Seismic Analysis of Moment Resisting R.C. Frame with Base Isolation using Pushover Analysis in ETABSv17.

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Abstract*— At the present constructional scenario, conventional RC Frame buildings are commonly used for the construction work. In fact, the use of moment resisting frame building provides many advantages in terms of higher load carrying capacity and more resistance to lateral forces and shorter construction time. In the resisting R.C. frame structure model, two types of models are considered namely:-(1) Moment resisting frame building without base isolation system and (2) Moment resisting frame building with base isolation systems having G+10 story. The beams and column for both the building are as 400x250 and 400x400mm respectively. The grade of concrete and steel used in both the buildings are taken as M20,M25 and fe415 respectively .This study indicates an analytical approach for seismic assessment of RC frames using nonlinear static push-over analysis in order to determine the nonlinear behavior of buildings under lateral loads as well as base shear- displacement relationships, i.e. capacity curve . A pushover analysis is a type of non-linear static analysis, in which the strength of the structure is tested beyond the elastic limit of the structure. The analysis of the building has been done using ETABSv17 software. The results, obtained have been compared in terms of base shear, story displacement and storey drift. The primary objective of this work was to study the non linear behavior of moment resisting frame building with and without base isolation systems under seismic excitation. To observe the comparative results on the basis of various seismic parameters such as base shear, displacement, story drift etc, IS code-1893:2016 for different models has been adopted. From above research work it has been concluded that the building model 2 i.e. Moment resisting frame with base isolation system is comparatively better (in every parameters mentioned above) than the building model 1 i.e. moment resisting frame building without base isolation system.

Index Terms— *pushover analysis, base shear, story displacement, moment resisting frame, G+10 building.*

1. INTRODUCTION

Seismic analysis is a subset of structural analysis and is the calculation of the response of a building (or nonbuilding) structure to earthquakes. It is part of the process of structural design or earthquake engineering in regions where earthquakes are prevalent. The earliest provisions for seismic resistance were the requirement to design for a lateral force equal to a proportion of the building weight (applied at each floor level). It later became clear that the dynamic properties of the structure affected the loads generated during an earthquake. Since from the last century, structural designing problem has taken various forms, and improvements in design philosophy and methods have been done. There are two types of methods for the seismic design of structures,

1) Conventional method: This is the traditional method to resist lateral force is by increasing the design capacity and stiffness. Ex- shear wall, Braced frames or Moment resisting frames.

2) Non conventional method: Based on reduction of seismic demands instead of increasing capacity. Ex-Base isolation, Dampers.

1.1 MOMENT-RESISTING FRAME

It is a rectilinear assemblage of beams and columns, with the beams rigidly connected to the columns. Resistance to lateral forces is provided primarily by rigid frame action i.e. by the development of bending moment and shear force in the frame members and joints. By virtue of the rigid beam–column connections, a moment frame cannot displace laterally without bending the beams or columns depending on the geometry of the connection. The bending rigidity and strength of the frame members is therefore the primary source of lateral stiffness and strength for the entire frame. These connections between beams and columns are formed through the use of rigid moment connections. A Moment Connection is a joint that allows the transfer of bending moment forces between a column and beam (or any other two members). This is different to shear or pinned connections that prevent a moment-resisting frame to occur.

1.2 BASE ISOLATION SYSTEM

It is one of the most popular means of protecting a structure against earthquake forces. It is a collection of structural elements which should substantially decouple superstructure from its substructure resting on a shaking ground thus protecting a building or non-building structure's integrity. The main aim of base isolation is to reduce the earthquake force produced on building. To some extent by reducing the superstructure's spectral acceleration, the reduction in seismic force at superstructure is achieved. By increasing the base isolated structure fundamental period and dissipation energy within bearing the accelerations are reduced.

