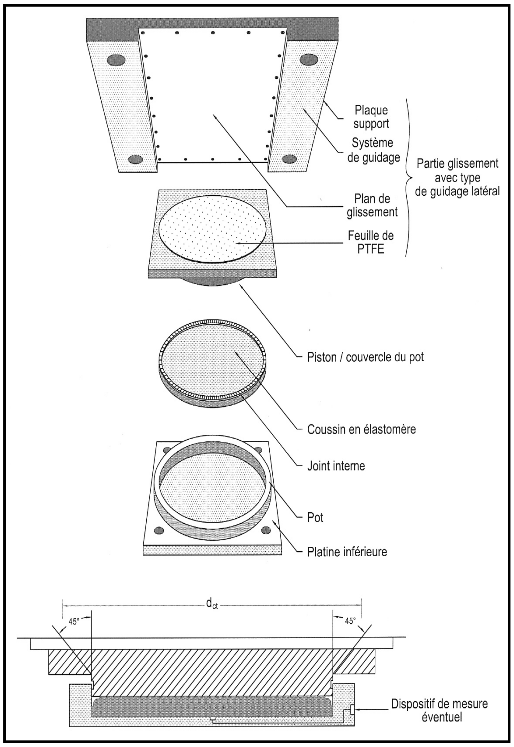


Figure 1: Layout of Pot Bearing

The primary function of the bearings is to accommodate the relative movements that occur between the bridge superstructure and its support due to various factors such as rotation thermal effect, creep, shrinkage, traffic, wind loading and settlements of foundation etc. To transfer forces from one part of the bridge one another, usually from the superstructure to the sub structure.

To allow movements (Translation along, and or rotation above any set of axis) of one part of the bridge in relation to another. By allowing free movements is some directions by in other constraints that, part of the bridge supported by the bearings to defined positions and or directions. The function of the pot bearing is all translation fixed, rotation is allowed.

2. Literature Review

Many researches have been carried out in the area of pot bearing analysis. Ankit Gupta(2014) [2], has reviewed about the Suitability of Pot PTFE bearings in bridges design of pot-PTFE bearing is governed by the minimum average stress on the PTFE disc, elastomer pad on the top plate at which all the system is fixed. Young jin Kim (2013) [5], has discussed load measuring pot bearing with built in load cell part I design and performance on load measuring pot bearings with built in small size load cells inserted to the base plate of the bearing has inserted one load cell at the center of the pot bearings base plate is more advantageous that inserting several load cells. Jared Weisman(2011),discussed about the parametric finite element investigation of the critical load capacity of elastomeric strip bearings. The critical load varies significantly with different individual rubber layer thickness and bearing width at a given lateral displacement. Vinodkumar Ishwaral Jangid (2014) discussed about the design development and analysis of structural bearings for torsional forces by analytical calculation sizes of bearing parts are selected and 3D model is created to reduce the large bearing size and easy to handle.

3. Design of Pot PTFE Bearing

Pot bearing is consisting of metal piston supported by a disc of unreinforced elastomeric pressure pad, confined within a metal cylinder for allowing rotational movement about any axis in horizontal plane and to bear and transmit the vertical load. Pot bearing is to be designed, duly considering the effect on load, force and movements of the structure. While designing the bearing resistance due to friction at the sliding interface of the bearing if any may be ignored.
Pot bearings will not permit translation. When subjected to high compressive forces, the unreinforced elastomeric disc behaves similarly to a liquid. Rotations can occur due to a constant volume of the elastomer. This type of bearing combines two desirable properties, rotation capacity with a very small resistance and transmission of the bearings reaction over a defined area. Pot bearings are used for vertical forces from 1000 kN up to 100000 kN. These bearings have the advantage of very high vertical stiffness. the standard type of pot bearing allows only rotation. Vertical forces are transmitted to the pad, horizontal forces from the lid to the pot.

