The International Journal Of Engineering And Science (IJES)
|| Volume || 5 || Issue || 1 || Pages || PP -42-46|| 2016 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

The effect of varying load on Design of Elastomeric pad bearing

Neeraj Kumar

Assistant Professor , Department of Civil Engineering ,Bipin Tripathi Kumoan Institute of Technology (BTKIT) Dwarahat, Almora, Uttrakhand-263653

ABSTRACT

Bearings are an important part of overall transportation and structural system. Bearings are provided in bridges to transmit the load from the superstructure to the substructure and thereby to soil mass in such a manner that the bearing stresses induced are within permissible limits. It accommodates certain relative movements between the superstructure and the substructure. This paper describes the design of elastomeric pad bearing with loads varying from 300 KN to 1500KN. In this paper shows that rotation (α_{bimax}) and permissible rotation with increasing load decreases and shape factor(S) increases with increasing load of elastomeric pad bearing.

Keywords: *Bridge, bearing, elastomeric bearing, elastomeric pad bearing, rotation and shape factor.*

Date of Submission: 13 January 2016 Date of Accepted: 28 January 2016

I. INTRODUCTION

Bearings are provided in bridges to transmit the load from the superstructure to the substructure and thereby to soil mass in such a manner that the bearing stresses induced are within permissible limits. It accommodates certain relative movements between the superstructure and the substructure. Bearing are basically classified in two types based on D.O.F. as Fixed bearing and Expansion bearing.

The expansion bearings are that bearing in which rotation and translation both occurring. Expansion bearing are of five types as Sliding plate bearing , sliding-cum-rocker bearing, Steel roller-cum-rocker bearing, R.C. rocker expansion bearing, Elastomeric bearing.

Elastomeric Bearing consisting of one or more internal layers of elastomeric bond to internal steel is laminated by the process of vulcanization. The bearing shall cater for translation and / or rotation of the superstructure by elastic deformation. Elastomeric bearing are four types as- a) Laminated Bearing, b) Pad Bearing, c) Strip bearing, d) Pot Bearing

Elastomeric Pad Bearing is that bearing which is the Sandwich structure made of elastomer and natural rubber. In this steel bearing is not used. This bearing will be vulcanised in a mould under pressure. It is also widely used because it is able to prevent and reduce the movement of the bridge due to few factors (like earthquake, creep, etc)

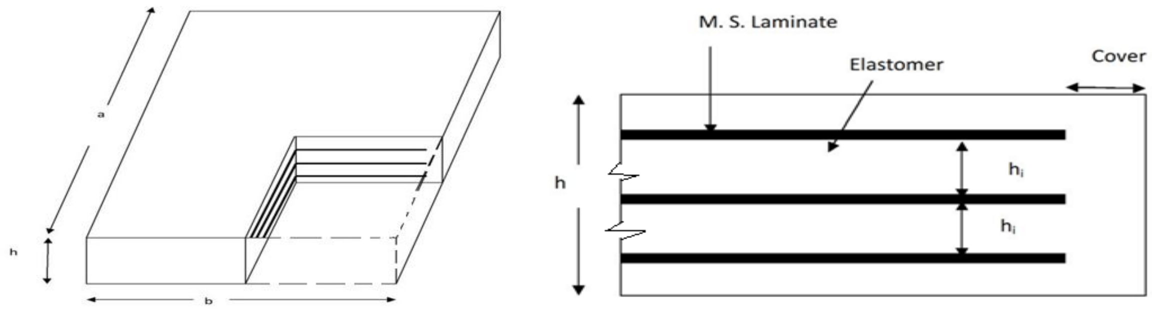

Figure 1: Components of Elastomeric pad bearing

The following guidelines that considered when selecting a bearing are:

i. Transverse and vertical load capacity
ii. Movement capability
iii. Durability and environment condition
iv. Life cycle costing of bearing including initial cost and maintenance cost with frequency
v. Aesthetic consideration
vi. Unique factors specific to particular bridge
vii. Effect of bearing selected on the subsurface because of longitudinal forces created by bearing friction or some specific cap width

Generally, only one type of bearing should be used for each structure.

