



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 8, August 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.569**

9940 572 462

6381 907 438

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# Buildings with Base Isolation Techniques using SAP 2000

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**ABSTRACT:** Numerous attempts on research and development for anti seismic structures or the structures that can withstand seismic hazards and lend some ground resistance in earthquakes haven't yielded any satisfactory conclusions. Even though after decades of study and implementation of advanced designing, execution and maintenance tactics in high rise structures, many construction aspects have found a new ways to deal with structural hazards, yet the concerns of seismic hazards are relatively found unanswered. These seismic hazards are prime matter of concern in Earthquake prone zones or the seismic zones worldwide. Over the period of time the research on structural dynamics, study and analysis of the same are carried on using series of earthquake movements by means of varying the earthquake or the seismic intensity. Studies shows those analyses were being performed on a fixed based structures, whereas here it could also be performed on isolated structures with nonaligned isolator elements. As per the analyses with effect of isolated structures, it was discovered that the isolators minimize the lateral load imposed on the structure and in accordance to that it also tend to reduce the size of the building components.

Base isolation has turned out to be a trending design over past few years; here we take a detailed glance at the designing, working, testing as well as the suitability of base isolation design as per Indian Standard using SAP 2000 will be done. The study would also comprise use of designing software's for the analysis taking a building structure as a model in consideration for case study and later concluding the subject post results. The probable merits of base isolation over the conventional approach of dynamic analysis will be discussed..

**KEYWORDS:** Base Isolation, SAP 2000, Structural Dynamics, Frequency distribution, non aligned isolator

## I. INTRODUCTION

An earthquake (also known as a quake, tremor or temblor) is the shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to toss people around and destroy whole cities. At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic activity. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its focus or hypocenter. The epicentre is the point at ground level directly above the hypocenter. Earthquakes are usually caused when rock underground suddenly breaks along a fault. This sudden release of energy causes the seismic waves that make the ground shake. When two blocks of rock or two plates are rubbing against each other, they stick a little. They don't just slide smoothly; the rocks catch on each other. The rocks are still pushing against each other, but not moving. After awhile, the rocks break because of all the pressure that's built up. When the rocks break, the earthquake occurs. During the earthquake and afterward, the plates or blocks of rock start moving, and they continue to move until they get stuck again.

## II. LITERATURE REVIEW

The present work is aimed at designing suitable base isolation systems for 5, 15 and 30 story building using SAP 2000. Various studies have been carried out till date for base isolation but none of them compared static, response spectrum and time history analysis for 5, 15 & 30 story using SAP 2000 software.

**Baruwala et al. (2018)**, study the seismic response of 4 x 4 with 5m bay width in both x and direction from 4 to 30 storey RC Building providing EL CENTRO earthquake data for time history analysis in ETABS. Models are prepared with cross bracing, LRB base isolation and fluid viscous damper. Data for damper is taken for Taylor Device Inc. having damping coefficient: 770 kN-s/m, velocity exponent: 0.3, bracings are made with different ISMB sections at each exterior corner bay of RC building. Analysis results show maximum time period for 30 story buildings is 6.181sec, 5.250sec, and 3.776sec in building with LRB, with FVD, with bracing respectively. Similarly, maximum story displacement is 63.2mm, 46.4mm, 30mm respectively. They concluded the result from analysis as maximum time period with base isolation in 4 story building are 83.47% & 71.34% than with bracing & with FVD respectively. Similarly, the minimum time period with base isolation in 30 storey building is 38.90% & 15.06% than with bracing & with FVD respectively. 30 storey building with bracing shows 52.53% lesser displacement than LRB and 35.24% than FVD. LRB shows maximum drift and bracing shows minimum drift in low rise building while in high rise (more than 14 storey) building FVD shows maximum and bracing shows minimum drift.

**Polat (2017)**, study the seismic behavior and soil interaction of 3 storeys 21.60 x 14.35m floor plan with 3m storey height frame shear wall concrete building by changing the beam, column and slab sizes. The analysis was done by equivalent static and time history analysis method according to the 1999 Marmara earthquake recorded at Duzce meteorology station data. The results concluded that base isolation is made on the time history analysis method. Natural period increases by 8 to 16 times more in a base isolation system than fixed-base buildings. Bending capacity in all columns and shear wall is inadequate. Base isolation system is the alternative solution to construct more secure structures in settlement density regions.

