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Dynamic Analysis of RCC Framed Structure Considering Effect of Base Isolation

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Abstract: *Base isolation is a system that protects a building from the damaging effects of a seismic movement. If the structure separates from the ground during an earthquake, the ground is moving but the structure is still dormant. However, this scenario is not realistic. The current technology that is active and expanding is the introduction of a low lateral stiffness support that isolates the structure from the ground movement. The objective of base isolation system is to decouple the structure from the ground. It lowers the effect of ground motion transmitted to the structure. Behaviour of multi-storey buildings during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and vertical planes of building. A complete literature review is undertaken in this study to better understand seismic evaluation of building structures, the use of time-history analysis, and free vibration analysis. Design the footing for the G+14 building and assess its spring stiffness, as well as analyses the G+14 storey building and compare the findings of the fixed base structure with the isolated building structure using ETABS. A time-history analysis of fixed foundation structure and base isolation at building footing levels is performed to determine whether or not failure reduction occurs.*

Keywords: Base Isolation, Spring Stiffness, ETABS, G+14 Building

I. INTRODUCTION

The consensus on how to resist seismic forces is to strengthen the structure. Traditional architectural design ideas may not be the best solution based on whether the design can adapt to external needs and be robust. The problem with the latter is that all seismic forces from the base are absorbed by the superstructure. The basic extraction technology is the opposite of the standard design model.

Base insulation is a system that protects buildings from damage caused by seismic movements. If a structure separates from the ground during an earthquake, the ground moves but the structure remains stable. However, this is not true. A common technique that is now frequently used is the use of low-strength lateral supports to isolate the structure from ground motion. This technique was published as early as 1900; But it wasn't until the 1970s that it became a good idea for earthquake-resistant construction.

A. Principles and Concepts of Base Isolation

Geological and seismological discoveries during the 20thcentury have helped in initiating the development of seismic building codes and earthquake resistant buildings and structures. The improvement in seismic design requirements has led to more robust, safe and reliable buildings. Due to the earthquake many buildings collapsed killing thousands of people. Therefore, to protect the earthquake effects/earthquake damages to the buildings and to protect the life of people, it's important to use seismic control techniques. The base isolators are provided at the basement level to absorb the earthquake energy or earthquake forces. Not only important buildings such as Museum, Shopping Mall, Hospital, Water tanks, Dams, and Airports etc. are provided with base isolator, but if the occurrence of the earthquake is more often it can be provided for all types of buildings.

B. Application of Base Isolation

Medium models are the best candidates for mechanical isolation. In situations where strong seismic activity is likely to

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occur, an isolation foundation can be a good alternative to structural design. The initial cost of a separate base will be higher than the cost of a fixed base. However, in addition to the loss of time after a seismic event, the cost of repairing the structure can be very high.

In the western part of the United States, the most common form of isolation is the hospital. These facilities must be operational after a seismic event. The world's first isolation center is the University of Southern California Hospital in the United States, as shown in Figure 1.3. It remained active after the 1994 Northridge earthquake.

Other structures that can benefit from building insulation in the long term include factories that need to be put into operation after a seismic accident; Otherwise, financial loss will occur. In addition, historical buildings benefit from the use of a separate technology from recycling

Nonlinear Time History Analysis:

Nonlinear Time History Analysis can be used for all isolation systems regardless of height, size, geometry, location, and nonlinearity of the isolation system. Time-History analysis is a step-by-step procedure where the loading and the response history are evaluated at successive time increments. During each step, the response is evaluated from the initial conditions existing at the beginning of the step (displacements and velocities) and the loading history in the interval. Nonlinear time history analysis is the dynamic analysis in which the loading causes significant changes in stiffness. With this method, the non-linear behaviour may be easily considered by changing the structural properties (e.g. stiffness, (k) from one step to the next. Therefore, this method is one of the most effective for the solution of non-linear response. Non-linear time history analysis utilizes the combination of ground motion records with a detailed structural model, Response of base isolated structure on liquefiable soil. Therefore, is capable of producing results with relatively low uncertainty. In nonlinear dynamic analyses, the detailed structural model subjected to a ground-motion record produces estimates of component deformations for each degree of freedom in the model and the modal responses are combined using schemes such as the square-root-sum-of-squares.

