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Earthquake Resisting Building by using Base Isolation

Kaushal Lad[1], Sudeepa Manchekar[2], Omkar Patil[3], Sanchit Thakur[4], Anushri Isal[5]
[1, 2, 3, 4]*Diploma Student,* [5]*Guide, Department of Civil Engineering, V. E. S Polytechnic, Chembur, Mumbai-400071*

Abstract: ***Natural disasters have been always been a part of human life since the beginning of time, causing destruction to our lives and properties. Earthquake plays a major role in wreaking this havoc upon us. Various challenges have occurred to withstand structures on earth due to sudden moment of ground it also results in collapse of structure, due to inappropriate design consideration of structure without any seismic resistance. Various techniques to make the building earthquake resistant as well as various shapes and materials are being considered to achieve required strength to resist seismic forces. Various techniques like shear walls, bearings and base isolation are used to withstand the structure against seismic forces. In this project we have used base isolation technique, it is also known as seismic base isolation or base isolation system is a prominent technique to protect the structure against earthquake.***
We made a comparative analysis of two G+5 structures, one using base isolation system and the other one having fixed base. The software used for this purpose is ETABS V18.1. We calculated Story Drift, Shear force, Bending moment under seismic forces in this project. The results show a drastic difference between base isolated structure and fixed structure.
Keywords: Seismic, Forces, Base Isolation, Structure, Earthquake

I. INTRODUCTION

Due to earthquake, cyclones, blasts and storms immense dynamic forces acts on a structure however the most unpredictable and crucial amongst these are the earthquakes in a high seismic zone for low to medium rise building. Earthquake is one of the most devastating natural calamities which causes sudden shaking of the earth surface. India is categorized into 4 seismic zones i.e., Zone 2,3,4 and 5. In India, earthquakes of magnitude greater than 8 are more common in the northern part of the country, especially in the Himalayan region. This is due to the Indian plate moving at a pace of about 50mm per year towards the Eurasian plate [5]. Zone 2 being the lowest magnitude and 5 being the highest magnitude earthquake. Mumbai lies in the zone 3 category and falls under 'moderate risk' category.

Base isolation is the method in which the structure is decoupled or separated from the foundation. The concept of base isolation is explained through an example building resting on frictionless rollers [1]. When the ground shakes, the rollers freely roll, but the building above does not move [1]. Thus, no force is transferred to the building due to shaking of the ground; simply, the building does not experience the earthquake [1]. Base Isolation is one of the effective techniques which gives better result in seismic hazard mitigation less than earthquakes excitation particularly in building structure, Highway bridge and water tank etc [2]. Base Isolation techniques can be ideally used for emergency structures like Hospitals, Fire Stations and Police Station. The main feature of the base isolation technology is that it introduces flexibility in the structure [1]. Even after earthquakes, structures with base isolation system remains functional as it must be stable during such disasters so as to provide help to people and help prevent casualties. Rubber bearings offer the simplest method of isolation and are relatively easy to manufacture [3]. Lead rubber bearing (LRB) was firstly invented by Williamson in 1975. It was found in New Zealand [6]. Lead Rubber bearing consists of a laminated elastomeric rubber bearing equipped with lead cylinder at the center of the bearing [3]. A major advantage of the lead-rubber bearing is that it combines the functions of rigidity at service load levels flexibility at earthquake load levels and damping into a single compact unit [4]. The lead-rubber bearings represent an economic solution for the seismic isolation problems because it combines the functions of vertical support, of rigidity at service load levels, and of horizontal flexibility at earthquake load [3]. In this comparative study we analyzed the merits of using based isolated structures over fixed based structures.

India has experienced the world's largest earthquakes in the last century, whether in Bum (2005), Latur (1993), or Jabalpur (1997), where thousands of people were injured, many died, and thousands of buildings were destroyed [5]. The highest earthquake occurred in Mumbai was in 1967 of 6.5 magnitude which caused lives of 2000 people and 14,000 were injured. In last 10 years 18 earthquakes of magnitude 4 and above have occurred within 300km in Mumbai. An active fault line in the earth's crust that runs from Panvel all the way north to Koparkharine and Bhiwandi increases the earthquake risk for Mumbai.