**Pathan (2017)**, study the control of seismic force on 193.6 m<sup>2</sup>, 13 storey C type building for the seismic parameters; storey stiffness, storey displacement, base shear, time period providing dampers and shear wall according to IS 1893:2002. After analysis, they concluded that displacement and storey drift decreases but base shear & stiffness is increased by the use of friction dampers.

**Anwar et al. (2016)**, study the soil structure interaction of base-isolated system for seismic performance of structures resting on different types of soli (limestone, stiff clay, and loose sand) on 18 & 14 storey both symmetric and asymmetric plan RC building. Nonlinear analysis of 6 models with a fixed base, 6 models considered of soil-structure interaction and 6 models are with base isolation system for comparing the seismic parameters: base shear, storey displacement, and torsion in SAP2000. They find the resulting structure resting on medium and soft soil is more significant than on hard soil. Base isolation system is best suited for hard soil. Also, base shear, storey displacement, and torsion are reduced. The base isolated structure with soil-structure interaction reduces torsion by 81% on limestone, 76% on stiff clay, and 75% on loose sand.

**Thriveni et al. (2016)**, study the comparative seismic behavior of 64.7m X 17.12m irregular G+7 storey with 3m storey height and 1.5m bottom height. The analysis was done by equivalent static and response spectrum analysis method in ETABS according to IS 1893:2002 for seismic zone II and IV. The result shows that model with base isolator has higher displacement and storey drift than fixed base and shear wall model but the shear wall has maximum base shear & stiffness than fixed base and base isolator respectively. The time period is increased by 31% in base isolator than the fixed base.

## III. METHODOLOGY

In this study, 5, 15 & 30 story buildings will be designed using SAP. Static, Response Spectrum and Time History analysis will be done on base fixed and base isolated building and the conclusion will be comparison on their analytical results.

1. A theoretical RCC model of a five story, fifteen story & thirty story building was calibrated for stiffness to obtain the natural period of oscillation of 1 second using ritz analysis.
2. A model of a five story, fifteen and thirty story RCC frame was made using the structural analysis software SAP2000.
3. Modal analysis of the building was performed and the actual fundamental period of the structure was compared to the period of 1 second, for which the building was designed. The strong-motion records from earthquakes were found out.
4. Base isolation parameters will be chosen and the bearings will be designed. " Same response spectrum and time-history analyses were performed but on an isolated building.
5. Based on the results feasibility of base isolation system will be discussed both from structural and economic point of view

#### IV. STRUCTURAL MODELLING

In this study, structure will be model for the following cases:

1. The primary lateral resisting system for all the building consists of a moment resisting frame is designed.
2. Columns and beams were modeled as frame elements while the floor slabs were modeled as thin shell elements.
3. The columns of the structure were assumed to be moment connected at the base. Therefore, a fixed joint restraint was assigned at the nodes corresponding to the base connections of the structure.
4. In order to ensure that, in the model, the beams do not act as composite members with the floor slab i.e. the floor slab does not act in compression as a top flange of the beams, area stiffness properties of the shell elements were modified.
5. Each floor needs to be assigned a separate diaphragm constraint, otherwise the relative motion of the nodes between stories will be inhibited and the whole building will behave as a rigid body.
6. The mass and gravity loads from the framing however were included in the analytical model. Each member was assigned gravity loads. The gravity loads consisted of the self-weight of the member and any supported dead load that corresponded to the weight of the structure distributed to that member
7. To accurately simulate the dynamic behavior, the Mass Source for the model was defined to be taken from Element and Additional Masses and Load

#### V. PRELIMINARY DATA

Following are the data assumed for carrying out this study-

- A. For Five Story Building-
  1. Type of Building- 5 Storey RCC building
  2. Floor Height- 4 m uniform, 3 X bays and 2 Y bays @ 5 m
  3. Concrete Frame-
    - a. Beam- 300 mm x 500 mm

