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Development of Flexible Bearing

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Abstract

Elastomeric base isolation systems are proven to be effective in reducing seismic forces transmitted to buildings. However, due to their cost, the use of these devices is currently limited to large and expensive buildings. A fiber reinforced elastomeric isolator utilizes fiber fabric, such as carbon fiber, glass fibre, and etc. as the reinforcement material instead of solid steel plates. The fibre fabric reinforcement is extensible in tension and has no flexural rigidity. Elastomers normally used in the isolator are natural rubber; neoprene, butyl rubber and nit rile rubber etc. These devices were fabricated by binding alternating layers of rubber and fibre mesh. The fibre mesh is used to increase the vertical stiffness of the bearings while maintaining low lateral stiffness. Characterizing the behaviour of a fibre reinforced bearing "shape factor" of the bearing, Poisson's ratio of the elastomeric material and flexibility of the reinforcing sheets and investigate the effect of reinforcement flexibility on compressive behaviour of elastomeric bearings with different geometrical and material properties. Bonding with fibre reinforcements can increase the stiffness of elastic layers only when the elastic layer is compressed.

Keywords: SRBI (Steel reinforced base isolator), FRBI (Fibre reinforced base isolator), NR (Poly isoprene), Reinforcements..

Introductions

Elastomeric bearings are finding ever increasing application in today's construction industry. Although used extensively in Bridges, bearing pads are being specified in a wide variety of applications where flexible structural support and/ or vibration isolation is required. The typical application range is from concrete buildings and parking garages to heavy industrial equipment, storage tanks and pipe supports. Their popularity is understandable in view of the following advantages Performs required functions efficiently Totally maintenance free No moving parts and therefore no wear & tear No corrosion Absorbs shocks & vibrations Cheaper than mechanical bearings Simple to install Capable to accommodate small irregularities in the loading surface.

A. *Function of a base isolator*

A base isolated bearing must perform the following basic functions Support vertical loads with a minimum of deflection. Allow horizontal movement with minimal resistance thereby reducing detrimental Effects of creep, shrinkage and temperature change. Allow rotational movement with minimum resistance. Obtain uniform distribution of loads.

B. *Elastomers*

Elastomeric Bearings have no moving parts to perform their required functions. Instead, they achieve this through deformation of the Elastomers. Obviously then, the properties of the Elastomers largely determine the behaviour of the bearing. Although a wide variety of Elastomers are available, only two types are allowed in base isolated bearings (I) Natural Rubber (ii) Neoprene

C. *Natural rubber*

Natural rubber is an elastomeric material which is used as Low frequency anti vibration mountings Structural bearings. So that it should have the following properties Very high resilience , low damping for maximum vibration isolation efficiency , very low creep and low chemical and oil resistance

D. *Reinforcements*

Enforcing a material into another material will produce new kind of structure with enhanced properties of primary material. In flexible bearings steel and fibber used as the reinforcements which will stiffen the its structure when it is subjected loading

E. *Steel*

Bonding of sheets of rubber to thin steel reinforcing plates to produce a composite with very

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high vertical and low in-plane stiffness. Present applications of these isolators, which are in general expensive and heavy, are often restricted to the protection of critical facilities, such as command centres, computer facilities, hospitals, landmark and historic structures.

F. *Fibre*

For the effective use of fibres in Elastomers Fibres should be significantly stiffer than the matrix,i.e. have a higher modulus of elasticity than the matrix Fibre content by volume must be adequate. There must be a good fibre-matrix bond. Fibre length must be sufficient. Fibres must have a high aspect ratio, i.e. they must be long relative to their diameter. Fibre fabrics used in the bearings are bi-directional carbon fibre fabric and twisted bi-directional glass fibre fabric.

