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Response Spectrum Analysis of Base Isolated Regular and Vertical Irregular Building in Different Types of Soil

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Abstract: These days earthquake is a major problem for development of high rise building in seismic zone areas. Researchers have developed devices to overcome these earthquake problems. So we need to design a structure which can withstand against the seismic loads. There for it became necessity to provide passive control device "base isolation" to resists large horizontal and vertical loads which lead the structure to collapse. In present workthe effectiveness of the fixed base and Base isolation (LRB) with different type of vertical irregularities in different type of soil (Hard, Medium, Soft soil) in plan are concerned the vibration of the structure. The present work G+10 story Building of different vertical irregularities (Regular building, vertical irregular Type-I, vertical irregular Type-II, vertical irregular Type-III) Situated in zone IV are analyzed under the various Loading such as dead load, live load and earthquake load. Free vibration analysis, response spectrum analysis have been carried out for these model of building with a fixed base and base Isolation Devices. It is observed that story displacement in response spectrum is significantly increases at top stories with the base isolated building. And this work shows that the response of building reduced by using base isolation (LRB) devices in all different typeof vertical irregularities building, but the same isolation device is more effectively work in Vertical irregular Type-II Building
Keywords: Base isolation Techniques, LRB, Base Shear and Etabs etc.

I. INTRODUCTION

Since an earthquake causes ground movement, it produces inertia force, which is proportional to the mass of the structure. Along these lines, the seismic research is controlled by the mass of the structure being analyzed, which adds some stiffness to the structure. Because it is economical to construct a structure that is entirely vibration, it is important for the structure to suffer some damage, spreading the vitality provided to it during the seismic tremor. According to India Standard, the structure is created specifically to avoid any structural damage even under slight shaking, so that they can be structured individually for a portion of the forces that they may encounter However, there would be some initial stiffness. To make the task practical, the seismic investigation should have the ability to adjust economy and adequate hard. This is possible, as it were, based on extensive research and specific post-quake harm assessment considerations. In this method, structures might be designed to withstand the effects of seismic tremors rather than quake verification. The structure has to survive a massive relocation movement request without causing structural damage, failure, or a loss of cohesive for a safe and conservation development.

II. BASE ISOLATION

A base isolation system is a type of seismic protection that separates the structure (superstructure) from the foundation (foundation or substructure).The amount of energy delivered to the superstructure during an earthquake is greatly reduced when the structure is separated from its base. One of the most common methods of safeguarding structure against earthquake effect is base isolation. It's a passive control device that's positioned between the buildings foundation and base. As with bridge bearings, base isolators are positioned between the deck and the pier for bridges. In structure, base isolator protects the structure against seismic effect. In the base isolator protects structure against earthquake force in two ways: (i) by deflecting the force of earthquake away from the structure. (ii) By absorbing seismic energy. As a result, the superstructure will not be affected by earthquake force. Simply put, the structure above the ground will float on the base with the base movement having no bearing on the superstructure. The transfer of ground vibration will cause significant harm to a fixed base construction. During an earthquake however, an isolated building resting on flexible base or pads known as an isolator will move just slightly or not at all. The isolators work in the same sway as automotive suspension does allowing a car to go rough terrain without throwing its occupants around. Alternatively, a bird flying above the earth will see no effect from the earth the act of moving. Base isolation is a technique for preventing or minimizing structure damage during an emergency a natural disaster. It s been utilized in New Zealand, India, Japan, Italy and the United States.

For seismic base isolation, there are six basic types of base isolation devices that are extensively used.
1) Elastomeric Bearing
2) Lead Rubber Bearing
3) High Damping Bearing
4) Curved Slider Bearing or Pendulum Bearing
5) Flat Slider Bearing
6) Ball and Roller Bearing

III. LEAD RUBBER BEARING SYSTEM

For seismic isolation, lead rubber bearing, which are used in building and bridge structure, are a practical and cost- effective option. It’s made up of a laminated elastomeric bearing pad, top and bottom sealing and connecting plates, and a lead plug put in the bearing’s center. This type of bearing is made up of rubber laminated layers sandwiched between two layers of steel. In the middle of this bearing is a solid lead plug. Two steel plates are utilized to join the bearing to the building and foundation at the top and bottom. The bearing is important, in the vertical direction, it is highly rigid and robust, yet in the horizontal direction, it is highly flexible.

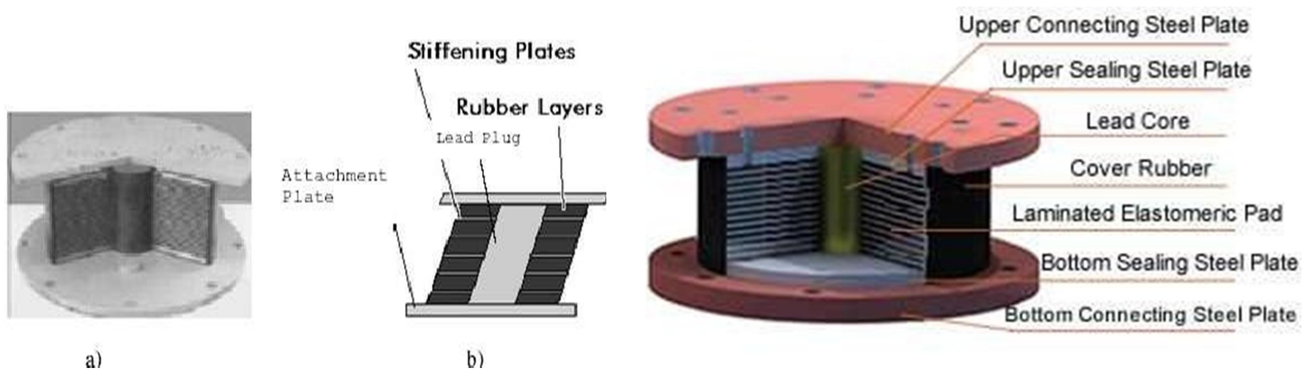

Figure 1 - Lead Rubber Bearing (LRB)

