International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

# Study on the Earthquake Response of a RC Building with Base Isolation

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**Abstract:** ***Base isolation is an effective method for earthquake resistant design to reduce vibrations transmitted from ground to the structure. The principle of seismic isolation is to introduce flexibility in the structure. In the present study of base isolation, a plus shaped G+6 storey with rubber isolation and friction isolation have been analyzed using SAP 2000 software. The analysis is done using nonlinear seismic Time History data for with and without base isolation condition. Time history analysis has been performed on earthquakes EL Centro, 1940. So in this work the performance of RC building in dynamic are studied with base isolation and the results are compared with the results obtained for building without base isolation. It was observed that base isolation increases the time period of the building & hence correspondingly reduces the base shear.***

**Keywords:** Base Isolation, Rubber isolators, Friction isolators, Time History Analysis

## 1. Introduction

Earthquakes are one of nature's greatest hazards, throughout historic time they have caused significant loss of life and severe damage to property, especially to man-made structures. The first step in understanding earthquake risk is to dissect the earthquake risk or loss process into its constituent steps. Earthquake risk begins with the occurrence of the earthquake, which results in a number of earthquake hazards**.** The most fundamental of these hazards is faulting, that is, the surface expression of the differential movement of blocks of the Earth's crust. To avoid the consequences of earthquake there is a technique known as base isolation.

Recently, even the structures constructed with good techniques and machines also had destroyed due to earthquakes leading to immense loss of life and property and immeasurable sufferings to the survivors of the earthquake hit area. This compelled the engineers and scientists to think of new techniques and methods to save the structures from the destructive forces of earthquake. The earthquakes in the recent past have given new ideas to them by giving enough evidence of performance of different type of structures under different earthquake conditions and foundation conditions. This has given birth to different type of innovative techniques to save the structures from the earthquakes. The technique of base isolation has been developed in an attempt to reduce the response on buildings and their contents during earthquake attacks and has proven to be one of the most effective methods for a wide range of seismic design problems on buildings in the last two decades. Base isolation systems are increasingly utilized methods of advanced seismic resistance, and the effects of these systems on the seismic responses of structures are studied in this paper.

The main objective of this paper is to find out the response of RC building subjected to a selected earthquake ground motion by Time History Analysis(EL-Centro, NS-Component 1940) , to compare the performance of a base isolated building (rubber isolator and friction isolator) with fixed base building and measure the vibration parameters (Natural frequency , mode shape ).

## 2. Modeling of RC Building

In the present study reinforced concrete moment resisting frame of G+6 storey with and without base isolation are considered. Analysis is done by using SAP 2000 v14 software. A Time history analysis is carried out for the 1940 El Centro earthquake. The following are the specification of G+6 storied irregular RC building located in seismic zone V. Here the plus shaped building is selected**.**

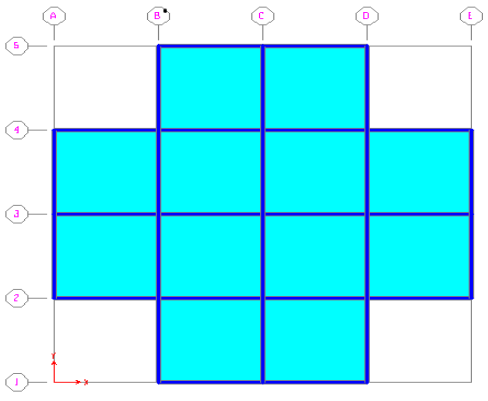


**Figure 1:** Plan of the model

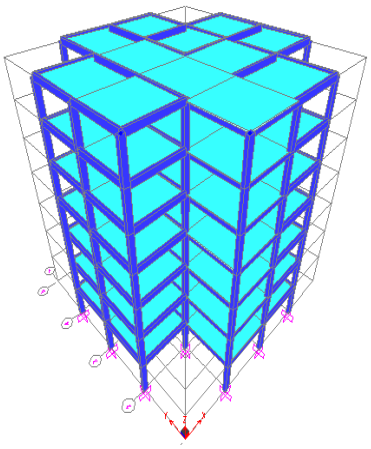

**Figure 2:**.3D view of the model

The plan and 3D view of the model is as shown in Fig 1 and Fig 2. The material properties and structural properties of RC building located in Zone V are as follows in Table 1 and Table 2.In the modelling material is considered as an isotropic material.