II. METHODOLOGY

A. Bearing Data/ Description

In this paper, all varying load of elastomeric pad bearings are designed for longitudinal force per bearing and vertical reaction induced by longitudinal forces per bearing is 33000 N and 0 N respectively. The rotation at bearing of superstructure is 0.0025 radian. The ratio of effective area of bearing required to loaded area is limited to 2.

B. Methods

The design and analyses of all bearings are done manually considering as per Indian Road Congress IRC: 6 - 2000, IRC: 83 (Part II)-1987 and IRC: 21-2000. This conventional method is widely used with design steps as given in several text books on bridge engineering (Victor 2007, Rajagopalan 2006).

C. Design Rules

The dimensioning of the bearing and the number of internal layers of elastomer chosen are arranged in such a manner that the following design criteria are satisfied:

i) The plan dimensions are conform to 'preferred numbers' R'20 series of IS: 1076, e.g., 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 71, 80, 90, 100 cm
ii) The effective area of the bearing should be sufficient such that the average normal stress is less than the permissible contact pressure for the concrete structure.
iii) The overall length to breadth ratio is equal to or less than 2.
iv) The total elastomer thickness is occurs between one-fifth and one-tenth of the overall breadth of the bearing.
v) Translation: The thickness of the elastomer in the bearing should be adequate to restrict the shear strain due to horizontal load and horizontal movement due to creep, shrinkage and temperature to a value less than 0.7. In the absence of more accurate analysis, the longitudinal translation due to creep, shrinkage and temperature can be computed assuming a total longitudinal strain of 5 x 10^{-4} for common RC bridge decks. The shear modulus of the elastomer is assumed as 1 N mm^2 (IRC: 83-1987 permit the value of shear modulus to be between 0.8 N/mm^2 and 1.2 N/mm^2).
vi) The thickness of an internal layer of elastomer h_i, the thickness of a laminate h_s, and the elastomer cover at top and at bottom h_e are related as below :

h_i, mm	8	10	12	16
h_s, mm	3	3	4	6
h_e, mm	4	5	6	6

vii) The side cover of elastomer for the steel laminates is 5 mm to 6 mm on all sides.
viii) Shape factor: The shape factor S is defined as the ratio of one loaded area to the total force-free surface area, generally, shape factor S is between 6 and 12.

For the notation indicated in Figure 1, the shape factor may be computed from Equation (1).

$$S = \frac{(a - 2c)(b - 2c)}{2(a + b - 4c)h_i} \quad (1)$$

Where, a = Overall length of elastomeric bearing, b = Overall width of elastomeric bearing
c = Side cover, h_i = Internal layer thickness

ix) Rotational deformation: The number of elastomer layers provided shall satisfy the relation

$$\alpha \leq \beta\, n\, \alpha_{bi,max} \quad (2)$$

Where, α = angle of rotation, which may be taken as 400 M_{max} L/ (EI) ×10^{-3}
M_{max} = maximum midspan bending moment in superstructure
L = Effective span of superstructure
E = Elastic modulus of concrete in superstructure
I = moment of inertia of superstructure section
n = number of elastomer layers

$$\alpha_{bi,\ max} = 0.5 \frac{\sigma_m h_i}{b\, S^2} \quad (3)$$

For calculating $\alpha_{bi, max}$, σ_m may be taken as 10 MPa.

x) Frictional stresses: Under any critical loading, the following limit shall be satisfied, to ensure adequate friction.

Shear strain < 0.2 + 0.1 σ_m, where, 10 MPa > σ_m> 2 MPa (4)

xi) Total shear stress: The total shear stress due to normal load, horizontal load and rotation should be less than 5 MPa.

Shear stress due to normal load =1.5 σ_m/S MPa (5)

Shear stress due to horizontal load assuming shear modulus as 1MPa
= (Shear strain) ×1 MPa = (Shear strain value) MPa. (6)
Shear stress due to rotation = $0.5\,(b/h_i)^2\,\alpha_{bi}$ MPa (7)

xii) Standard plan dimensions and design data are as per IRC: 83(Part II)-1987 in Appendix I.