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In a study by IIT Bombay states that the city's eastern suburbs are prone to earthquakes. In localities like Shivaji Nagar, Ghatkopar, Vikhroli, Bhandup, Powai, Vidyavihar, Govandi and Mulund face greater risk of earthquakes.

II. METHODOLOGY

Step 1: Understand the requirement and specification for analysis of structures.
We considered two structures for the analysis. One with Lead rubber bearing and other is a fixed based structure.
Step 2: Selection of software based on the above requirement for the analysis of the structure.
To understand the structural behavior of both the structures we have used ETABS Software.
Step 3: Setting of Indian Codes as per the Specification.
For the analysis of the structures, we have considered IS1893:2016 for the load calculation.
Step 4: Establishing of grid points and Formation of structure.
In ETABS Software for the both the structure a grid of 5mx5m is considered and a G+5 structure is established of each story height of 3m.
Step 5: Determining the Building components.
We have defined each of the structural components i.e., beam, column and slab by assigning them frame section properties.
Step 6: Provision of Rubber Isolators/ Restraints at the base of the structure.
Assigning rubber isolators at the base of the base isolated structure and restraints at the base of fixed structure.
Step 7: Assigning various load cases such as live load, dead load, wind load and seismic load.
The Load cases are defined and then assigned to each of the component for both the structures.
Step 8: Analyzing Fixed Based Building Model and Base Isolated Building Model.
Check is applied to both the models and then the load cases are run.
Step 9: Comparison of Results of Base Isolated Building Model with Fixed Based Building Model.
Both the structure is compared with respect to maximum story drift, maximum bending moment in beam and column and maximum shear force in beam and column.

III.MODELLING AND ANALYSIS

Comparative study of two type of buildings: Fixed Based Building and Base Isolated Building were made using ETABS Software. Each building of G+5 story was analyzed using this software. The Length and Width of both the structure is 25m x 25m. The height between corresponding stories is 3.3m. The other dimensions of the various building components are listed below:

TABLE.1 BUILDING COMPONENT WITH ITS DIMENSION

SR. NO.	DESCRIPTION	DIMENSSIONS
1	BEAM	230mm X 450mm
2	COLUMN	400mm X 400mm
3	SLAB THICKNESS	150mm
4	SPACING BETWEEN TWO COLUMNS	5m

TABLE.2 LOAD CASES

SR. NO	DESCRIPTION	LOAD
1	DEAD LOAD (BEAM+COLUMN+SLAB)	10.33 kN/m2
2	LIVE LOAD	3 kN/m2
3	SEISMIC LOAD	1.5 kN/m2
4	WIND SPEED	50 m/sec (Considering Mumbai region)

A. Other Properties

Concrete: M20
Steel: Fe 415
Terrain category: 3
Response Reduction Factor: 5.0
Importance factor: 11
Seismic zone: 3

B. Rubber isolator properties

Linear Effective Stiffness: 3296.0151 KN/m
Non-linear Effective Stiffness: 10777.51 KN/m
Stiffness ratio: 0.1