IV. MODELING AND ANALYSIS

The 3D model of R.C.C. building in plan area 1050m2 of G+10 stories building are modeled different four model for various vertical irregularity model with and without base isolation system with fixed base and base isolation system (LRB) analysis are done in different type of soil like Hard soil, Medium soil, Soft soil using ETABS v19.Response Spectrum and linear time history analyses are done on these R.C.C. building models using IS 456:2000 and IS 1893:2016 with the help of ETABS Software. Seismic zone select for IV (0.24) and Response Reduction Factor (R) is taken as 5; important factor is 1 also the mass source taken as DL+0.25LL. Wall load is 10.92 kn/m and floor Finishing Load (Dead Load) 1 kn/m2Live load on Slab is 3 kn/m2. Also Included Thickness of slab 125 mm, Steel is HYSD 415.

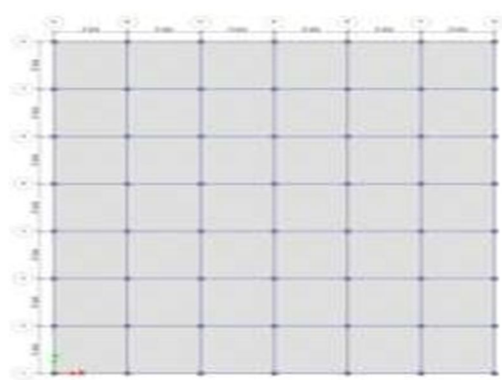

Figure 2- General Plan of Structure G+10 building

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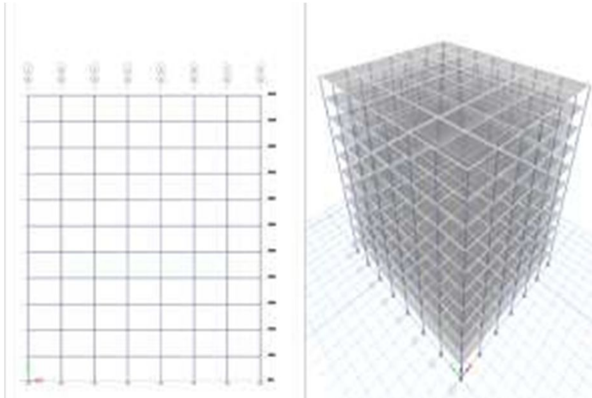

Figure 3 - Elevation and 3D view of Regular G+10 Building on fixed base in different type of soil

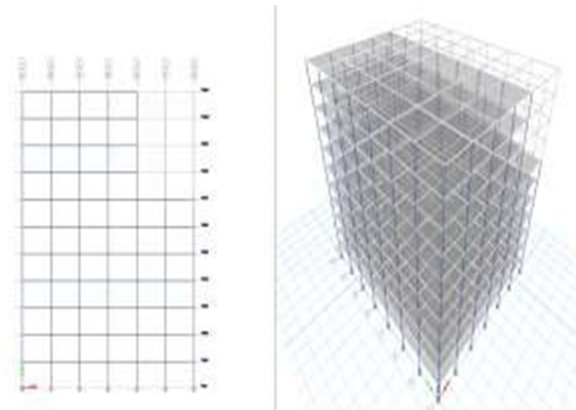

Figure 4 - Elevation and 3D view of Vertical irregular Type I (G+10) building on fixed base in different type of soil

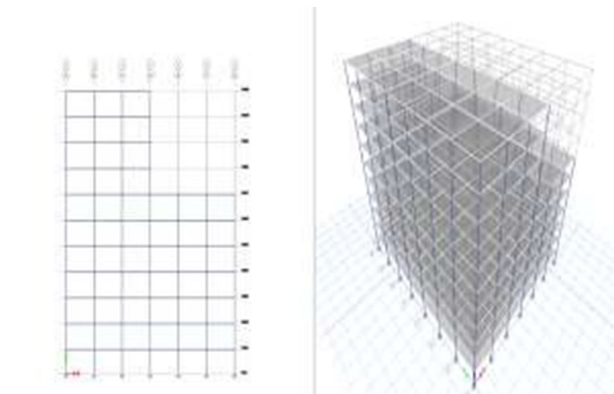

Figure 5 - Elevation and 3D view of Vertical irregular Type III (G+10) Building on fixed base in different type of soil

