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Seismic Analysis of Base Isolated Building Using LRB Technique

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ABSTRACT: Base isolation system is a concept which is used to protect any structure from effect of damage due to earthquake. This is done by isolating or decoupling the super structure from sub structure. By bring in the base isolation system at the bottom of the super structure one can boost the flexibility of the structure. In this project modelling & analysis for a G + 10 storey building is made using ETABS software. Basically, two models are done. First one without base isolation and the second building with base isolation. To perform analysis Response Spectrum Method is used. Analysis results say story displacement, story shear, acceleration storey drift etc. are obtained for both the models and compared in the structure of tables and charts at the end of the report.

KEYWORDS: Storey drift, Storey displacement, Base shear, Response spectrum analysis, Mode shapes, lead rubber bearing,

I. INTRODUCTION

Base isolation system provided for the structures is one among the most appropriate ways in protecting the structure to resist earthquake forces. It is one among the basic method in seismic engineering which is termed as split up an upper building from its sub structure. It will result in lessening of an effectual displacement & inter storey drift in all floor levels of a structure provided with base isolation system, this will result in minimal damage to the structure and in turn helps in providing safety to whole structure and habitat.

Basically, we have two different category of isolation systems available. First type base isolation method has set of lower sideways rigidity material in the middle of super, sub structure. Due to this sort of isolation system the natural period will be longer that the structure with no base isolation system. Due to longer natural period, pseudo- acceleration will be reduced and this in turn decreases the seismic forces. This system is adopted most commonly. Second one is characterized by wriggling method. Its functions on restricting the transferring of the shear over a given an interface of an isolation. Multi layered elastomeric bearings were very rigid in a vertically downward supervision and could take an erect downward load of whole structure and simultaneously they are very flexible in the horizontal way, in that way helping the structure to move in lateral direction like a single rigid unit even under strong land movement. The chief intention of our study is to evaluate the behaviors of a chosen structure in seismic zone by adding base isolation system and in that way decrease seismic parameters like storey acceleration, storey drift and also amplify the period of swinging due to quake. This idea is implemented to an office building with Ground + 10 floor by introducing LRB (lead rubber bearing) base isolators at the Level of foundation and after that evaluate various parameters in the middle of rigid/fixed base 2 foundation and state of base isolated. This whole exercise is done by using popular E-TABS 2016 software.

1. Objectives

• To carry out structural modelling, perform structural study for both fixed base conditioned building (model-1) and building with LRB (building-2) using E-TABS software and compare various analysis results obtained.

• To carry out design process and study to see how effective lead rubber bearing is, which can be used as an isolation system at base of the building.

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• To carry out a comparative study for base isolated building & fixed base building based on dynamic properties like max shear force, max bending moment, base shear etc.

• To perform a comparative study of the response of the buildings in a form of Time period, Maximum displacement, Maximum drift, Base shear.

1.2 Scope of The Study

By studying above various literature survey, the researchers were compared fixed base with LRB Isolated building and come across various results in different zones.

Present research involved in the modelling of two unsymmetrical building were done in zone IV conditions. The first building was provided with fixed base type and second one with isolation system at base level. The work here involves the analysis of Ground +10 storey R.C.C. office Building in according with IS 1893:2002 requirements; First model will have a with fixed base type and the 2nd one will have Lead Rubber Bearing type base isolation system. First by doing analysis of fixed base building, the base reaction at fixed end of each column is noted down and then the LRBs are designed by grouping the columns with almost same reactions. Then fixed ends are replaced by LRBs and finally various analysis parameters are noted down for both model one with fixed base & then the model 2 with LRB. Finally, a comparative study is performed. Response spectrum analysis is executed for these buildings

II STRUCTURAL DETAILS

To study the time history analysis of steel structure, G+9 multi-storied building is considered. The modelling and analysis of work is done by using STAAD.PRO software. Story shear, story drifts and story Displacement is compared for different types of brased structural system.

