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SEISMIC EXCITATION OF LOW TO HIGH RCC STRUCTURES

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ABSTRACT

Base isolation is the best technique to prevent or minimize damage to buildings during an earthquake disaster. In the present study of base isolation in Nonlinear analysis for five, ten, fifteen, twenty storied reinforced concrete moment resisting frames with lead rubber base isolator and various parameters base shear, moment, drifts, displacements, modal periods were considered. So in this research paper the performance of moment resisting frame in dynamic analysis studied with base isolation and results are compared with the results obtained for moment resisting frame without base isolation. The symmetrical frame is used as test model. The analysis of using nonlinear time history data for with and without base isolation condition.

Keywords:- Nonlinear Time History Analysis, Base isolation, Lead Rubber Isolator, base shear, base moment, storey drifts.

I. INTRODUCTION

An earthquake is shaking caused by sudden movements of rocks in the Earth's crust. The energy that is discharged from those seismic activities makes wakes, these waves are called as primary waves and secondary waves. These waves cause ground movement transmitted to the structure via foundation. Depending on the intensity of these vibrations, cracks and settlement is caused to the structure. Inertia force is induced in structure because of this earthquake movement as result damage of the structure increases with the ground motion .It's permissible to the engineers to use ductility to attain more deformation on the structure than the permitted elastic limit by increasing small sum of forces. The maximum point at which the structures can deform and come to its original shape is called as Elastic limit. If building deforms more than its elastic limit, it cracks in the structure. However, ductility will induce some acceptable damage to the structure. But if more elasticity is introduced to the structure, it may tend to increase the overall cost and decrease the damage by increasing the strength, which in turn will be harmful to the components of the building with the less strength.

Earthquakes are unanticipated phenomena if the structure is located in seismic zones. The engineer has to step in so as to save lives and cause minimal damage to the structures in times of earthquake. As many researchers studied reviewed that seismic isolation (base isolation) is the best solution for the earthquake resistant of the most constructive technique to protect structures against vandalization from the earthquake strike and has gained growing majority during past decades.

Base isolation system is the frequently adopted earthquake resistance system. It reduces the effect of ground motion and thus leads to nullify the effect earthquake to the structure.
Base = a part that supports from beneath or serves as a foundation for an object or structure.
Isolation = the state of being separated and (definition according to concise oxford dictionary), is that of decoupling a structure from its foundation, separating the superstructure from the columns or piers.

II. BASE ISOLATION

The concept of protecting a building from the damaging effects of an earthquake by introducing some type of effort that isolates it from the shaking ground is an attractive one, and many mechanisms to achieve this result have been proposed. Although the earlier proposals go back hundred years, it is only in recent years that base isolation has become a practical strategy for earthquake resistant design. It is a passive control device that is installed between the foundation and the base of the building.

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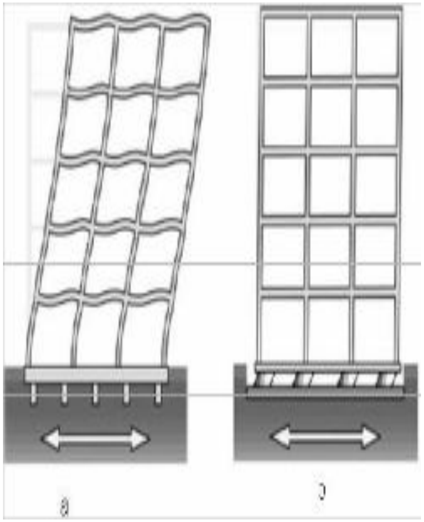

Fig.1 Performance of building with and without isolation

The base isolation system introduces a layer of low stiffness between the structure and the foundation. With this isolation layer the structure has a natural period which is much longer than its fixed base natural period. This lengthening of the period can reduce the pseudo-acceleration and hence the earthquakes induced forces in the structures.