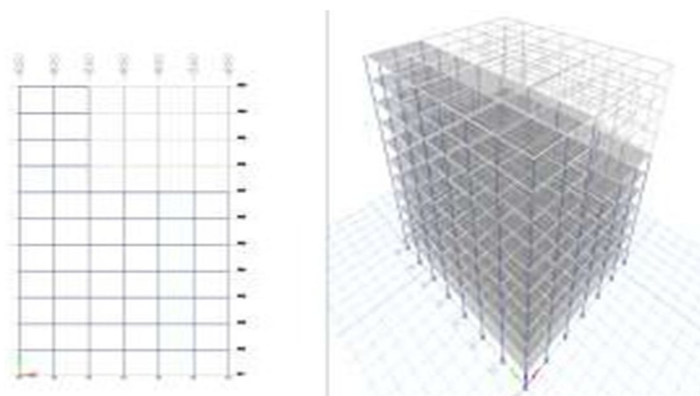

Figure 6 - Elevation and 3D view of Vertical irregular Type IV (G+10) building on fixed base in different type of soil

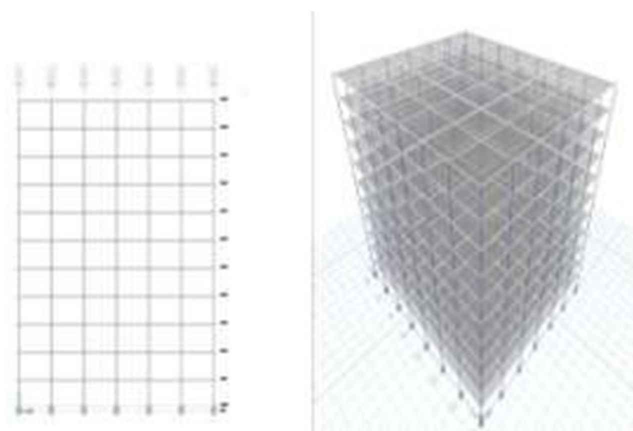

Figure 7 - Elevation and 3D view of Regular G+10 Building on Lead rubber bearing base isolation in different type of soil

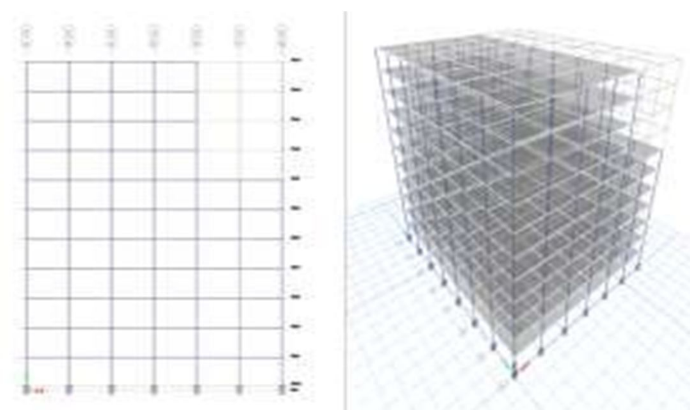

Figure 8 - Elevation and 3D view of Vertical irregular Type I (G+10) building on Lead rubber bearing base isolation in different type of soil

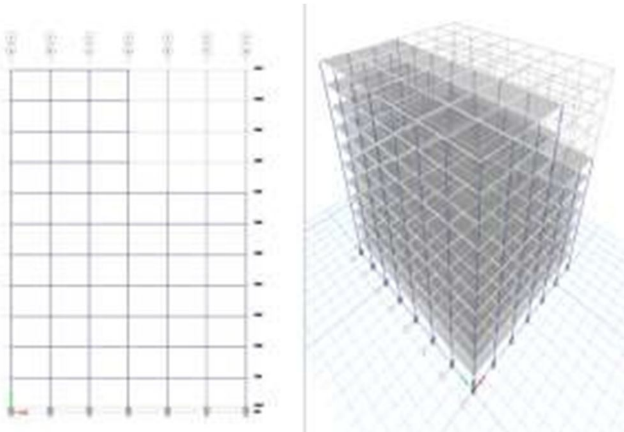

Figure 9 - Elevation and 3D view of Vertical irregular Type III (G+10) Building on Lead rubber bearing Base isolation in different type of soil

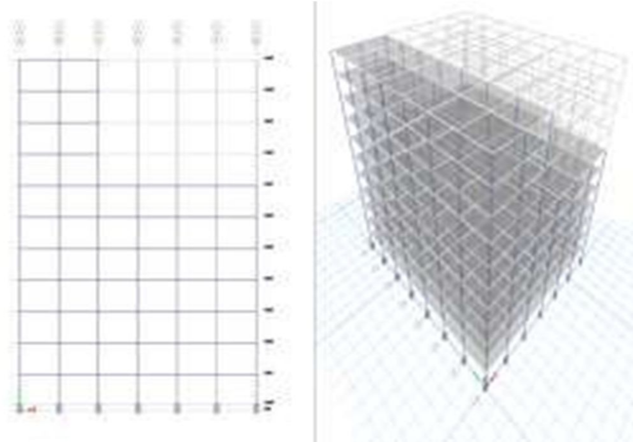

Figure 10 - Elevation and 3D view of Vertical irregular Type IV (G+10) building on Lead rubber bearing Base isolation in different type of soil

The following parameters for Lead Rubber Bearing are determined for each model and are listed in Table 1

Table 1- Detail Specification LRB

The bearing's total height is,	h=378mm
Is the bearing's diameter,	D= 600mm
Number of rubber layers,	N= 15
Individual layer thickness,	T=20mm
The diameter of the lead core,	Dp =90mm
Number of steel plates,	Ns= 14
Steel plate thickness,	Ts= 2mm
Top and bottom cover plate thickness ,	25mm

The point springs are attached at the base of the Isolated Model by changing the fixed supports of the building withlinked properties that have the following qualities regarding stiffness and damping values as calculated.

