Seismic Analysis of Fixed Base and Base Isolated RC Buildings Having Diaphragm Discontinuity

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Abstract - *Now a days need and demand of latest generation has made architects and engineers to plan the buildings having irregularity. The present study deals with plan irregular buildings having diaphragm discontinuity. Often buildings with Discontinuities or openings are provided for many reasons like stair cases, architectural beauty, lighting purposes etc. These openings will cause for stresses at the buildings. When these buildings are constructed in seismic areas, it may be vulnerable to earthquake.so the buildings should designed to resist such earthquake forces.Base isolation is one of the promising and widely accepted passive control device to resist these forces by isolating the super structure from the sub structure, among that lead rubber bearing (LRB) is chosen as an isolator.LRB has the ability to carry the vertical load of the building and it is very stiff in vertical direction but are flexible in horizontal direction. For the analysis, different shapes of diaphragm openings at various positions such as openings at the Centre, openings at the Corners and opening at the Periphery are considered. Analysis is done to find out the most vulnerable building among them. The response of Base isolated building and fixed base building are evaluated for G+4 Storey level. Response spectrum analysis is carried out in terms of Storey Displacement, Base shear, Time period and Storey drift using ETABS software. For Base isolated building, the results shows that there is an increase in Storey displacement and Time period and decrease in Base shear and Storey drift compared with Fixed Base building.*

Key Words: **Irregularity, Diaphragm discontinuity, Base isolation, Base shear, Storey displacement, Time period, Storey drift.**

1. INTRODUCTION

For decade many strong earthquakes have conquered the life due to the impact of strong vibration on building one after the other in many countries. To save the life of human beings and to mitigate the response of earthquake on the structure many engineers and architects trying to find out the best applicable method to reduce the response given to ground motion by the structures. According to the Indian Standard, structures are designated as structurally regular or irregular. Irregularity in buildings can cause damages easily. A regular structure has no significant discontinuities in plan, vertical configuration or lateral force resisting systems. An irregular structure has significant discontinuities such as those in IS 1893 (Part 1): 2002 Table 4(plan irregularities) and Table 5(vertical irregularities).In structural engineering, a diaphragm is a structural system used to transfer lateral loads to shear walls or frames through in plane shear stress. Two primary types of diaphragm are rigid and flexible. Flexible diaphragms resist lateral forces depending on the area, irrespective of the flexibility of the members that they are transferring force to. Rigid diaphragms transfer load to frames or shear walls depending on their flexibility and their location in the structure.

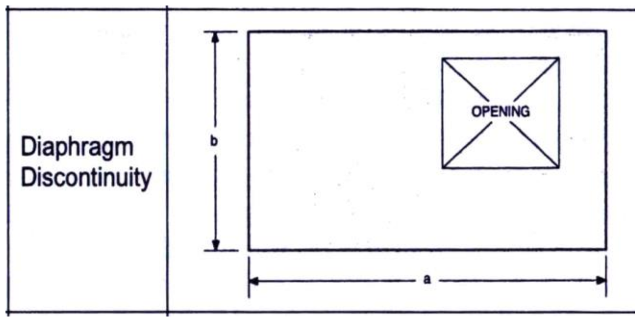

Fig -1: Diaphragm discontinuity

There are two basic different approaches to ensure the earthquake resistance design and construction of structures, i) Conventional earthquake resistant design approach. ii) Seismic isolation earthquake resistant design approach. Conventionally, the seismic design of building structures is based on the concept of increasing the resistance capacity of the structures against earthquakes by employing eg; the use of shear walls, braced frames, or moment-resistant frames. However, these traditional methods often result in high floor accelerations or large inter-story drifts for buildings. Because of this, the building contents and non structural components may suffer significant damage during a major earthquake. Seismic isolation an earthquake resistant design is increasingly being adopted nowadays. Base isolation is a method in which the structure (superstructure) is separated from the base (foundation or substructure) by introducing a suspension system between the base and the main structure. The three basic characteristics of an isolation system are: i) horizontal flexibility to increase structural period and reduce spectral demands (except for very soft soil sites), ii) energy dissipation to reduce isolator displacements, and iii) sufficient stiffness at small displacements to provide adequate rigidity for service-level environmental loadings. In seismic isolation, the fundamental purpose is to reduce substantially the ground motion forces and energy transmission. Installing isolating layers with a considerable horizontal flexibility is a good way to achieve that aim. Base isolation is classified under two categories. They are elastomeric bearings and sliding type bearings.

