

# An Experimental Study on the Bolted Joints with Elastomers with Emphasis on the Joint Stiffness

Prashant B Tadalagi

P.G. Student

Department of Mechanical Engineering

Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka

**Abstract**— Bolted joint is one of many fastening technologies used in most of the equipment and structures. A bolt reacts with tension when the nut is tightened to clamp the members to be assembled. Bolt tension would be equal to the initial clamping force referred as pre load. Elastomers are formed by the linkage of a large number of very small structural units (monomers). Elastomeric materials are broadly used for damping augmentation in varieties of applications. The objective of this project is to introducing the elastomers in joints and to study their effect on joint stiffness. The study is predominantly experiment in nature and to evaluate the effect of different parameters like bolt diameter, tightening torque, clamping force and different elastomeric material on the joint stiffness.

**Key words:** Bolted Joint, Elastomers, Joint Stiffness

## I. INTRODUCTION

In engineering and day to day life, many cases arise when we have to join the two members. A common practice in joining the assembly structures is by mechanical fasteners. Depending on the direction of external loads (forces), bolted joints are classified into two types: Tensile joint or Shear joint. In shearing connections, a load above the certain level will most likely result in the occurrence of slip between the plates. Once slip occurs the bolts will tend to bear against the sides of holes in the connected material.

Elastomers are very large molecules that are formed by the linkage of a large number of very small structural units (monomers). The monomers are linked by means of functional, reactive groups, thereby creating composites that exhibit completely different properties to the starting materials. The degree of polymerization – i.e. the number of monomers in a polymer chain – has a significant influence on the mechanical properties of the polymers.

In this investigation three types of elastomers are used (CR, NBR and EPDM) based on availability of material.

## II. EXPERIMENT DETAILS:

A simple versatile test rig was designed and fabricated for the purpose of conducting detailed experimentation facilitating the study of effect of elastomer on joint stiffness when introduced in mechanical joint.

The rig essentially consists of three sub – assemblies. (i) Bolted joint assembly. (ii) Load measurement assembly. (iii) Application of torque facilitating assembly. The experimental details are shown in figure 1. Provision has also made in the rig to incorporate thrust bearing in between the load measurement assembly in order to reduce the frictional effects. The actual deflection in the bolted joint resulting from the application of load as a result of the applied torque is measured using a dial indicator.



Fig. 1: Experimental set up to evaluate joint stiffness.

### III. RESULTS AND DISCUSSIONS

#### A. Effect of Tightening Torque on Resulting Deflection:

The load – deflection variation for different levels of input tightening torque for different elastomers when M10 bolt is used is shown in Figure 2. Looking at the figure 2, one can conclude that there are three regions in the load – deflection plot in presence of elastomer. In region one, the rate of increase of deflection is extremely low as the load increases indicating relatively higher stiffness. In region two, a large amount of deflection results for relatively lower increase in load because of the slipping phenomenon and in region three, the deflection variation indicates a higher level of stiffness which is more or less closer to the stiffness realized in region one.

It can also be observed from the figure that the load at which the slipping occurs is higher when the input tightening torque is higher. The results are plotted when experiments are conducted without using elastomer and with an elastomer CR. The deflection substantially increases when the elastomers are used in the joint. This is due to the shearing of the elastomer within itself.

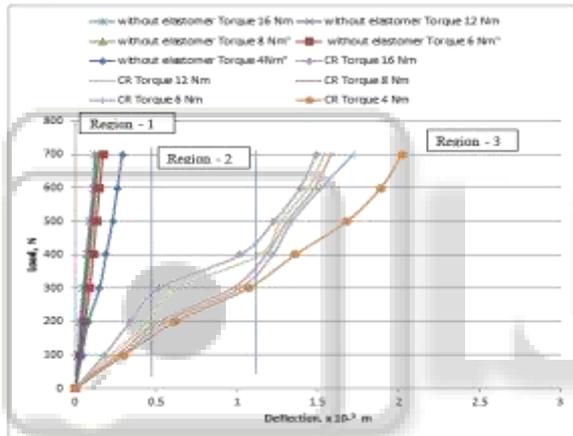


Fig. 2: Load vs. Deflection for different tightening torques for M10 bolt.

#### B. Effect of Elastomer Materials on Resulting Deflection:

It is interesting to note that the relative deflection values for different elastomer materials depends on the shore ‘A’ hardness values. The shore ‘A’ hardness values of the different elastomers is tabulated below.

	CR	NBR	EPDM
Hardness	55	65	80

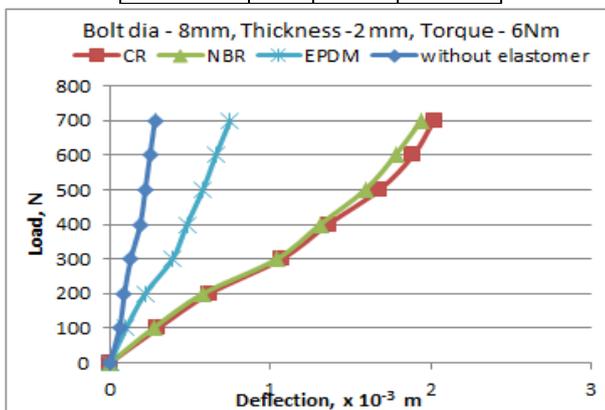


Fig. 3: Load vs. Deflection for different elastomeric materials.

