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Comparative Study on RCC Building Structure in Regular Ground and Sloping Ground with Fixed Base and Base Isolation

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Abstract - *In this project, (G+6) building structure on regular ground and sloping ground with fixed base and base isolation have been studied. The ground slope has been considered 25° for analysis. The modelling and analysis of building has been done by using ETABS software. The lead rubber bearing (LRB) is used as an isolator in this study. The seismic analysis was done by equivalent static analysis and the response spectrum analyses have been carried out as per IS code 1893: 2016. The results have been carried out by using response spectrum analysis. The results are taken that are displacement, storey shear, storey drift, time period and frequency and then results have been compared.*

Key Words: **Base isolation, ETABS, Fixed Base, sloping ground, Equivalent Static Method, Response Spectrum Method, etc...**

1. INTRODUCTION

The constructions are usually built on level land. The ground itself is a slant in some places. Excavation and levelling are extremely difficult and costly in that situation. Engineers began building on sloppy terrain due to a lack of flat ground. Earthquakes are more common in steep places and are one of the most dangerous natural disasters. Earthquakes are caused by sudden movement of tectonic plates, which releases a tremendous quantity of energy in a matter of seconds. This function has the most negative impact since it affects a vast area and occurs suddenly and without warning. It results in widespread loss of life and property, as well as damage to critical infrastructure such as sewerage systems, communication, power, transportation, and water supply, among other things. They not only devastate towns, cities, and villages, but they also wreak havoc on the country's financial and social structures.

1.1 Fixed Base

Fixed base buildings are those that rest directly on the ground. When the ground shakes strongly due to an earthquake, the fixed base building shakes strongly and swings left and right, eventually collapsing.

1.2 Base Isolation

Base Isolation is one of the passive energy dissipation techniques used in the design of earthquake-resistant structures. Controlling the energy that flows from the foundation or ground to the upper levels is advantageous. The superstructure and foundation of a building are separated by connected isolation devices, and these buildings are known as base isolated buildings. Base isolation can significantly minimize earthquake severity and losses, reducing the amount of shaking and damage that permanent equipment and building contents experience during earthquake ground shaking. The fundamental purpose of an isolation system is to reduce structural displacements, base reactions, and member forces.

Lead Rubber Bearing

Lead rubber bearings have a considerably superior ability to offer enough rigidity for wind loads and superior damping properties than natural rubber bearings. The configuration of a lead rubber bearing is similar to that of a natural rubber bearing, with the exception of one or more cylindrical lead plugs in the centre, as shown in Figure. When the lead plug is combined with the rubber, the gadget exhibits bilinear behaviour. Under low service wind loads, the lead plug's high rigidity attracts the majority of the load, and the arrangement is rigid. When subjected to high seismic stresses, lead deforms plastically, reducing the device's rigidity to that of rubber. Furthermore, energy is wasted in a hysteretic way during the plastic deformation of the lead plug.

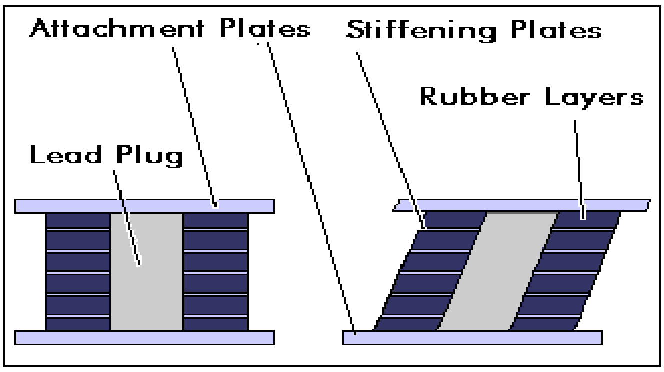

Fig-1: Lead Rubber Bearing

The lead plug deforms similarly to rubber during intense events, but it generates heat or releases kinetic energy by converting it to heat. As a result, the plug's hysteretic behavior aids in lowering the amount of energy absorbed by the structure. As a result, lead rubber bearings have desirable hysteretic damping qualities, which improve the system's structural response. The quantity of energy wasted is proportional to the maximum bearing displacement.

