Earthquake Resistant Structure Using Base Isolation Technique

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Abstract - *Base isolation method is one of the passive seismic isolation systems commonly used in earthquake prone areas. Over the past several decades, base isolation has been considered for structures like buildings and bridges subjected to earthquake ground motion. The main application of base isolation system is to reduce base shear, displacement and increases the period of oscillation due to earthquake ground excitation. In this project, three-dimensional nonlinear analysis is performed on RC residential building. The design and analysis of building is done using computer program SAP 2000 v 16.0.0. The performance of the considered building with and without base isolator is studied. The main objective is to compare efficiency of fixed base and isolated base building. The laminated rubber bearings are used as a base isolation system.*

Key Words: **Base isolation, Lead rubber bearing, Response spectrum method, Storey displacement, base shear, Storey drift.**

1. INTRODUCTION

Seismic base isolation is one of the most popular methods of protecting a structure against seismic forces. The seismic isolation can be implemented by means of ball bearings, spring systems, rubber bearings (Fig 1), friction bearings etc. The application of base isolation can increase the structure's seismic performance. The principle of base isolation explains it changes the response of the structure which allows moving the ground below the structure so that seismic ground motion is not allowed to reach the structure. The system can be defined as a flexible interface between foundation and structure to decouple horizontal motions of the ground from the horizontal motions of the structure. The isolators also possess inherent damping characteristics which will be added to overall damping of the structure. A considerable reduction in demand forces as well as in inter storey drifts is achieved. Base isolation system concept mainly focuses on the shift of structure's fundamental period out of dominant earthquake energy frequencies range and also increases energy absorbing capabilities. In this process, superstructure and the foundation are decoupled from strong motion horizontal components of ground motion because of which devastating strong motion signals are filtered out.

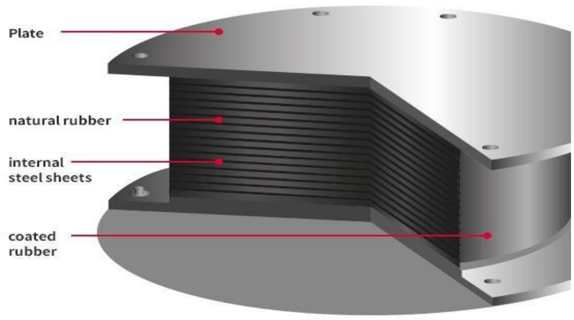

Fig -1: Elastomeric Bearing

1.1 Literature Review

James M. Kelly [1986] [3] described the theoretical aspects of seismic isolation and implementation of those isolation systems in structures. The paper describes the use of different base isolation systems including many modern approaches used in structures and characteristics of the implemented systems with an indication of their range of applicability. A review of all papers on the topic published from 1900 to 1984 has been included. In recent years many practical systems of seismic isolation have been developed and application of this technique for earthquake protection is tested.

Prashika Tamang et.al [2016] [5] adopted base isolation using lead rubber bearing at foundation for the protection of buildings from seismic vibration. The isolation system consists of alternative rubber layers which are bonded between thin steel plates to provide lateral flexibility. During the seismic event the rubber provides flexibility that allows it to move along the movement of the earthquake and slowly comes back to its original shape or position when the shaking is off. Steel which is bonded between the rubber layers holds the rubber in a vertical direction by providing stiffness.

Syed Ahmed Kabeer K I [2014] [6] performed analysis to check the adequacy of the base isolation against earthquake damage when compared to the conventional earthquake resistant design. A building was analysed using the equivalent lateral force method and response spectrum analysis as fixed base (FB) and as isolated base (IB) with lead rubber bearing. The analysis represented a case study for reinforced concrete to show the ultimate capacity of the selected bearing system, and to make a comparison for the difference between the isolated base and the fixed base buildings. Results showed that the presence of the lead rubber bearing reduces significantly the displacement, moment and shear generated for the same mode and hence the reinforcement required is also lesser when compared to the traditional fixed based structure.

Dr. G. V. V. Satyanarayana (2018)[7] illustrated the effect of lead rubber bearing base isolation system for symmetric and asymmetric low rise as well as high-rise buildings. Different parameters like model period, frequency, storey displacements, storey drifts, storey shear were compared. Time history analysis of 5 storied and 20 storied RC frame buildings were done using ETABS software. From the time history analysis it was observed that base isolation method increases the flexibility at the base of the building, displacement, acceleration, velocity was low for base isolated structure which makes the structure more rigid. Ductility demands of the buildings decreases, helped in energy dissipation due to the earthquake forces and also reduces the deformations of the buildings, storey drift and storey shear.

2. OBJECTIVE OF THE PROJECT

- To ensure structural reliability without structural damage due to ground shaking of moderate intensities.
- To carry out the analysis of a multi-storey RCC building with and without laminated rubber bearing base isolator using SAP200 software.
- To compare parameters like storey displacements, storey drifts, base shear.
- To design laminated rubber bearing base isolator for RCC building.

