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Study of Torsional Irregularity in Irregular Structure Provided with Lead Rubber Bearing Isolator

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Abstract:
In this paper, torsional behavior of irregular structures with fixed base and lead rubber bearing isolated base has been compared. Studied Structures are three-dimensional, 10 story RC structures whose linear Response Spectrum analysis was conducted. Practical solutions to strengthen torsional of the base-isolated irregular structures have been proposed. The results are presented in terms of displacement, base shear, storey drift, and torsional irregularities.

Key words: Response spectrum analyses, torsion irregularity, lead rubber bearing isolator

1. INTRODUCTION

Seismic isolation is a method to reduce or eliminate the potential damages caused by earthquakes. This method is the only practical way to reduce the drift and acceleration of stories simultaneously. Practical solutions to strengthen torsional of the base-isolated irregular structures have been proposed. Base isolation is defined as a flexible material which is provided at base of the building to reduce seismic forces of any structures. Torsional irregularity is one such horizontal irregularity which has to be looked upon while designing a structure. Before explaining the term torsional irregularity; one has to be acquainted with the terms drift, storey drift, eccentricity and torsion. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structure transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure as shown in figure a. In this paper, torsional behaviour of irregular structures with fixed base and isolated base has been compared. Studied Structures are three-dimensional, 10 story RC structures whose linear Response Spectrum analysis was conducted.

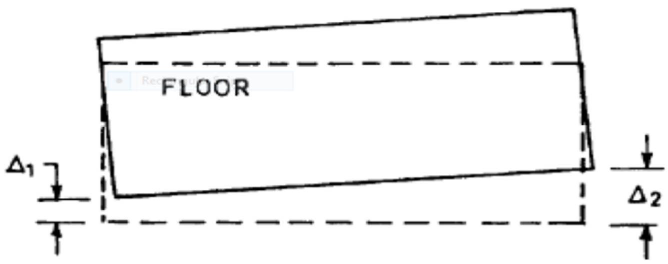


Figure.1.Torsion irregularity.

1.1OBJECTIVE

1) To find out the response of a RC frame structure i.e., displacement, base shear, storey drift, mode shapes and torsional irregularities by dynamic using software ETABS 2015.
2) Response spectrum method is carried out as per IS 1893 (Part 1):2002.
3) All the models are studied and analyzed using response spectrum method.

1.2 SALIENT FEATURES OF THE BUILDING

The Constant Parameters of Building Model is studied using ETABS software of version 2015. The buildings considered for this analytical study is G+ 10 storeys

TYPE OF STRUCTURE	COMMERCIAL
Number Of Stories	G+10
Height Of Typical Floor	3.0
Beam Size (Mm)	230X450
Column Size (Mm)	230X450
Slab Thickness (Mm)	150
Masonry Wall Thickness (Mm)	230
Characteristic Strength Of Concrete, F_{ck}	25 KN/m^3
Grade Of Steel, F_y	500N/mm^2
Density Of Concrete	25 KN/m^3
Modu1us Elasticity of Concrete	25000N/mm^2
Poisons Ratio Of Concrete,	0.3
Density Of Brick Masonry	19 KN/m^3
Modu1us Elasticity Of Brick Masonry	14000N/mm^2
Poisons Ratio Of Brick Masonry	0.2
Damping Ratio	5%
Live Load	3 KN/m2