V. RESULT AND DISCUSSION

According to Indian Standards, the analysis in conducted using a static and dynamic technique, due to static analysis, the results of free vibration analysis, displacements, and drift ratios resulting from static analysis, displacements and drift ratios resulting from response spectrum analysis, and displacement and drift from critical load combination are compared for both fixed base and base isolation building models using four model in various vertical irregularities in various type of soil (Hard soil ,Medium soil ,Soft soil) in X and Y direction. The base shearfor the same was also explored.

A. *Modal Participation Period*

If the result shows that irregularities building is reduced the time period base isolation and fixed base. The Time period of the Base Isolation Building of different Vertical Irregularities is Increases with Respect to the fixed base Building of Respective different type of soil (Hard, Medium, Soft Soil).The frequency isreduced as the model time period is increases, which means the dynamic reaction of various building shapes as likewise Reduced.

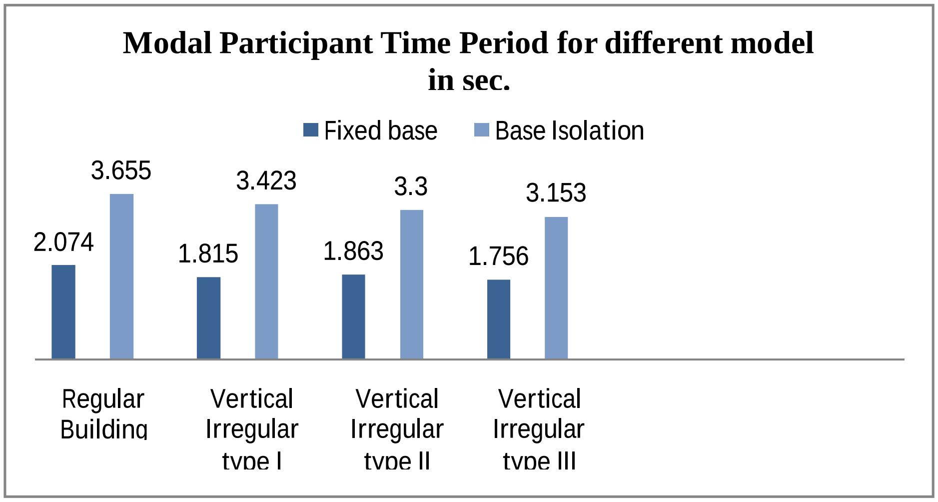

Figure 11 - Fundamental Time Period for Different Model

B. *Displacement*

1) *Due to Static Lateral Load Method in X Direction:* The value of displacement under static analysis in the X direction is increases up to 15.4% in regular Building, 7.50 % in vertical Irregular Type- I Building, 7.03% in vertical Irregular Type-II Building, 4.97% in vertical irregular Type -III Building the base of the building are Isolation In Hard Soil comparesto Fixed Base System. The value of displacement under static analysis in the X direction is increases up to 23.55% in regular Building, 15.025 % in vertical Irregular Type- I Building, 17.73% in vertical Irregular Type-II Building, 16.13% in vertical irregular Type -III Building the base of the building are Isolation in Medium Soil compares to Fixed Base System. The value of displacement under static analysis in the X direction is increases up to 23.5% in regular Building, 20.4 % in vertical Irregular Type- I Building, 24.1% in vertical Irregular Type-II Building, 26.69% in vertical irregular Type -III Building the base of the building are Isolation in Soft Soil compares to Fixed Base System.

