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Performance of Base Isolator from Scrap Tyre Rubber Pads on Building

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***Abstract*:- One of the most common areas in structural engineering study is reducing the consequences of strong ground vibrations on buildings. The installation of devices with low horizontal stiffness can reduce seismic strain on structures by offering a certain degree of flexibility in the structure. The most common types include elastomeric bearings, sliding bearings, and hybrid systems. The introduction of flexible layer increases the deflection of the structure, thereby increasing the time period of the structure and decreasing the base shear. The Eco-friendly Scrap Tyre Rubber Pads (STRPs) provide several advantages such as low-cost, ease of handling and, simple shear stiffness adjustments, by changing the number of layers. They also provide environmental benefits, by recycling scrap tyres unlike other commercially available base isolators. In the present study, the properties of STRP specimen are evaluated experimentally. The STRPs are prepared by inserting layers of thin steel shims between rubber pads. Steel plates are provided at top and bottom and the entire assembly is subjected to vulcanization process. The tests conducted are (a) axial compression test and (b) horizontal shear test. Using the properties of STRPs obtained experimentally, a base-isolated G + 5 Reinforced Concrete (RC) building is analysed on software ETABS. It is found that there is considerable reduction in the base shear and storey drift by installation of STRPs. Hence the innovative base isolators from Scrap Tyre Rubber Pads can be used for low rise structures as base isolators.**

Keyword: Elastomeric bearings, stiffness, base isolators, base shear, seismic strain, Scrap Tyre Rubber Pads

INTRODUCTION

Base isolation is an effective and tested method for reducing impact of seismic activity of civil engineering structure. It also acts as a tool in providing control in the energy and vibrations which get transmitted from base foundation to superstructure. In order to acquire this process multiple pliant layers of isolators are fixed between super and sub structure as a result natural period of time gets increased and natural vibrational frequency gets reduced. This will disturb the resonance between ground acceleration and structural vibrations. Base isolation system reduces displacement, activity at the bases and member forces in the structure. Different types of base isolator are: Lead Rubber Bearings, Laminated Steel Rubber Isolators, multi-layer stones, elastomeric bearings, High Damping Rubber Bearings, Flat slider bearings, Friction pendulum bearings, Ball and Roller Bearings. Most commonly used bearings are Rubber Bearings and friction bearings, which depends on energy dissipation of the bearings.

Scrap Tyre Rubber Pads provide several advantages such as low-cost, easy in handling and provide simple shear stiffness adjustments, by changing its number of rubber layers. They are ecofriendly by recycling scrap tyres unlike other commercially available base isolators. In the present study, the properties of STRP specimen are evaluated experimentally. The STRPs are prepared by inserting layers of thin steel shims between rubber pads. Steel plates are provided at top and bottom and the entire assembly is subjected to vulcanization process. Rubber segments between reinforcement layers give low horizontal stiffness, whereas steel or fibre reinforcement within the elastomeric isolators provides significant vertical stiffness. The steel plates within traditional elastomer-based isolators have the same effect as tyres. As a result, rectangular shaped layers are cut from worn tyres and stacked on top of one another, acting as an elastomeric bearing. For base isolation of heavy structures, masonry structures, pedestrian bridges, equipment isolation, and other applications, STRPs can be employed as a low-cost alternative to conventional elastomeric bearings.

LITERATURE REVIEWS

1 **(Mishra and Igarashi) et al 2020** developed low-cost seismic isolators, researchers conducted trials as well as an analytical study on layer-bonded Scrap Tyre Rubber Pad (STRP) isolators in 2020. Vertical compression and horizontal shear tests were carried out with variable axial loads, and the findings were utilized to calculate various mechanical parameters of the STRP isolators, such as damping ratios, vertical stiffness and horizontal stiffness.

2 **(Turer and Ozden) et al 2020** used discarded automotive tyres in studies to build low-cost seismic base isolation pads. Experimentally, the mechanical and dynamic properties of STRP specimens constructed from several tyre brands, with varying numbers of layers and orientations, were assessed. These STRP tests were compared to each other as well as a commercially available Laminated Rubber Bearing (LRB) specimen.

3 **(Karim S Numayr, Rami H Haddan, 2020) et al** paid serious concern on effectiveness of base isolation of an asymmetric single-story building subjected to the EL-CENTRO earthquake is explored in this research. Three distinct isolators (lead rubber bearing, high damping rubber bearing, and coil spring) were used, and their

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effectiveness in minimizing seismic reaction was assessed. To improve the efficacy of different isolators, a magneto-rheological damper is used. The impact of incorporating the SOFT SOIL INTERACTION on the performance of various isolators was also looked into. As a result, HDRB outperformed all of the isolators in this scenario. Single-story buildings are also displacing more people.