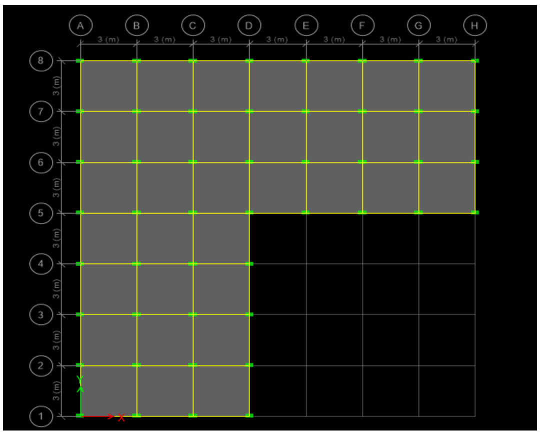


Figure.2. irregular plan view of l shape model

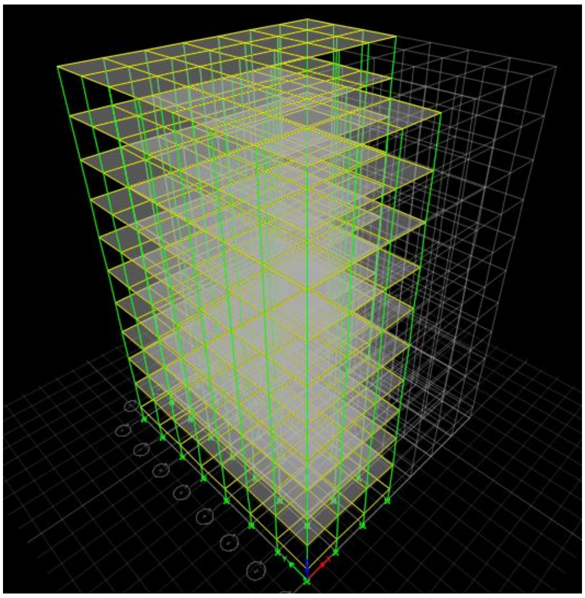


Figure.3. 3d view of l shape model

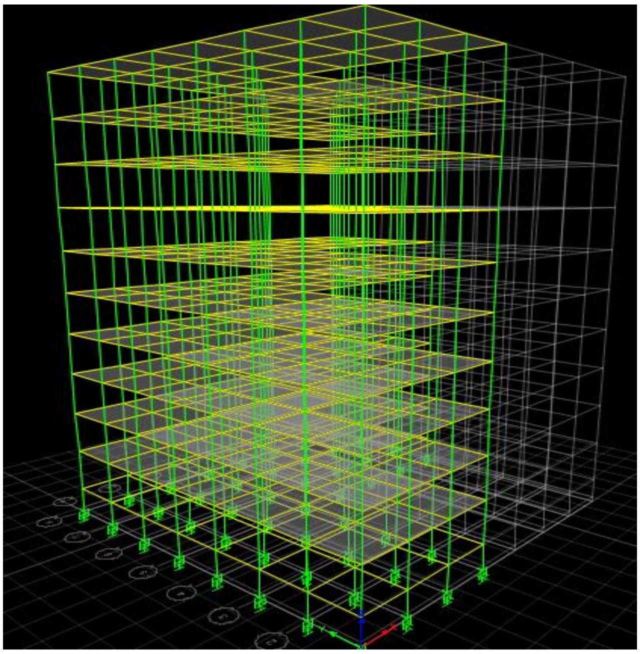


Figure.4. l r b provided for l shape in 3d view

1.3 RESPONSE SPECTRUM DATA

This analysis technique mainly concerned with joint displacement, forces and moments induced due to dead load, live load, supper dead load and earthquake loads in both X and Y direction. The Dead load case indicates the self weight of the building. The wall loads on beam is indicate as supper dead and live loads on floor as been Indicate as Live and analysis is performed for five cases. This analysis technique is carried out for obtaining the resultant natural frequencies, and other parameters of the model. This analysis performed for the zone V, and for soft soil sites as per IS 1893 (Part 1) 2002 for the five different cases. where, Zone factor for zone v (Z) = 0.36 Importance factor (I) = 1.0 Response reduction (SMRF) (R) = 5.0 Ground acceleration (Sa /g) = 2.5

1.4 ANALYSIS OUTPUT

Analysis Results of Fixed base and Base isolator:

When analysis is completed, the comparison of the fixed base and base isolation storey drifts, displacement, base shears and mode shapes values and torsional irregularities values are taken and graphs are plotted.

1.5 RESULTS AND DISCUSSION

This study is carried out to check the effect of the irregular building in zone 5 fixed base and LRB base model. Overall four models are considered i.e. I SHAPE model of fixed base in Zone-5 with G+ 10 storeys and I SHAPE model of G+10 storey building with Lead Rubber Bearing in Zone-5. The L SHAPE model is G+10 storey irregular building in Zone-V with Fixed base. Whereas the L SHAPE model is an irregular building with G+10 storeys provided with LRB. The analysis is carried out with Response Spectrum to all the models and the results are obtained and tabulated and later the results of response spectrum are compared for all the models. The results tabulated are displacement, Storey drifts, Base shear and torsional irregularities.