A fixed based building (built directly on the ground) will move with an earthquake's motion and sustain extensive damage as a result. When a building is built away (isolated) from the ground, resting on the flexible bearings or pads known as base isolators it will only move a little or not at all during an earthquake.

In buildings, the base isolator protects the structure from earthquake forces in two ways:

1. By deflecting the seismic energy and
2. By absorbing the seismic energy. The seismic energy is deflecting by making the base of the building flexible in lateral directions, thereby increasing the fundamental time period of the structure.

III. LEAD RUBBER ISOLATOR

A lead rubber bearing is nothing else but a bigger laminated bearing manufactured from layers of rubber, sandwiched together with layers of steel, except for that in middle of bearing there will be a solid lead plug. Top and bottom of the bearing is fitted with steel plates, which are used to attach bearing to building through its foundation. These lead rubber bearings are designed in such a way that bearing is very stiff and strong in vertical direction, but flexible in horizontal direction.
Lead rubber isolator consists of three basic components

1. Lead plug
2. Rubber
3. Steel

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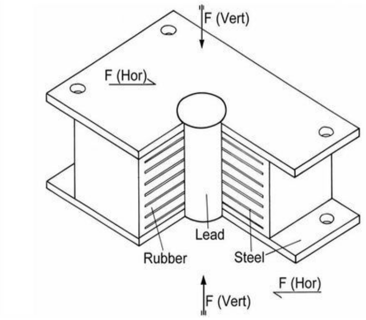

Fig.2 components of lead rubber isolator

Rubber

The rubber provides flexibility through its ability to move but return to its original position. At the end of an earthquake, if a building hasn't returned to its original position, the rubber bearings will slowly bring it back. This might to its original position.

Lead

Lead was chosen because of its plastic property while it may deform with the movement of the earthquake, it original shape, and it is capable of deforming many times without losing strength. During an earthquake, the kinetic energy of the earthquake is absorbed into heat energy as the lead is deformed.

Steel

Using layers of steel with the rubber means the bearing can move in a horizontal direction but is stiff in a vertical direction.

Parametric design of lead rubber bearing base isolators (New Zealand Rubber Bearing)

- The maximum vertical reaction R of the footing is estimated for the fixed base structure.
- The fundamental time period of the structure should also be calculated
- The effectivess stiffness of the isolator is calculated by,

$$Keff = \frac{4\pi 2R}{gTb2}$$

- From the response spectrum curves of the fixed base isolation system, the design(maximum) displacement of the base isolator is,

$$Sd = \frac{Sa\mathrm{T}b2}{4\pi 2}$$

- The energy dissipation per cycle, Wd can be approximately calculated by assuming for a very small post yield stiffness as

$$Wd = 2\pi KeffSd\,2\zeta eff$$

- The short term yield force Qd is

$$Qd = \frac{Wd}{4Sd}$$

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$$= \frac{\pi}{2} Keff\zeta effSd$$

- The post yield horizontal stiffness can be obtained as

$$Kd = Keff - \frac{Qd}{Sd}$$

Using the expression for Dy and the approximate value of Ku =10, Deformation force is given by

$$Dy = \frac{Qd}{9\mathrm{K}d}$$

- The yield force Fy is given by

$$Fy = \mathrm{K}uDy$$

Where,

$$\mathrm{K}u = 10 \times \mathrm{K}d$$

IV. DISCRIPTION OF THE BUILDING

In the present work, the considered buildings are reinforced concrete ordinary moment resisting space frames of 5, 10, 15 &20 storeys symmetric. All these buildings have been analyzed by nonlinear time history analysis method. The layout of plan having 3x3 bays of equal length of 7.32m. The storey height is kept uniform of 3m for all kind of building models. Theoretical comparison is then worked out between the fixed base and the base isolated structure and the parameters such as base shear, base moment, mode period, storey displacement and storey drift by using SAP2000