- b. Columns- 500 mm x 500 mm
- 4. Concrete Slab-
  - a. Floor Slab Thickness- 250 mm

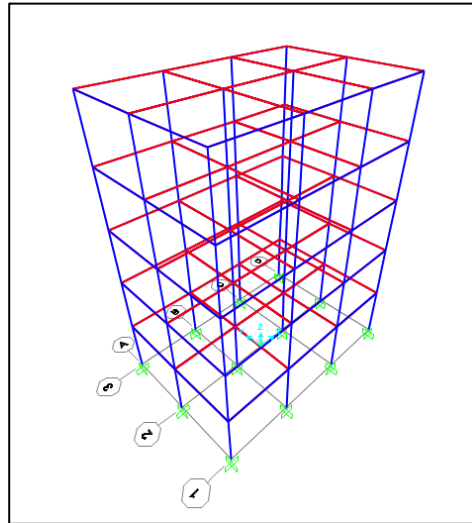


Figure 1 Five Story 3D Model SAP 2000

- B. For Fifteen Story Building-
  - 1. Type of Building- 15 Storey RCC building
  - 2. Floor Height- 4 m uniform, 7 X bays and 9 Y bays @ 5 m
  - 3. Concrete Frame-
    - a. Beam- 530 mm x 580 mm
    - b. Columns- 750 mm x 750 mm
  - 4. Concrete Slab-
    - a. Floor Slab Thickness- 250 mm

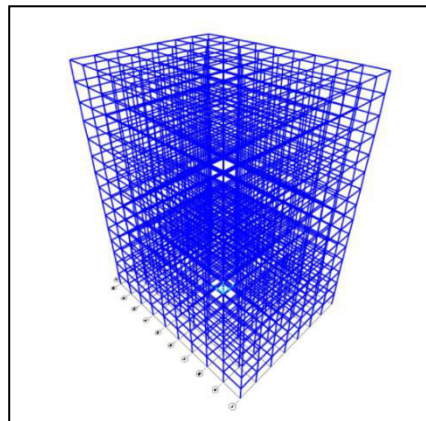
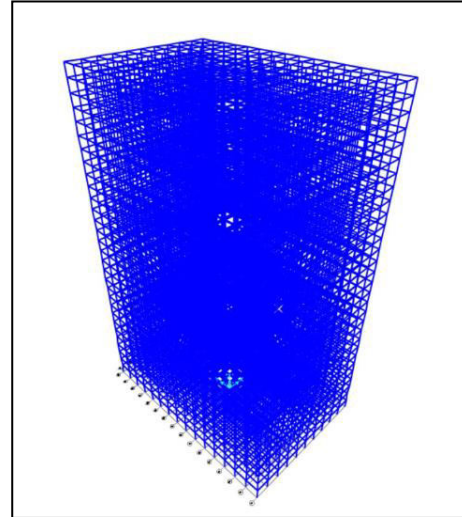


Figure 2 Fifteen Story 3D Model SAP 2000

- C. For Thirty Story Building-
  - 1. Type of Building- 30 Storey RCC building
  - 2. Floor Height- 4 m uniform, 10 X bays and 15 Y bays @ 5 m
  - 3. Concrete Frame-
    - a. Beam- 530 mm x 580 mm
    - b. Columns- Floor 1-10- 800 mm x 800 mm, Floor 11-20- 650mm x 650 mm, Floor 21-30- 470 mm x 470 mm

4. Concrete Slab-
  - a. Floor Slab Thickness- 250 mm



**Figure 3 Thirty Story 3D Model Using SAP 2000**

## VI. CONCLUSION

Seismic Analysis was carried out on 5, 15 & 30 storey building using different analysis using SAP 2000 on fixed base building model. Three different analysis were used such as static analysis, response spectrum analysis and time history analysis. Modal results for have shown that the time period has been reduced and deflection is observed. Deflections have been observed in the building when exposed to seismic loads. To reduce the effect we need to design Lead rubber based isolation system for base isolation in all the three buildings.

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