Table 1: Properties of Ground Motion

Earthquake Area	Magnitude	Record/ Component	PGA
EI-Centro (1940)	7.2	El-Centro 1940,	0.35 g
Bhuj (2001)	7.7	Bhuj (2001), India	0.38 g
Uttarkashi (2001)	6.6	Uttarkashi (2001), India	0.31 g
Koyna (1967)	6.5	Koyna(1967)	0.31g
Chamoli (1999)	6.8	Chamoli(1999)	0.31g

II. METHODOLOGY

The finite element method (FEM) is a widely used method for numerically solving differential equations arising in engineering and mathematical modelling. Typical problem areas of interest include the traditional fields of structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The FEM is a general numerical method for solving partial differential equations in two or three space variables.

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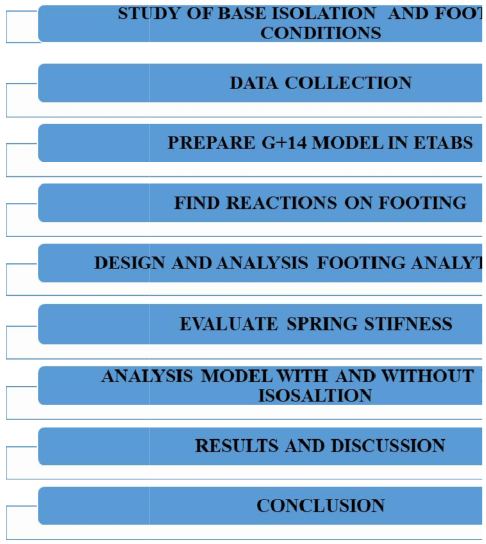

A. Problem Statement

In this research, a G+14 storey structure of a rectangular building with 3 m floor to floor height has been analysed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using ETABS software in zones III. The plan selected is Rectangular in shape. The structure has been analysed for both static and dynamic forces. Soft soil condition has been selected for the structure. Gust factor method is method of calculating load along wind or drag load. Gust factor method is given in the code since IS 2015, these methods for calculating load across-wind or other components are not fully matured for all types of structures.

Table 2 Parameters to be consider for rectangular geometry analysis

Sr. No.	Parameter	Values
1.	Number of storey	G+14
2.	Base to plinth	1.5m
3.	Floor height	3.2m
5.	Materials	Concrete M30 and Reinforcement Fe 500
6.	Frame size	18m X 18m building size
7.	Grid spacing	6 m grids in X-direction and Y-direction.
8.	Size of column	750mm x 750 mm
9.	Size of beam	300mm x 500 mm
10.	Depth of slab	125 mm

III. DESIGN AND ANALYSIS SPRING STIFFNESS

G+14 storey structure of a rectangular building with 3 m floor to floor height has been analyzed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using ETABS software in zones III.

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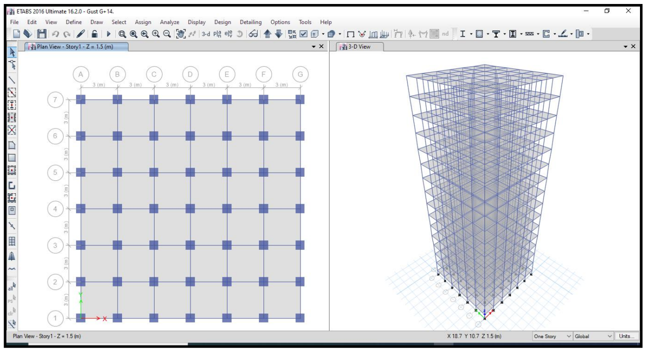