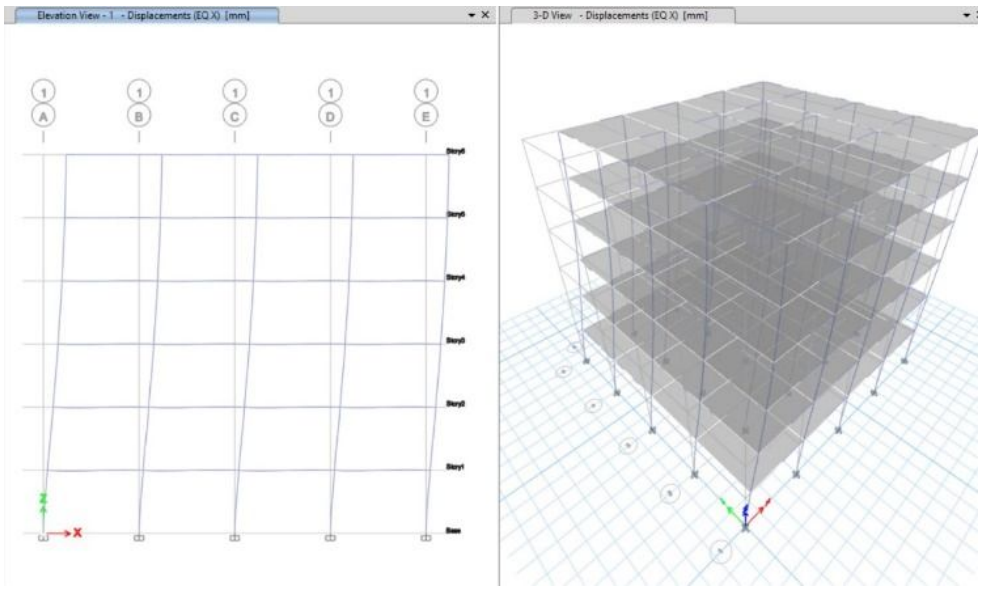


Fig 1. Fixed Based Structure

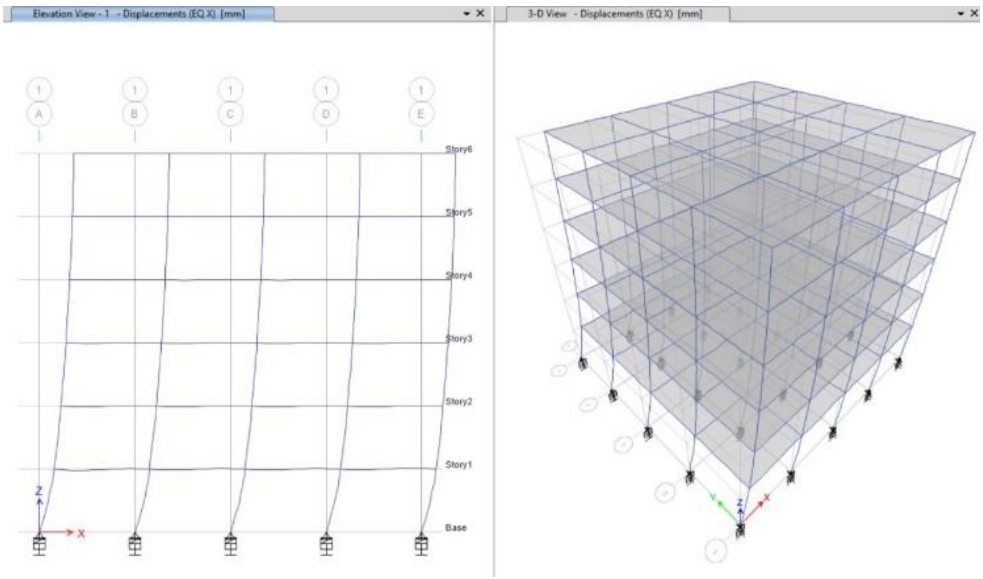


Fig 2. Base Isolated structure

IV. RESULTS

The following are the results that were acquired from the analysis of structure from the ETABS Software:

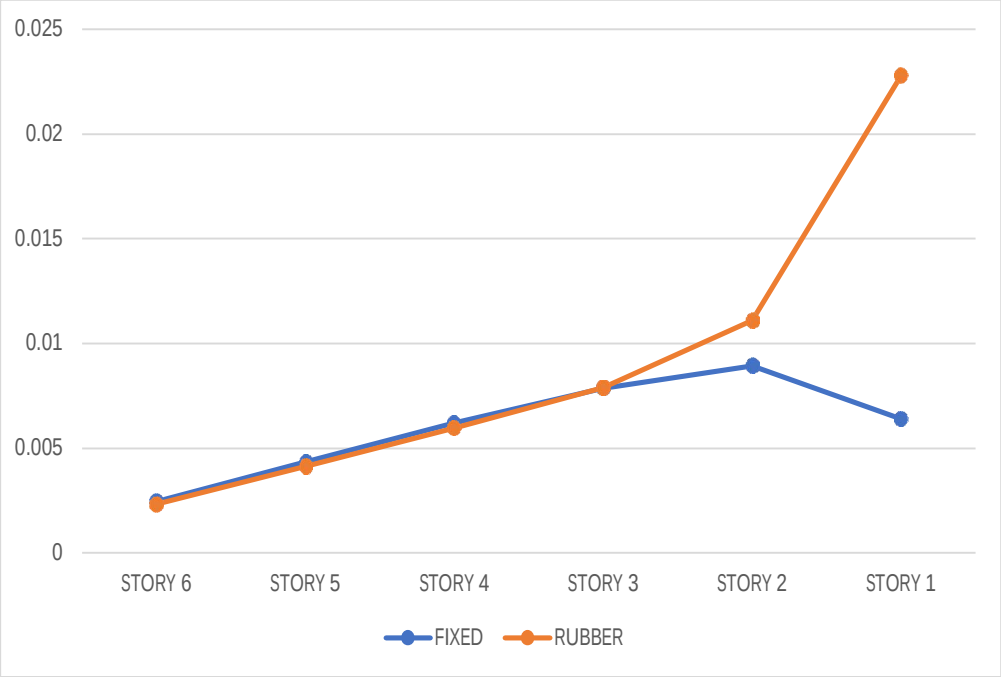


Fig 3. Maximum Storey Drift

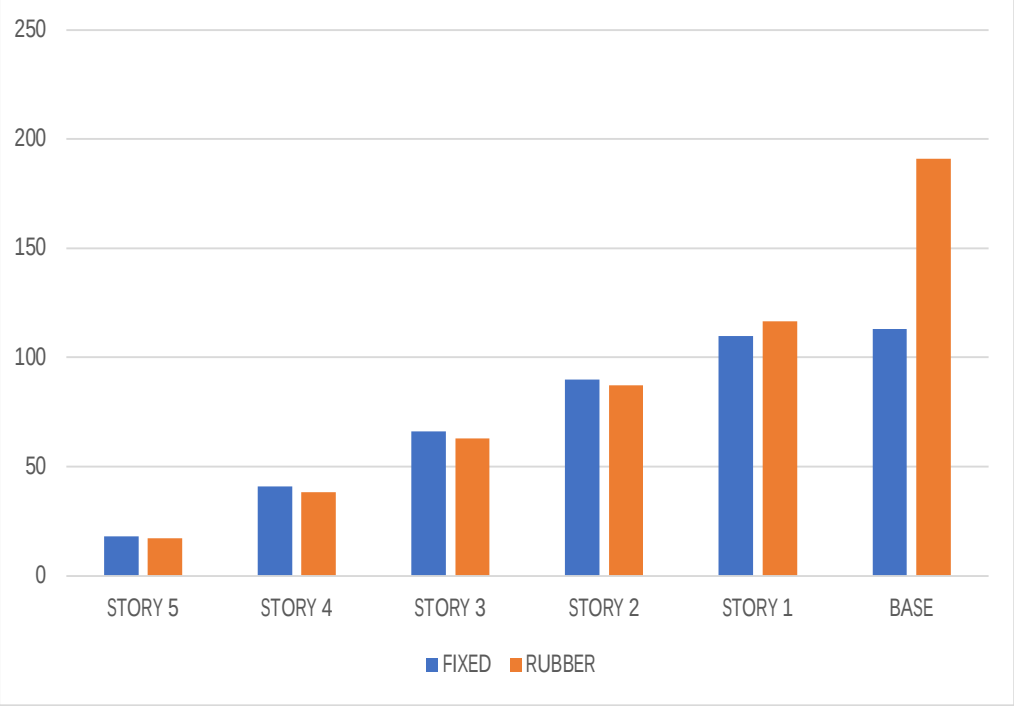


Fig 4. Shear force in the frame object local 2-axis direction (beams)