3. METHODOLOGY

G+6 story RCC building was considered for the study. The total load on the structure was calculated manually and obtained value was 26814kN. IS 1893: 2002 is used for the load calculations. The base isolator considered for design was laminated rubber bearing which includes alternate layers of rubber and steel shims. At the top and bottom steel plate is connected. The assumed shape of bearing is circular. Following details were obtained after the design of base isolator [8].

Table -1: Value obtained from design of base isolator

Parameter	Obtained Value
Total thickness of rubber	0.180 m
Area of rubber obtained	9.542 m^2
Stiffness value (K_2)	269176.92 kN/m

Time period (assumed)	= 2 s
From site-specific spectra Sa/g	= 0.105
Damping ratio	= 0.1
Shear modulus of rubber	= 0.5 MPa
Vertical frequency	= 15 Hz
Horizontal frequency	= 0.5 Hz
Diameter of circular bearing provided	= 750 mm
No. of rubber layers provided	= 12 Nos
Thickness of each rubber layer	= 15mm
No. of steel shims provided	= 11 Nos
Thickness of each steel shims provided	= 3 mm
Total thickness (rubber layers + steel shims)	= 313 mm
Thickness of top and bottom plates	= 50 mm
Total height of the isolator	= 365 mm

4. RESULTS AND DISCUSSIONS

The evaluation of seismic resistance of reinforced concrete buildings with and without base isolator was analysed using SAP 2000. G+6 storey building was analysed using the software.

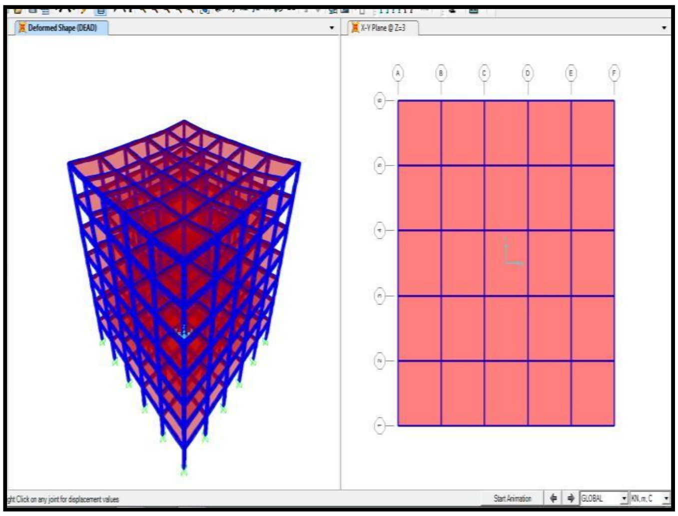

Fig -2: Deformed Shape of RCC building without base isolator

Time history analysis were performed for both the conditions (with and without base isolator).

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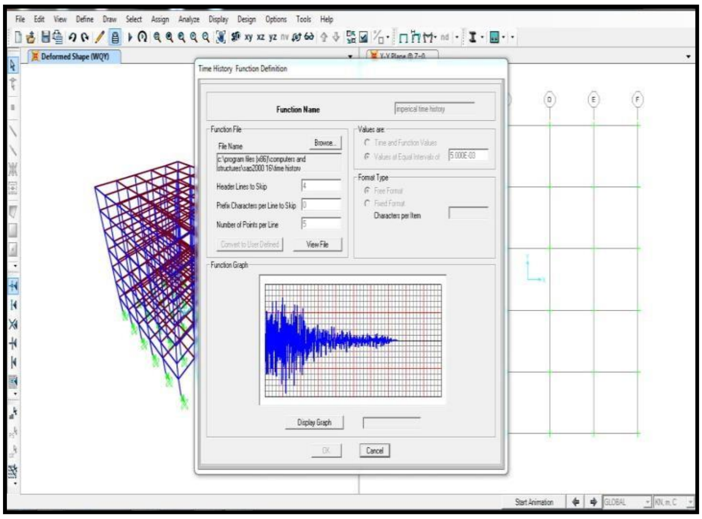