Table.1 building data

S.no	Variable	Data
1	Type of structure	Moment resisting frame
2	Number of stories	5,10,15&20
3	Floor height	3 m
4	Live load	2 kN/m^2
5	Super dead load	1.25 kN/m^2
6	Wall load	External wall=11 kN/m Internal wall=5.5 kN/m
7	Materials	Concrete M_{20},M_{25} and reinforced with HYSD bars Fe_{415}
8	Size of columns	450x450 mm

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9	Size of beams	380x230 mm
10	Depth of slab	125 mm
11	Specific weight of RCC	25 kN/m^3
12	Zone	II
13	Importance factor	1
14	Response reduction factor	3
15	Type of soil	Medium

Models

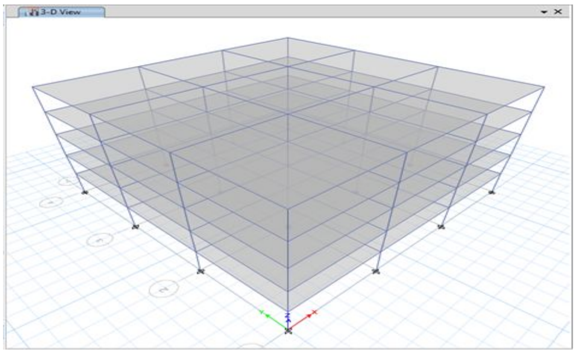

Fig.4 Isometric view of five storey building

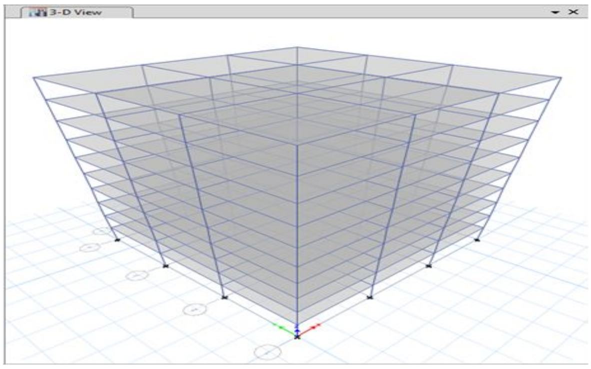

Fig.5 Isometric view of ten storey building.

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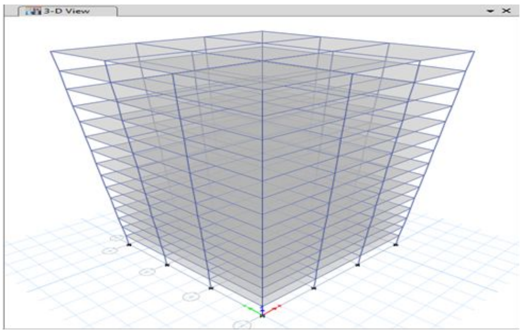

Fig.6 Isometric view of fifteen storey building

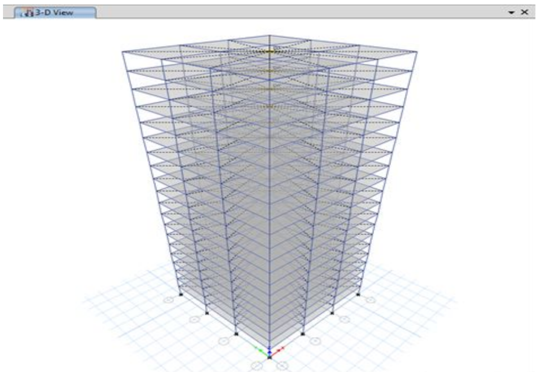

Fig.7 Isometric view of twenty storey building

V. RESULTS

The Results obtained are of different parameters such as Storey drifts, Base shear, Modal Periods, Torsion etc. Firstly the results obtained by carrying out Non-Linear Time History Analysis using Base Isolation techniques for Symmetric building for 5, 10, 15& 20storeys and then the Results obtained are listed.. Subsequent Discussions are made about the Results Obtained of Base isolation based on the store drifts, Base shear, Torsion etc. for Symmetric buildings individually and also considering the Storey effect of both Symmetric buildings by comparing the Responses of the structure for 5,10,15&20 storey Buildings.