#### C. Effect of Bolt Diameter on Resulting Deflection and Stiffness:

Experiments were conducted to obtain the effect of bolt diameter on the deflections keeping the tightening torque and type of elastomer materials when used constant. Relevant results are shown in figures 4. It can be very clearly seen that the joint stiffness (in view of relatively lower deflection) increases as the bolt diameter increases.

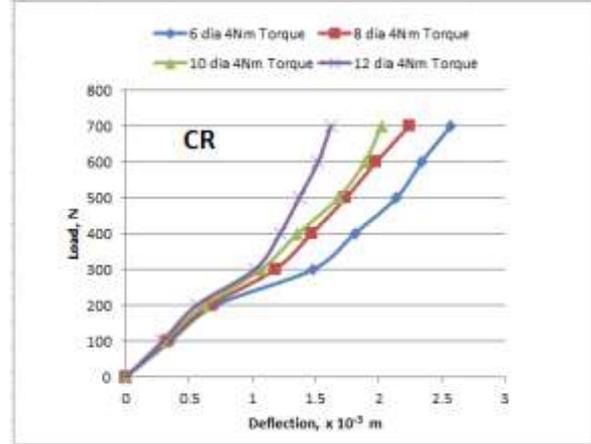


Fig. 4: Deflection vs. load for 4 Nm tightening torque for different diameters for CR

#### D. Effect of Elastomer Thickness on Resulting Deflection

The results are graphically shown in figure 5. In terms of deflection as a function of load. The typical results are very clearly indicated that the deflection increases when an elastomer thickness is increased. Similar results have been found for different kind of elastomers used in present investigation.

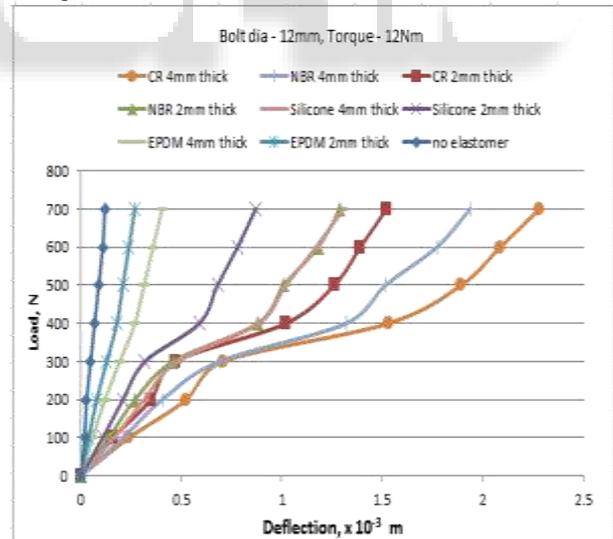


Fig. 5: Load vs. deflection for elastomer thicknesses 2mm and 4mm.

#### E. Limiting Load

Limiting load in this investigation is defined as the load required causing maximum possible deflection between the bolted members. (Bolted members to be in contact with the bolt)

It can be very clearly observed that there is a sharp increase in load (after a particular loading level) resulting the negligible increase in deflections. This indicates the

deflection in the joint has attained a maximum level and the jointed members are in contact with the bolt in the lateral plane.

This phenomenon could not be observed for the case of other elastomers in view of the limitations of load cell capabilities. The corresponding stiffness values are represented in figure 6.

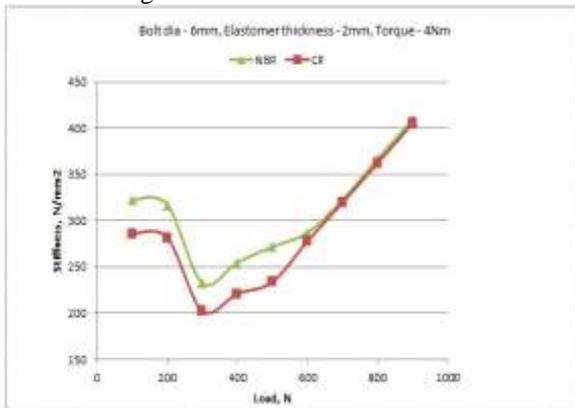


Fig. 6: Load vs. stiffness for elastomer thicknesses 2mm and tightening torque 4Nm

#### IV. CONCLUSION

The parameters varied during present investigation include tightening torque, bolt diameter, different kinds of elastomer and different thickness of elastomers. All the results have been presented graphically clearly indicating the effect of different parameters.

- 1) Joint stiffness increases with increase in shore 'A' hardness of elastomer used.
- 2) For similar tightening torque the joint stiffness increases with increase in diameter of bolt.
- 3) The increase in thickness of the elastomers results in decrease in joint stiffness for similar tightening torque.

#### REFERENCES

- [1] Rajaneesh. M. K, "Joints Stiffness Studies In Bolted Connections" in 2004.
- [2] E. Hemmati Vand, R. H. Oskouei, and T. N. Chakherlou, "An Experimental Method for Measuring Clamping Force in Bolted Connections and Effect of Bolt Threads Lubrication on its Value" in 2008.
- [3] Liang MI\*, Guo-fu YIN, Ming-nan SUN and Xiao-hu WANG, "Effects of preloads on joints on dynamic stiffness of a whole machine tool structure" in 2011.
- [4] J. Kadlowec, Glassboro, New Jersey, and A. Wineman and G. Hulbert, Ann Arbor, Michigan, "Elastomer bushing response: experiments and finite element modeling" in 2003.
- [5] Weiwei Xu • Daniel P. Hess, "Effect of Fastener Preload on Structural Damping" in 2013.
- [6] Umransendemir and Ayseondurucu, "Comparison of bolted joints with two different clearance types" in 2011.