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Suitability of POT PTFE bearing in Bridges

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KEYWORDS

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A B S T R A C T

The design of elastomeric bearings for heavy load requires that the stability of the individual bearings be demonstrated at the maximum bearing displacement and loading condition. A component of the stability assessment is the determination of the critical load of the bearing at a given lateral displacement. Currently, the critical load is estimated through literature and is used for further study. This study verifies the finite element method for the suitability of POT PTFE bearing as a bridge bearing predicting critical loads in elastomeric bearings. The results of FEM are also validated through the literature available and the mathematical model

Introduction

The pot bearing consists of circular, non-reinforced natural rubber or 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 & pot. As the elastomeric is fully confined within a metal cylinder, it provides a load carrying medium whilst at the same time providing the bearing with a multidirectional rotational capacity. By themselves, pot bearings do not permit translation. In order to permit translational movement in addition to rotation, plain sliding arrangement is provided over the top plate of pot bearing.

PTFE (Poly tetra fluro ethylene) which is having very low coefficient of friction is generally used with stainless steel to design this sliding arrangement.

The weight of POT PTFE bearing is about 50% of the weight of conventional rocker & roller bearing for the same span. Due to its less weight and due to almost no maintenance, it is desired to provide POT PTFE bearings instead of conventional rocker-roller bearings. However, due to certain design constraints these bearings cannot be designed for all type of spans.

The behaviour of a multi-span bridge simply supported by fixed and movable bearings before and after bearing damage, using analytical models concluded that damage in a pot bearing due to excessive seismic forces transmitted from the superstructures during seismic excitations played a major role in the unseating failure of a bridge system was studied by Sang-Hyo Kim et al (2006) . Huth and Khbeis (2007) studied the behavior of pot bearings after 32 years of service by in situ and laboratory tests.

It is observed, through the study of accumulated sliding path, restoring moments etc. as well as visual inspections that sensitive parts of pot bearings, e.g. inner sealing and lubrication, showed clear deterioration appearances and during in situ measurement they discovered that pot bearings after 32 years of service were in an acceptable working condition assuming unchanged loading. They concluded that pot bearings serviceability would not be affected, but unacceptable damage to the bearings at higher vertical loads and/or higher rotational movements would occur with time.

It is clear from the figure 1 and figure 2 that how much POT PTFE bearing is using in industrial application. POT bearings have been used in many important bridges on Indian Railways. It was used, in Addition to many other bridges, in the construction of 3rd Godavari Bridge at Rajamundry having bow string arch girders of 90 m span, on Zuari and Mandovi bridges on the KRCL having 120m span open web steel girders. Recently these have also been used on a number of bridges on Jammu-Udhampur Rail Link Project (JURL) e.g. Tansi bridge (71.4+102+71.4m), Dudhar bridge (64+92+64m) and E-18 viaduct (40+29.68m) etc. POT-PTFE bearings are being used on Udhampur-Srinagar section also.

POT bearings, both fixed and sliding type can be used to advantage in all situations where there is a limitation on overall height of the bridge girder coupled with large force/movements involved. This is so because the POT bearings are substantially thinner as compared to roller bearings. PTFE sliding sheets have also been used for the launching of superstructures of bridges in Konkan Railway and JURL with great advantage.

Design Consideration of POT PTFE Bearing

In absence of 3D - FEM analysis, simplified design can be adopted. For POT bearings of vertical load capacity 7500 KN or higher, the analysis should always be done using 3D–FEM with authentic software.

POT bearings are fixed against all translation unless they are used with a PTFE sliding surface. The POT may either be one piece construction shaped by machining or fabricated by welding ring on to the base plate. The elastomer pad inserted into the POT is restrained from being squeezed out of the annular gap between the side wall and the piston by means of a set of two or three flat brass rings. The circular rings have traditionally been brazed into a closed circle, whereas the flat ones are usually bent from a strip and the ends are not joined. Brass rings are placed in a recess on the top of the elastomeric pad. PTFE rings have been tried, but have been abandoned because of their poor performance. The cover piston which fits into the POT is placed in contact with the elastomer pad. In the POT type sliding bearing the cover/piston is mounted by a sliding assembly. The upper surface of the piston is recessed and filled with the PTFE disc. The upper sliding plate is provided with a sheet of stainless steel or chrome nickel alloy steel. The PTFE disc is provided with small cavities (lubrication pockets) containing a special lubricant which ensure lifelong lubrication of the sliding surface.