Table .2. Results of parameters

Para meter		Displa ce Ments (mm)	Storey Drifts mm	Base Shear kN/m	Base Mom ent kN/m	Mod al time perio d (sec)
g + 5	with out isol ator	156.72	0.0058	425.9	2795	1.19
	with isol ator	293.3	0.004	141.2	1490	1.98
g + 1 0	with out isol ator	425.5	0.0047	4083	4131	2.56
	with isol ator	464.4	0.0044	2261	2380	3.24

g+15	Without isolator	488.96	0.0026	2719	27200	3.95
	with isolator	547.67	0.0027	2048	18560	4.58
g+20	without isolator	479.19	0.0025	2719	27200	4.19
	with isolator	563.57	0.0028	2048	18560	4.66

Comparison of displacements is mentioned below

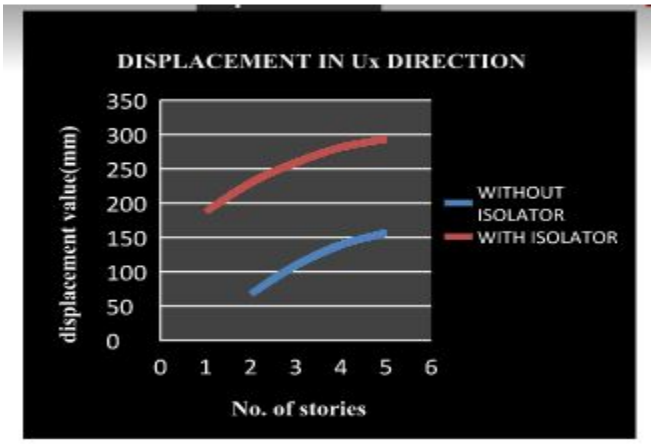

Fig.8 displacement of five storied building.

Fig.9.displacement of Ten storied building.

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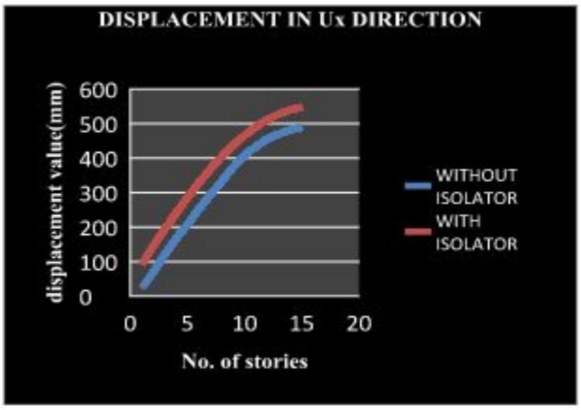

Fig.10.displacement of fifteen storied building.

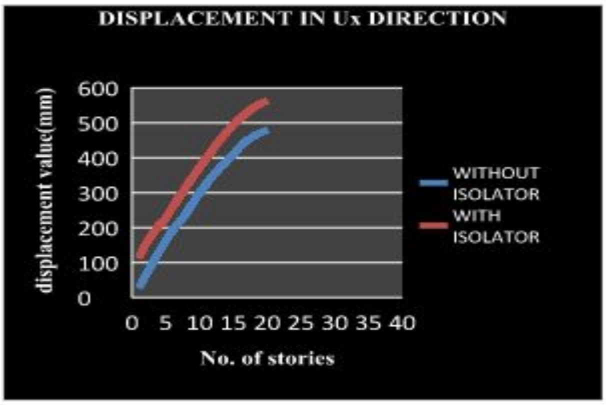

Fig.11.displacement of twenty storied building.