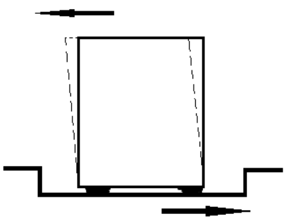


Fig.1 structure fixed to the ground

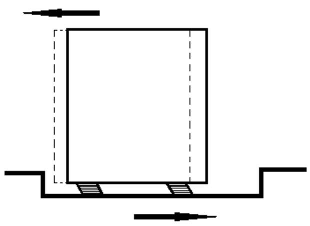
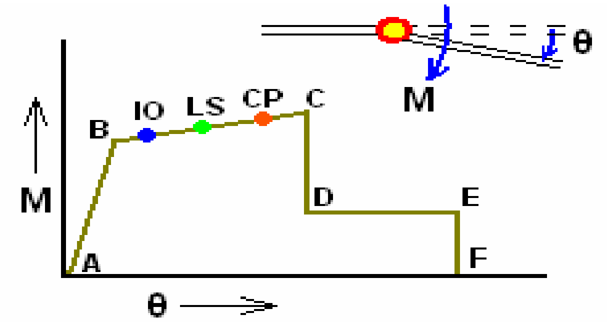


Fig.2 base isolated structure

1.3 LEAD RUBBER BEARING

A variety of isolation devices including elastomeric bearings (with and without lead core), frictional/sliding bearings and roller bearings have been developed and used practically for a seismic design of buildings during the last 25 years. Among the various base isolation system, the lead rubber bearing had been used extensively. Lead Rubber

Bearing or LRB is a type of base isolation employing a heavy damping. It was invented by William Robinson, a New Zealander. Heavy damping mechanism incorporated in vibration control technologies and, particularly, in base



isolation devices, is often considered a valuable source of suppressing vibrations thus enhancing a building's seismic performance. However, for the rather pliant systems such as base isolated structures, with a relatively low bearing stiffness but with a high damping, the so-called "damping force" may turn out the main pushing force at a strong earthquake.

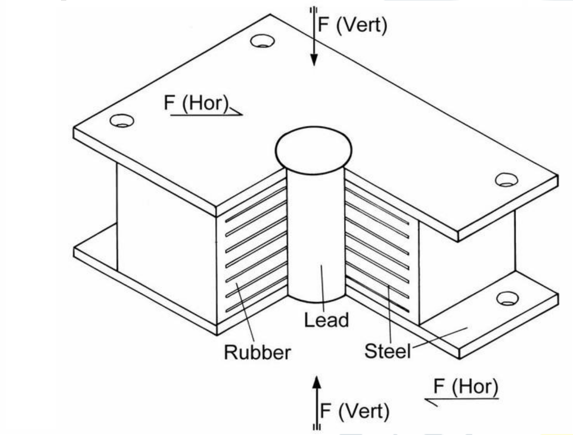


Fig.3 Lead Rubber Bearing with Layers of Rubber and Steel and Lead Core

It consists of alternate layers of rubber and steel plates with one or more lead plugs that are inserted into the holes. Due to lateral forces the lead core deforms, yields at low level of shear stresses approximately 8 to10 Mpa , so the lead bearing lateral stiffness is significantly reduced. Due to this period of structure increases. One of the feature of lead core is that it can recrystalize at normal temperature and will not encounter the problems of fatigue failure under cyclic loadings.

2. OBJECTIVES OF THE STUDY.

In the present study, the work includes the analysis of a G+10 storey moment resisting frame buildings in accordance with IS1893-2016 provisions; one with fixed base and other with base isolated system. The objectives of the study are as follows;

- To carry out modeling and analysis of fixed base and base isolated building by using ETABS.version17 software and study the effect of seismic forces on both models.
- To design and study the effectiveness of lead rubber bearing used as a base isolation system.
- To carry out comparison between fixed base and base isolated buildings by pushover analysis method on the basis of seismic properties like storey displacement, inter storey drift, base.

3. METHODOLOGY

To examine the seismic behaviour of moment resisting frame building with and without base isolation system, comparative analytical study has been carried out between the models using static non-linear pushover analysis method. The analyses have been performed using ETAB version 17.0. In pushover analysis method, for the calculation of different parameters like displacement and member forces, only the maximum values are considered.