Result and Discussion

It is clear from the table 1 that different material property has been taken for FEM analysis for PTFE bearing. A von mises criterion is chosen for the decision of failure analysis. Figure 3 shows the sectional elevation of PTFE bearing in which all the dimension has been shows after taken the load capacity 4500 KN in the vertical direction which is acting at the top plate of PTFE bearing and 450KN in the horizontal direction due to consideration of shock or unnatural and unpredictable vibration.

It is clear from the Figure 5 that maximum stress developed is in the range of $8.1E^{-3}$ to $204E^{-3}$which is absolutely expectable in the design. It is noteworthy that lot of literature review is also available in which the limit of stress falls in the same range. Table no 2 shows the result & model analysis which is absolutely satisfy the requirments when the seismic effect is also in consideration. In practical when the bearing is supposed to taken a heavy loads and there would be a lots of vibration which have to be taken in to consideration .in the design of PTFE bearing. all the analysis has been done in the view of above mention condition.

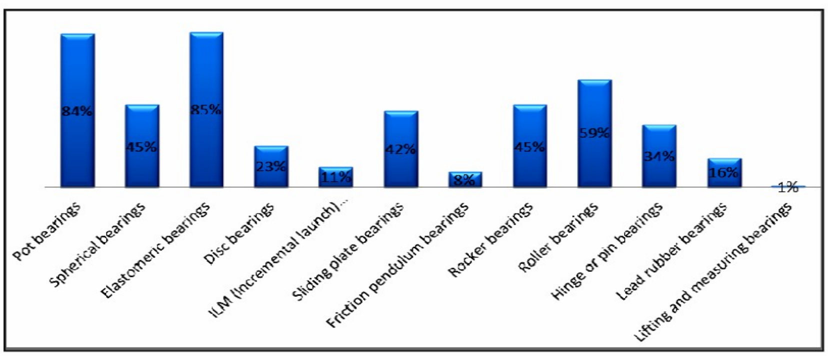


Fig.1 Bearing types familiarities (Gordon, W., Jared, W., 2011.)

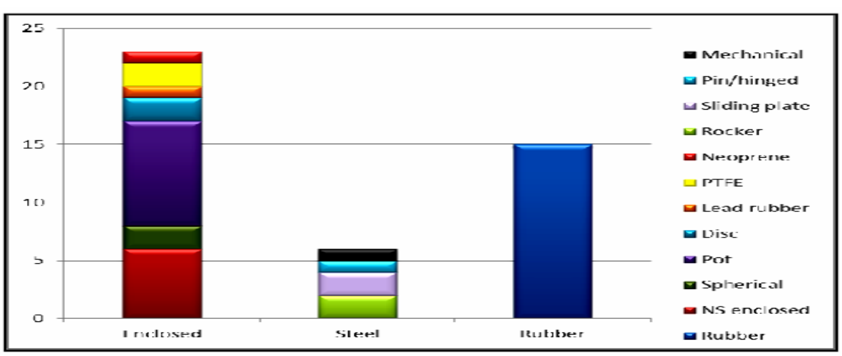


Fig.2 Most designed, specified or selected by respondents (IRICE, 2006.)

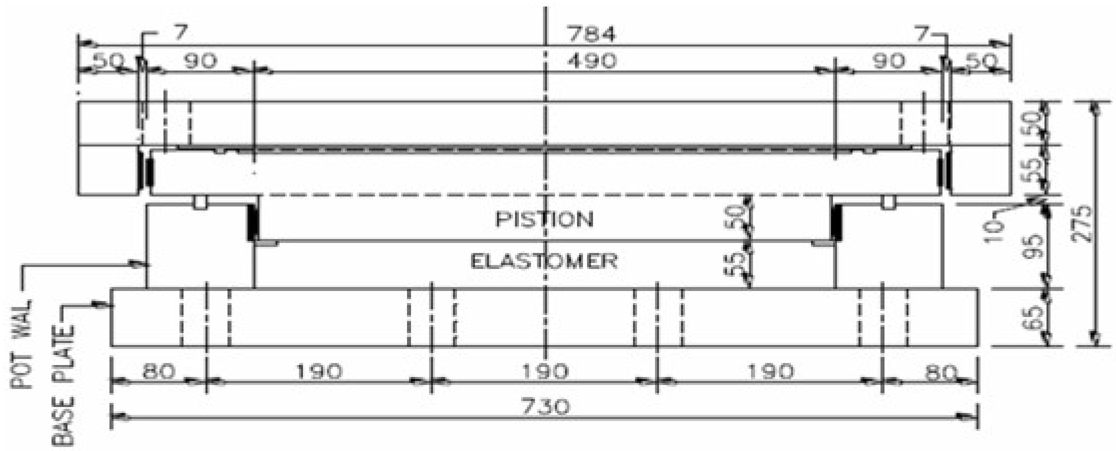


Fig.3 Sectional Elevation of Pot PTFE Bearing (BS-5400: Section 9.1,)