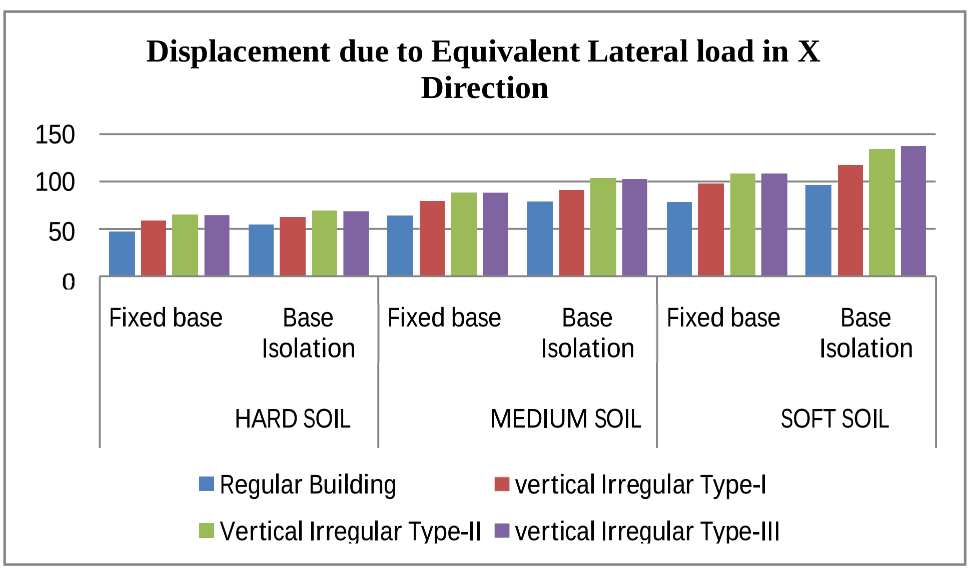

Figure 12 - Displacement due to Equivalent Lateral load in X Direction

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1) *Due to Static Lateral Load Method in Y Direction:* The value of displacement under static analysis in the Y direction is decreases up to 29.12% in regular Building, 33.92 % in vertical Irregular Type- I Building, 34.54% in vertical Irregular Type-II Building, 33.56% in vertical irregular Type -III Building the base of the building are Isolation In Hard Soil compares to Fixed Base System. The value of displacement under static analysis in the Y direction is decreases up to 21.24% in regular Building, 28.84% in vertical Irregular Type- I Building, 30.17% in vertical Irregular Type-II Building, 29.13% in vertical irregular Type -III Building the base of the building are Isolation in Medium Soil compares to Fixed Base System. The value of displacement under static analysis in the Y direction is decreases up to 9.43% in regular Building, 18.17% in vertical Irregular Type- I Building, 19.70% in vertical Irregular Type-II Building, 18.50% in vertical irregular Type-III Building the base of the building are Isolation in Soft Soil compares to Fixed Base System.

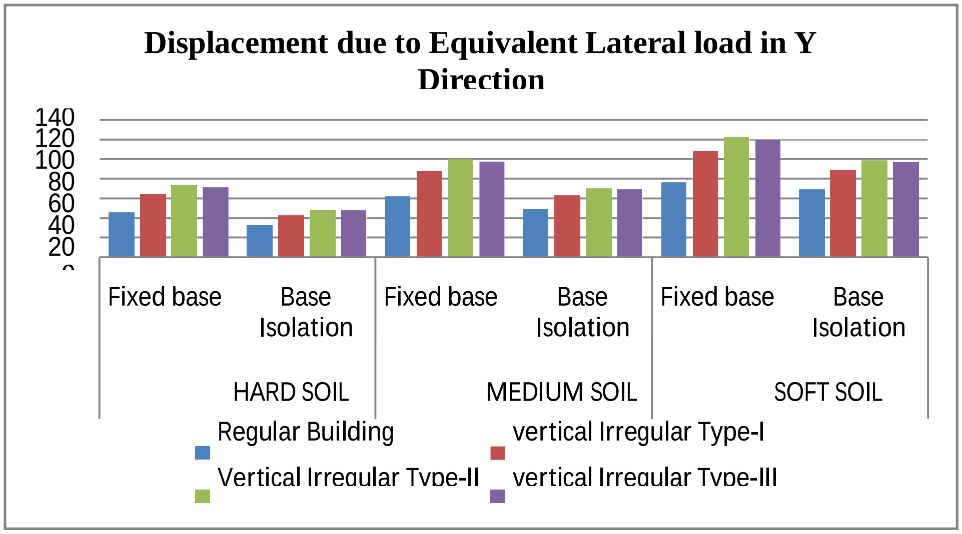

Figure 13 - Displacement due to Equivalent Lateral load in Y Direction

2) *Due to Response Spectrum Analysis in X Direction:* The value of displacement under Response spectrum Analysis in the X direction is increases up to 30.17% in regular Building, 35.028 % in vertical Irregular Type- I Building, 23.36% in vertical Irregular Type-II Building, 21.33% in vertical irregular Type -III Building the base of the building are Isolation In Hard Soil compares to Fixed Base System. The value of displacement under Response Spectrum Analysis in the X direction is increases up to 30.19%in regular Building, 35.03 % in vertical Irregular Type- I Building, 24.43% in vertical Irregular Type-II Building, 21.41% in vertical irregular Type -III Building the base of the building are Isolation in MediumSoil compares to Fixed Base System. The value of displacement under Response Spectrum analysis in the X direction is increases up to 30.35% inregular Building, 35.16 % in vertical Irregular Type- I Building, 24.5% in vertical Irregular Type-II Building, 21.45% in vertical irregular Type -III Building the base of the building are Isolation in Soft Soil compares to Fixed Base System.