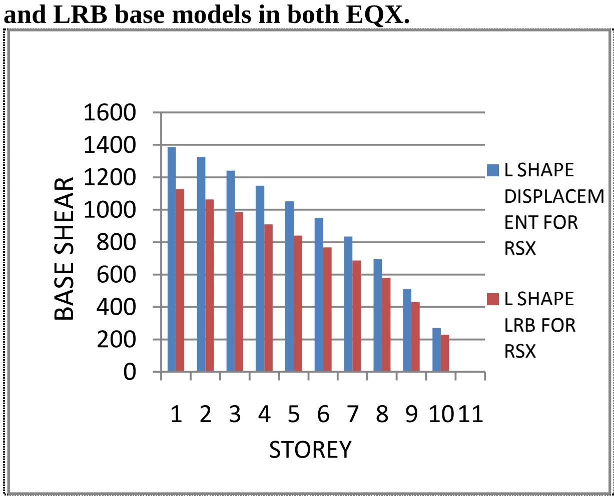
2. DESIGN OF ISOLATOR

The isolator considered in this work is Lead Rubber Bearing and designed follow the available recommendations of the ―Earthquake Engineering Handbook by W.H Chen and Charles Scawthorn. The mechanical properties of the LRB isolation system are set to comply with the recommendation of the Earthquake handbook. The design parameters considered are: Vertical stiffness (KV), Horizontal stiffness (KH), Pre yield stiffness (KU), Yield force of lead plug (Qd) and Post Yield Stiffness Ratio. The values obtained are tabulated in the table.

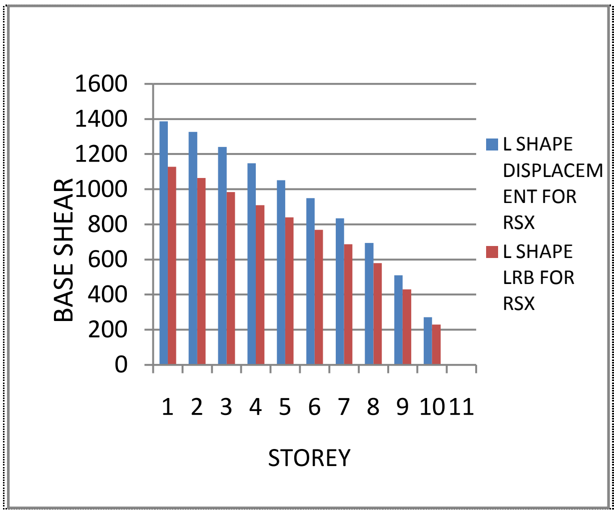
PARAMETERS	L SHAPE ZONE -5
Vertical stiffness (Kv)	1408.50KN/M
Horizontal stiffness (Kh)	331KN/M
Required stiffness(Kreq)	152430.95KN/M
Yield force of lead plug (Qd)	7.7KN
Stiffness ratio	0.1
Damping ratio	0.05

2.1 BASE SHEAR

The Base shear has been tabulated for L shape fixed base and LRB base models in both EQX.