2. LITERATURE REVIEW

a) "Comparative Study On Fixed Base And Base Isolation Having Regular And Irregular RC Frames" DR. G.V.V. SATYANARAYANA AND J.GOPAL, **2018,** The buildings studied in this paper are 5 and 20 storey RC frames that were designed for gravity and earthquake loads utilising a linear dynamic analysis approach (time history analysis method) and a finite element method (FEM) tool (ETABS 2016 structural analysis software). The base isolation technique is a highly successful earthquake-resistant design technique. From the time history analysis results, the four RC frame models are analyzed and modelled in ETABS. The basic isolation technique lessens the buildings' ductility demands and minimizes their deformations.

b)"Comparative Study On Seismic Performance Of Fixed Base RC Structure & Base Isolated RC Structure Using Sap2000" CHIKHALEKAR ANIKET ARUN, CHAUDHARI PRACHI VINAYAK, BHARADE ROSHAN DATTATRAY, ROY SUNITA NARAYAN, TRUPTI NARKHEDE, **2018,**. For two situations, Fixed base RC structure and Base Isolation RC structure, SAP2000v16 software was used to analyze the (G+8) storied RC frame structure. The analysis uses a High Damping Rubber Bearing (HDRB) as the base isolation mechanism since it produces good findings. Models are created in accordance with IS 1893:2002 and are utilised for analysis. When compared to the fixed base condition, the end result demonstrates that using the HDRB base isolators reduces storey drift, storey acceleration, storey velocity, and storey displacement while increasing the structure's time period.

c)"Comparative Study For Seismic Performance Of Base Isolated & Fixed Based RC Frame Structure" S. M. DHAWADE, **2014,** The G+14 storied frame structure is used in this paper to compare the seismic effect of fixed base structure versus isolated structure. Using the ETABS software, the (G+14) storied frame structure is designed with base isolation. High Damping Rubber Bearing (HDRB) is used as an isolator for frame structure over fixed base structure that produces better results than any other isolation system.

d) "Comparative Study On Fixed Base And Base Isolated For Building On Sloping Ground" CHIRANJEEVI, MANJUNATHAL, **2017**, The ground slope varying from 0° to 30° has been considered for the analysis and comparison in this G+9 storey RCC building. The modelling and analysis of the building was done using structure analysis tool ETAB, and the lead rubber bearing has been considered to study the effect of the building on sloping ground with and without base isolation during the earthquake. The results were compared to those of a building with and without a base isolation system. Linear static analysis was used for the seismic study, and response spectrum analyses were performed in accordance with IS: 1893 (part 1): 2002. Top storey displacement, drift, base shear, and time period were used to produce the results.

3. METHODOLOGY

3.1 Methods of Analysis

Seismic analysis is a key tool in earthquake engineering that is used to better understand the response of buildings to seismic excitations. After deciding on a structural model, an analysis can be run to calculate the seismically induced forces in the structure. Three factors can be used to categories the analysis process are type of external load applied, behaviour of structure/structural element, type of structural modelselected. The seismic analysis used are equivalent static analysis and response spectrum analysis during the modelling. The level of force and its distribution along the height of the structure is the significant difference between linear static and linear dynamic analysis.

3.2 MODELING IN ETABS SOFTWARE

While modelling in the ETABS software the following models were modelled and the respective results were determined.