Comparison of storey Drifts are mentioned below

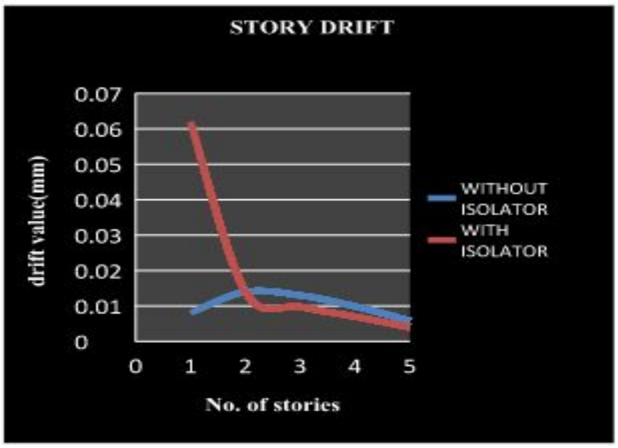

Fig.12.storey drifts of five storied building.

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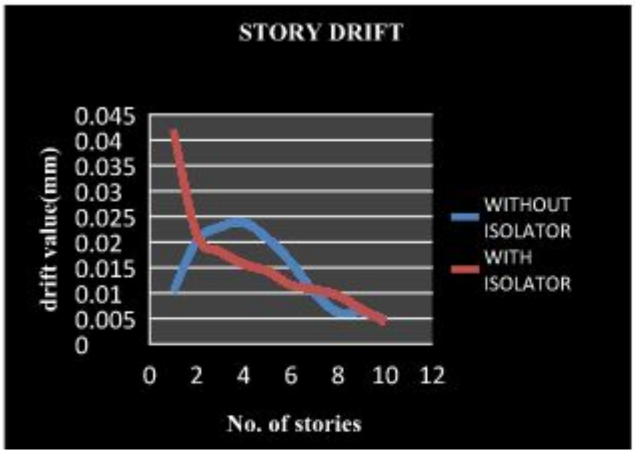

Fig.13.storey drifts of Ten storied building

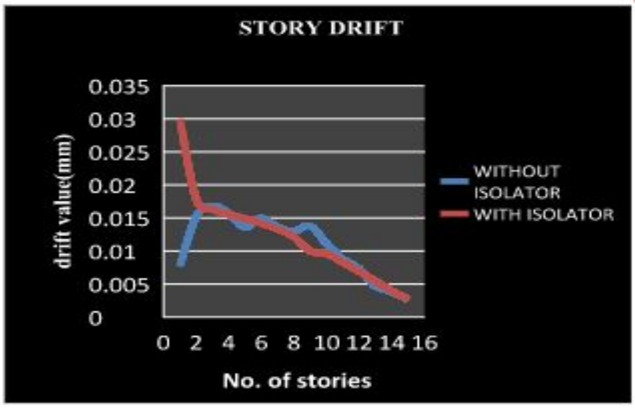

Fig.14.storey drifts of fifteen storied building.

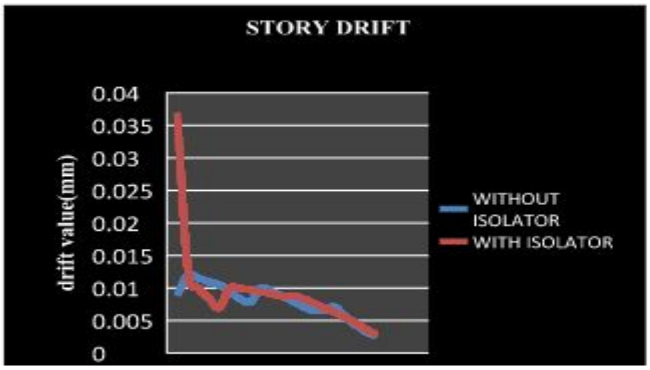

Fig.15.storey drifts of twenty storied building.

Base shear variations in different storied building

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Fig.16.base shear of five storied building.