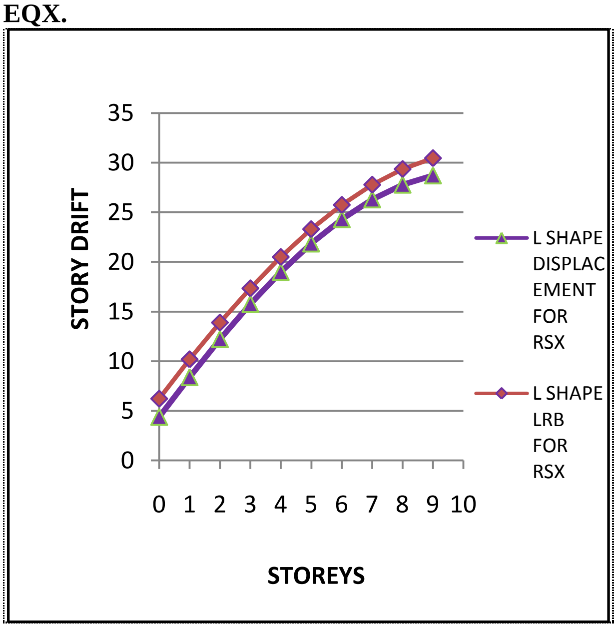


Base shear in L Shape fixed base and LRB base model for RSX

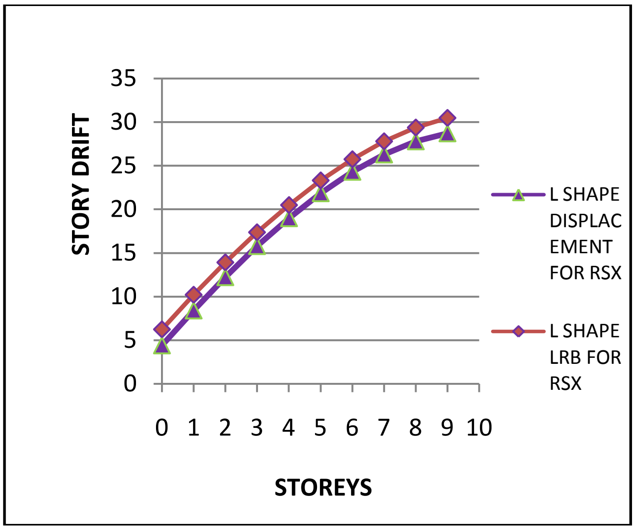


2.2 STORY DRIFT

Storey drift in L Shape fixed base and LRB base model for EQX.



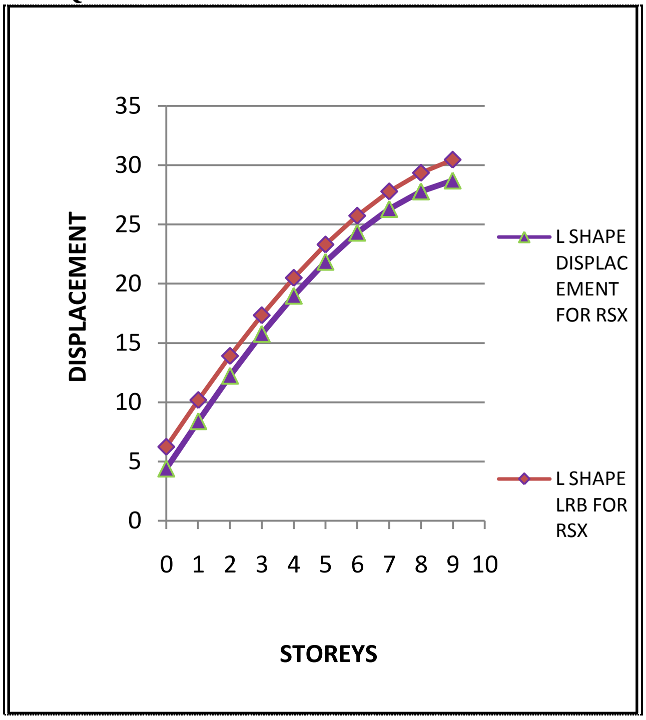
Story drift in L Shape fixed base and LRB base model for RSX.



