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Comparative Study, Design and Analysis of a G+12 Structure in Earthquake Zone in India

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Abstract: Seismic isolation is a technology that decouples a building structure from the damaging earthquake motion. It is a simple structural design approach to mitigate or reduce potential earthquake damage. In base-isolated structures, the seismic protection is obtained by shifting the natural period of the structure away from the range of the frequencies for which the maximum amplification effects of the ground motion are expected; thus, the seismic input energy is significantly reduced. At the same time, the reduction of the high deformations attained at the base of the structure is possible, thanks to the energy dissipation caused by the damping and the hysteretic properties of these devices, further improving the reduction of responses of the structures. Base isolation is also an attractive retrofitting strategy to improve the seismic performance of existing bridges and monumental historic building.

- ***The method of base isolation was developed in an attempt to mitigate the effects of earthquakes on buildings during earthquakes and has been practically proven to be the one of the very effective methods in the past several decades.***
- ***Base isolation consists of the installation of support mechanism which decouples the structure from earthquake induced ground motions.***
- ***Base isolation allows to filter the input forcing functions and to avoid acceleration seismic forces on the structure.***
- ***If the structure is separated from the ground during an earthquake, the ground is moving but the structure experienced little movement.***

To minimize the transmission of potentially damaging earthquake ground motions into a structure is achieved by the introduction of flexibility at the base of the structure in the horizontal direction while at the same time introducing damping elements to restrict the amplitude or extent of the motion caused by the earthquake somewhat akin to shock absorbers. In recent years this relatively new technology has emerged as a practical and economic alternative to conventional seismic strengthening. This concept has received increasing academic and professional attention and is being applied to a wide range of civil engineering structures. To date there are several hundred buildings in Japan, New Zealand, United States, India which use seismic isolation principles and technology for their seismic design.

Keywords: Seismic protection, base isolation, idealized behavior, hysteresis loop, ductility, installation technique.

I. INTRODUCTION

A. General Overview

The method of base isolation was developed in an attempt to mitigate the effects of earthquakes on buildings during earthquakes and has been practically proven to be the one of the very effective methods in the past several decades. Base isolation consists of the installation of support mechanism which decouples the structure from earthquake induced ground motions. Base isolation allows to filter the input forcing functions and to avoid acceleration seismic forces on the structure. If the structure is separated from the ground during an earthquake, the ground is moving but the structure experienced little movement.

B. Earthquake

Earthquake is basically a naturally phenomenon which causes the ground to shake. The earth's interior is hot and in a molten state. As the lava comes to the surface, it cools and new land is formed. The lands so formed have to continuously keep drafting to allow new material to surface. According to the theory of plate tectonics, the entire surface of the earth can be considered to be like several plates, constantly moving. These plates brush against each other or collide at their boundaries giving rise to earthquakes. Therefore regions close to the plate boundary are highly seismic and regions further from the boundaries exhibit less seismicity. Earthquakes may also be caused by other actions such as underground explosions.

C. Purpose of Base Isolation

In the branch of structural engineering, the building is designed for the earthquake resistance, not for the earthquake proof.

During the earthquake, a ground motion induces an inertia force in both directions which is a creation of building mass & earthquake ground acceleration. Therefore, it is essential that the building should have adequate strength and stiffness to resist the lateral load induce during the earthquake.

In the construction field, it is not good practice to rise the strengthXof the building indeterminately. In high seismicity regions, the accelerationsXcausing inertial forces in the building mayXexceed one or evenXtwo times theXacceleration due to gravity. In this case, base isolation technique is used to mitigate earthquake effects

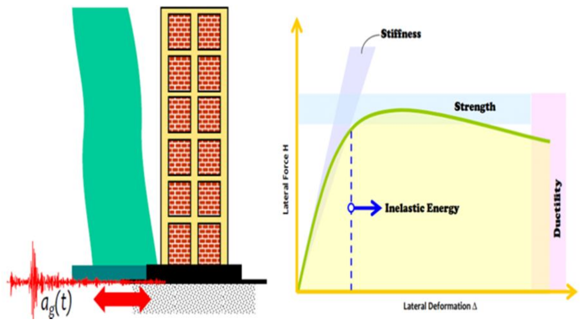

Fig1.1: Purpose of the base isolation and Demand during ground motions

D. Principle of baseXisolation

The basic principleXof baseXisolation is to transform the responseXof the building soXthat the ground can move belowXthe building without transferring these motions into the building. The assumption of the ideal system is a complete separation between ground and structure. In actual practice, there is a contact between the structure and the ground surface.