Fig 1 Prepare modelling in ETABS

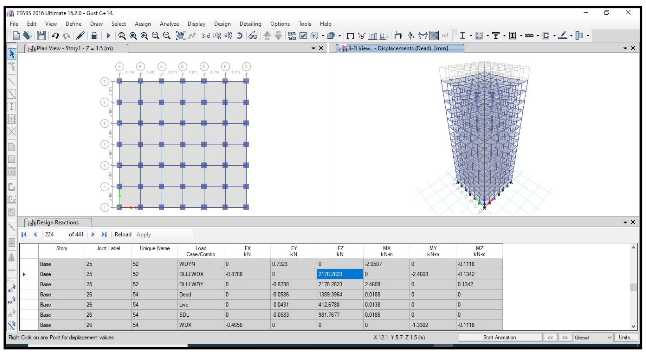

Fig 2 Design Reaction

Table 3. Results of G+14: Design Reaction

Soil Type	**Soft**
Reaction In Kn	2178 Kn

Table 4 Design Details Isolated

Data	Soft
P_u (Design Reaction)	2178 KN
Adopted Size Of Footing	x= 4000 mm y=4000 mm D= 550mm
Adopt depth of Footing	550 mm
No. Of Bar Req.	16T - 20

Table 5 Spring Stiffness

Spring Stiffness			
Sr No	**Degree of Freedom**	**Spring Stiffness**	**Spring Stiffness Per Footing (Total Footings =49)**
1	**Vertical Ky**	553926.741	11304.63
2	**Horizontal (Lateral Direction)Kx**	366030.886	7470.02
3	**Horizontal (Longitudinal Direction) Kz**	366030.886	7470.02

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4	**Rocking (about the Longitudinal) krx**	164713.898	3361.51
5	**Rocking (about the Lateral) krz**	164713.898	3361.51
6	**Torzion Kry**	151902.817	3100.06

