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Innovative Elastomeric Element for Earthquake Isolation

A modern tool to study the behavior of elastomeric elements for earthquake isolation is the Finite Element Method. The results of the simulations obtained in this way provide a large series of data about the behavior of the elastomeric elements under different types of loads and help in taking right decisions regarding geometrical optimizations needed for improve such kind of devices.

Keywords: *elastomeric isolation systems, earthquake, safety, finite element method*

1. Introduction

The use of seismic isolation for structures has been gaining worldwide acceptance as an approach to aseismic design. Seismic isolation is achieved by providing suitable devices called base isolation devices between the superstructure and the foundation. The principle of base isolation is to reduce the structures natural frequency by using devices with low horizontal stiffness at the base to decouple the structure from the ground.

A variety of base isolation devices including Natural Rubber Bearing (NRB), Lead Rubber Bearing (LRB), High Damping Rubber Bearing (HDRB), frictional bearing (FB), etc., have been developed. Among the isolation systems that have gained acceptance for practical implementation, LRB isolation pads are most widely used. Full scale and reduced scale isolation devices have been developed and tested in countries like Italy, Japan, South Korea and USA.

Many experimental and numerical studies are required on isolation pads to substantiate the adequacy of design and service conditions behaviors and damping of isolation pads.

In this context IAEA is sponsoring Coordinated Research Programme (CRP), were India have a long term R&D interest in the development of seismic isolation bearings, is participating with the countries, Italy, USA, Japan, South Korea, Russia and European Commission. In this CRP, the participants were provided with experimental data on the base isolation devices and the dynamic response of structures isolated with these base isolation devices.

In the paper we studied the behavior of two elastomeric isolation element one actual and other innovative.

2. Analytical considerations of the earthquakes isolation

In our study we analyze two earthquake isolation systems, an actual elastomeric isolator and one new, one composed of intercalated layers of elastomer bonded 3, with steel 4 and at the top and the bottom with steel plates 1 and 5, which serve its attachment, figure 1. And another in which we intercalate two lamellar elements made by elastic steel 7, between them and the elastomer. Blades are united with the elastomer and are fixed in the plates 2 and 5 through two bosses 6, figure 2.

Horizontal forces are transmitted from the plates in elastomer through the slats across the bosses, the reinforcement plate can be manufactured from other materials (fiberglass), for better compressive strength.

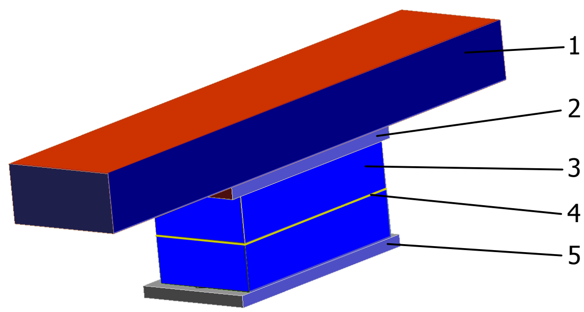

Figure 1. The actual earthquake isolator

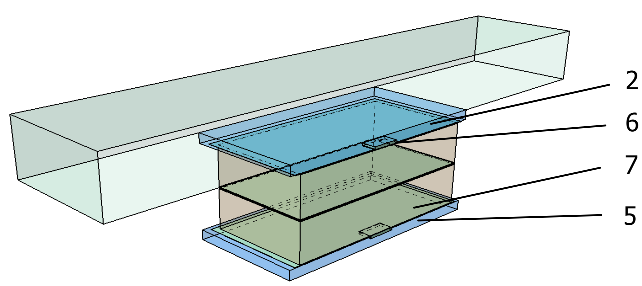

Figure 2. The new innovative earthquake isolator

The both earthquake isolators have the same dimensions 400×400×160 mm. For a better understanding of the earthquake isolators considered, first we determined the working parameters of elastomer that goes into it.

For elastomer we used the experimental characteristics of the ANSYS library obtained by DuPont, in figure 3, is presented the Neo Hookean test for elastomer.

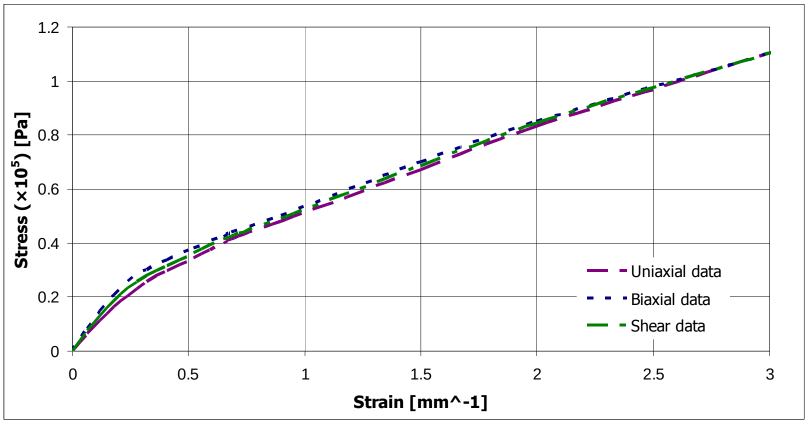

Figure 3. The neo-Hookean test for elastomer

The meshing was achieved with tetrahedral elements for the thin plats and with hexahedral elements for the massive bodies. Analyze was made in the plane of symmetry *xOz*, that allowed the reduction to half of the elements number.