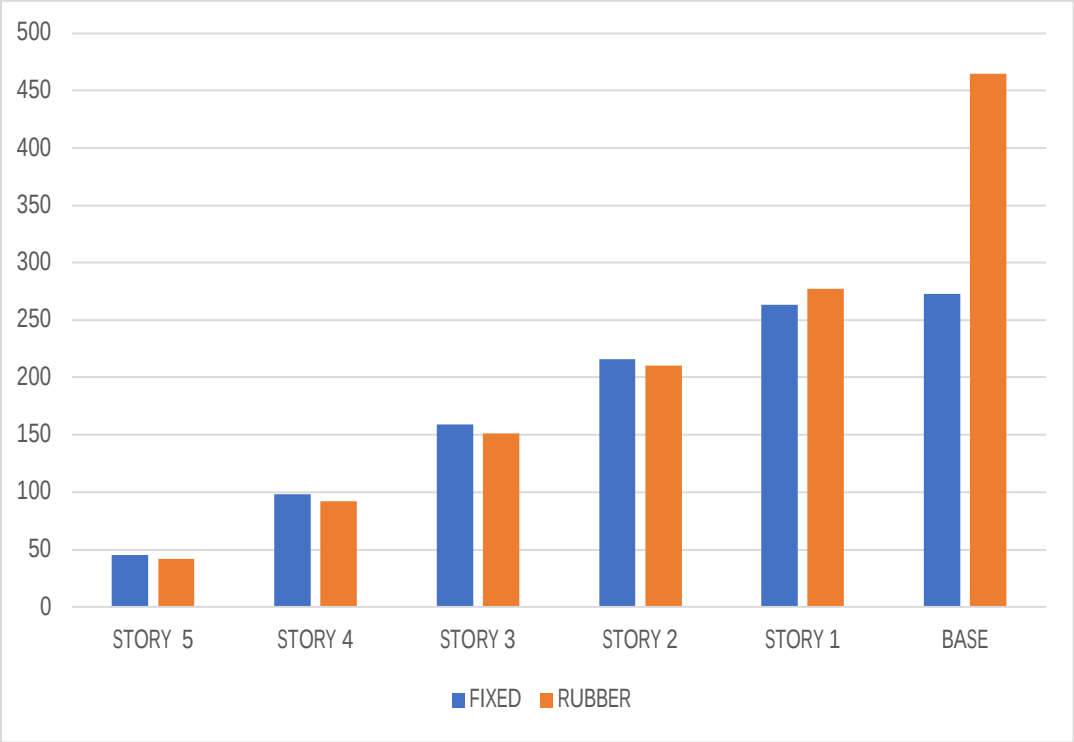


Fig 5. Bending moment in the frame object local 3-axis direction. (beam)