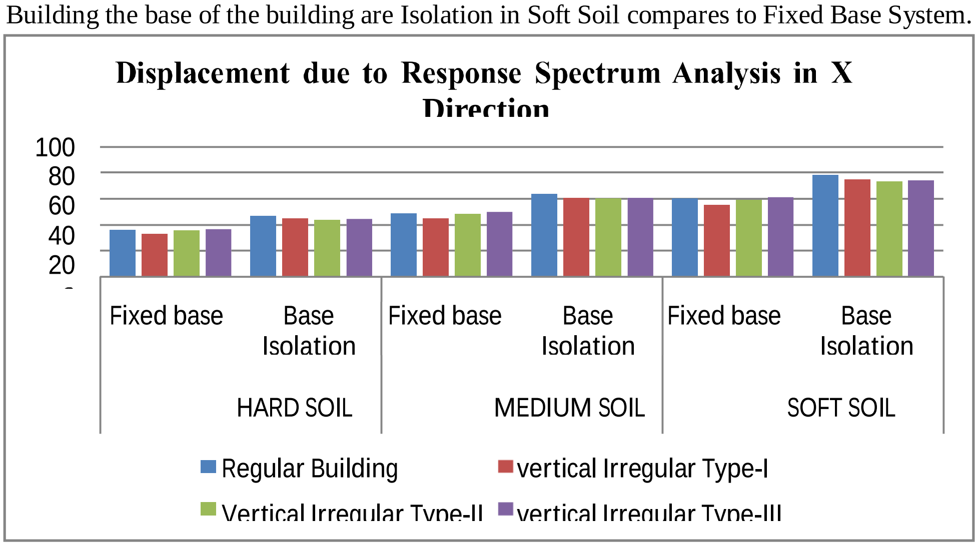

Figure 14 - Displacement due to Response Spectrum Analysis in X Direction

3) *Due to Response Spectrum Analysis in Y Direction:* The value of displacement under Response spectrum Analysis in the Y direction is increases up to 16.08% in regular Building, 27.25% in vertical Irregular Type- I Building, 34.82% in vertical Irregular Type-II Building, 30.49% in vertical irregular Type -III Building the base of the building are Isolation In Hard Soil compares toFixed Base System. The value of displacement under Response Spectrum Analysis in the Y direction is increases up to 31.58% in regular Building, 44.24 % in vertical Irregular Type- I Building, 51.10% in verticalIrregular Type-II Building, 54.65% in vertical irregular Type -III Building the base of the building are Isolation in Medium Soil compares to Fixed Base System. The value of displacement under Response Spectrum analysis in the Y direction is increases up to 39.39% in regular Building, 57.10 % in vertical Irregular Type- I Building, 60.07% in vertical Irregular Type-II Building, 75.27% in vertical irregular Type -III Building the base of the building are Isolation in Soft Soil compares to Fixed Base System.

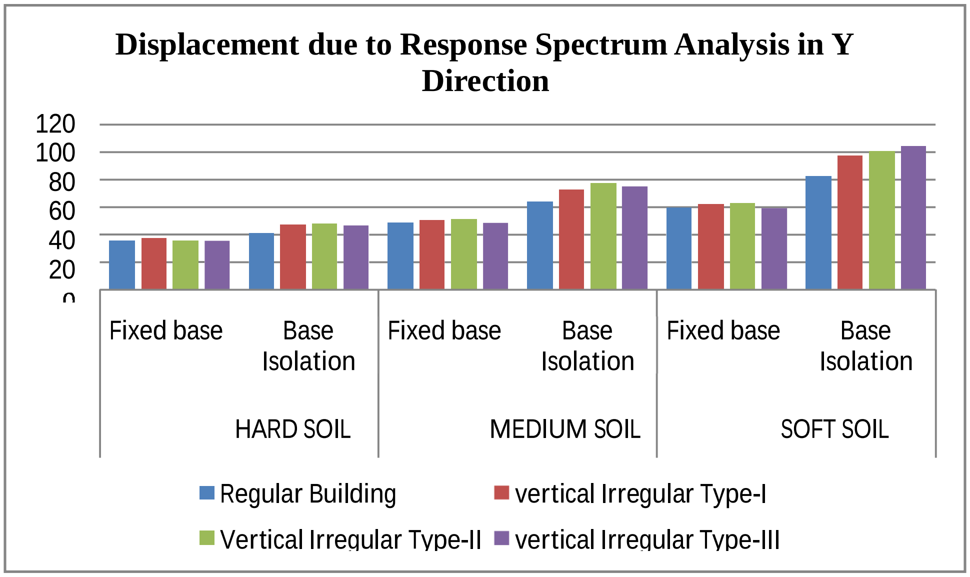

Figure 15 - Displacement due to Response Spectrum Analysis in Y Direction

C. DRIFT

In the X direction with respect to the floor in level , According to static lateral load method and Response spectrum analysis show the variation of the story drifts for the 4 different model in fixed base in different type soil like hard ,medium, soft soil and base isolation (LRB) in different soil buildings. There is a rapid increase in story drift at the level of the base to story one for base isolation building .The drift is then gradually reduced.

D. Base Shear

1) *Base Shear Due to Equivalent Lateral Load Method:* Base shear due to Equivalent Lateral Load Method in different Four Model regular building, vertical irregular Type-I, vertical irregular Type-II, vertical irregular Type-III in different type soil (Hard, Medium, Soft Soil) also decreases in Base Isolation building compare to fixed base. Base shear due to Response Spectrum Method Analysis n different Four Model irregular building, vertical irregular Type-I, vertical irregular Type-II, vertical irregular Type-III in different type soil (Hard, Medium, Soft Soil) also decreases i n Base Isolation building compare to fixed base. Compare the value of base shear for fixed base building in both Equivalent lateral load and Response spectrum method in hard, medium, soft soil, as well as base isolation building in both Equivalent lateral load and Response method in hard, medium, soft soil. The base shear due to Equivalent lateral load fixed base and base isolation (LRB)different model in Hard soil are model regular building , vertical irregular type -I, vertical irregular type – II, vertical irregular type-III are 3167.6499 KN, 4388.1096 KN, 3937.9325KN,3666.4266KN and 3139.0395KN , 2781.937KN , 2603.3854KN, 2424.8334KN respectively.