III. RESULTS AND DISCUSSION

This paper presents the design of elastomeric pad bearings thirteenth cases considered with varying load:

A. Summary of data for Elastomeric Pad Bearing

This paper describes the data adopted for the entire thirteenth elastomeric pad bearing which were used for parametric study in conventional method of design of elastomeric pad bearing. For all the bearing longitudinal force, and rotation properties are same.

B. Summary for Parametric study

The Shape factor, rotation and permissible rotation, obtained from conventional method as per IRC: 83 (Part-II)-1987. The properties have also been computed for internal layer of elastomer (h_i) = 10mm and 12mm. The table for the both case are presented as below:

Case.1 If internal layer of elastomer (h_i) = 10mm, then, the obtained parametric data is shown in table: 1.

Table 1: Summary of Characteristics for thirteen cases when h_i = 10mm

Maximum load reaction per bearing N_{max} (KN)	Internal layer of elastomer h_i (mm)	Number of elastomer layer n	Shape factor S	Rotation $\alpha_{bi,max}$ (radian)	Permssible rotation (radian)
300	8	1	5.835025	0.00731	0.006266
400	8	1	6.387931	0.006449	0.005608
500	8	1	7.428571	0.003775	0.003255
600	8	2	8.054795	0.003211	0.005278
700	8	2	8.054795	0.003211	0.006158
800	10	2	7.428571	0.003775	0.006567
900	10	2	7.988981	0.003292	0.005108
1000	10	2	8.054795	0.003211	0.005536
1100	10	2	8.054795	0.003211	0.00609
1200	10	2	9.49375	0.00179	0.002863
1300	10	2	9.49375	0.00179	0.003102
1400	10	2	9.49375	0.00179	0.00334
1500	10	2	9.49375	0.00179	0.003579

Case.2 If internal layer of elastomer (h_i) = 12mm, then, the obtained parametric data is shown in table: 2

Table 2: Summary of Characteristics for thirteen cases when h_i = 12mm

Maximum load reaction per bearing N_{max} (KN)	Internal layer of elastomer h_i (mm)	Number of elastomer layer n	Shape factor S	Rotation $\alpha_{bi,max}$ (radian)	Permissible rotation (radian)
300	8	1	5.835025	0.00731	0.006266
400	8	1	6.387931	0.006449	0.005608
500	8	1	7.428571	0.003775	0.003255
600	8	2	8.054795	0.003211	0.005278
700	8	2	8.054795	0.003211	0.006158
800	12	1	6.146432	0.006673	0.005803
900	12	1	6.657484	0.005688	0.004413
1000	12	1	6.665748	0.005674	0.004891
1100	12	1	6.665748	0.005674	0.00538
1200	12	2	7.867617	0.003147	0.005035
1300	12	2	7.867617	0.003147	0.005455
1400	12	2	7.867672	0.003147	0.005875
1500	12	2	7.867672	0.003147	0.006294

C. The variation of shape factor, rotation and permissible rotation with load

It can be observed that as the load increase the rotation and permissible rotation are decreases and also observed that as the load increases the shape factor increases. The variation of shape factor, rotation and permissible rotation for (h_i) = 10mm and (h_i) = 12mm are shown below:

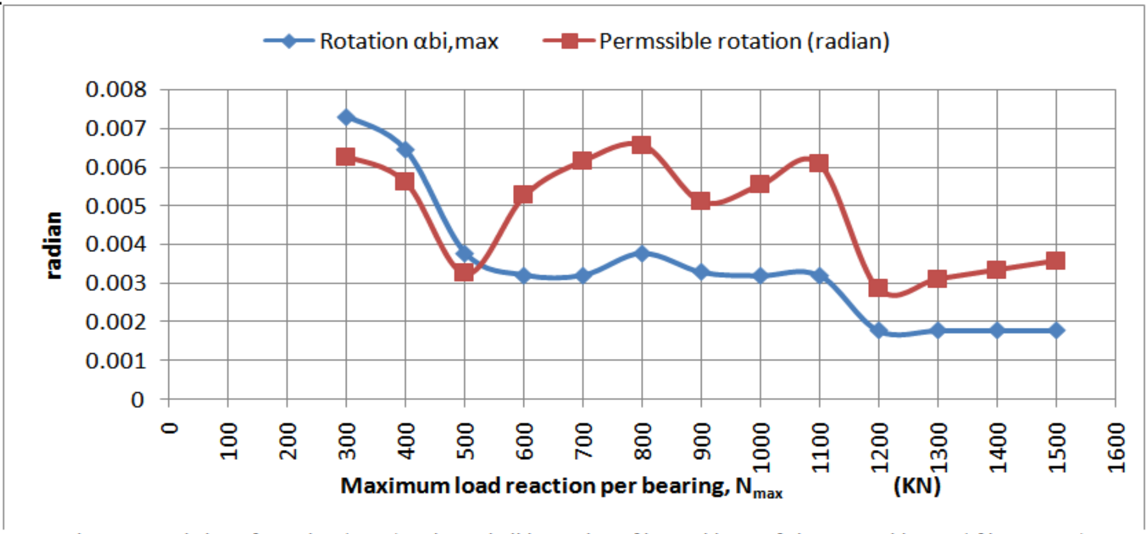

Figure 2: Variation of Rotation ($\alpha_{bi,max}$) and Permissible rotation of internal layer of elastomer with N_{max} (If h_i = 10mm)

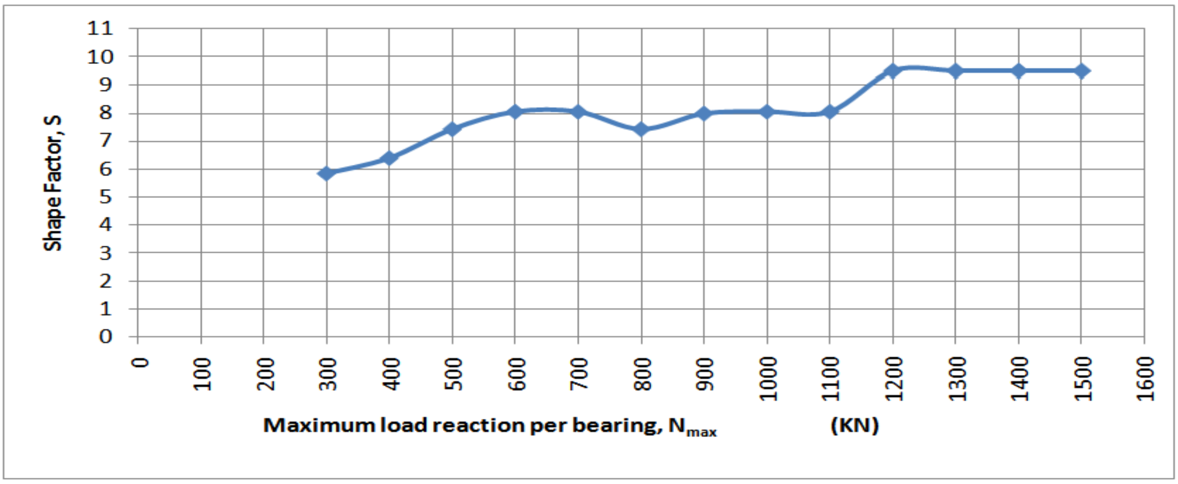

Figure 3: Variation of Shape factor (S) with N_{max} (If h_i = 10mm)