Types of Base Isolators are;

i) Laminated Rubber Bearing
ii) Lead Rubber Bearings (LRB)
iii) High Damping Rubber Bearings (HDRB)
iv) Friction Pendulum System (FPS)

Among these lead rubber bearing are chosen for the present study. Lead rubber bearing (LRB) are the laminated rubber bearing containing one or more lead plugs to deform in shear.

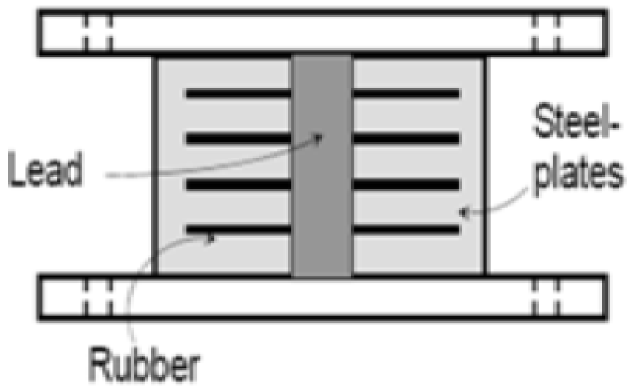

Fig -2: Lead Rubber Bearing

Lead core is the device that will supply extra stiffness to the isolators and appropriate damping to the system. It has low maintenance when compared to other types of isolators.

1.1 Objective

- To model and analyze the seismic response of multi Storey Fixed Base buildings having diaphragm discontinuity by using ETABS software.
- To evaluate the effect of slab openings on the seismic response of a multi storied building in order to find more vulnerable building among them.
- To design and study the effectiveness of lead rubber bearing used as a Base isolator for the most vulnerable building.
- To model and analyze the seismic response of Base isolated buildings having diaphragm discontinuity by using ETABS software.
- To compare the seismic response of the Fixed Base and Base isolated building in terms of Time period, Storey displacement, Base shear and Storey drift by response spectrum analysis.

1.2 Need for study

In multi Storey buildings, damages from earthquakes generally affected at the locations having structural weakness. When such irregular buildings are constructed in severe seismic zone, the analysis and design becomes more complicated. Studies have revealed that the isolated structure gives better performance to resist the earthquake forces.In order to evaluate the effect of slab openings in the regions having severe seismicity and the performances of Base isolation in the building, this study will be useful.

2. MODELLING AND ANALYSIS

The design software ETABS 2015 has been used for the modelling and analysis of the buildings. For the present study response spectrum analysis is carried out.

2.1 Building and Geometry

Plan dimension in x direction (m): 24
Plan dimension in y direction (m): 32
Storey height (m): 3.5
Slab thickness (mm): 125
Size of beams (mm): 350×350
Size of columns (mm): 400×400
Parapet height: 0.7 m.
The Slab is modelled as a rigid diaphragm

Table -1: Seismic Parameters considered

Particulars	Details
Seismic Zone	IV
Building Type	SMRF
Response Reduction Factor	5
Plan Irregularity	Diaphragm Discontinuity
Soil Type	Type 1(Rock or Hard soil)
Importance Factor	1.5

For the study the region having severe earthquake such as seismic zone IV is chosen as per IS 1893:2002, clause 6.4.2. 1/3 percentage of the total area is considered as diaphragm openings in order to find the influence of slab openings in building. Response reduction factor R for special RC moment resisting frame (SMRF) is 5 as per IS-1893:2002, clause 6.4.2, Table 7.Importance factor, I for public building is 1.5 as per IS 1893:2002, clause 6.4.2, Table 6. Load Combination are taken as per IS 456:2000, load combinations provided are; i) DL+LL ii) 1.5 (DL+ LL)
iii) 1.2 (DL+ LL + ELx) iv) 1.2 (DL+ LL +ELy)

