TENSION-RESISTANT DEVICE IN BASE ISOLATION

National Science Foundation of China(NSFC)

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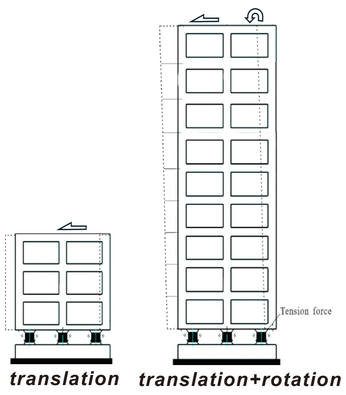
1. Introduction



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Isolation technology has long been seen as an effective method in mitigating the seismic hazards.

Elastomeric bearings such as lead rubber bearing, natural rubber bearing and so on have been wildly adopted in many isolated buildings. However, the application was mainly restricted within the scope of low-rise buildings due to the potential tensile stress in the bearings.

Recently, the number of high-rise isolated building keeps increasing. The two pictures present the tallest isolated buildings in Japan and China separately.

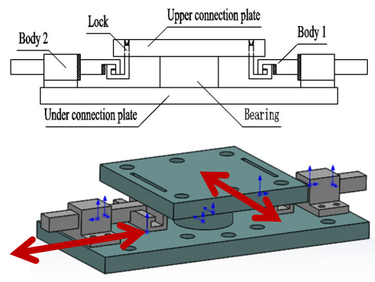
In the design process of high-rise isolated building, how to avoid tension force in isolators in the main concern.

On that occasion, a novel form of tension-resistant device is proposed.

Japan
177.4m
50 storey

China
106.6m
LRB

2. Design Concept



Model of Bearing with TReD

The mechanical device which is shorted as TReD is designed along with the bearing. It is comprised of 5 sub-parts as shown in the figure.

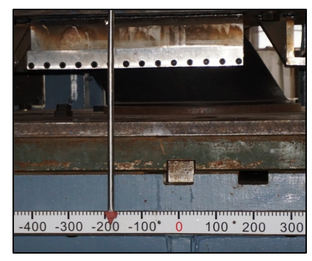
According to the 3D model of bearing with TReD, it is clearly shown that the bearing can move freely except on the vertical direcition. If the bearing is loaded with tensile force, the TReD would protect the bearing from too much vertical deformation.

3. Testing method

3.1 Static cycle load test

Comparison cycle load test of ordinary bearing and bearing with installation of TReD (Prototype):

① Ultimate Tensile Strength Test
② Compression-Shear Test
③ Tension–Shear Test



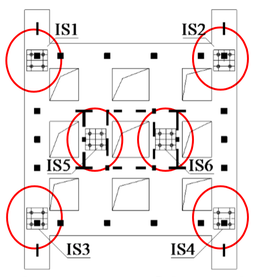
Photos of Apparatus and Experiment

3.2 Shaking table test

Model TReD and rubber bearing was manufactured and tested in a shaking table test to verify its effectiveness and applicability.

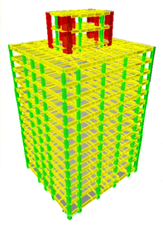
Model Super-structure

Model Bearing with TReD



Layout of bearing
6 bearing in isolation floor

Scaled Model TLRB
max shear deformation=200%

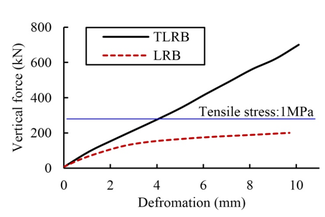


3D Model
super-structure

Model LRBs and TLRBs were manufactured to be tested in the following shaking table test aiming at figuring out the applicability of TReD under seismic excitation.

4. Results

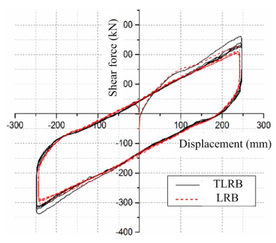
4.1 Static cycle load test



Tensile Property Comparison
LRB: lead rubber bearing
TLRB: bearing with TReD

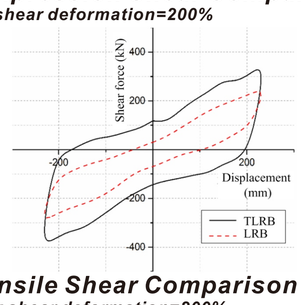
Tensile resistant capacity of LRB was insufficient and it has been into nonlinear stage which may lead to high risk of overturning failure.