The work started with modeling and analysis of RC building for two cases. The first one is fixed base and the second is base isolated. In the present study Lead Rubber Bearing is used as a base isolator. After analysis of fixed base regular or rectangular model using E-TABS 15.1 version software, maximum vertical reaction is obtained. By using this vertical reaction lead rubber bearing is designed manually and the same is used as a base isolator for the second model considered.

3.1 METHOD USED FOR ANALYSIS

3.1.1 Pushover Analysis: Pushover is a static-nonlinear analysis method where a structure is subjected to gravity loading and a monotonic displacement-controlled lateral load pattern which continuously increases through elastic and inelastic behavior until an ultimate condition is reached. Lateral load may represent the range of base shear induced by earthquake loading, and its configuration may be proportional to the distribution of mass along building height, mode shapes, or another practical means.

3.1.2 Why Pushover Analysis method: The need for a simple method to predict the non-linear behaviour of a structure under seismic loads saw light in what is now popularly known as the Pushover Analysis (PA). PA is a non-linear analysis procedure to estimate the strength capacity of a structure beyond its elastic limit (meaning Limit State) up to its ultimate strength in the post-elastic range.

3.1.3 The Plastic Hinges- Hinges are points on a structure where one expects cracking and yielding to occur in relatively higher intensity so that they show high flexural (or shear) displacement, as it approaches its ultimate strength under cyclic loading. These are locations where one expects to see cross diagonal cracks in an actual building structure after a seismic mayhem, and they are found to be at the either ends of beams and columns, the 'cross' of the cracks being at a small distance from the joint. Hinges are of various types – namely, flexural hinges, shear hinges and axial hinges.
in Fig4. AB represents the linear elastic range from unloaded state A to its effective yield B, followed by an inelastic but linear response of reduced (ductile) stiffness from B to C. CD shows a sudden reduction in load resistance, followed by a reduced resistance from D to E, and finally a total loss of resistance from E to F. Hinges are inserted in the structural members of a framed structure typically as shown in Fig.2. These hinges have non-linear states defined as 'Immediate Occupancy' (IO), 'Life Safety' (LS) and 'Collapse

Fig.4 capacity curve for pushover analysis

Fig. 5 formation of plastic hinges

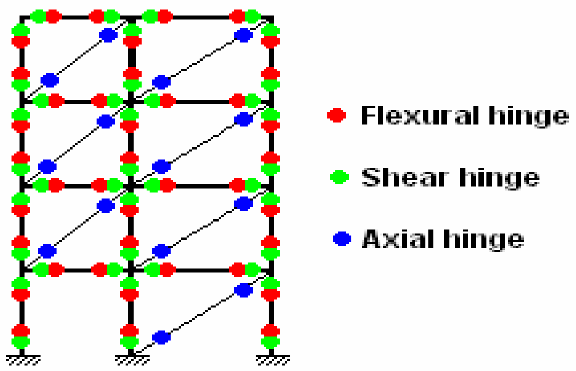
Prevention' (CP) within its ductile range. This is usually done by dividing B-C into four parts and denoting IO, LS and CP, which are states of each individual hinges (in spite of the fact that the structure as a whole too have these states defined by drift limits)

4. DESCRIPTION OF THE BUILDING

4.1 Geometrical Properties

Table 1

S.No	Parameters	Dimension
1	Building Type	Commercial Building
2	Type Of Frame	Moment resisting frame
3	Plan Dimension	25x15 (X*Y)
4	No. Of Stories	G+10
5	Bottom Storey Height	3m
6	Floor To Floor Height	3m
7	Total Height Of Building	30m
8	Slab Thickness	150mm
9	Column size	400x400mm
10	Beam size	400x250mm



4.2 material properties (IS 456:2000)

Table 2

S.No	Material	Grade(N/mm^2)
1	Grade of concrete (beam & slab)	M20
2	Grade of concrete(column)	M25
3	Rebar	Fe415