2.2 Models Considered for the analysis

The following models are considered for G+4 Storey buildings and it is developed using ETABS software.
Type 1: Square shaped openings at the Centre of the building
Type 2: Square shaped openings at the Corner of the building
Type 3: Square shaped openings at the periphery of the building
Type 4: L shaped openings at the Centre of the building
Type 5: L shaped openings at the Corner of the building
Type 6: L shaped openings at the periphery of the building

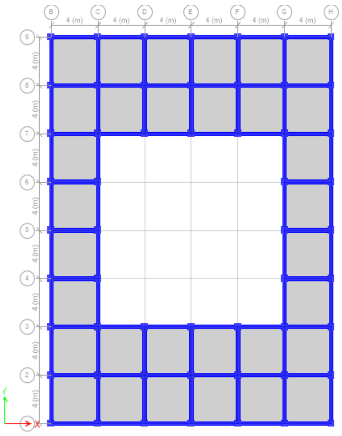

Fig-3: Type 1

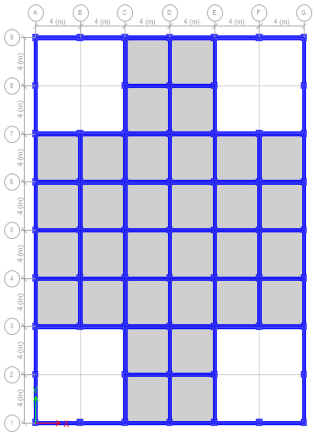

Fig- 4: Type 2

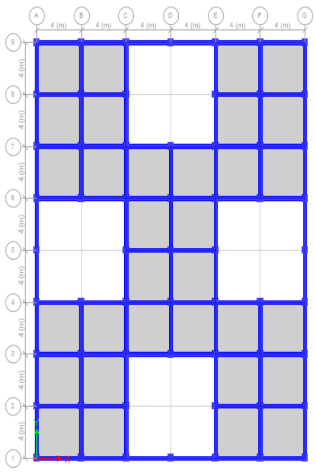

Fig- 5: Type 3

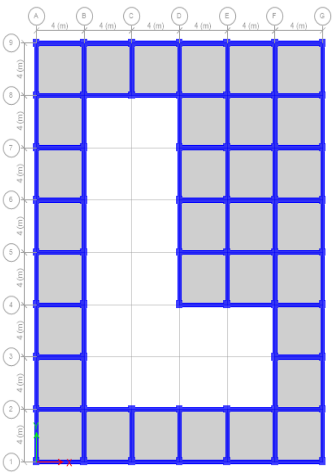

Fig- 6: Type 4

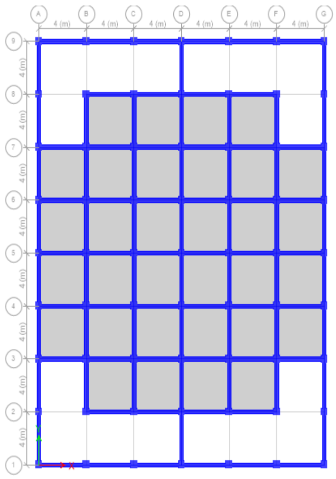

Fig- 7: Type 3

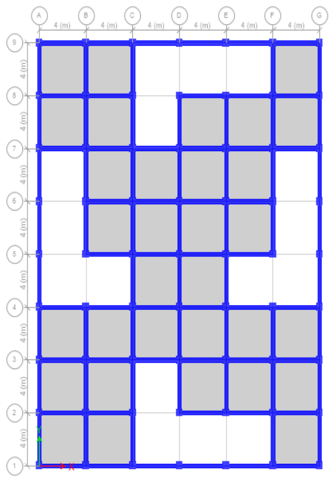

Fig- 8: Type 4

2.3 Analysis Method Considered

Analysis methods are broadly classified as linear static, linear dynamic, nonlinear static and nonlinear dynamic methods. In these the first two methods are suitable when the structural loads are small and no point, the load will reach to collapse load and are differs in obtaining the level of forces and their distribution along the height of the structure. Analysis of a structure is mainly concerned with the behavior of the structural element under different lodes like dead load , live load ,and some other loads caused by nature (earth quake). Hence the loads are classified as static load and dynamic load. In present generation many computer applications are invented for analysis and design of structure under this loading conditions dead load and live load comes under static load where seismic load comes under dynamic loading. In response spectrum analysis, the maximum response plotted against of undamped natural period and for various damping values and can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.Detailed information from the structural model is coupled with the corresponding spectral values for each specific mode of vibration. The independent results are then