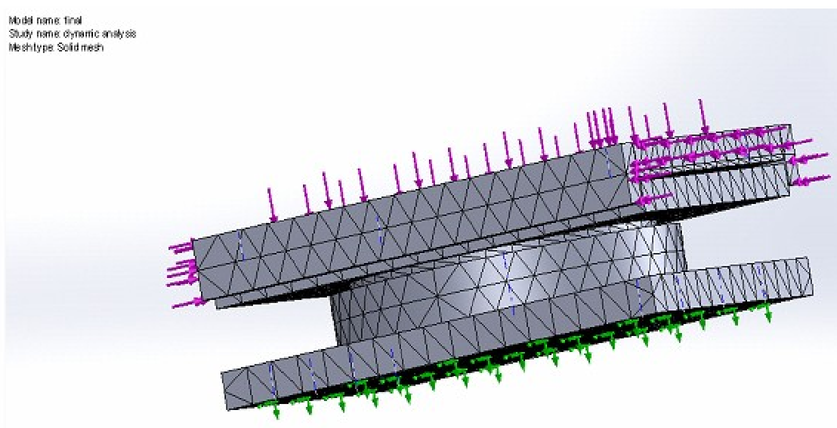


Fig.4 Load distribution and Discritization of PTFEBearing

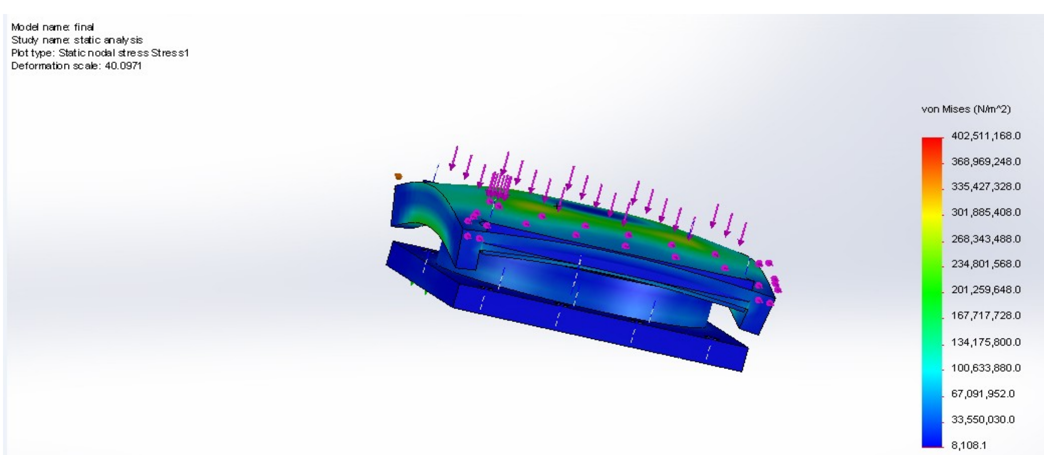
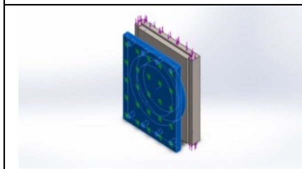
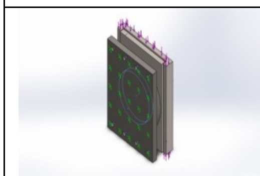
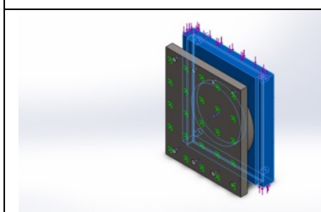
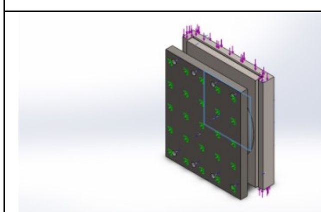
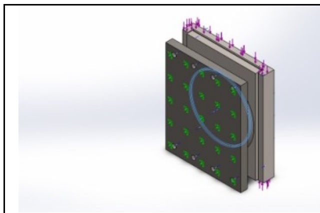