5. MODELLING AND ANALYSIS

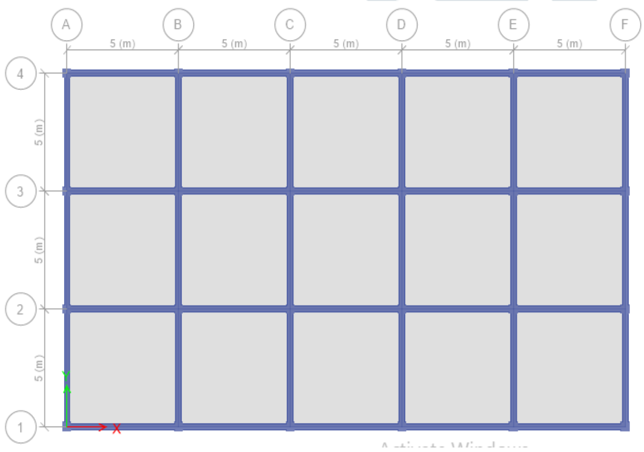


Fig. 6 Model 1 without base isolation (plan view)

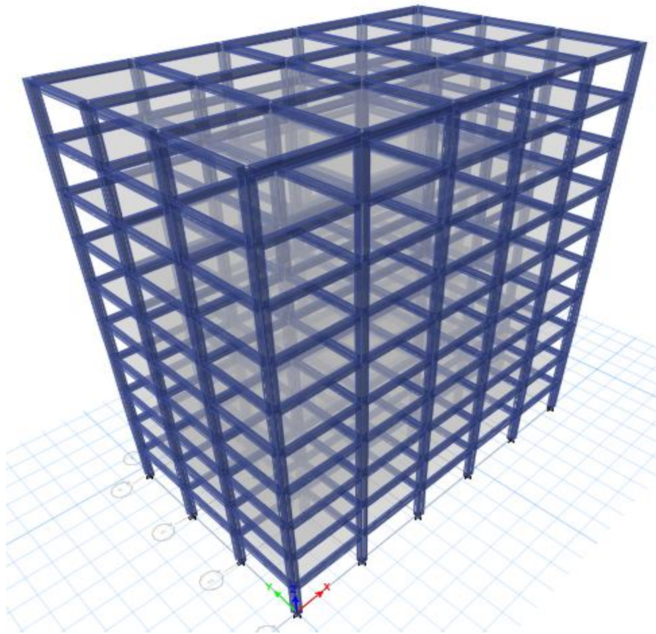
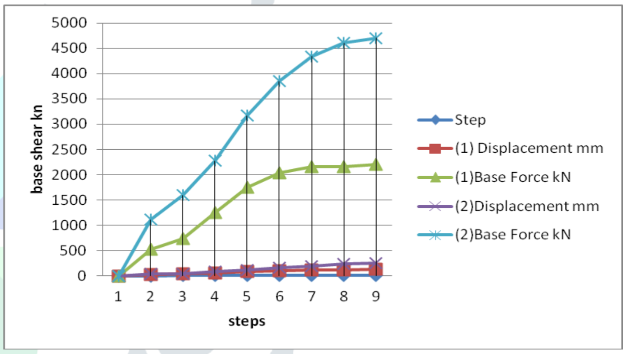


Fig. 7 Model 1 without base isolation (3D view)

Fig. 8 Model 2 with base isolation (3D view)