combined using an appropriate technique to determine the response of the overall structure. This spectra helps in obtaining peak structural responses (only when linear), it is also possible to find lateral forces developed in a building due to an earthquake, hence used for design of earthquake resistant structure. Response spectrum method is applicable for only linear systems and for nonlinear systems whose nonlinearity is same in whole system.

3. RESULT AND DISCUSSIONS

Among the various models considered in fixed base building, the building which is more vulnerable to earthquake is Base isolated in order to find out the effectiveness of lead plug rubber bearing (LRB) used as a Base isolator. From the analysis, Type 4 which is irregular openings at the Centre shows more vulnerable to earthquake ground motions.so these building are Base isolated and the result is compared with Fixed Base Building.

3.1 Storey Displacement

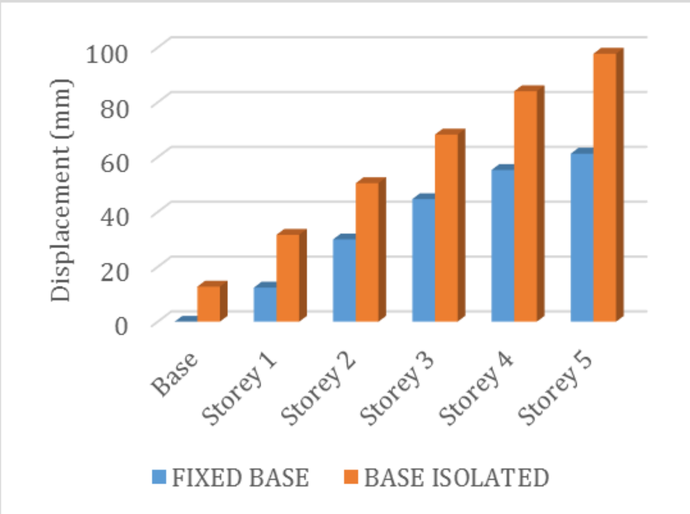

Fig-9: Storey displacement for fixed base and Base isolated building

From the result, it is observed that the displacement is being 61.3 mm in fixed base building and it is increased drastically to 98.7 mm in base isolated building due to the presence of LRB (lead rubber bearing).here, We can see that Base isolated building increases the flexibility by separating superstructure from the foundation in comparison with fixed base building.

3.2 Time period

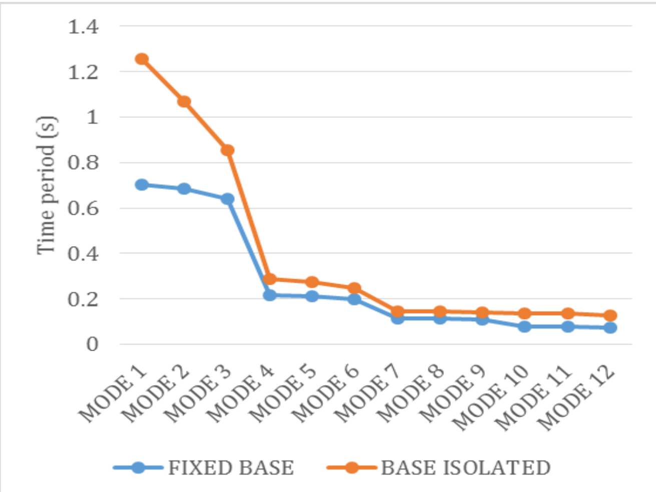

Fig-10 Time period for fixed base and Base isolated building

As a result of the increased flexibility of the system, the Time period which is the number of seconds for the building to vibrate back and forth is 0.702 sec in fixed condition and is increased to 1.255 sec. If the buildings were rigid then every point in it would move by the same amount as the ground. But most of the buildings are flexible and different parts move back and forth by different directions.it is found that the time period is almost increased after providing lead rubber isolator when compared to fixed base building.