4 **(Mikayel Gregor Melkumyanm, 2018) et al** describes in detail the new structural concepts of retrofitting by base isolation. The results of analyses of these buildings in accordance with the provisions of Armenian Seismic Code and also time history analyses. Retrofitting is done with modifying the property of laminated rubber. This reduce the overall cost of base isolation up to 25%.

5 **(OMKAR SONAWANE, SWAPNIL B. WALZADE) et al** study the performance of base isolation i.e. comparing the effectiveness in regular and irregular multi storied RC frame building using Time History analysis with ETABS software version 2013. The time period for the building in all modes is found to increase after the installation of Base isolation. This in turn decreased the value of Sa/g and thus reduced the value of Base Shear. This provide stability to the structure during earthquake.

OBJECTIVE

This objective of the work is to propose a low-cost alternative seismic base isolation system, making use of scraped used tyre rubber. The primary objective of the research is to develop a base isolation system, which shall be effective in reducing the seismic demand and force on structures, made from affordable cost and easily available materials.

- To study and examine the behavior of scraped tyre rubber pads (STPs) under compression and shear pressures.
- Analysis of fixed base Reinforced Concrete (RC) buildings in seismic zone 4 using ETABS 2019 software.
- Analysis of Reinforced Concrete (RC) building with same parameters installed with Lead Rubber Bearing base isolation system in ETABS 2019 software.
- Analyze of Scrap Tyre Rubber Pads (STRP) base isolated Reinforced Concrete (RC) building on ETABS 2019 software.

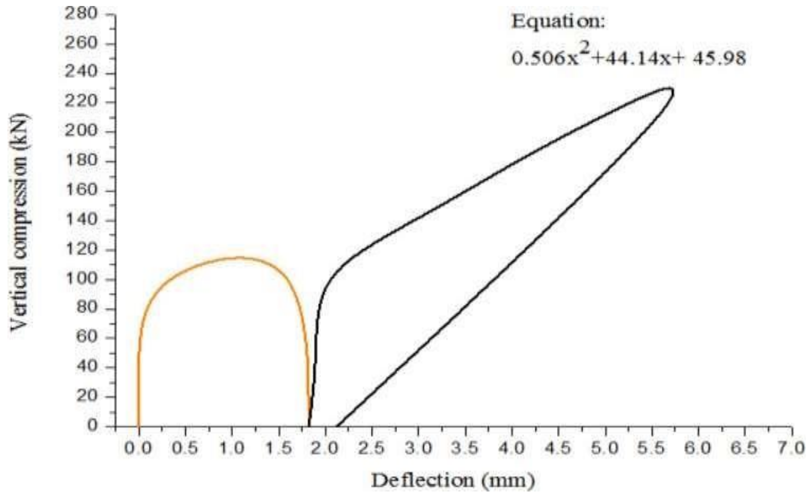
METHODOLOGY

Experimental test

Preparation of Scrap Tyre Rubber Pads sample

The specimen samples were prepared by using scrap tyres of heavy automobile vehicles. Square samples of size 150 mm and 200 mm were prepared. The layers were glued for bonding and to keep them together such that they act like a single unit. Epoxy araldite RB -106 was used as an adhesive. Using four such layers, the total thickness of the STRP was 62 mm. Two pieces of plywood, one above the sample and the other below the sample were placed to fix the C-clamp, to provide load on the sample for their proper bonding. The samples were then kept undisturbed for 7 days, as the epoxy requires 7 days for curing.

Compression test on STRP



In order to investigate the vertical stiffness and vertical load carrying capacity of the layer- bonded Scraped Tyre Rubber Pad axial compression test was performed. Three samples of Radial tyre were tested. One sample of tyres was tested to determine the maximum load carrying capacity until failure, initiated by severe cracking.

S. No.	Sample	Load Bearing Capacity(KN)	Max. Deflection(mm)
1.	Sample 1	610.1	2.16
2.	Sample 2	567.4	2.19
3.	Sample 3	604.9	3.2
Average		594.13	2.18

Fig. 1 Graph of cyclic loading

Maximum vertical load carrying capacity of Radial Tyres was obtained was 594.13 KN Cyclic loading test was carried out on this sample to find the vertical stiffness.