IV. MODEL DESCRIPTION

A. Time History Analysis

Table 6 Models Description

Model 1	**Fix Base**	**M1- (FB)**
Model 2	**Base Isolation**	**M2- (BI)**

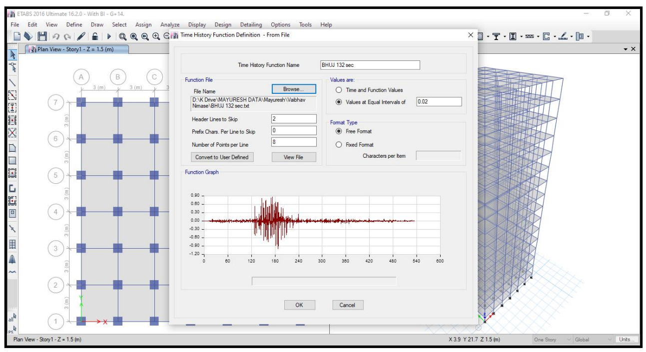

Fig 3 Add Bhuj Earthquake Data in model

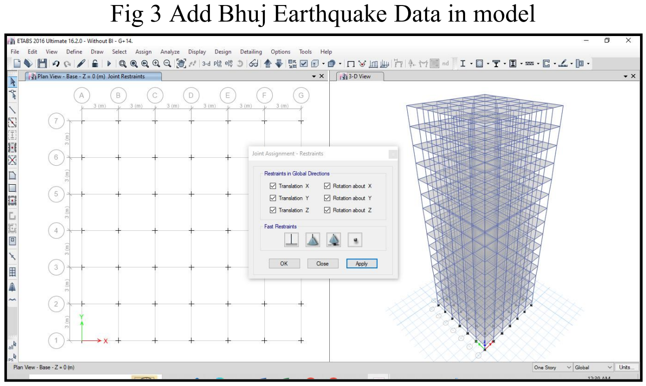

Fig 4 Fix Base Model

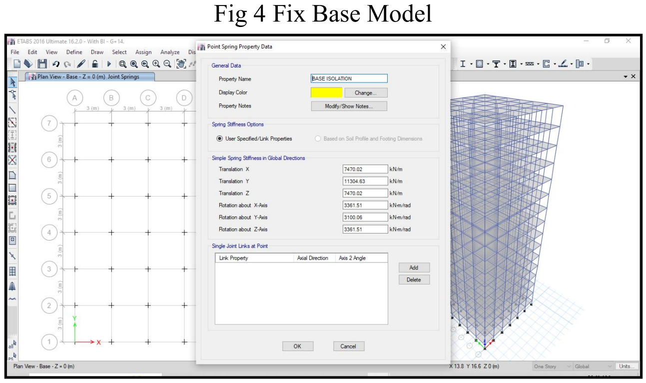

Fig 5 Base Isolation Spring Properties

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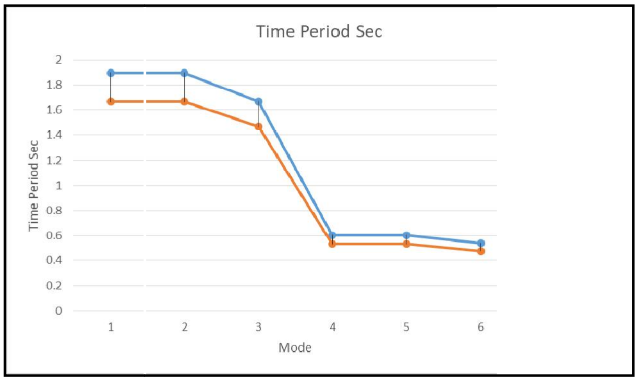
Table 7 Time Period Sec.

TIME PERIOD Sec		
MODE NO	**M1- (FB)**	**M2 - (BI)**
1	1.895	1.667
2	1.895	1.667
3	1.669	1.468
4	0.606	0.533
5	0.606	0.533
6	0.541	0.476



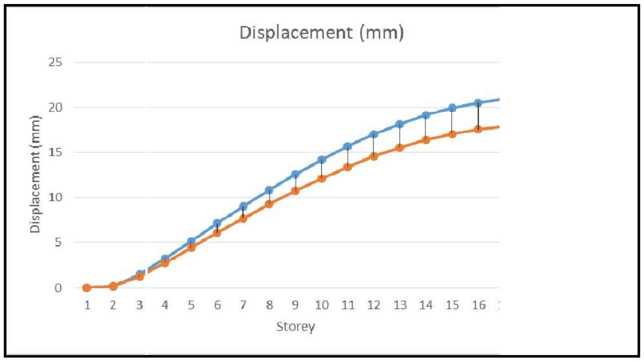
Graph 1 Time Period Sec.

From the above table & graph, we can observe that percentage variation for Time Period for Time History Analysis for model 2 is less than model 1. The variation is found to be 10-15% less for model having Base Isolation than model have fix base only.

Table 8 Time History - Displacement (mm)

Displacement (mm)		
Storey	**M1- (FB)**	**M2 - (BI)**
16	20.975	17.924
15	20.525	17.543
14	19.92	17.03
13	19.131	16.36
12	18.155	15.526
11	16.998	14.534
10	15.673	13.397
9	14.195	12.129
8	12.581	10.747
7	10.851	9.269
6	9.022	7.71
5	7.118	6.087
4	5.173	4.428
3	3.248	2.783
2	1.476	1.266

1	0.197	0.169
Base	0	0



Graph 2 Time History - Displacement (mm)

From the above table & graph, we can observe that percentage variation for Displacement for Time History Analysis for model 2 is less than model 1. The variation is found to be 15-20% less for model having Base Isolation than model have fix base only.

VI. CONCLUSION

The main aim of the project is to evaluate the seismic behaviour of RCC buildings with Fixed Base and Base Isolation. For this purpose, a dynamic method of analysis is used to evaluate the behaviour of the building. Analysis by the Time History and response spectrum method is also carried out to study the dynamic behaviour. The modelling and analysis are carried out using ETAB software. According to FEA results, the results for storey share were found to be maximum for the first storey, and it decreased to minimum in the top storey in all cases. Drift and displacements were found to be minimum for the first storey, and they increased to the top storey in all cases. According to the analysis, it's concluded that model 2 (Base Isolation) is more economical than model 1 (Fixed Base). All results are concluded from the following discussion.

- Time Period for Time History Analysis for model 2 is less than model 1. The variation is found to be 10-15% less for model having Base Isolation than model have fix base only.
- Displacement for Time History Analysis for model 2 is less than model 1. The variation is found to be 15-20% less for model having Base Isolation than model have fix base only

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- IS: 875 (Part 2) – 1987: Imposed loads.