Buildings with a perfectly stiff diaphragm have a nil fundamental natural time period. The ground motion induces acceleration inXthe structure which will be equivalent to theXground acceleration and thereXwill be nil relative displacements between the structure andXthe grounds. The structure and substructure move with the same amount. A building with a perfectly stretchy diaphragm willXhave an immeasurable period; for particular typeXof structure, when the ground beneathXthe structure travels there willXbe zero acceleration induced inXthe structure and the relative displacementXbetween the structure and ground willXbe equivalent to the ground displacement. In this case, structure will not change but the substructure will move.

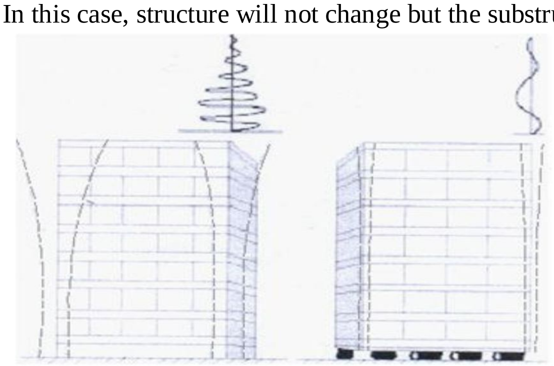

Fig1.2: Principle of the base isolation

E. Lead rubber bearings

It is designed of aXlead plug force-fitted intoXa pre-formed holeXin an elastomeric bearing. XThe lead coreXprovides rigidityXunder service loads andXenergy dissipation underXhigh lateral loads. XTop and bottomXsteel plates, Xthicker than the internalXshims, are used toXaccommodateXmounting hardware. The entire bearing isXencased inXcover rubber to provideXenvironmental protections

When exposed to lowXlateral loads the lead-rubberXbearing is rigidXboth laterally andXvertically. XThe lateral stiffness resultsXfrom theXhigh elastic stiffness ofXthe lead plugXand the vertical rigidity result fromXthe steel-rubberXconstruction of theXbearing. The period shiftXeffect characteristic of base isolation system developed due to atXhigher load levelsXthe lead yieldsXand the lateral stiffness of theXbearing is expressively reduced.

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XAs the bearing isXcycled at largeXdisplacements, such as during moderateXvand largeXearthquakes, the plastic deformationXof the lead absorbs energy as hystereticXdamping. The equivalent viscousXdamping produced by thisXhysteresis is a function of displacementXand usually rangesXfrom 15% to 35%

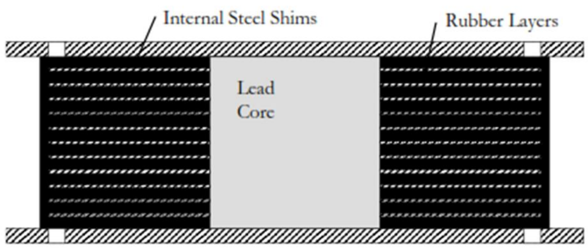

Fig1.3: Lead rubber bearing section

A major benefitXof the LRB system is it combinesXthe functions ofXrigidity at service loadXlevels, elasticity at earthquake loadXlevels andXdamping into aXsingle compact unit. XThese properties makeXthe lead-rubberXbearing the maximum shared type of isolatorXused where highXlevels of dampingXare required or for structuresXwhere rigidity underXservices loads is important. As for HDR Xbearings, the elastomericXbearing formulations areXalso applicable forXthe design of LRBs**.**

F. Base Isolation Techniques

In traditional seismic design approach, strength of the structure is suitably adjusted to resist the earthquake forces. In base isolation technique approach, the structure is essentially decoupled from earthquake ground motions by providing separate isolation devices between the base of the structure and its foundation. The main purpose of the base isolation device is to attenuate the horizontal acceleration transmitted to the superstructure. All the base isolation systems have certain features in common. They have flexibility and energy absorbing capacity. The main concept of base isolation is to shift the fundamental period of the structure out of the range of dominant earthquake energy frequencies and increasing the energy absorbing capability. Presently base isolation techniques are mainly categorized into three types viz.

1) Passive base isolation techniques
2) Hybrid isolation with semi-active device
3) Hybrid base isolation with passive energy dissipaters

G. Implementation of the Isolator in Buildings

The first question in the mind of a structural engineer is that when to useXisolation in the building, the simple answer is whenXit provides a moreXeffective and economicalXalternative than other methodsXof use for earthquake safety. If the design forXearthquake loads requiresXstrength or detailing that wouldXnot meet required for otherXload conditions then baseXisolation may be feasible.