Model 1: (G+6) storey building on regular ground with fixed base

Model 2: (G+6) storey building on regular with isolated base (Lead Rubber Bearing)

Model 3: (G+6) storey building on sloping ground (ɵ=25°) with fixed base

Model 4: (G+6) storey building on sloping ground (ɵ=25°) with isolated base (Lead Rubber Bearing)

Table -1: Model Nomenclatures

Sr. No.	(G+6) building	Zone V
1	Regular ground with fixed base	**MODEL 1**
2	Sloping ground (ɵ=25°) with fixed base	**MODEL 2**
3	Regular ground with base isolation (LRB)	**MODEL 3**
4	Sloping ground (ɵ=25°) with base isolation (LRB)	**MODEL 4**

Analysis by using Equivalent Static Method:

Initially, the G+6 building is created in the software here the plinth height applied from foundation is 2m and for each storey height is 3.3 m. In the x-direction there are four bays each at 6.8624 m and in y-direction there are four bays each at 4 m. The properties for column and beam, grade of concrete, grade of steel, material properties, load cases were given. The Load Pattern was given to the model which are Self weight, Full Brick Wall, Half Brick Wall, Parapet Wall, EQ-x, EQ-y.

Analysis by using Response Spectrum Method:

A new load case as response spectrum was added and the name of function IS2016H is written. Load is applied as RSx = Response spectrum in x-direction and RSy = Response spectrum in y-direction. The Scale factor was calculated and added to the load cases and finally the results on the basis of displacement, storey drift, storey shear and time period were analyzed. The same analysis was done for Model 3 and Model 4 with ground slope 25°.

Preliminary Data as Building Description:

The (G+6) building on regular ground and sloping ground with fixed base and base isolation (LRB) is used to this study. The height and dimension of building is taken as same for all four Model. The data is taken for the analysis is as follows:

- Storey height = 3.3m each
- Plinth height from foundation = 2m
- Bays at x axis = 4 at each 6.8624m
- Bays at y axis = 4 at each 4m
- Grade of concrete = M30
- Grade of steel = Fe500
- Column size = 375mm x 375mm
- Beam size = 230mm x 375mm
- Thickness of slab = 150mm
- Height of parapet wall = 1050mm
- Unit weight of concrete = 25 KN/m^3
- Unit weight of brick wall = 20 KN/m^3
- Full brick wall load = 13.5 KN/m
- Half brick wall load = 6.75 KN/m
- Parapet wall load = 4.83 KN/m
- Live load at floors = 4 KN/m^2
- Live load at roof = 2 KN/m^2
- Floor finish at floors = 0.75 KN/m^2
- Floor finish at roof = 1.5 KN/m^2
- Zone factor = 0.36 (For Zone V)
- Response factor = 5
- Importance factor = 1
- Soil type = II (Medium)