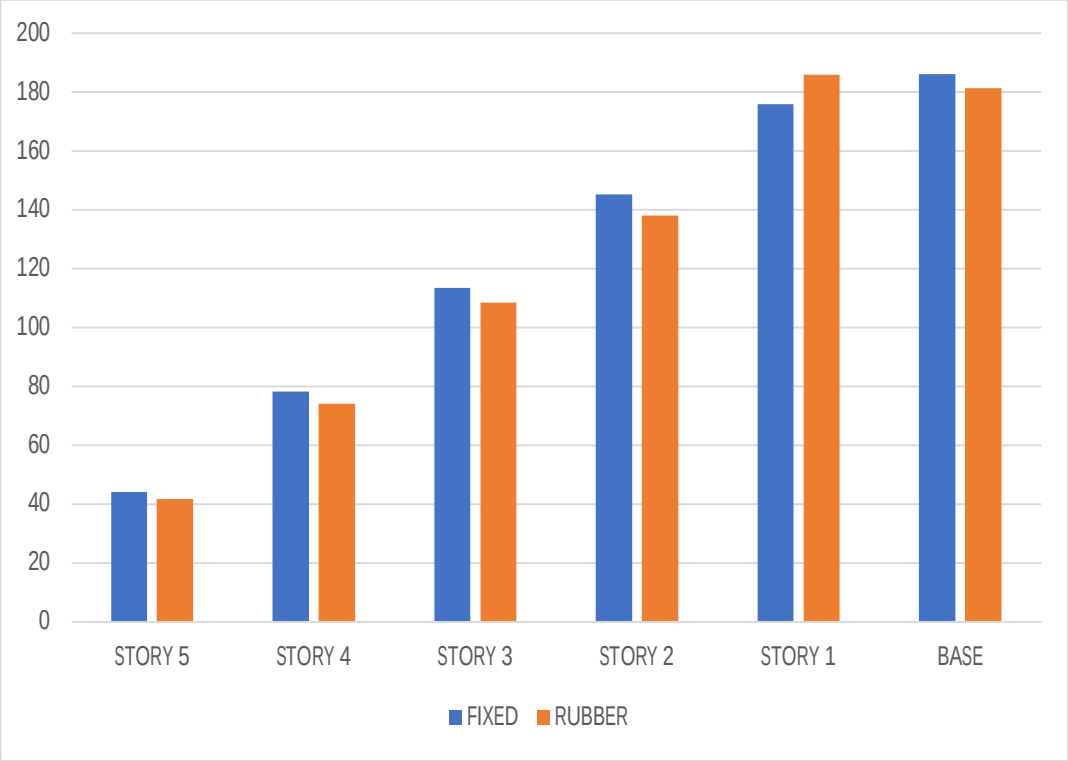


Fig 6. Shear force in the frame object local 2-axis direction (column)

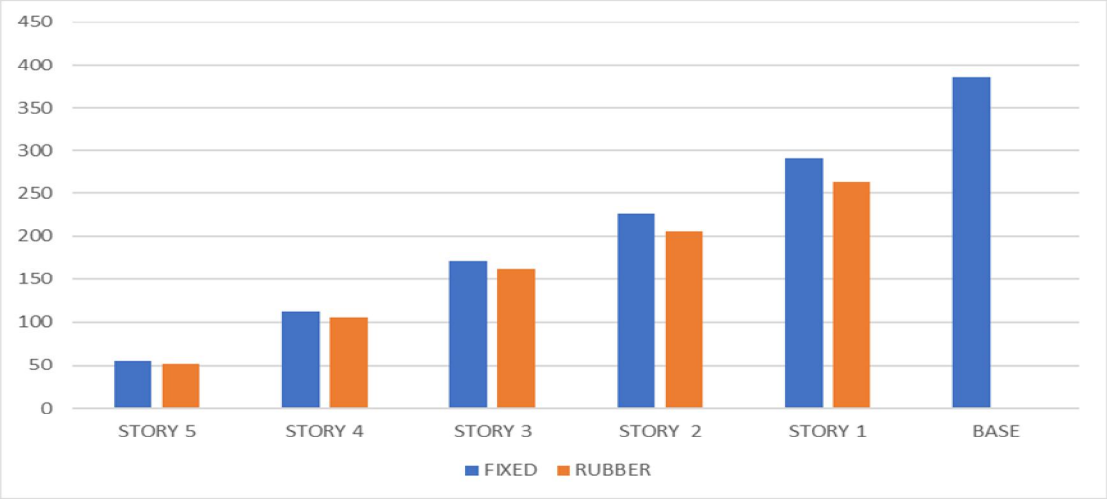


Fig 7. The bending moment about frame object local 3-axis (column)

V. CONCLUSIONS

The main aim of this project is to analyse the structure with and without base isolators and to study the behaviour of these structure under the impact of seismic forces. Base Isolation Technique not only improves the structural safety but also preserve the functions and properties of the structures. We obtained the following results from the above analyses: -

A. Story Drift

As we can see maximum story drift decreases with increasing height of the structure.