3. FEM analysis of the earthquake isolators

For a good and accurate simulation, some condition was defined in order to have a succession of contacts between the components of the seismic isolator, figure 3:

- frictionless contacts between the massive plate 1 and the top plate 2;
- bounded links between the top plate 2 and the elastomeric element 3, as between the elastomeric element 3 and the lower plate 5.

Analysis's was performed in two steps:

- the massive plate 1 is driven vertically in the sense of gravity acceleration with a force uniformly distributed, which increases from zero to nominal value in the first second of analysis, then remains constant until the final analysis;
- the upper plate 2 is driven by horizontal with forces uniformly distributed on the transverse faces.

In finite element analysis for the same load conditions as described at time t = 1s, after compression vertical displacement changes is less than 1% for both earthquake isolators figure 4.

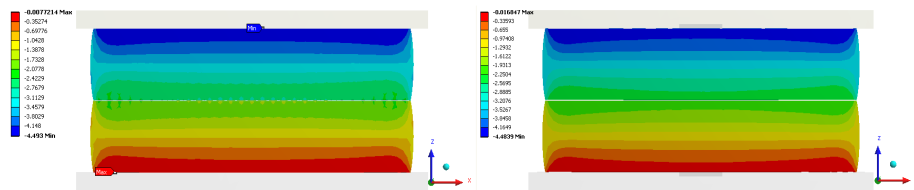

Figure 4. The vertical displacement on the Oz

For maximum horizontal force applied (t = 2 s), movements in the sense of force (the Ox), the movements of the new earthquake isolator increase by 11.9% compared with the classical isolator figure 5.

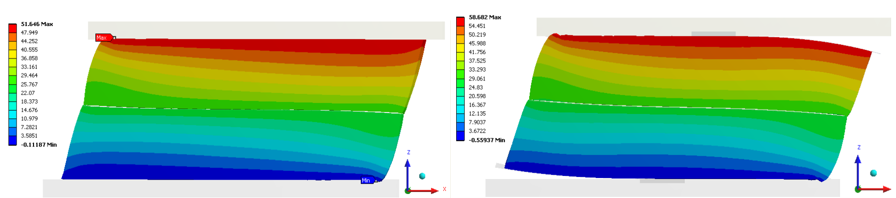

Figure 5. The horizontal displacement on the Ox

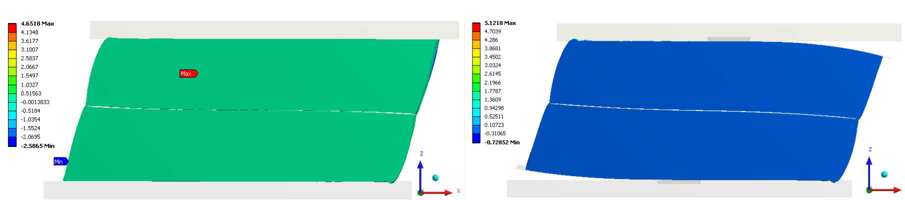

Figure 6. The horizontal displacement on the Oy

At t = 2s is observed that brazed blades deform, therefore the normal stress is reduced by about one order of magnitude on the axis Oz and on the Ox and Oy, these tensions are reduced by 50% figure 6.

This reduce the tendency of the elastomer to separat of the metallic elements that is bonded and earthquake isolation system provides increased durability. The phenomenon of separation of the upper plate that slides into the bottom appears only if the horizontal force exceeds a critical value figure 7.

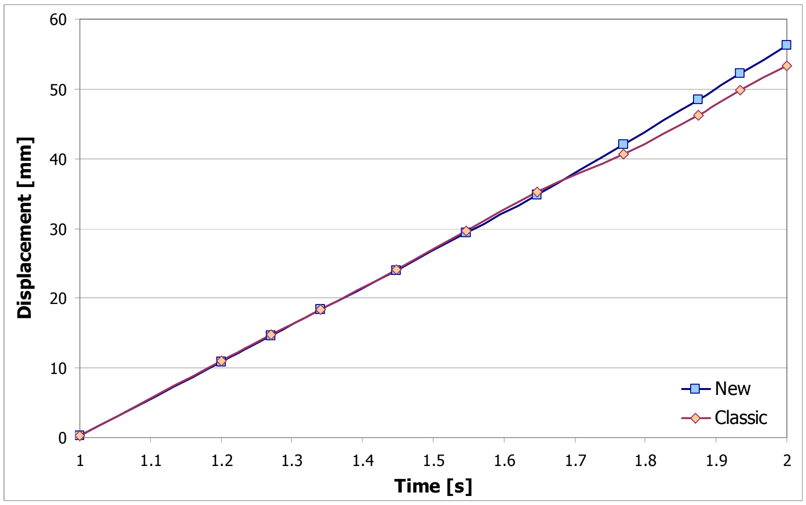

Figure 7. The horizontal displacement

4. Conclusion

The innovative elastomeric element for earthquake isolation presented in this paper allows to choose for early design stage the elastomer stiffness and the steel blades, also you can define a dynamic response application customized for each earthquake system isolation.

Finite element analysis performed using standardized systems for both classical and innovative earthquake system, revealed the higher elastic possibilities setting and absorption characteristics for the new system. However, analysis indicates that normal tensions that lead to the disposal of earthquake systems are significantly reduced for the innovative earthquake system.

Acknowledgements

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