4. RESULTS AND DISCUSSION

4.1 Analysis results for building on regular ground with fixed base and base isolation

1) Storey Displacement

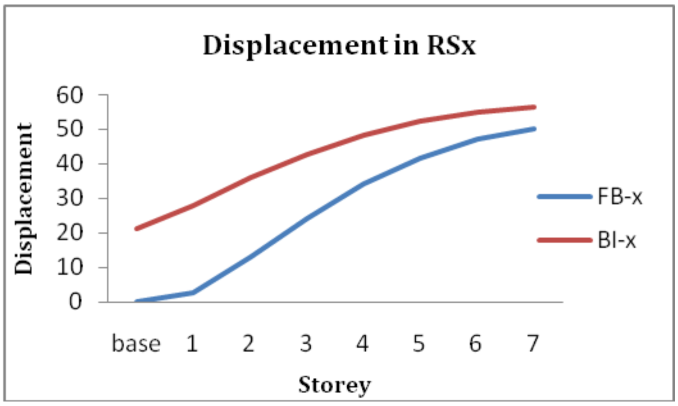

Chart -1: Storey Displacement in x-direction

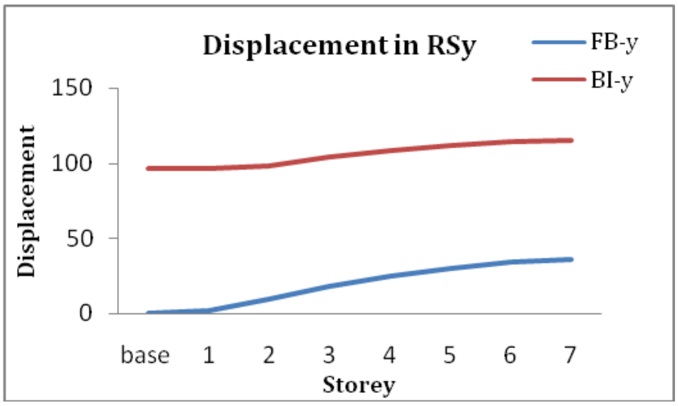

Chart -2: Storey Displacement in y-direction

It can be observed in the graph, which shows response spectrum analysis results, that storey displacement rises as the height of the structure grows in a fixed base building. In a base isolated building, displacements occur solely in the isolation devices; nonetheless, the storey displacement rises somewhat as the building's height grows in both directions.

2) Storey Shear

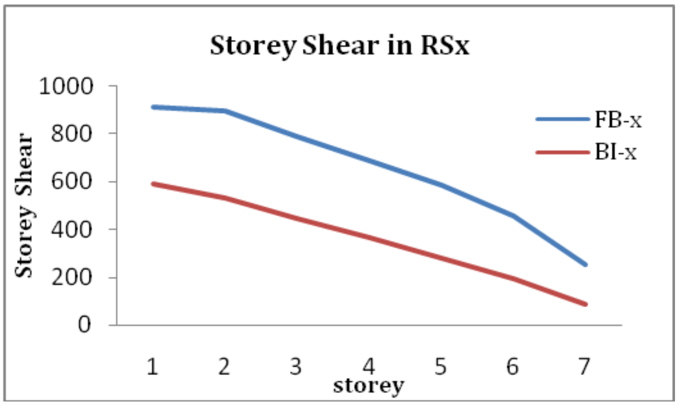

Chart -3: Storey Shear in x-direction

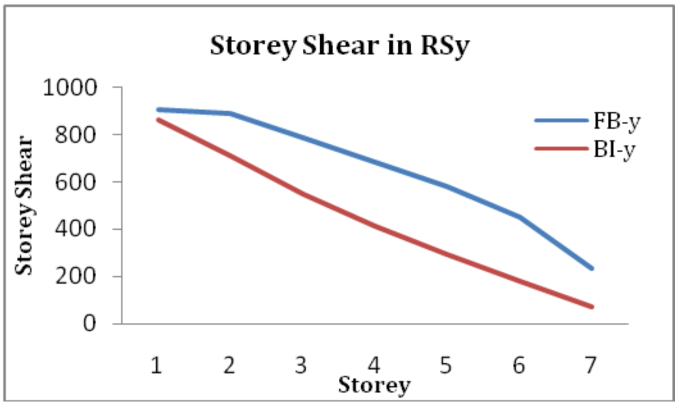

Chart -4: Storey Shear in y-direction

According to the graphical depiction of the response spectrum analysis, the storey shear in each storey of a fixed base building and a base isolation building on normal ground is lowered in both directions. In the X and Y directions, however, the storey shear in the base isolated model is lower than in the fixed base model.