Fig.5 Structural analysis of POT PTFE Bearing

Table.1 Material properties of Individual part of PTFE Bearing

Components	Properties			
	Name:	**Wrought Stainless Steel**	Elastic modulus:	**2e+011 N/m^2**
	Model type:	**Linear Elastic Isotropic**	Poisson's ratio:	**0.26**
	Default failure criterion:	**Max von Mises Stress**	Mass density:	**8000 kg/m^3**
	Yield strength:	**2.06807e+008 N/m^2**	Shear modulus:	**7.9e+010 N/m^2**
	Tensile strength:	**5.17017e+008 N/m^2**	Thermal expansion coefficient:	**1.1e-005 /Kelvin**
	Name:	**elastomer**	Elastic modulus:	**2e+009 N/m^2**
	Model type:	**Linear Elastic Isotropic**	Poisson's ratio:	**0.394**
	Default failure criterion:	**Max von Mises Stress**	Mass density:	**1020 kg/m^3**
	Yield strength:	**4e+007 N/m^2**	Shear modulus:	**3.189e+008 N/m^2**
	Tensile strength:	**3e+007 N/m^2**		
	Name:	**Stainless Steel (ferritic)**	Elastic modulus:	**2e+011 N/m^2**
	Model type:	**Linear Elastic Isotropic**	Poisson's ratio:	**0.28**
	Default failure criterion:	**Max von Mises Stress**	Mass density:	**7800 kg/m^3**
	Yield strength:	**1.72339e+008 N/m^2**	Shear modulus:	**7.7e+010 N/m^2**
	Tensile strength:	**5.13613e+008 N/m^2**	Thermal expansion coefficient:	**1.1e-005 /Kelvin**
	Name:	**ptfe**	Elastic modulus:	**2e+009 N/m^2**
	Model type:	**Linear Elastic Isotropic**	Poisson's ratio:	**0.394**
	Default failure criterion:	**Max von Mises Stress**	Mass density:	**1020 kg/m^3**
	Yield strength:	**1.2345e+010 N/m^2**	Shear modulus:	**3.189e+008 N/m^2**
	Tensile strength:	**3e+007 N/m^2**		



Name:	**Brass**	Elastic modulus:	**1e+011 N/m^2**
Model type:	**Linear Elastic Isotropic**	Poisson's ratio:	**0.33**
Default failure criterion:	**Max von Mises Stress**	Mass density:	**8500 kg/m^3**
Yield strength:	**2.39689e+008 N/m^2**	Shear modulus:	**3.7e+010 N/m^2**
Tensile strength:	**4.78413e+008 N/m^2**	Thermal expansion coefficient:	**1.8e-005 /Kelvin**

Table.2 Frequency of POT PTFE bearing

Mode Number	Frequency(Hertz)	X direction	Y direction	Z direction
1	429.54	3.0385e-007	0.0010728	1.9704e-007
2	454.08	1.6029e-009	3.4922e-007	2.1236e-007
3	468.27	0.00053679	3.5393e-007	1.9991e-006
4	474.53	2.1709e-007	1.1508e-007	0.19264
5	492.23	1.6893e-009	1.6691e-008	3.6768e-008
6	639.99	7.6519e-005	0.41706	6.1403e-008
7	643.68	0.00017571	2.7869e-005	0.0010784
8	655.38	0.52112	6.5322e-005	1.7409e-006
9	687.75	7.5941e-006	2.9555e-007	0.012208
10	743.64	1.8545e-005	0.12923	1.7382e-009

Conclusions

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 stress developed in the PTFE disc ,elastomer 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.

References

Burtscher, S.L., Dorfman, A., 2004 Compression and shear tests of anisotropic high damping rubber bearings. Engineering structures 26 (13), 1979-1991.

Gordon, W., Jared, W., 2011. Parametric finite element investigation of the critical load capacity of elastomeric strip bearings. Engineering structures 33 (12), 3509-3515.

Hakan, S., 2009. Infrastructure structures. Lecture notes, Royal Institute of Technology.

IRICE, 2006. Bridge bearings. Indian Railways Institute of Civil Engineering

Mori, A., et al, 1996. Compression behaviour of bridge bearings used for seismic isolation. Engineering structures 18 (5), 351-362.

Margot, G., et al, 1998. Metals in America's historic buildings. Diane publishing.

Olaf, H., Halim, K., 2007. Pot bearings behaviour after 32 years of service: in situ and laboratory tests. Engineering structures 29 (12), 3352- 3363.

IRC-83 (Part III), Standard Specifications and Code of Practice for Road Bridges, Section:IX, Bearings, Part-III:Pot, Pot cum PTFE, Pin and Metallic Guide Bearings.

BS-3784 Grade „A", Specifications for Poly tetra fluro ethylene (PTFE) Sheet

BS-5400:Section 9.1, Design of Pot-PTFE Bearings.

LEE, DAVID J., Bridge Bearings and Expansion Joints, E & FN Spon London, UK.

IRS Steel Bridge Code, Research Design and Standard Organization, Ministry of Railways, Govt. of India, Lucknow (U.P.)

RDSO Design Documents for design of Pot-PTFE bearings for different spans and loadings