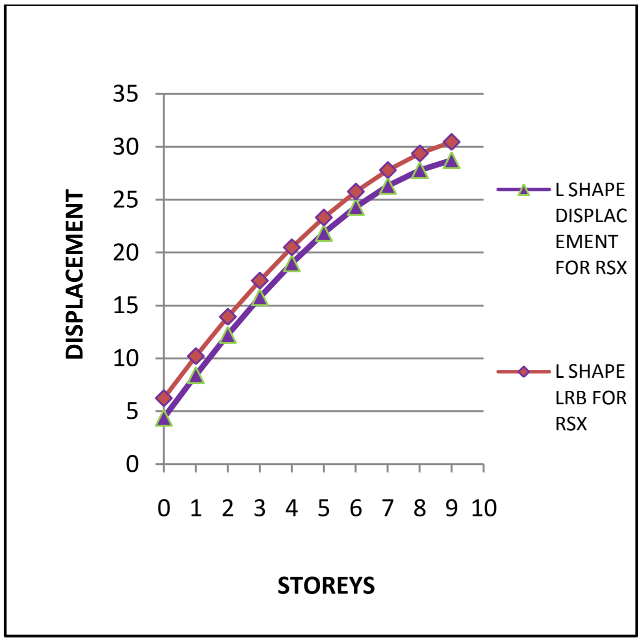
2.3 DISPLACEMENT

A point at which the multi-storey displacement occurs is called as the Displacement. Displacements of G+10 storey structure models subjected to EQX & RSX direction for zone-5 are as listed below.

Displacement in L Shape fixed base and LRB base model for EQX



Displacement in L Shape fixed base and LRB base model for RSX



2.4 TORSIONAL IRREGULARITY

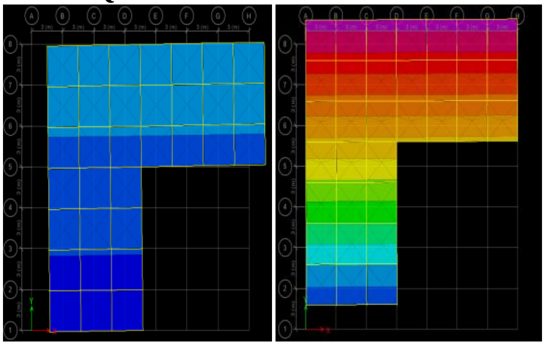
Torsional irregularity is one such horizontal irregularity which has to be taken care while designing a structure. To determine the torsional irregularity of the building the column sizes has been reduced and earthquake forces has been considered for the same model and the total drifts has been determined and the cross check of the total drift has been done. Dmax = Highest value of the total drift in the earthquake considered direction.

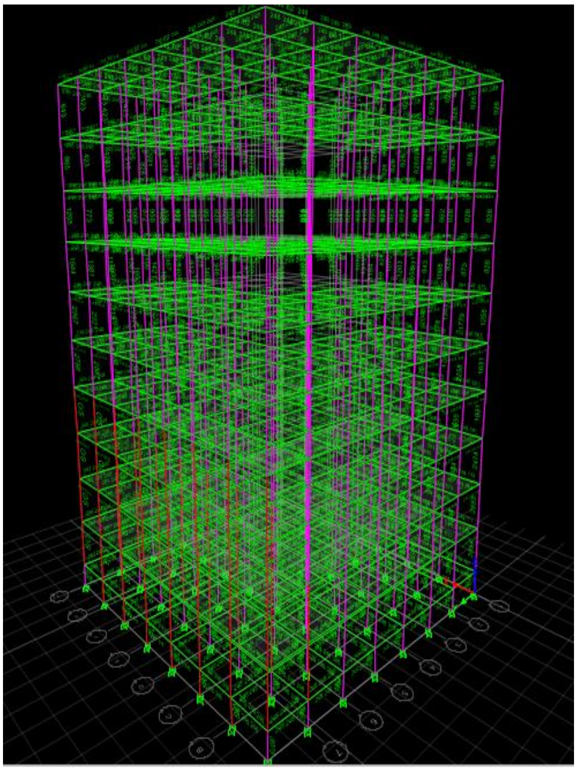
Davg = (R1 + R2)/2.

(Dmax/Davg) < 1.2

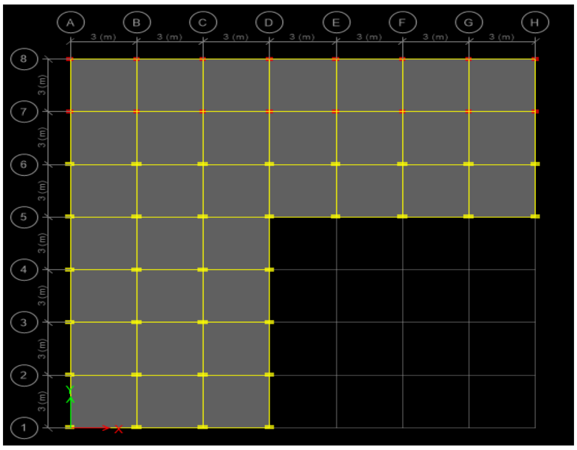
Davg should not more than the 1.2 in the both directions. If the storey drift is more than 1.2 then the structure column section should be revised.