3) Storey Drift

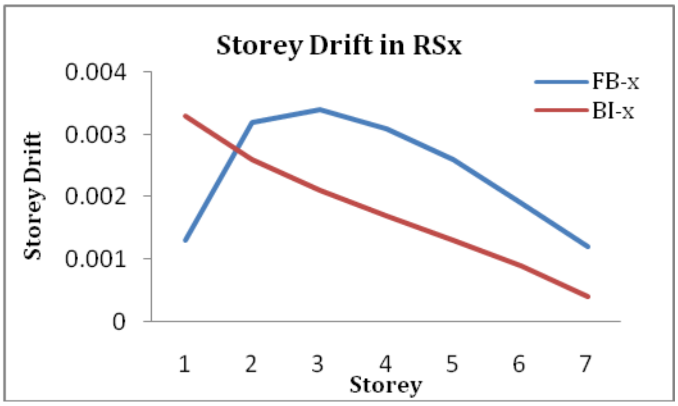

Chart -5: Storey Drift in x-direction

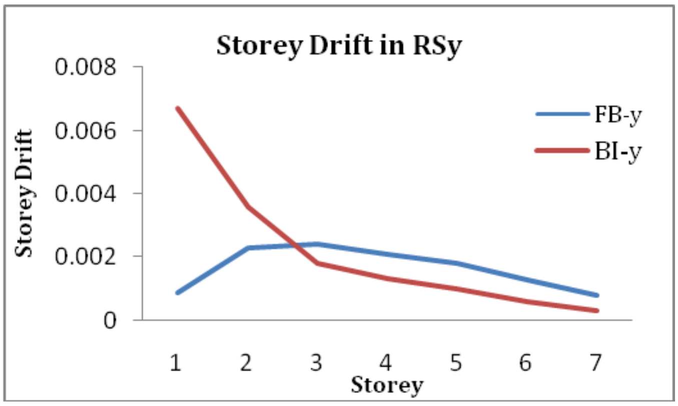

Chart -6: Storey Drift in y-direction

According to response spectrum analysis, storey drift at the top floor in the base isolated building is considerably reduced in both directions when compared to the equivalent fixed base models.4) Time Period