Fig -3: Time History Function Graph with base isolator

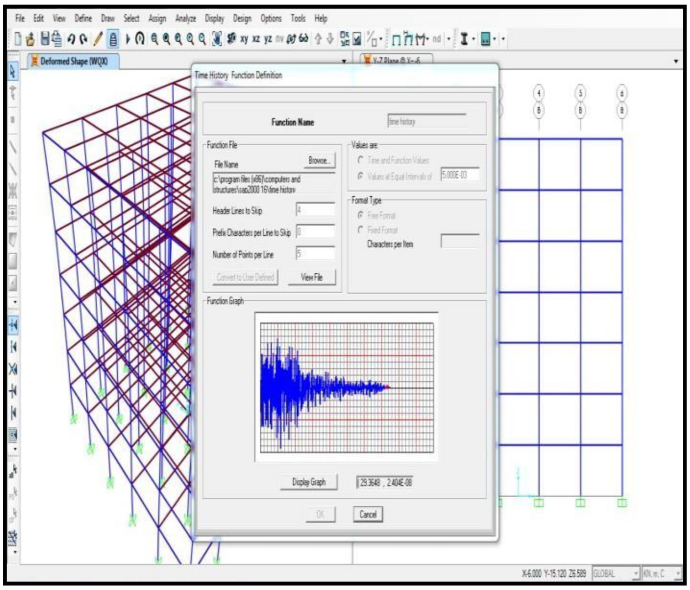

Fig -4: Time History Function Graph without base isolator

Different parameters like storey displacement, base reaction and storey drift are compared and results obtained from the software are shown in the chart -1,2 and 3 shown below.

From chart 1, It was observed that, the displacement in case of Base isolated models is usually more at top floor level compared to fixed base model because of reduction in stiffness of base isolated models.

From chart 2, It was observed that storey drift is reduced at top storey as compare to base of structure due to the decrease in storey stiffness.

From chart 3, It was observed that, base reaction in Base isolated models is reduced compared to fixed base model because of higher time period of base isolated models.

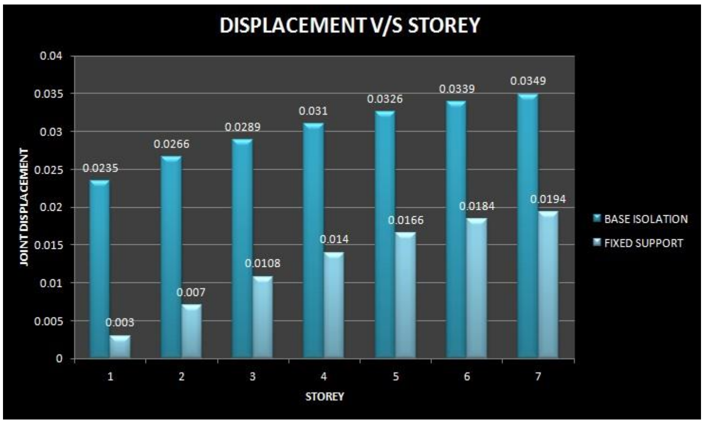

Chart -1: Displacement v/s Storey in X- direction

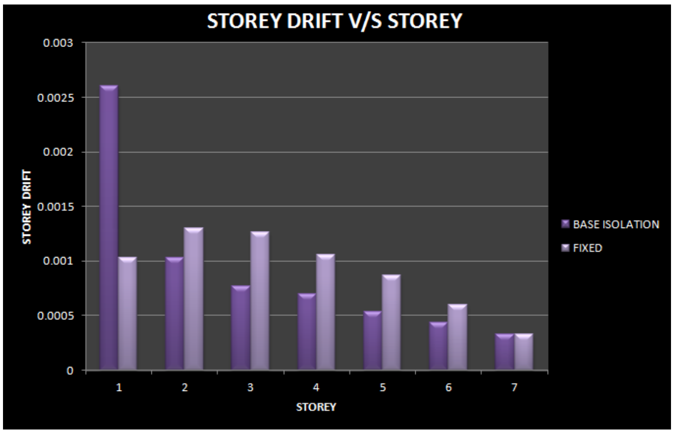

Chart -2: Storey Drift v/s Storey X- direction

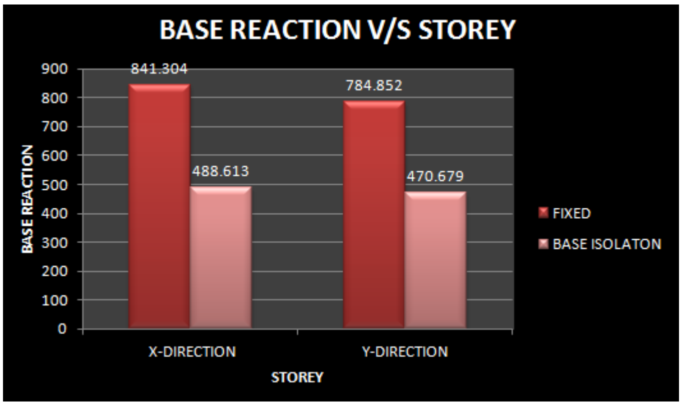

Chart -3: Base Reaction v/s Storey in X &Y direction

5. CONCLUSIONS

Based on the theoretical and modeling finding, the following conclusions were drawn.

1. From the response spectrum analysis, the base shear of base isolated structure is minimum when compared with the fixed base structure

indicating response of building is better in base isolated structure.

2. Base isolated structure shows slighter lateral deflection when compared to a fixed base structure.
3. Due to increase in flexibility of structure, displacement of isolated building increases.
4. The base isolation system maintains longer fundamental period.
5. The base isolation system decouples the building from the earthquake when compared to that of the fixed base building..

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