3.1. Material Specifications

i)	Mild Steel	:	IS: 2062 Grade-B
ii)	Stainless Steel	:	IS: 6911
iii)	Cast Steel	:	IS: 1030 grade 280-520W
iv)	Elastomer Pad	:	a) IRC: 83(Part-II) Standard Specifications and code of practice for Road Bridges - Elastomeric Bearings.
			b) IRC: 83 (Part-III) Properties of confined elastomer.
v)	PTFE	:	a) BS: 3784 grade 'A' Specification for poly tetrafluroethylene (PTFE) sheet.
			b) IRC: 83 (Part-III) for permissible pressure on confines PTFE.
			c)BS: 5350 Standard method of test for adhesives, Part-c9, Floating Roller Peel Test.

Table 1

3.2. Codes of Practice

In absence of standard code of practice for Railway bridges, the design of bearings to railway bridges is done in accordance with following documents:

i) IRS Bridge Rules

ii) IRS Steel Bridge Code

iii)IRC-83 Standard Specifications and code of practice for Road Bridges, Section: IX Bearings, Part-III: Pot, Pot-cum-PTFE, pin and metallic guide bearings.

3.3. Bearing Reactions

i) Maximum vertical force and minimum horizontal force.

ii) Minimum vertical force and maximum horizontal force.

iii) Maximum horizontal force and maximum vertical force.

iv) Minimum horizontal force and minimum vertical force.

4. Result and Discussion

It is clear from that different material property has been taken from FEM (Finite Element Method) analysis for PTFE bearing. 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 shows after taken the load capacity 600KN in the vertical direction which is acting at the top plate of PTFE bearing and 500KN in the horizontal direction due to consideration. The sectional elevation and typical plan of pot bearing as shown in Figure. 2.

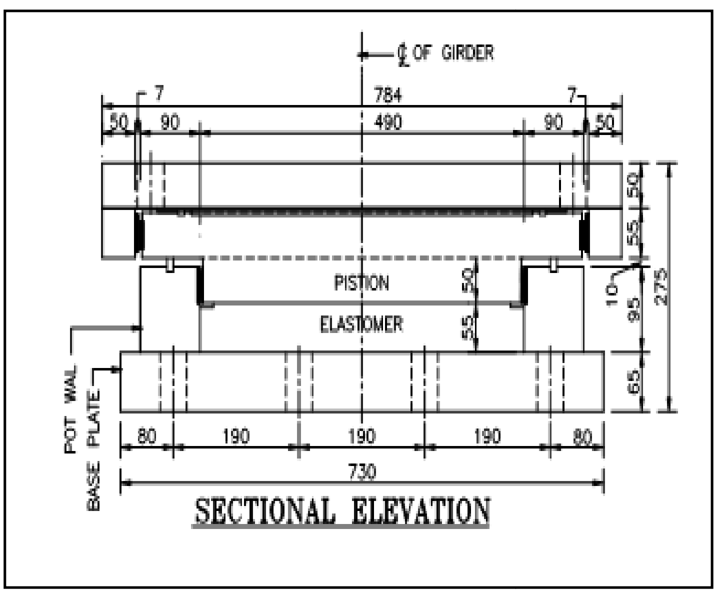


Figure 2: Sectional elevation of Pot PTFE bearing

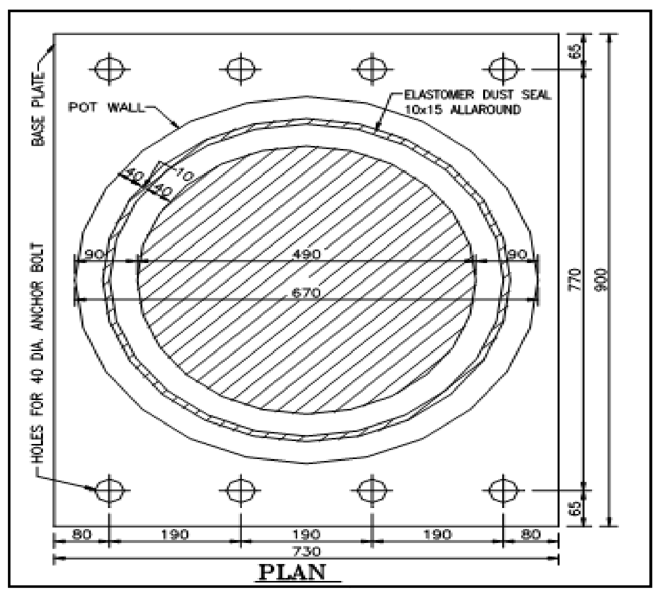


Figure 3: Typical Plan of Pot PTFE bearing

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. The modeling of pot bearing as shown in Figure. 4.