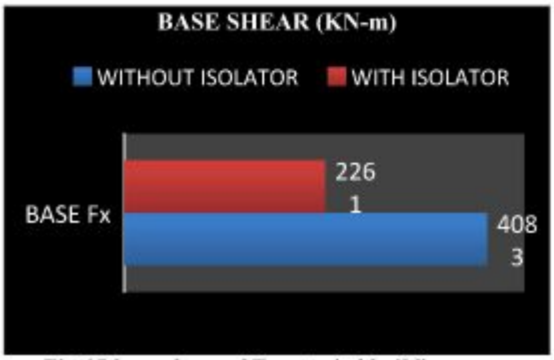

Fig.17.base shear of Ten storied building.

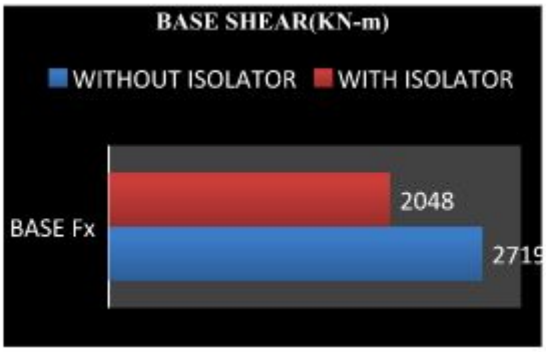

Fig.18.base shear of fifteen storied building.

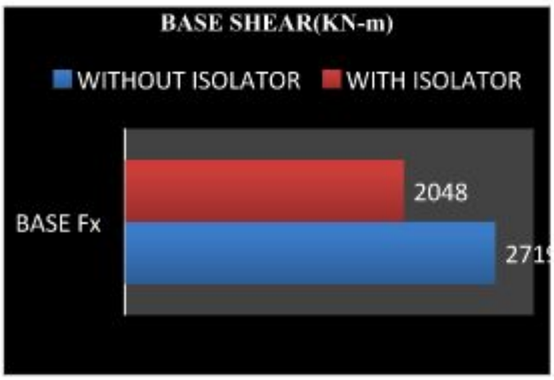

Fig.19 base shear of twenty storied building.

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Base moment variations in different storied building

Fig.20 base moment of five storied building.

Fig.21 base moment of ten storied building.

Fig.22 base moment of fifteen storied building

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Fig.23 base moment of twenty storied building.

Comparison of mode shapes for different storied buildings

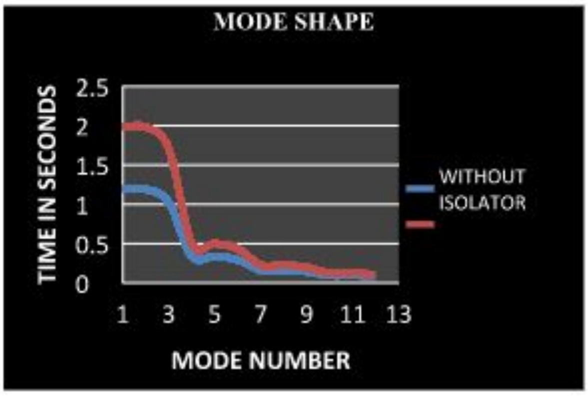

Fig.24 modal time period of five storied building.