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$$K_h = \frac{f(+)-f(-)}{\delta(+)-\delta(-)} = \frac{506.147-505.91}{1.86-0.938} = 0.257\ KN/mm = 257\ KN/m$$

Equation of curve is

$$y = 0.506x^2 + 44.14x + 45.98$$

$$K_v = \frac{dy}{dx} \text{............ } (K_v \text{ indicates vertical stiffn}$$

$$\frac{dy}{dx} = 1.102x + 44.14$$

At $x = 2.187mm$ (average)

$$K_v = \frac{dy}{dx} = 46.35\ MN/m$$

Therefore, the vertical stiffness of the sample is **46.35 MN/m**.

Result of Horizontal Shear test on STRP

S. No.	Sample	Cyclic Loading (N/mm^2)	Deflection (mm)	Horizontal Load(KN)
1.	Sample 1	0.3 N/mm^2 to 1.2 N/mm^2 to 0	1.86	506.147
2.	Sample 2	0.4 N/mm^2 to 1.6 N/mm^2 to 0	0.938	505.91

The horizontal stiffness for this sample is
257 kN/m.

Modeling

The present study is carried out to study different structure aspects related to Base isolation system. To study the performance of base isolation using Scraped Tyre pads, a comparative study will be done among fixed base and isolated base. Scraped Tyre pads base isolation will be compared with conversional Elastomeric bearing i.e. Lead Rubber Bearing.This impact can be considered in the seismic investigation by utilizing comparable spring to address the SSI impacts. The building considered in the analytical study is a RC Frame structure of

The 5 storey a G+5 Reinforced Concrete buildings of plan 12m x 14m with each grid spacing 3m in both directions are modeled and analyzed. The software ETABS 2019 is used for modeling and analyzing of the building. The analysis of building is done for zone IV (severe seismic zone).

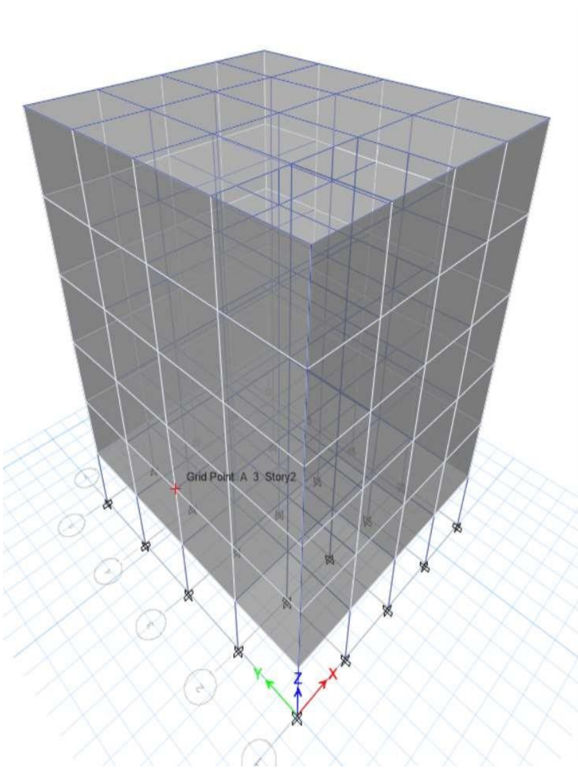
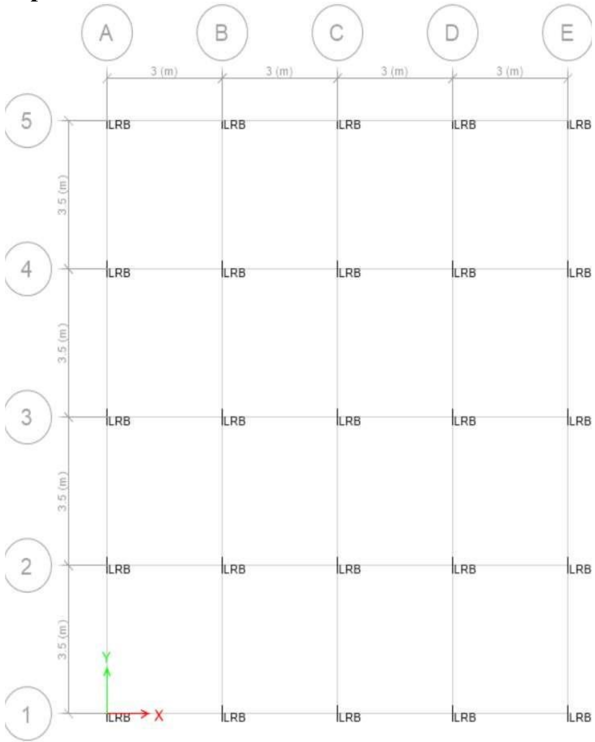


Fig.2 Isometric view of G+5 RC bulding fixed base.