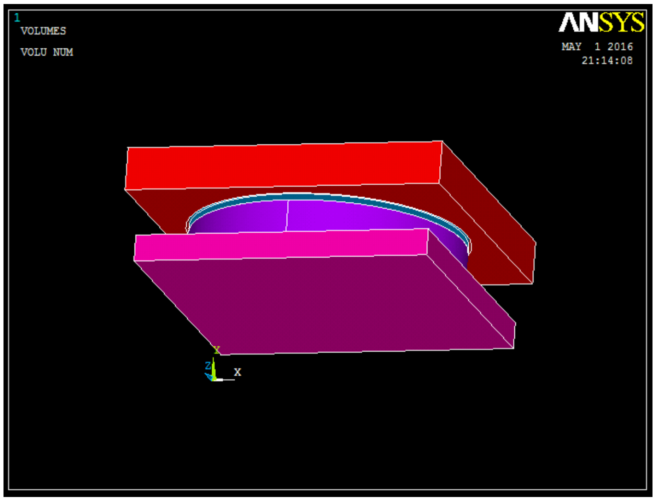


Figure 4: Modeling of Pot bearing

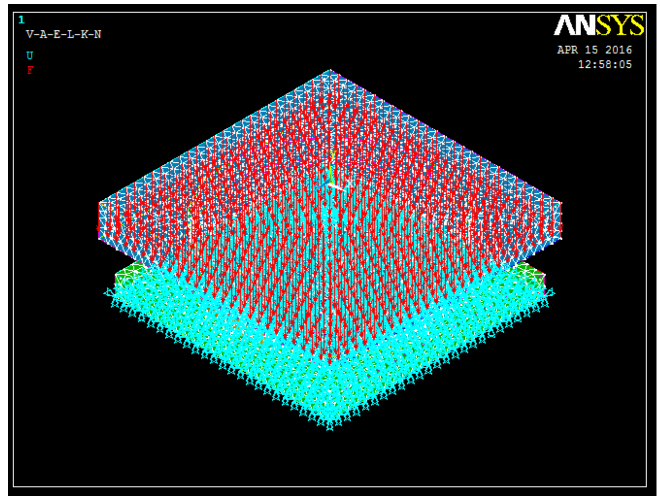


Figure 5: Vertical load of pot bearin

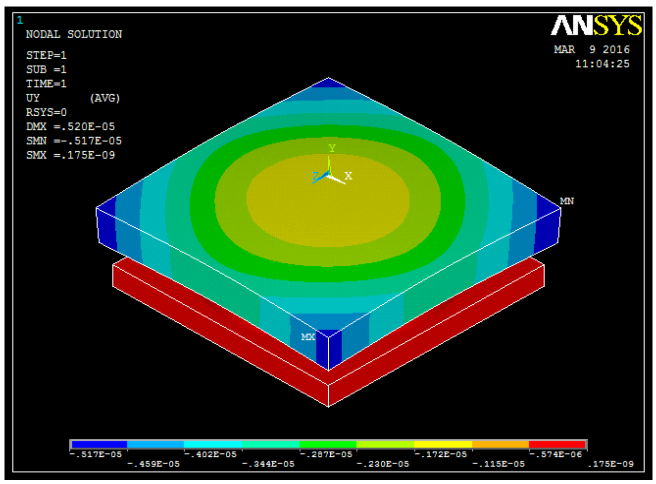
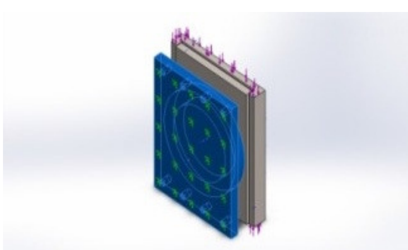
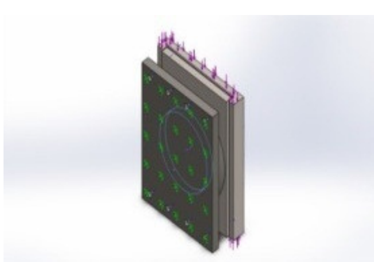