**Table 1:** Material Properties

| *Material Property* | *Values* |
|---|---|
| Density of concrete | 25 kN/m$^3$ |
| Grade of concrete | 30 MPa |
| Grade of reinforcing steel | Fe 415 MPa |
| Modulus of Elasticity of concrete | 27386 MPa |
| Modulus of Elasticity of steel | $2\times10^5$ MPa |

**Table 2:** Dimension of Structural Member

| *Dimension of Structural Member* | |
|---|---|
| Beam | 0.23m × 0.50m |
| Column | 0.30m × 0.50m |
| Thickness of wall | 0.23 m |
| Thickness of slab | 0.16 m |
| Storey Height | 3 m |

Here this building frame is investigated in different models. It is firstly investigated as a fixed-base case without base isolators by considering only bare frames. In the second model, rubber isolators of rubber are used at the base level of the building. In the third model, friction isolators are used at the base level of the building. The properties of the isolators are shown in the Table 3 and Table 4.

**Table 3:** Properties of Rubber Isolators

| | *U1* | *U2* | *U3* |
|---|---|---|---|
| Linear effective stiffness (kN/m) | 1500000 | 800 | 800 |
| Nonlinear stiffness (kN/m) | | 2500 | 2500 |
| Yield Strength (kN) | | 80 | 80 |
| Post yield stiffness | | 0.1 | 0.1 |

**Table 4:** Properties of Friction Isolators

| | *U1* | *U2* | *U3* |
|---|---|---|---|
| Linear effective stiffness (kN/m) | 15000000 | 750 | 750 |
| Non-linear stiffness (kN/m) | | 15000 | 15000 |
| Friction coefficient, slow | | 0.03 | 0.03 |
| Friction coefficient, fast | | 0.05 | 0.05 |
| Rate parameter | | 40 | 40 |
| Radius of Sliding surface | | 2.23 | 2.23 |

## 3. Analysis using SAP 2000

The three structural models under consideration are analysed in SAP 2000 (Ver.14.2) for Time History (EL- Centro, NS Component 1940) analysis.It is known as Non-linear dynamic analysis. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step-by step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake.After assigning the loads to the structure, analysis is done to evaluate base shear, displacement, and time period. After analysis design can be executed in SAP 2000 as it includes various international codes and the structure can be designed using these codes.

## 4. Result and Discussions

### 4.1Base Shear

The base shear of the building were acquired from seismic analysis using the Time History Analysis corresponding to 5% critical damping considering both fixed base condition and isolated base condition. Fig 3 shows the comparison graph of base shear in fixed base and isolated base (rubber isolator and friction isolator) buildings for the analysis.

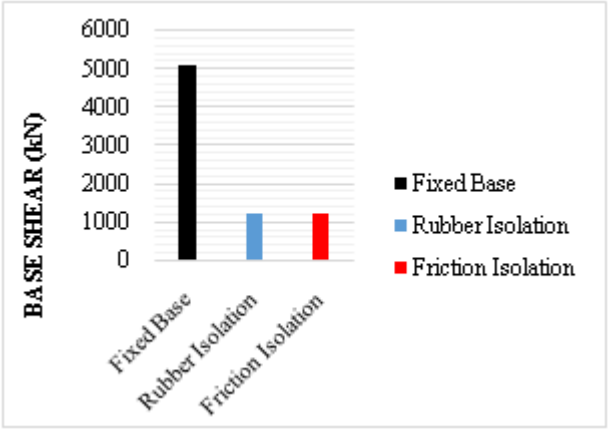


**Figure 3:** Comparison Graph of Base Shear

### 4.2 Displacement

Lateral displacements were estimated for all the three cases and are shown in Fig 4. It gives minimum lateral displacement values for the buildings with fixed base situation. While lateral displacement is same in all the storeys with isolated base situation as the building is separated from the ground.