L SHAPE FIXED BASE DEFORMED SHAPE FOR EARTHQUAKE IN BOTH X AND Y DIRECTIONS





L SHAPE FIXED BASE TORSION IRREGULARITY



PLAN VIEW OF L SHAPE FIXED TORSION IRREGULARITY

CALCULATIONS:

Earthquake in X-dir: R1 = 29.387mm, R2 = 35.132mm.
Earthquake in Y-dir: R3 = 46.284mm, R4 = 44.389mm.
Permissible Drift = H/250 = 31.5/250 = 126mm

So our storey is within permissible drift.
Check for Torsional irregularity in X-dir.
Dmax = 35.132
Davg = (R1+R2)/2 = (29.387 + 35.132)/2 = 32.2595
(Dmax/Davg) = (35.132/32.2595) = 1.089 < 1.2
Check for Torsional irregularity in Y-dir.
Dmax = 46.284
Davg = (R1+R2)/2 = (46.284 + 44.389)/2 = 45.3365
(Dmax/Davg) = (46.284/44.389) = 1.042 < 1.2

So the torsional irregularity of the fixed base for both directions does not exist.

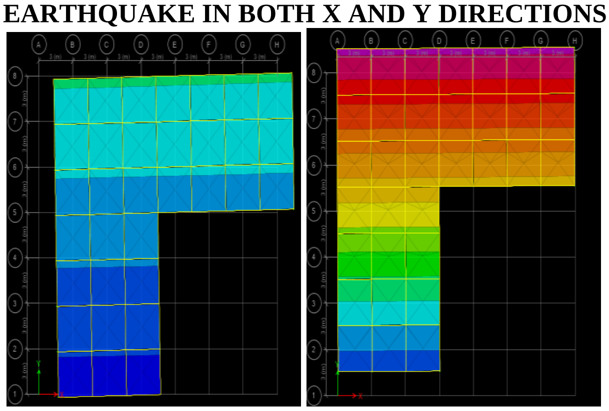
To check the torsional irregularity of the structure when the column section has been revised for the same model and the earthquake forces has been considered and then the comparsion has been done.

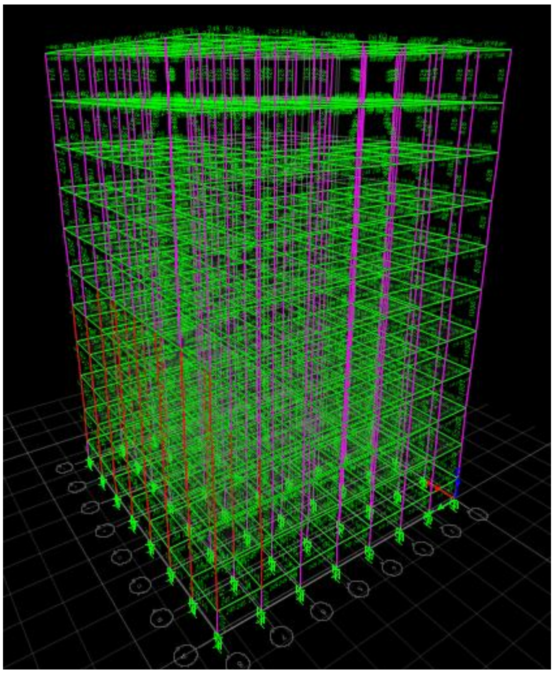
Earthquake in X-dir: R1 = 49.209mm, R2 = 26.457mm.
Earthquake in Y-dir: R3 = 51.454mm, R4 = 45.512mm.
Check for Torsional irregularity in X-dir.
Dmax = 49.209
Davg = (R1+R2)/2 = (49.209 + 26.457)/2 = 37.833
(Dmax/Davg) = (49.209/37.833) = 1.3 > 1.2.