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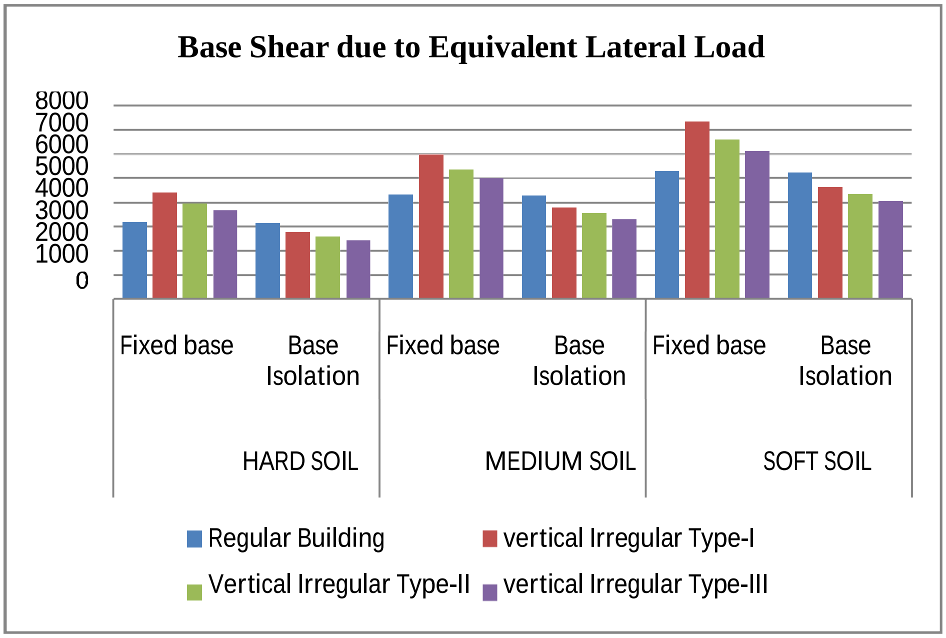

Figure 16 - Base Shear due to Equivalent Lateral Load

2) *Base Shear Due to Response Spectrum Analysis:* The base shear due to Equivalent lateral load fixed base and base isolation (LRB) different model in Medium soil are model regular building , vertical irregular type -I, vertical irregular type –II, vertical irregular type-III are 4308.0038 KN, 5967.82981 KN, 5355.5882 KN, 4986.3402 KN and 4269.0937 KN , 3783.4343 KN , 3540.6042KN, 3297.7735 KN respectively. The base shear due to Equivalent lateral load method in Soft soil discuss below. The base shear due to Response spectrum method fixed base and base isolation (LRB) different model in Hard soil are model regular building , vertical irregular type -I, vertical irregular type –II, vertical irregular type-III are 3161.3977 KN, 3333.5997 KN, 2932.0066 KN, 2871.134 KN and 2481.7434 KN ,2391.6422 KN , 2330.7868KN,2308.2182 KN respectively. The base shear due to response spectrum method in Medium soil and Soft soil are discussed below. The damping and stiffness of the structure have an impact on the building's base shear. As the structure's stiffness and damping rise, it becomes more resistant to lateral force, reducing the structure's base shear.

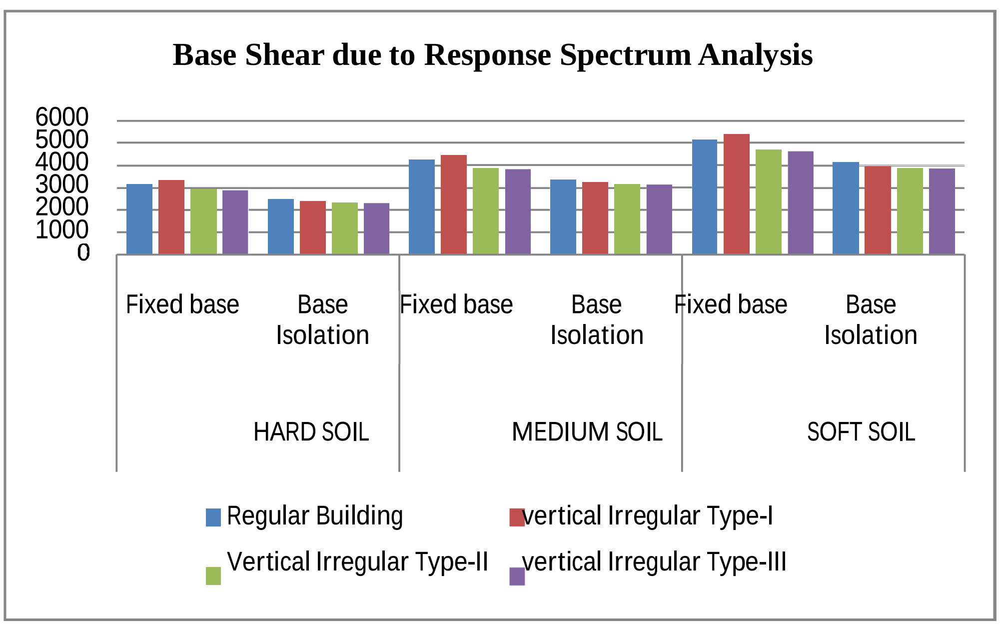

Figure 17 - Base Shear due to Response Spectrum Analysis

VI. CONCLUSION

This study explains the behavior of Lead Rubber Bearing isolation system under the performance of dynamic loads from the results following conclusion are drawn.