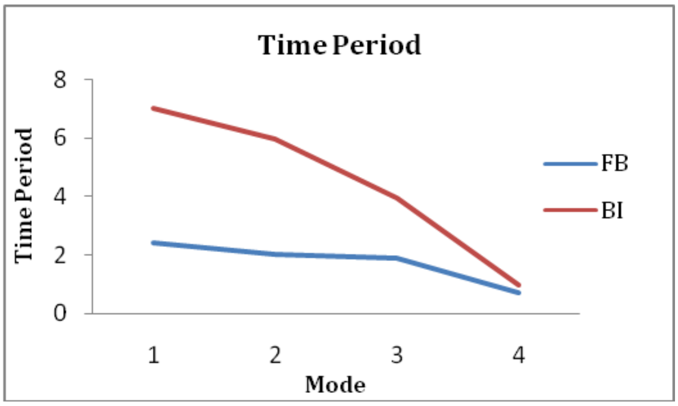

Chart -7: Time Period for building on regular ground

4.2 Analysis results for building on sloping ground with fixed base and base isolation

1) Storey Displacement

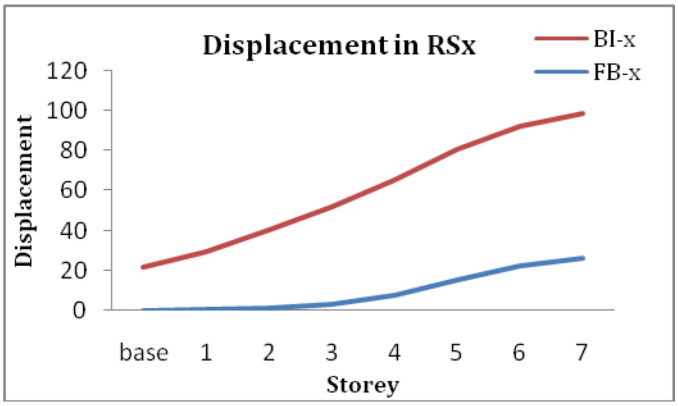

Chart -8: Storey Displacement in x-direction

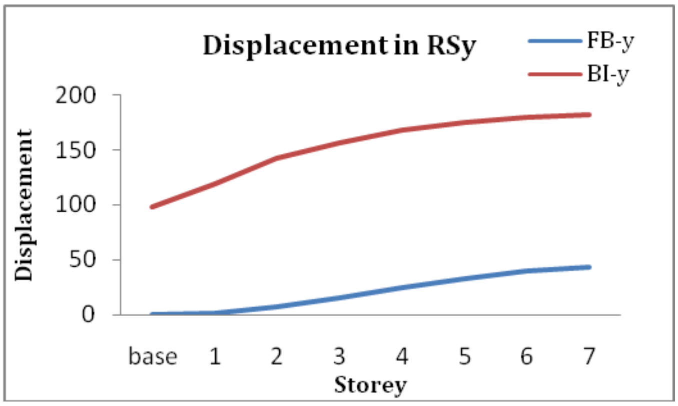

Chart -9: Storey Displacement in y-direction

It can be observed in the graph, which shows response spectrum analysis results, that storey displacement rises as the height of the structure grows in a fixed base building. In a base isolated building, displacements occur solely in the isolation devices; nonetheless, the storey displacement rises somewhat as the building's height grows in both directions.

2) Storey Shear

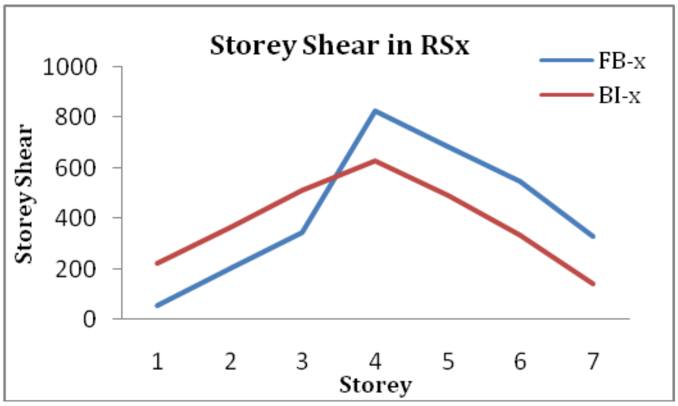

Chart -10: Storey Shear in x-direction

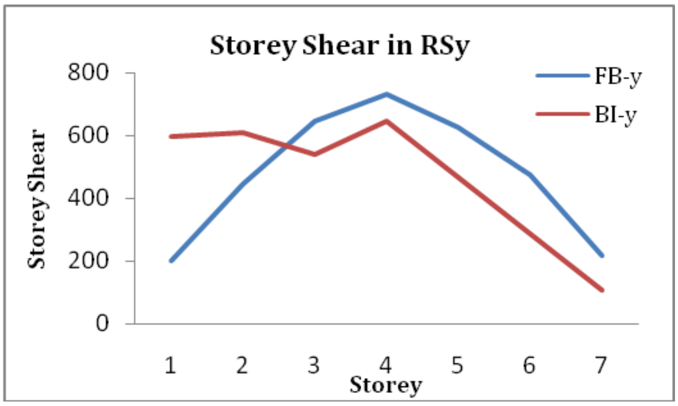

Chart -11: Storey Shear in y-direction

According to the graphical depiction of the response spectrum analysis, storey shear rose up to the 4th floor and then significantly decreased up to the top storey of fixed base and base isolation buildings on sloping ground in both directions. In the X and Y directions, however, the storey shear in the base isolated model is lower than in the fixed base model.