2.1 Model description

ABOUT E-TABS MODELS

- Model 1 = With Fixed Base for GROUND + 10 R.C.C OMRF Building
- Model 2 = With LRB for GROUND + 10 OMRF Building

BUILDING DETAILS

- Structure = RCC (Ordinary Moment Resistance Frame)
- Shape = L shape Building
- Dimension = As mention above
- Total Height of Building from Plinth
- (Ground +10 + Head Room) = 43.29 m
- ground floor height = 3.5 m
- typical storey height: 3.81m
- In X-direction = 5 bay of 10.0 m length each
- In Y-direction = 4 bay of 10.0 m length each

MATERIAL DETAILS

- Concrete = M40: foundation & columns: M30: other members
- Steel = Fe550
- Concrete density = 25KN/m³

SECTIONAL DETAILS

- Beam = 600mmx600mm
- Column = 750mmx750mm
- Slab = 200mm
- Wall = 230mm, 115mm

LOADS TAKEN

- Flooring Finish: 1.0 kN/sqm, inside wall load on the slab 1.0 kN/sqm,
- Water Proofing at terrace: 1.0 kN/sqm
- Imposed Load :4.0 kN/sqm floors and 1.5 kN/sqm terrace

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Main Wall Load

Density of brick [0.23m thk] = 18.85*0.23	= 4.34 kN/sqm
Density of Mortar [0.012+0.02] =20.40* 0.032	= 0.65 kN/sqm
Total	= 5.0 kN/sqm
Between floor height	= 3.81 m
Depth of beam	= 0.6 m
Wall height = $3.81 - 0.6$	= 3.21 m

Main Wall UDL = 5.0*3.21 = 16.05 kN/m = 16.00 kN/m (say)

Inside Wall Load

Density of brick [0.115m thick [= 18.85*0.115	= 2.17 KN/sqm
Density of Mortar [0.012+0.012] =20.40* 0.024	= 0.49 kN/sqm
Total	= 2.66 kN/sqm
Between floor height	= 3.81 m
Depth of beam	= 0.6 m
Wall height = $3.81 - 0.6$	= 3.21 m

Inside Wall = 1.93*2.6 = 8.54 kN/m

GRAVITY LOAD

- Dead load -- Column, Beam, Slab
- Live load -- 4.0 KN/m2, 1.5 KN/m2
- Floor Finish -- 1.0 KN/m2

RESPONSE SPECTRUM ANALYSIS FOR LATERAL LOAD

Soil Profile -- Medium Zone Factor -- Zone 4 Response Reduction Factor -- 5.0 Importance Factor -- 1.0 Damping -- 5.0 %

2.2 Loading

a. dead loads: as per IS875 part-1 1987

b. live loads: as per IS875 part-2 1987. For seismic live load taken by IS1893-2002

c. earthquake loads: All frames are analyzed for zone 3. The earthquake load calculation is as per IS1893-2002 **d. seismic factors for lateral load analysis**

PROCEDURE FOLLOWED FOR LRB DESIGN

1. The reactions at the base of each column for a building with fixed type same are obtained and are grouped as mentioned below

• 11000 KN

2. A target time period of 2.5 seconds and β effective damping of 5% for RCC building is accounted as per the clause 7.8.2.1 in IS 1893:2002.

3. Spectral acceleration read from response spectrum graph is 0.55 with time period (T) being 2 sec. From table 3 of IS 1893:2002 damping multiplying factor of 1 is taken for the design

III. ANALYSIS AND MODELING

3.1 Modeling

The analyzes are carried out using the framework of dynamic analysis in E-TABS2017. E-TABS2017 model calculated storey shear, acceleration values, and displacements. Such methods include continuing with the Research.

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III. RESULTS AND DISCUSSION

DEFLECTION SHAPE FOR 1.0DL + 0.8LL + 0.8RSX



Deflection for both buildings

Following are the results obtained for Model-1 with fixed base & Model-2 with LRB isolator

MAXIMUM STOREY DRIFT RESULTS AND GRAPHS

The storey drift obtained from models by Response spectrum analysis are shown in Table and are graphically represented in Graph