A. The Time period of the Base Isolation Building of different Vertical Irregularities is Increases with Respectto the Fixed base Building of Respective different type of soil (Hard, Medium, Soft Soil).The frequency isreduced as the model time period is increases, which means the dynamic reaction of various building shapes as likewise Reduced.
B. Displacement in x direction in static lateral load method is also reduced in base isolation buildings compareto fixed base. And building very small displacement produced due to earthquake.
C. Displacement in x direction in Response spectrum analysis is also reduced in base isolation buildings compare to fixed base. Base isolation building very effective work in Hard Soil.
D. The performance of a building with base Isolation is superior to that of fixed base in all different type of vertical irregularities.
E. It is observed that the value of base shear of the base isolation building of all regularities is reduced approximately 5 time of the fixed base.
F. Is show that base shear is also reduces when the used of base isolation system displacement also reduced inhard soil upto 10% but when used of Medium and soft soil reduce up to 20%.
G. In the preceding Analysis, the vertical Irregular Type- II performed the best out of all Different Models.

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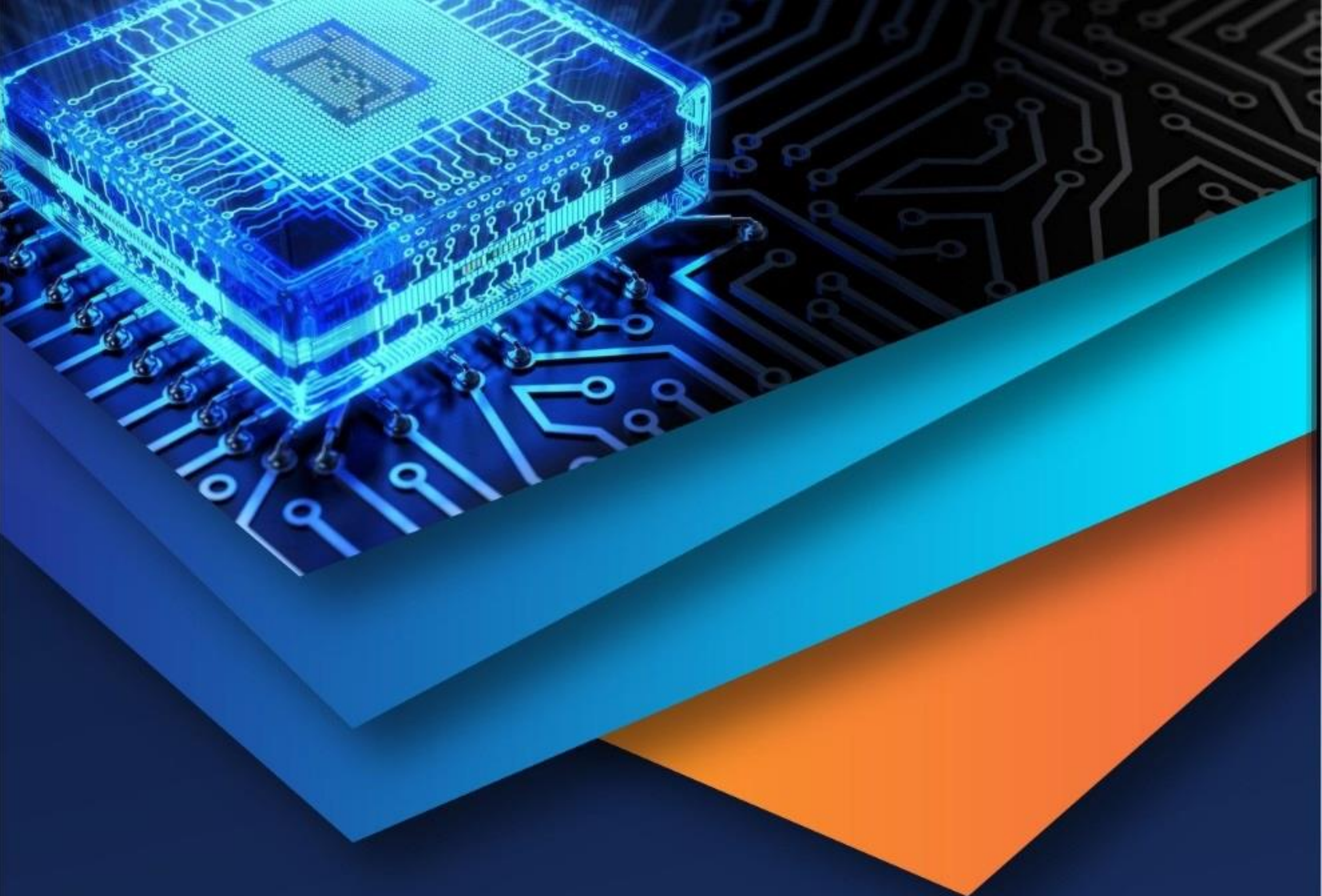

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