3.3 Base shear

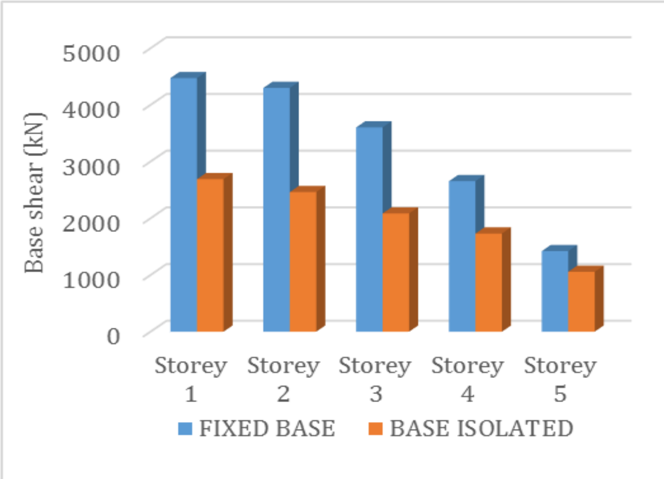

Fig-11 Base shear for fixed base and Base isolated building

In response spectrum analysis the Base shear is reduced in Base isolated by 39.86 % compared to fixed base. Reduction of the Base shear force is evident in implementing seismic isolation by reducing the amount of seismic forces that act at base of the structure.

3.4 Storey drift

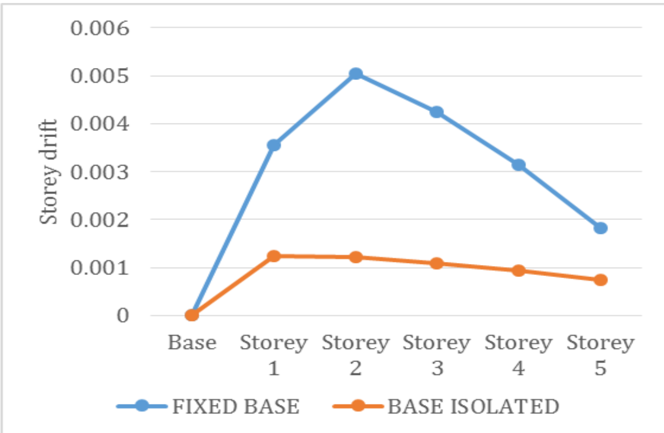

Fig-12 Storey drift for fixed base and Base isolated building

The story drifts is reduced in base isolated when compared to fixed base which is the effect of lead rubber bearing. This enables the structure to behave as almost ideally stiff and in this way the damage risk of the structural and non-structural elements is minimized. So, rigid body movement has been taken in base isolated buildings.it is important to reduce story drifts of top stories which damage structure during earthquake. In base isolated building story drift is reduced by 59.53 % when compared to fixed base building.

4. CONCLUSIONS

- The building having irregular opening (L shaped opening at the centre, Type 4 is more vulnerable to earthquake than rest of the models considered.
- It is found that when placing lead rubber bearing (LRB) as an isolator in building which is more vulnerable to earthquake, displacement is increased drastically in comparison with fixed base building due to the presence of isolators in between foundation and superstructure.
- The Fixed base building have zero displacement at base of building whereas, all base isolated building models shows increase in amount of storey displacements at base.
- It is found that the time period is increased in base isolated building due to the presence of flexible interface.
- The Base shear is also reduced by 40 % after providing LRB in G+4 storey building which makes structure stable during earthquake when compared to fixed base building.
- In Base isolated building story drift is reduced by 60 % at the top storey when compared to fixed base building by the use of LRB as an isolator. Hence the damages for structural and non structural elements are greatly reduced.
- From the study it shows that, the buildings having diaphragm discontinuity gives better performance by the use of isolators as compared to fixed base building for regions having severe seismicity.

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