Figure 6: Vertical displacement of pot bearing

Components	Properties
	**Name:** Wrought Stainless Steel **Model type:** Linear elastic isotropic **Default failure criterion:** Max Von Misses Stress **Elastic modulus:** 2e+011 N/m² **Poisson's ratio:** 0.26 **Mass density:** 8000 Kg/m³
	**Name:** Elastomer **Model type:** Linear elastic isotropic **Default failure criterion**: Max Von Misses Stress **Elastic modulus:** 2e+009 N/m² **Poisson's ratio:** 0.394 **Mass density:** 1020 Kg/m³

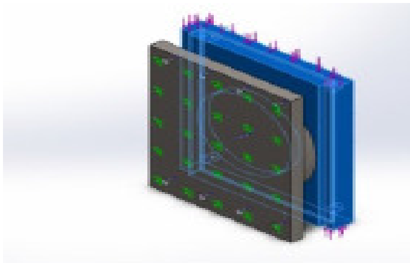
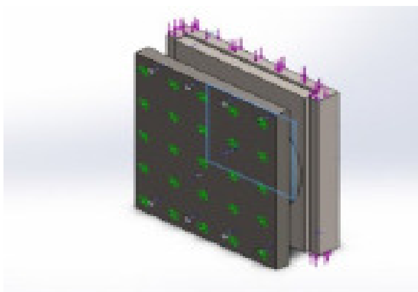
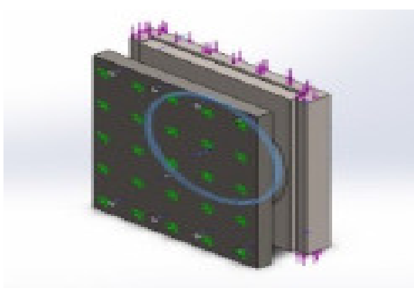
	**Name:** Stainless Steel **Model type**: Linear elastic isotropic **Default failure criterion:** Max Von Misses Stress **Elastic modulus**: 2e+011 N/m² **Poisson's ratio**: 0.28 **Mass density**: 7800 Kg/m³
	**Name**: PTFE (Poly tetra fluro ethylene) **Model type:** Linear elastic isotropic **Default failure criterion:** Max Von Misses Stress **Elastic modulus:** 2e+009 N/m² **Poisson's ratio:** 0.394 **Mass density**: 1020 Kg/m³
	**Name:** Brass **Model type**: Linear elastic isotropic **Default failure criterion:** Max Von Misses Stress **Elastic modulus:** 1e+011 N/m² **Poisson's ratio:** 0.33 **Mass density:** 8500 Kg/m³