G. *Glass fibre*

Unlike glass fibber used for insulation, for the final structure to be strong, the fibber's surfaces must be almost entirely free of defects, as this permit the fiber to reach gigapascal tensile strengths. If a bulk piece of glass were to be defect free, then it would be equally as strong as glass fibre; however, it is generally impractical to produce bulk material in a defect-free state outside of laboratory conditions. The manufacturing process for glass fibber suitable for reinforcement uses large furnaces to gradually melt the silica sand, limestone, kaolin clay, fluorspar, colemanite, dolomite and other minerals to liquid form. Then it is extruded through bushings, which are bundles of very small orifices (typically 5–25 micrometers in diameter for E-Glass, 9 micrometers for S-Glass).

H. *Metal and fiber reinforced isolator*

The reinforcing elements of multi-layer elastomeric isolation bearings, which are normally steel plates, are replaced by a fibre reinforcement. The fibber-reinforced isolator is significantly lighter and could lead to a much less labour-intensive manufacturing process. In contrast to the steel reinforcement, which is assumed to be rigid, the fibber reinforcement is flexible in extension. The primary weight in isolators due to the reinforcing steel plates, which are used to provide vertical stiffness to the rubber-steel composite element. The high cost of producing the isolator's results from the labour involved in preparing the steel plates and assembly of the rubber sheets and steel plates for vulcanization bonding in a mold. Both the weight and the cost of isolators can be significantly reduced by eliminating the steel reinforcing plates and replacing them with a fibre reinforcement. The reduction in weight is possible because fibber materials are now available with an elastic stiffness that is of the same order as steel. The reinforcement needed to provide the vertical stiffness may be obtained by using a similar volume of a very much lighter material. Manufacturing cost may be reduced if the use of fibber allows a simpler, less labour-intensive process

I. *Fundamental concepts of base isolation*

The term base isolation uses the word a) isolation in its meaning of the state of being separated and b) base as a part that supports from beneath or serves as a foundation for an object or structure. The structure (a building, bridge or piece of equipment) is separated from its foundation. The original terminology of base isolation is more commonly replaced with seismic isolation nowadays, reflecting that in some cases the separation is somewhere above the base – for example, in a building the superstructure may be separated from substructure columns. In another sense, the term seismic isolation is more accurate anyway in that the structure is separated from the effects of the seismic, or earthquake.

Experimental section

The steps involved in the experimental work is carried out in following order Mixing, Making RC & sizing fibre to the required shape, Applying bonding agent, Molding, testing & results.

TABLE NO.1 Specification of Base Isolator

Bearing type	**SRBI**	**FRBI**
Elastomer used	Natural rubber	Natural rubber
Reinforcements	Steel	Glass fibre
Shape	Circular	Circular
Size	150mm dia	150mm dia
Thickness of rubber layer	1-2mm	1-2mm
Thickness of reinforcement	1-1.5mm	0.5-1mm
No. of. rubber layers	25	22
No. of. Reinforcement layer	23	20

A. *Preparation of rubber compound*

With 40 or 50phr of filler (HAF), rubber compound will be prepared, other all ingredients will be taken to the required amount, Mixing can be done by a 2 roll mill or a kneader in 25minutes, each and every ingredient are to be taken constant intervals to mix thoroughly.

B. *Making rubber compound & fibre*

Sheeting out the rubber compound from 2 roll mill in the thickness of 1or 2mm and then cut it

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to the circular shape with the diameter of 70mm. Fibre also has to cut at the same shape and size

Figure.1. (a) glass fibre, (b) steel plate.

C. *Making & applying adhesives on steel/fibre*

Ifsteel is the reinforcement; the adhesive slurry has toluene and chemlock and then applies it on the steel plates and dries it for one hour. If reinforcement is glassfibre, adhesive has to be prepared separately. For that, take equal amount of ingredients such as tetra methylthiuramdisulphide (TMTD), zinc oxide & tetraethyl orthosilicate (TEOS) and then mix it all thoroughly after that add 0.1% of potassium permanganate (KMNO4) with it, finally add methyl ethyl ketone (MEK) as it required to make slurry and then apply it on thecutted fibre layers, keep it all in an oven at 80 C for 1 to 3hours.