Column Load	1101 KN
Effective Stiffness (U1, U2 & U3)	708.65 KN/m
Effective damping	0.05
Distance from End –J	0.00317 m
Non- Linear Stiffness	6530.04 KN/m
Yield strength	20.73 KN
Rotational inertia	0.016603 KN-m^2

Input data of LRB in ETAB for External Column



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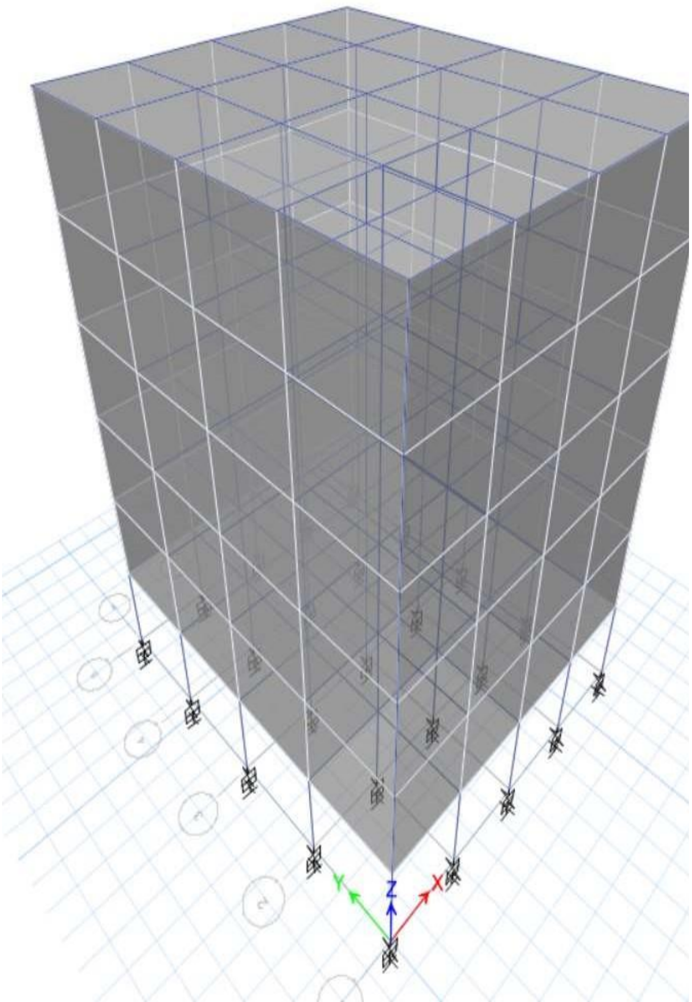

Fig.3 Plan and isometric view of G+5 RC bulding with LRB base

Column Load	1101 KN
Yield strength	594.13 KN
No. of pads required in internal column	2
Effective Stiffness (U1, U2 & U3)	47680 KN/m
Non- Linear Stiffness	257 KN/m
Effective damping	0.05
Rotational inertia	0.016603 KN-m^2