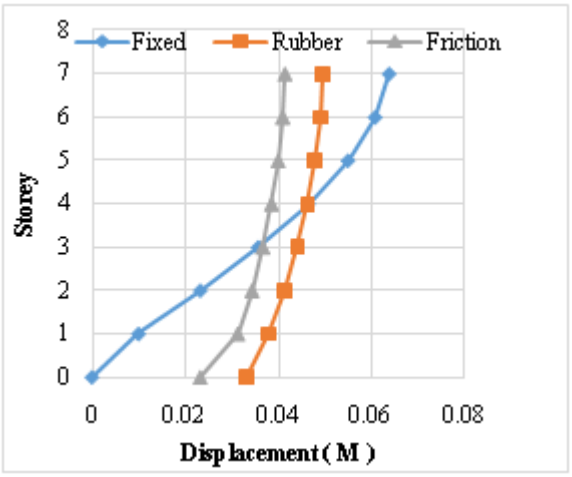


**Figure 4:** Comparison of Storey Displacements in Fixed and Isolated Building

### 4.3 Time Period

The increase in period for structure with isolated base makes sure that the structure being completely removed from the resonance range of the earthquake. Fig 5 shows that overall response is mainly affected when using isolators in the structure. The period of the structure is lengthened with the provision of isolators at the base.

**Table5:** Comparison of Modal Analysis Results for Fixed and Isolated Buildings

| Time Period (s) | | | | |
|---|---|---|---|---|
| Number | Mode Shape | Fixed | Rubber | Friction |
| 1 | Mode | 0.653720 | 1.354247 | 1.357622 |
| 2 | Mode | 0.552944 | 1.252153 | 1.246850 |
| 3 | Mode | 0.524178 | 1.234426 | 1.211166 |
| 4 | Mode | 0.337409 | 0.345389 | 0.344257 |
| 5 | Mode | 0.293297 | 0.304858 | 0.304192 |
| 6 | Mode | 0.273331 | 0.292300 | 0.291733 |
| 7 | Mode | 0.258263 | 0.276894 | 0.276360 |
| 8 | Mode | 0.215745 | 0.261831 | 0.261504 |
| 9 | Mode | 0.202279 | 0.256442 | 0.256065 |
| 10 | Mode | 0.185952 | 0.252457 | 0.251205 |
| 11 | Mode | 0.182258 | 0.203158 | 0.202913 |
| 12 | Mode | 0.176829 | 0.182429 | 0.182399 |

Table 5 shows that the fundamental period of the structure is approximately doubled for the isolated structure. Fundamental period is the period of first mode of vibration.

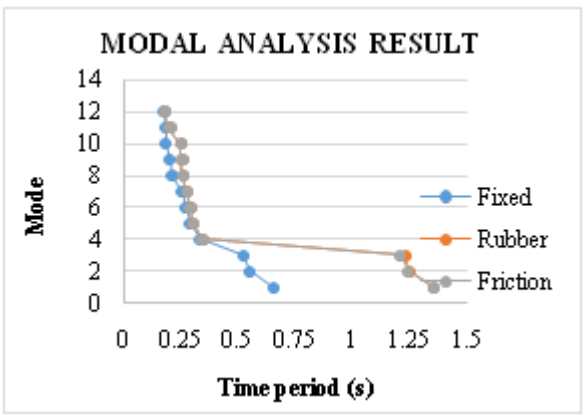


**Figure 5:** Comparison of Time Peroid in fixed base and isolated base building

## 5. Conclusions

In the present study, an attempt is made to compare the results obtained from Time History Analysis. Different models of G+7 storey of fixed base, rubber isolated and friction isolated buildings are modelled in SAP 2000. The seismic analysis is carried out taking into consideration that the buildings are located in zone V. The base shears, storey displacement, time period are plotted and compared with each model. The mode shapes corresponding to each time period is obtained.The major conclusions drawn from the present study are as follows:

- The Base isolation substantially increases the time period of the building & hence correspondingly reduces the base shear .The base shear is reduced upto 75 % of that of fixed one. The increase in period for structure with isolated base makes sure that the structure being completely removed from the resonance range of the earthquake. Analysis shows that the fundamental period of the structure is approximately doubled for the isolated structure. Increment in fundamental period reduces the maximum acceleration and hence the earthquake induced forces in the structure.
- From the tables and graphs it is clear that the storey displacements are much higher for isolated buildings, also the displacement of all the storeys are almost same. The isolator with rubber has more displacement compared to friction isolator.

## 6. Future Scope

- Study can be performed in Response Spectrum Analysis.
- Present study is limited to Plus shaped building, it can extended to different plan shapes.
- Effect of base isolation can be investigated on buildings with mass and area irregularity

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