6. RESULTS AND DISCUSSION

6.1 Base shear and monitored displacement curve :X



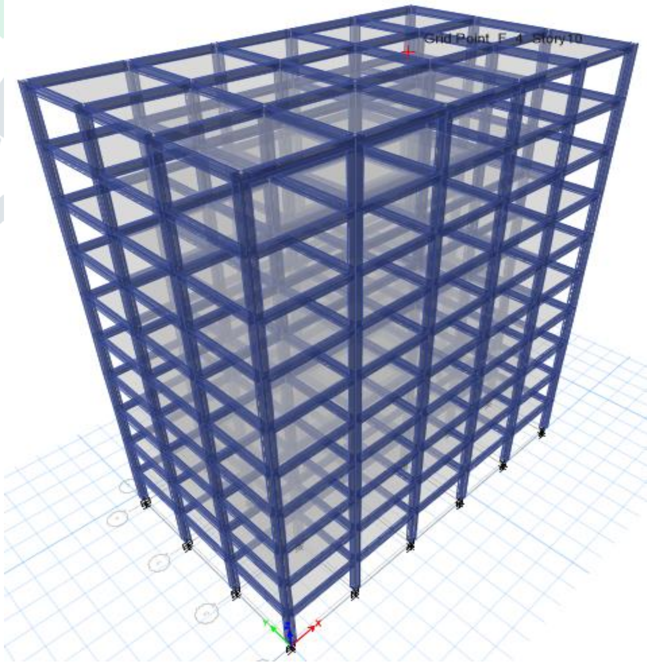


Fig. 9 pushover curve in x direction

6.2 Base shear and monitored displacement curve :Y

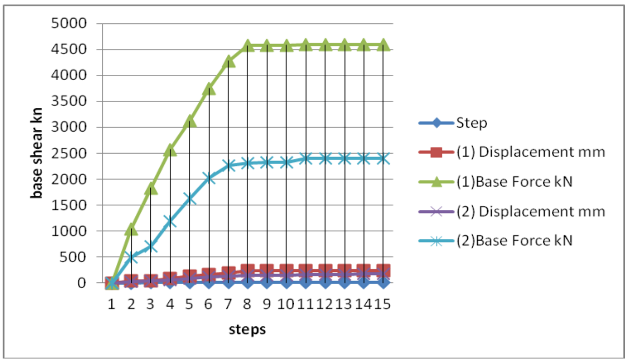


Fig. 10 pushover curve in y direction

6.3 Story Displacement :X

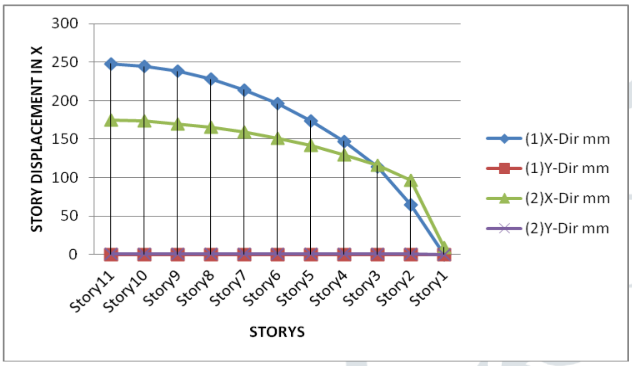


Fig. 11 story displacement curve in X direction

6.4 Story Displacement: Y

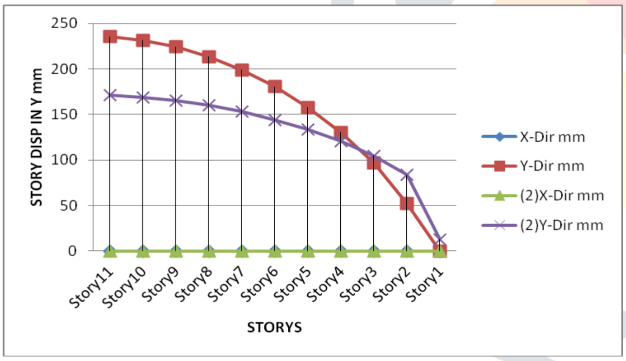


Fig. 12 story displacement curve in Y direction

6.5 Story Drift: X

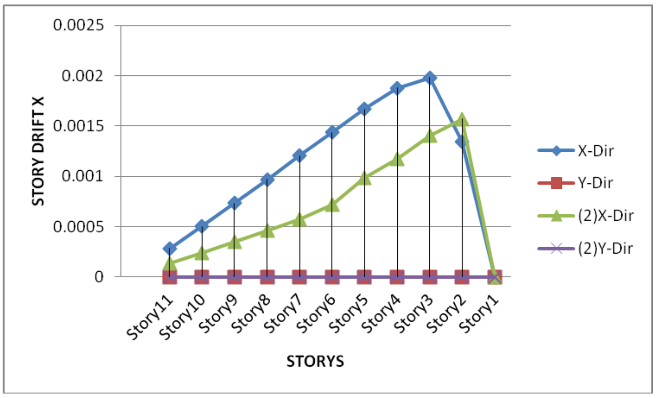


Fig. 13 story drift in x direction

6.6 Story Drift: Y

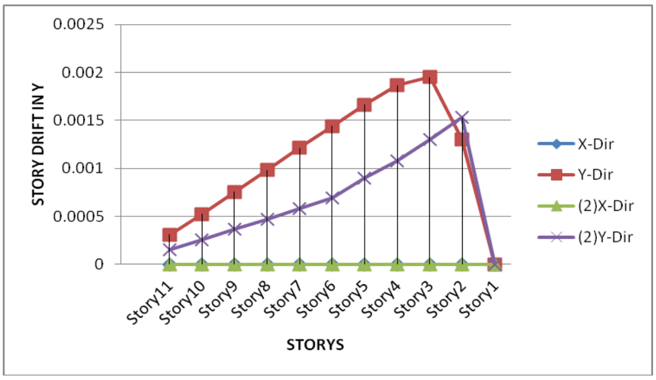


Fig. 14 story drift in y direction

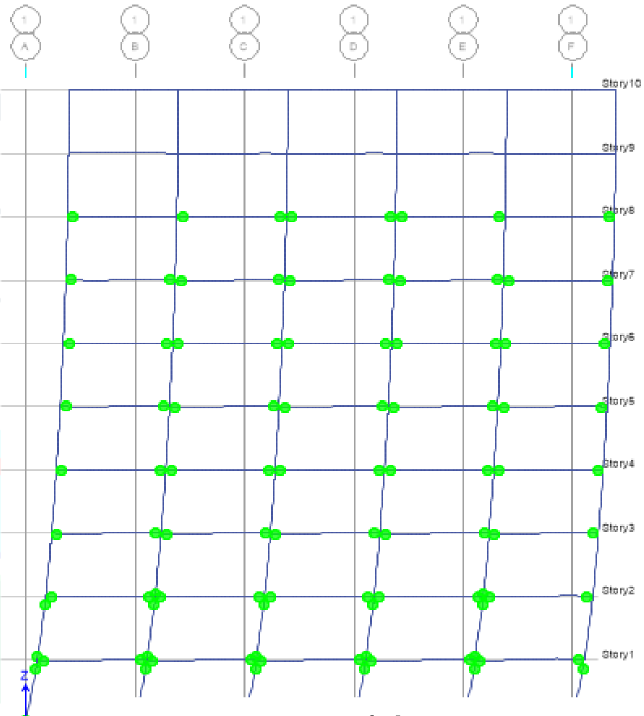


Fig. 15 Formation of Plastic Hinges

7. CONCLUSION

This research represents the study for moment resisting frame G+10 commercial building along with base isolation system, on the basis of analysis following conclusions have been drawn for M.R.F. structural framework:

1. Moment resisting frame building with fixed base shows poor performance during earthquake excitation when compared to moment resisting frame building with base isolation system due less lateral stiffness.

2. To increase the performance of the M.R.F. structure under horizontal loads, particularly when speaking about seismically prone areas modifications of such system can be done by adding structural elements such as base isolators.

3. The inter storey drift in m.r.f. building with base isolation model as per clause 7.11.1 in IS 1893:2016 part 1 did not exceed the allowable limits.

4. The overall performance of both the buildings has been studied with various seismic parameters. It was found that the base shear of the model 1 was comparatively greater than the other model structure i.e. model 2.

5. Within the limitations of this study, it is recommended that the moment resisting frame building with base isolation system should be preferred because of considerable difference in storey displacement, base shear and storey drift, when compared to the other model.

8. REFERENCES

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