D. *Molding*

Arrange equal number of steel/fibre and rubber layers in the mold. An isolator has maximum of 22 rubber layers and 20 fibre layers. After that keep it in compression molding machine at 150 C for 15 minutes. Finally take the product out from the mold and send it for testing.

Figure.2. Steel reinforced base isolator

Testing

Compression and Shear tests for the Elastomeric Isolators samples were done using Universal Testing Machine (UTM). It is shown in the figure given below.

Figure.3 (a) (b)

Figure.3 (a) shows the fixed base (bottom) and movable face (top), a job is fixed in between the faces by using an attachment and LVDT was fixed both sides of it.
(b) Shows the hydraulic actuator.

A. *Compression Test*

There are three types of isolators were produced .They are 1. Steel reinforced elastomeric isolator (SREI) 2. Wire mesh reinforced elastomeric isolator (WMREI) 3. Fibre reinforced elastomeric isolator (FREI). This test was done by applying the compressive load on the sample which was placed in the load cell and the load cell was placed on the base plate of the of the UTM machine. Force was given through the hydraulic actuator & it is shown in the figure.5. The result was obtained in form of graph which is plotted between load & deflection. From the graphs compressive stiffness for the three isolator can be calculated by using the formula given below.

Compressive (or) Vertical Stiffness = comp load / deflection ------------------ (1)

Result & discussion

As per the procedure said above, those three isolators were tested and the results of each and every isolators given in the graph below. It is followed by vertical stiffness's was calculated.

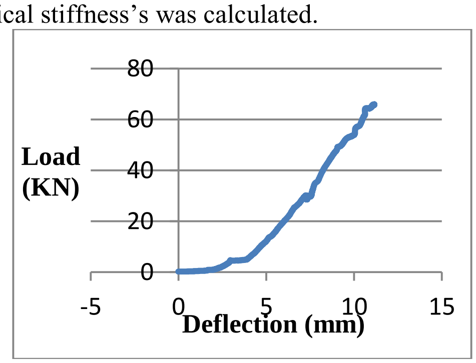

Figure.8 Load vs. deflection of (i) SRBI

(ii) FRBI

Calculations:
For SRBI-1(MS plate)

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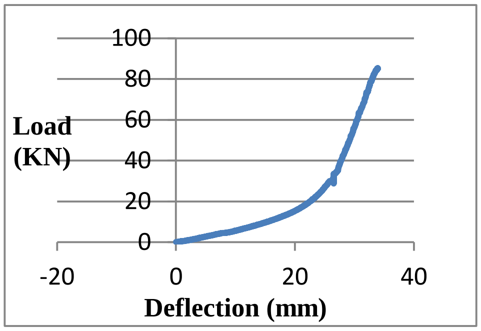
Steel = 65.9*1000/11.16303 = 5903.41 N/mm

For FRBI (Glass fiber)

Kg = 85*1000/33.94886 = 2506.71 N/mm

The graphs which are showing above are load vs. deflection of three different isolators. It is known that all the three isolators are able to withstand by the same extreme load of about 90KN. But the deflection varies from one isolator to another isolator. In steel reinforced elastomeric isolator (SRBI), deflection was low while comparing to wire mesh and glass fiber reinforced isolator, but there was some permanent deformation after removing the load. As like as SRBI, in Wire Mesh REI also was showing a permanent deformation after releasing the load, but it was lower than SRBI and higher than GRBI. So that vertical stiffness has been increased by replacing glass fiber instead of solid steel plate and horizontal stiffness was maintaining as low. It was proved that fiber has no flexural rigidity. Weight can be reduced and even cost has also been reduced by replacing the fiber instead of solid steel plate.



Conclusion

By replacing the glass fibre(S glass) as a reinforcement material instead of the solid steel plate, deformation has been reduced; strength of the isolator has increased. Horizontal deflection of FREI was more than WMREI and SREI. So that vertical stiffness has been increased but the lateral or horizontal stiffness has been reduced. Weight and cost was reduced also FREI doesn't require complicated process as like as SREI.

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