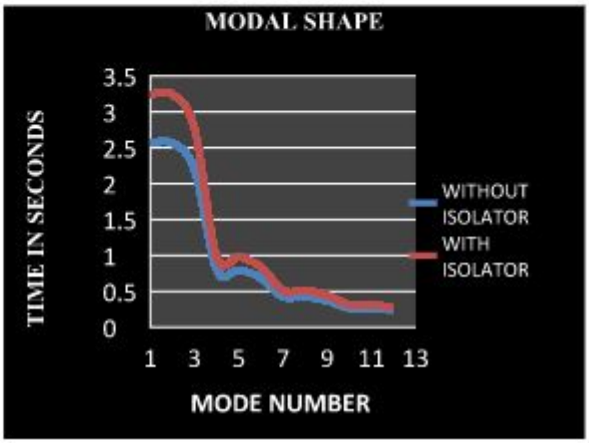

Fig.25 modal time period of ten storied building

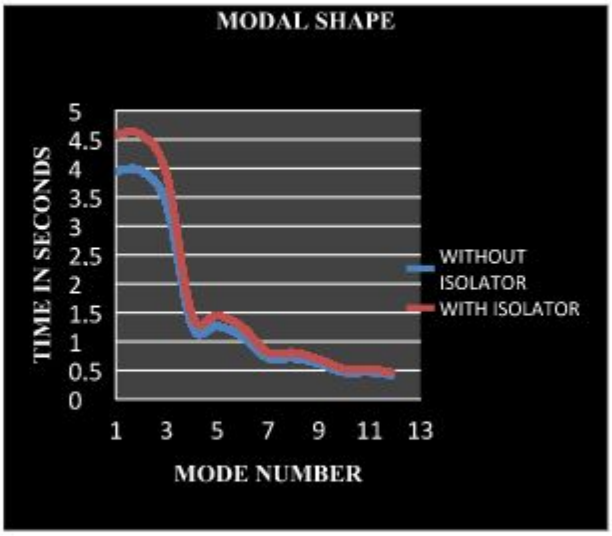

Fig.26 modal time period of fifteen storied building.

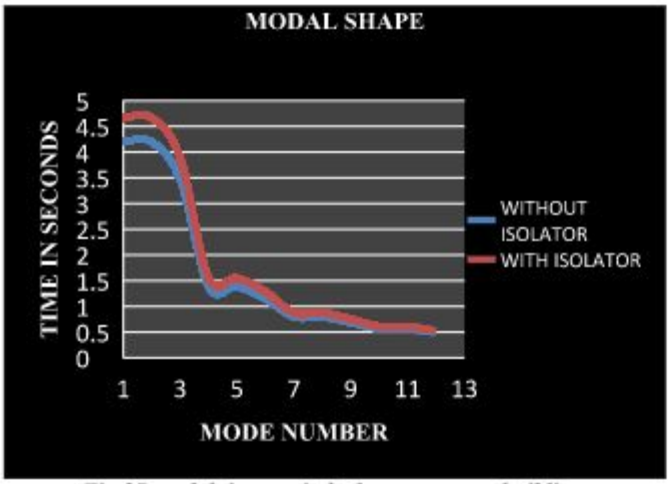

Fig.27 modal time period of twenty storey building.

VI. CONCLUSION

The main considerations in the thesis are represented below:

- Base isolation method has proved to be a reliable method of earthquake resistant design.
- Storey drifts were decreased by 98% for five storey symmetrical buildings.
- Storey displacements were decreased by 36% for five storey symmetrical building with base isolation compared to fixed base.
- Reduction in base shear and moment by 66.8% and 94% of five storey symmetrical buildings.
- Time period were increased by 75.4% of five storey building compared to fixed base building.
- Storey drifts were decreased by 31% for ten storey symmetrical building.
- Storey displacements were decreased by 72% for ten storey symmetrical building with base isolation compared to fixed base.
- Base shear and base moment were reduced by 83% and 79.7% compared to fixed base building.
- Time period were increased by 53.8% of ten storey building compared to fixed base building.
- Storey drifts were decreased by 71.3% for fifteen storey symmetrical building.
- Storey displacements were decreased by 83% for fifteen storey symmetrical building with base isolation compared to fixed base.
- Storey displacements were decreased by 94% for twenty storey symmetrical building with base isolation compared to fixed base.
- Base shear and moment were reduced by 24% and 31.7% compared to fixed base building.

- Time period were increased by 38% for fifteen storey building.
- Storey drifts were decreased by 33.3% for twenty storey symmetrical building.
- Base shear and moment were reduced by 11% and 19.4% compared to fixed base building.
- Time period were increased by 28.9% compared to fixed base building.

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