While the TReD bore most of the tensile force which realized the preset tension restraint goal and reduced the damage and failure risk of the rubber bearing under rensile force.



Compression Shear Comparison
max shear deformation=200%

Hysteretic performance of TLRB was close to LRB which indicate that the TReD did not significantly affect the mechanical properties of isolation berings under Shear Compression condition.



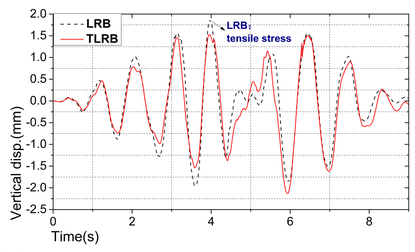
Tensile Shear Comparison
max shear deformation=200%

Shear performance of LRB degenerated seriously under tensile condition. However, for the bearing with TReD the horizontal mechanical parameters were obviously increased compared to LRB.

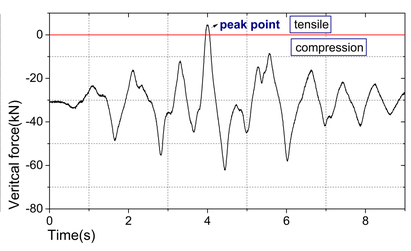
4.2 Shaking table test

Natural vibration frequencies before and after installing TRDs

Modal	1st	2nd	3rd
Frequencies-before installing /Hz	1.59	1.59	1.55
Frequencies-after installing /Hz	1.56	1.61	1.55
difference	-1.89%	1.26%	0.00%



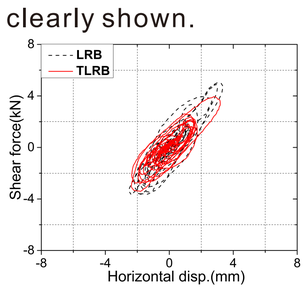
Vertical disp. Comparison
between LRB and TLRB

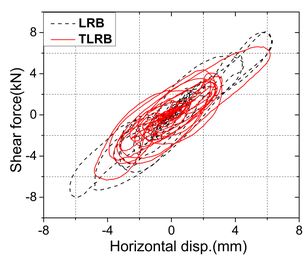


Vertical force of LRB
same excitaiton as previous figure

The table above shows the frequency comparison between isolated structure with and without installation of TReD. It clearly shows that this kind of device would not affect the dynamic mechanic property significantly.

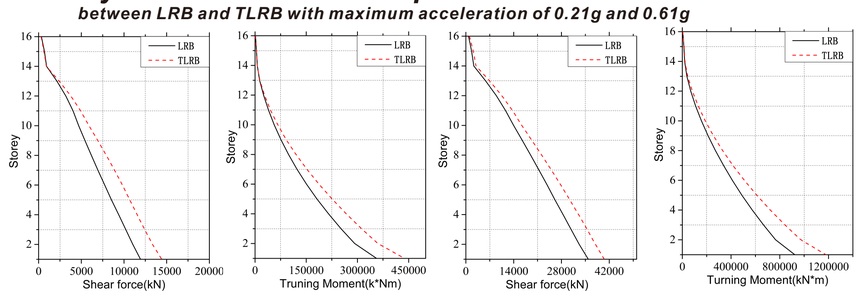
According to the data recorded by force censor, tension stress occured. And by comparison between load conditions with and without installation of TReD, the tensile resistant effect was clearly shown.





Hysteresis Curve Comparison
between LRB and TLRB with maximum acceleration of 0.21g and 0.61g

The horizontal hysteretic curve are compared. We can find that the area of the two curves for the bearing with and without TReD are almost the same, which means the device would not affect the energy dissipation ability significantly.



Storey Shear & Truning Moment Comparison
for prototype structure under maximum accleration of 0.21g and 0.61g

The response of the super-structure is investigated by comparison of the story shear and story turning moment. It is clearly shown that the response of the structure isolated by bearing with TReD is slightly larger.

5. Conclusion

1. Tension-resistant device (TReD) can well protect the rubber bearing under tension condition.
2. TReD would barely affect the horizontal mechanic property in working condition.
3. It is possible that the response of super-structure would be slightly amplified if TReD is installed.
4. More investigation should be paid on other form of isolators.

Acknowlegement

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