B. Shear Force

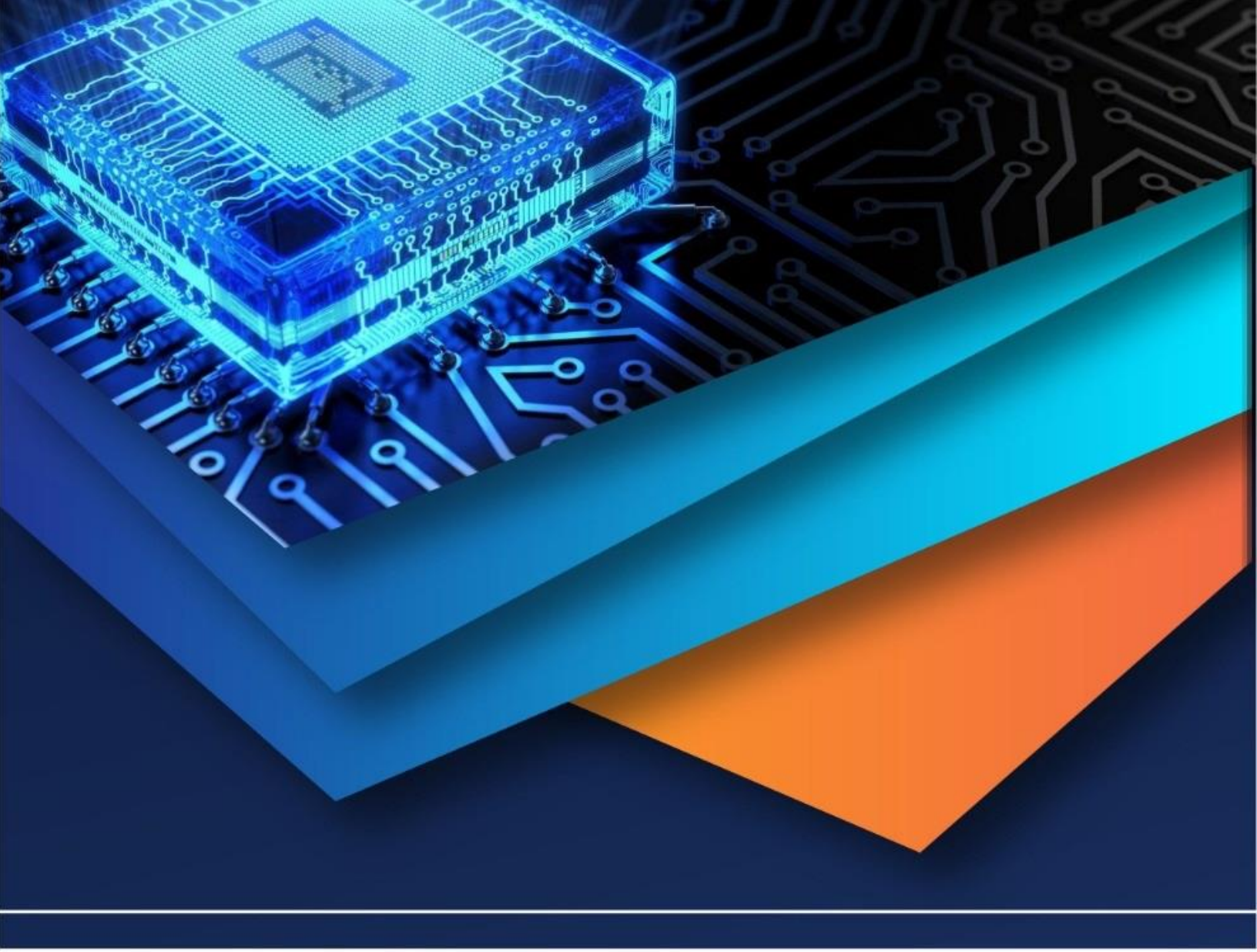
Even though shear force is more at first and second story it decreases rapidly with increasing number of stories.
Beam - The shear force in 2 axis direction decreases more in base isolated structure with increasing number of stories as compared to fixed base building.
Column - It can be seen that the shear force in column in 2 axis direction has increased distinctly in the first story on the base isolated structure.

C. Bending Moment

Beam - Analysis of Base Isolated model has shown a major difference in bending moment at each story. In Base Isolated Model Bending moment at the base of structure is more but it reduces as we go above.
Column - The bending moment in column at the top story is significantly less in isolated structure as compared to fixed structure. Also, the bending moment at the base story of the base isolated structure is 0.
As we have considered G+5 Story building the results may differ as base isolated technique is mainly used for high rise structure.

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