Input data of STRP in ETAB for External Column

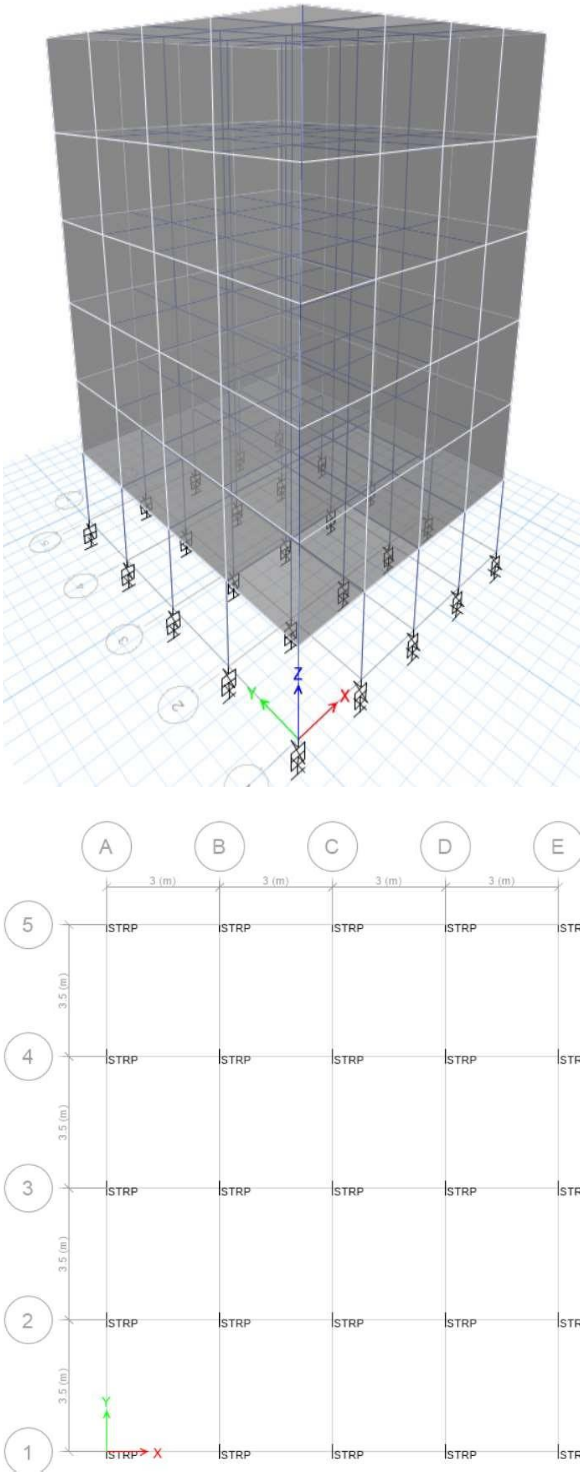

Fig.4 Plan and isometric view of G+5 RC bulding with STRP pads

RESULT AND DISCUSSION

There are various parameters for which the result of the structure can be compared or analyzed. In this work Maximum Storey Displacement, Lateral loads on each storey, Storey drift and Storey Shear of the structure are obtained. On basis of these results structure are compared and out of all these structures the safe, stabilized and efficient structure is selected in high sesmic zone.

Base Condition	Fixed Base	LRB Base	Tyre Pad Base	% diffrence in LRB Base	% diffrence in STRP Base
Max. Story Displacement (mm)	8.51	27.311	15.63	220.92	83.66
Max. Story Drift	0.0008	0.0012	0.0015	50	87.5
Storey Shear (KN)	442.15	189.49	236.87	-57.14	-46.42

Observation Table of G+ 5 Structures

- For low rise structure (G+5 story) displacement is optimum for isolated base; while LRB Isolated base the displacement has increased to maximum.
- Drift is almost the same for LRB and STRP base condition.
- Storey Shear reduced up to 57.1% when fixed base is changed to LRB isolated base and46.5% when base is changed from fixed base to Tyre base.
- Lateral Load is also reduced up to 50% when base is changed from fixed to isolated tyrebase.

CONCLUSION

Scraped Rubber pads can be used as alternative low-cost Base isolation system. Base Shear, shear drift and story shear in both cases of low and high rise seems to be reduced when base is installed with Scraped Tyre Rubber Pads.

Lead Rubber Bearing shows best result of all three base condition but result of scraped tyre varies from 10 – 15 % of LRB base. But considering economical point of view lead rubber bearing, laminated rubber bearing are very expensive isolation system. Tyre pads are much efficient and economical than LRB base isolation system considering only 10 – 15 % resultvaries.

- During the shear deformation, samples did not show layer separation. This indicates that the bonding agent utilized is capable of transmitting shear forces effectively.
- The damping ratio of the tested STRP isolator made of Radial tyres (18.48%) is found to be greater than the damping ratio of the natural rubber bearings (3.5%). Therefore, the use of additional damping enhancement mechanisms can be avoided when using the STRP isolator for a specified level of damping
- Storey shear force transmitted to the superstructure is reduced to 46.5% of that for the G+5 fixed base building and 52.5 % that for the G+10 fixed base building. These results show that the base isolation system using STRP isolators is an attractive alternative to commercially available isolation systems.
- The cost of one sample of Radial tyre (of dimensions 200 mm × 200 mm × 80 mm) works out to be Rs. 630/-, which is easily affordable, compared to the cost of elastomeric conventional isolators.
- The objective of making an isolator, which is easily reproducible, is also achieved, as the STRP requires no heavy machinery and no initial hefty investment.

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