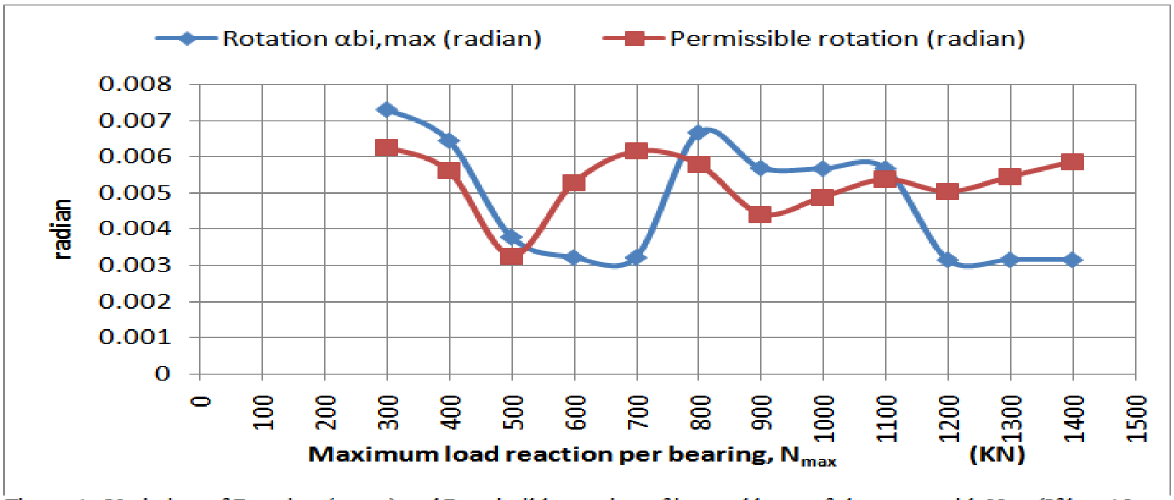

Figure 4: Variation of Rotation ($\alpha_{bi,max}$) and Permissible rotation of internal layer of elastomer with N_{max} (If h_i = 12mm)

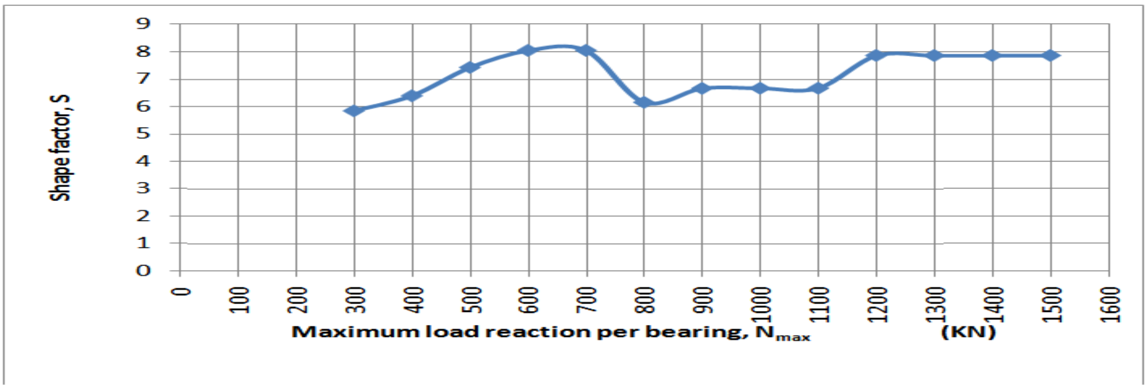

Figure 5: Variation of Shape factor (S) with N_{max} (If h_i = 12mm)

IV. CONCLUSION

This paper describes the design of elastomeric pad bearing with loads varying from 300 KN to 1500KN. On the basis of design it was concluded that rotation (α_{bimax}) and permissible rotation with increasing load decreases and shape factor (S) increases with increasing load of elastomeric bearing.

REFERENCES

[1] IRC: 6-2000, "Standard specifications and code of practice for road bridges: Section II, Loads and Stresses", Indian Roads Congress, 2000, 55pp.
[2] IRC: 21-2000, "Standard specifications and code of practice for road bridges: Section III, Cement concrete (plain and reinforced)", Indian Roads Congress, 2000, 80pp.
[3] IS: 456-2000, "Plain and Reinforced concrete, code of practice: 4th revision", Indian Standard, 2000, 81pp.
[4] IS: 1076-1967, "Indian Standard specification on preferred numbers", Indian Standard Institution, New Delhi.
[5] IRC: 83(Part II)-1987, "Standard specifications and code of practice for road bridges, Section IX, Bearing, Part II: Elastomeric Bearings", Indian Roads Congress, 1996, 29pp.
[6] Kumar N. and Mandal S. (2015), "The effect of varying span on Design of Short span Reinforced Concrete T-beam Bridge Deck", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 4, Issue 02, Feb 2015.
[7] Rajagopalan, N. (2006), "Bridge Superstructure", Narosa Publishing House, New Delhi.
[8] Victor , D. J. (2007), "Essential of Bridge Engineering", 6th edition, Oxford & IBH publishing Co. Pvt. Limited, New Delhi.