So torsional irregularity exist. Reconsider the design of structure.

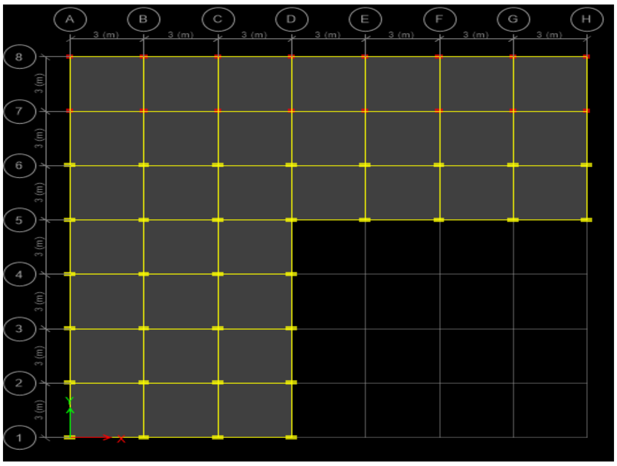
Check for Torsional irregularity in Y-dir.
Dmax = 51.454
Davg = (R1+R2)/2 = (51.454 + 45.512)/2 = 48.483
(Dmax/Davg) = (51.454/48.483) = 1.06 > 1.2.

SHAPE LRB BASE DEFORMED SHAPE FOR EARTHQUAKE IN BOTH X AND Y DIRECTIONS





L SHAPE LRB TORSION IRREGULARITY



PLAN VIEW OF L SHAPE LRB TORSION IRREGULARITY

CALCULATIONS:

Earthquake in X-dir: R1 = 34.673mm, R2 = 26.155mm.
Earthquake in Y-dir: R3 = 41.558mm, R4 = 38.650mm.
Permissible Drift = H/250 = 31.5/250 = 126mm
So our storey is within permissible drift.
Check for Torsional irregularity in X-dir.
Dmax = 34.673
Davg = (R1+R2)/2 = (34.673 + 26.155)/2 = 30.39
(Dmax/Davg) = (34.673/30.39) = 1.14 < 1.2
Check for Torsional irregularity in Y-dir.
Dmax = 41.558
Davg = (R1+R2)/2 = (41.558 + 38.650)/2 = 40.104
(Dmax/Davg) = (41.558/40.104) = 1.036 < 1.2
So the torsional irregularity for the LRB base for both directions does not exist.
To check the torsional irregularity of the structure when the column section has been revised for the same model and the earthquake forces has been considered and then the comparison has been done.
Earthquake in X-dir: R1 = 41.330mm, R2 = 26.482mm.
Earthquake in Y-dir: R3 = 45.591mm, R4 = 38.729mm.
Check for Torsional irregularity in X-dir.
Dmax = 41.330
Davg = (R1+R2)/2 = (41.330 + 26.482)/2 = 33.906
(Dmax/Davg) = (41.330/33.906) = 1.22 > 1.2.
So torsional irregularity exist. Reconsider the design of the structure.
Check for Torsional irregularity in Y-dir.
Dmax = 45.591
Davg = (R1+R2)/2 = (45.591 + 38.729)/2 = 42.16
(Dmax/Davg) = (45.591/42.163) = 1.08 > 1.2.

3. CONCLUSION

- Displacement Increases in the LRB base compared to Fixed Base for response spectrum analysis and for earthquake analysis the displacement in the LRB base increases at the middle but only 1% reduction of displacement is shown in the storey 10 compared to fixed base.
- Base shear has been reduced in the LRB base isolator model compared to the fixed base model.
- Storey Drift has been reduced in the LRB base isolator compared to the fixed base model.
- Torsional irregularity exists in the X-dir when the column size reduces in the fixed and LRB base model.
- So we must increases the lateral stiffness along the column with maximum storey drift by increasing the column sizes, retaining walls or bracings.
- So LRB and Torsional irregularity is important parameters for the design of the tall structures.

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