3) Storey Drift

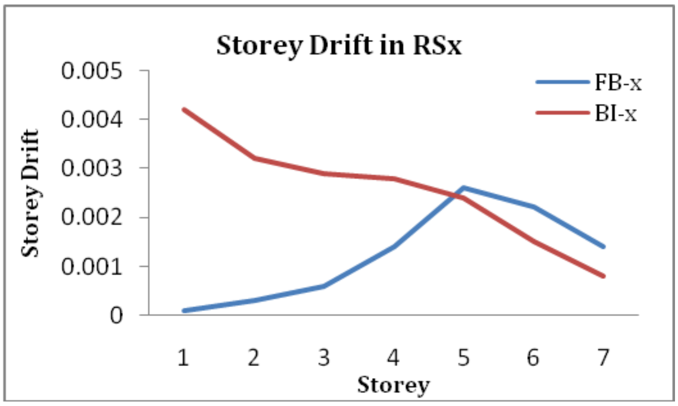

Chart -12: Storey Drift in x-direction

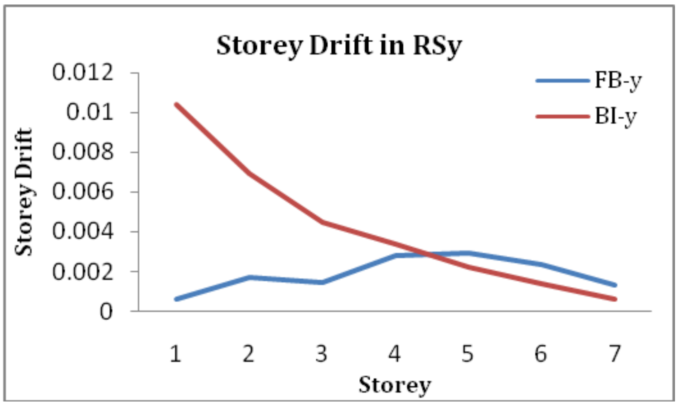

Chart -13: Storey Drift in y-direction

According to response spectrum analysis, storey drift at the top floor in the base isolated building is considerably reduced in both directions when compared to the equivalent fixed base models.4) Time Period

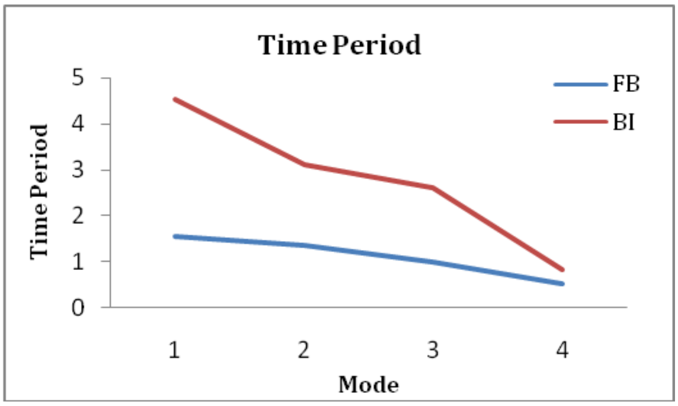

Chart -14: Time Period for building on sloping ground

5. CONCLUSIONS

- The Displacement is greater in base isolation (LRB) building as compared to fixed base building on regular ground and sloping ground in both directions. Hence, Base isolated building is more flexible than fixed base building.
- The storey shear is less in base isolated (LRB) building as compared to the fixed base building on regular ground and sloping ground in both directions. Thus, the response of building is good in base isolated structure than fixed base structure.
- The storey drift is more at base of building and reduces at top storey in base isolation as compared to fixed base building on regular ground and sloping ground in X and Y directions.
- The time period of base isolated (LRB) structure increases as compared to the fixed base on regular ground and sloping ground. It is concluded that the mode period is increased after providing rubber isolator due to the flexible property of the isolator.
- From the above points, it is concluded that the performance of Lead Rubber Bearing structure is

efficient in the Earthquake prone areas for regular and sloping ground.

6. FUTURE SCOPE

- While designing the building in the hilly region with the respective slope the results from given model that has been in the project will be helpful to analyze the results such as displacement, storey shear, etc.
- The comparison of fixed base and base isolation will be helpful to many new researches in this field to carry out essential results.
- As in the project, slope of 25° is taken and the results are concluded. In the same way the value of the slope can be changed and the results are obtained.
- The modeling was done with the help of ETABS software. In future any other software may be used to come up with the results. Then the comparison between the results with two different software can be done.

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