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IN X DIRECTION

Floor	Max Drift in X Direction, mm	
11001	Fixed Base	LRB
S/C Head Room	0.864	0.843
Terrace	0.726	0.65
9th F	1.141	1.033
8th F	1.522	1.4
7th F	1.821	1.701
6th F	2.055	1.944
5th F	2.253	2.149
4th F	2.436	2.343
3rd F	2.575	2.542
2nd F	2.537	2.742
1st F	1.85	2.774
Ground F	1.754	2.824





IN Y DIRECTION

Floor	Max Drift in Y Dir	ection, mm
Floor	Fixed Base	LRB
S/C Head Room	1.136	1.102
Terrace	0.815	0.737
9th F	1.111	1.004
8th F	1.375	1.26
7th F	1.582	1.47
6th F	1.747	1.642
5th F	1.9	1.796
4th F	2.052	1.948
3rd F	2.2	2.134
2nd F	2.284	2.454
1st F	1.856	2.891
Ground F	1.47	3.265

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MAXIMUM STOREY DISPLACEMNT RESULTS AND GRAPHS

The storey displacement obtained from models by response spectrum analysis are shown in and are graphically represented in

IN X DIRECTION

Floor	Displacement, mm X Direction	
	Fixed Base	LRB Isolator
S/C Head Room	9.047	10.246
Terrace	17.764	19.466
9th F	17.235	18.981
8th F	16.368	18.182
7th F	15.144	17.043
6th F	13.595	15.589
5th F	11.751	13.85
4th F	9.638	11.849
3rd F	7.278	9.597
2nd F	4.733	7.098
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IN Y DIRECTION

Floor	Displacement,	mm Y Direction
F 100r	Fixed Base	LRB Isolator
S/C Head Room	15.524	16.826
Terrace	15.908	17.831
9th F	15.287	17.248
8th F	14.431	16.454
7th F	13.325	15.426
6th F	11.988	14.178
5th F	10.434	12.724
4th F	8.664	11.068
3rd F	6.685	9.208
2nd F	4.514	7.117
1st F	2.236	4.677



STORY FORCES RESULTS AND GRAPHS

The storey force is obtained from the models by response spectrum analysis as shown in Table and graphically represented in Fig.

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Floor	Story Forces, kN	
	Fixed Base	LRB Isolator
S/C Head Room	1289.791	1485.7993
Terrace	14257.7963	15809.1449
9th F	32698.6226	34248.2555
8th F	51227.6521	52776.5681
7th F	69757.0749	71305.1902
6th F	88286.3917	89833.7887
5th F	106814.2201	108361.3994
4th F	125340.7452	126887.8284
3rd F	143867.3176	145413.7905
2nd F	162394.687	163940.0749
1st F	180921.6383	182359.6319
Ground F	188657.2711	189324.0751



IV. CONCLUSIONS

Two buildings were modelled. One with fixed base and the second one with LRB isolators. Both the buildings were G+10, were used for office Building. Response spectrum analysis was carried out for both the buildings and the conclusion were made as listed below:

- 1. The analysis results prove that the behavior and the performance of the building provided with LRB are much better in comparison with the building having fixed base support.
- 2. Two major design features were added by the LRBs to the structure. First one, reduction in quake forces by a factor between 0.3 to 0.8. Second one, controlling and reducing these the lateral forces by distributing them.
- 3. Storey drift is seen to be lowered as we go upwards along the floors in the base isolated building. Storey drift is reduced by 24% in base isolated building when compared to fixed base building. This obviously helps in making the building safer against quakes.

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- 4. Comparatively modal displacement is more in the building with LRB. The model displacement is 33% more in base isolated building as compare to fixed base. This helps the building to become more flexible during quake.
- 5. After providing LRB the mode period of structure is increased by 19% for G+10 storey building. It is studied that due to flexible property of the LRB mode period is increased.
- 6. The maximum storey stiffness of building is decreases in base isolated building.
- 7. As introducing the LRB in the building the decrease of 45% of storey stiffness seen so that the base shear demand will be decreased in the building
- 8. Even though introduction of LRB increase total cost of construction by 7-9 percent, it helps in reducing the damage to the building during quake conditions.
- 9. Last but not the least, introduction of LRB helps to enhance the stability of the building to face quake motion and also contributes in reducing the steel in RCC.

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