Table 2: Material Properties of Pot bearing

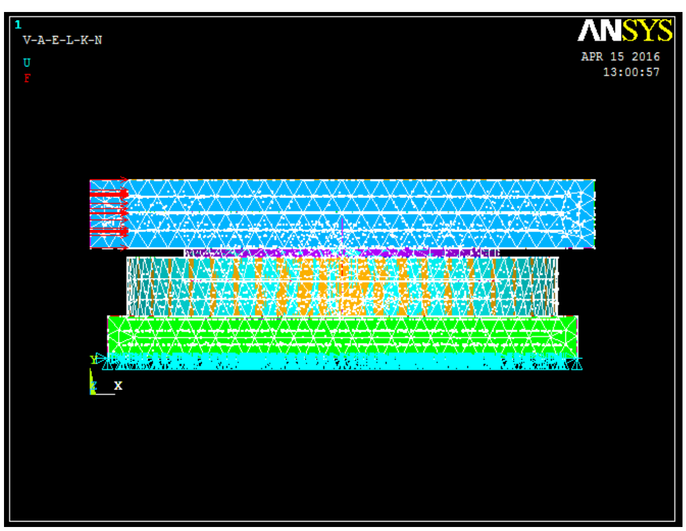


Figure 7: Horizontal load on pot bearing

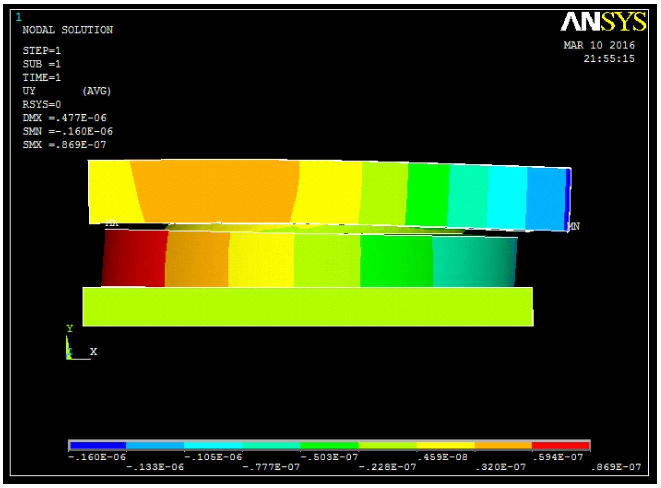


Figure 8: Horizontal displacement of pot bearing

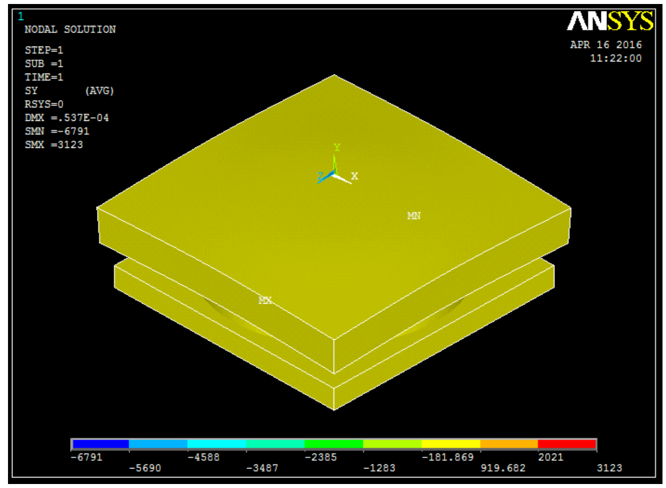


Figure 9: Stress diagram of pot bearing

4.1. Analytical Result

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
12	1500	0.437E-10
13	2000	0.583E-10
14	2500	0.728E-10
15	3000	0.874E-10
16	3500	0.102E-09
17	4000	0117E-09
18	4500	0.131E-09
19	5000	0.146E-09
20	5500	0.160E-09
21	6000	0.175E-09

Table 3: Load versus deflection

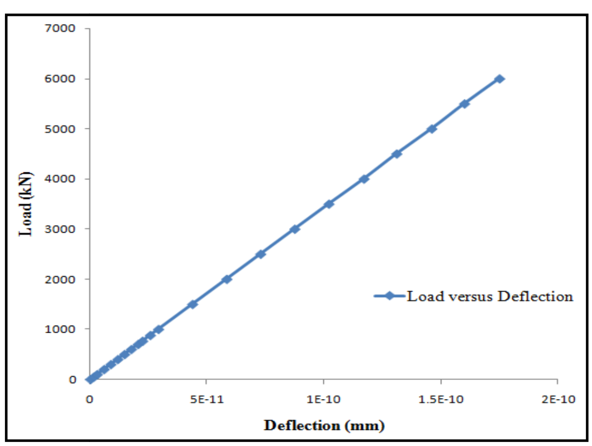


Figure 10: Load Versus Deflection

4.2. Comparison of Experimental and Analytical Pressure

It is clear that material property for the different types of materials involved in making pot bearing has been taken for FEM analysis (ANSYS). The sectional elevation of PTFE bearing in whichall the dimension has been shown after taken the load capacity 6000KN in the vertical direction which id acting at the top plate of PTFE bearing and 500 KN in the horizontal direction due to considered.

Sl.No	Vertical Load (KN)	Experimental Pressure	Analytical Pressure Result	Percentage 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	198.59	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

Table 4: Comparison of Experimental and analytical Pressure

5. Conclusion

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, elastomer 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 elastomer 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. It can be concluded that the POT PTFE bearing is very useful when it is subjected to the heavy load.

It is observed that the minimum percentage of error between the experimental and analytical applied pressure is 10.43 and maximum percentage of error is 16.61. It is observed that there is a tolerable difference between the experimental and analytical applied pressure on the pot bearing.

It is 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.

6. References

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