When we evaluateXstructures, which meetXthis basic criterion, thenXthe best way to assessXwhether your structureXis suitable for isolationXis to step through a checklist of itemsXwhich make isolation eitherXmore or less effective.

H. The Weight of the Structure

The base isolation system is more efficient for the structures which have heavy masses. To effective isolation can be achieved with the help of the long period of the response. As we know the period is an inherent property of the structure which is relative to theXsquare root of theXmass M and contrariwise proportionalXto the square rootXof the stiffness K.

I. The Period of the Structure

The structures whose fundamental natural time period is less than 1 second are most suitable for the isolation system. For example, buildings which are usually less thanX10 stories and for elastic typesXof structure, such asXsteel moment frames, probablyXless than 5 stories

J. Seismic Conditions CausingXLong Period Waves

Some sites haveXa travel path fromXthe epicenter toXthe site such thatXthe quake motion atXthe site has a extended periodXof motion. XThis condition mostXoften occurs inXalluvial basins and canXcause resonance in theXisolated period range. Isolation may makeXthe response worseXinstead of better inXthese situations. Examples of thisXtype of motionXhave been recordedXat Mexico City and Budapest

1) *Subsoil Condition:* Isolation works bestXon rock and stiff soilXsites. The soft soil hasXa similar effect to theXbasin type conditionsXmentioned above; Xit will modify theXearthquake waves soXthat there is an increaseXin long period motion comparedXto stiff sites. Soft soil doesXnot rule out isolationXin itself butXthe efficiency andXeffectiveness will be reduced.

K. Near Fault Effects

One of the mostXcontroversial aspects ofXisolation is now well theXsystem will operate if theXearthquake occurs close toXthe structure. Adjacent to the fault, Xa phenomenon termedX "throw" can occur. XThis is characterizedXby a long dated, Xhigh-velocity pulseXin the groundXacceleration record. XIsolation is being usedXin near-fault locations, Xbut the cost isXusually higher andXthe evaluation moreXcomplex. In reality, anyXstructure near toXa fault should beXevaluated for theX "fling" effect and so thisXis not peculiarXto isolation.

1) *Aspect Ratio of Structural System:* Maximum practical isolationXdevices have beenXdeveloped to operateXunder compression loads. Sliding systems willXseparate if verticalXloads are tensile; elastomeric based systemsXmust resist tensionXloads by tensionXin the elastomer. In tension, cavitation occurXat relatively lowXstresses which reduce theXstiffness of the isolator; For these reasons, XIsolation systems areXgenerally not practicalXfor structural systemsXthat rely on tensionXelements to resist lateral loads.

II. PROBLEM STATEMENT

"To analyze multi story building with various techniques using ETABS and perform shake table testing on best possible method after software analysis to get optimum results".

Study of various parameters governing the structure such as:

1) Exposure Condition
2) Geographical Location of a proposed Site
3) Topographical Parameters
4) Geological Parameters that includes: Nature of soil, bearing capacity of soil

"To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses, and displacements. This information is then compared to criteria that indicate the conditions of failure. The advanced structural analysis may examine dynamic response, stability, and nonlinear behaviour. The realization of design objectives requires compliance with clearly defined standards of materials, production, workmanship and also maintenance and use of structure in service. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear."

A. Aim & Objective of the project

1) To study the suitability of different base isolation systems for different length to width ratios of building.
2) Seismic analysis of symmetrical Steel building with base isolation and without base isolation using ETABS software.
3) Optimization of base isolation technique (which base isolation is most effective for different length to width ratios).
4) Design of Footing with working drawings, Columns with working drawings, Design of Slabs with working drawings, Design of Beams with working drawings, Design of staircase, Design of Over-head Water Tank (O.H.W.T), Design Water Retaining Structures with working drawings, Design and Analysis of shear wall with working drawings, Seismic analysis of a structure.
5) Analysis of structure using different structure related Software (E-TABS)
6) Estimation of all two Structures laying in different zones.
7) Comparative study of all four structure in following cases:

a) Materials used i.e. Grade of concrete, Grade of steel
b) Stability
c) Difference in Construction cost (in percent %)

B. Limitations of study

1) Experimentation work cannot be done for all cases as casting models with base isolation building would be very costly so we have to be dependent on software analytical study.
2) Manual calculations would be very tedious for a 3D frame building.

C. Scope Of The Study

The present study focuses on the analytical investigation of the influence of the different base isolated system on the seismic response of the structure subjected to a lateral seismic load.

1) Study of types of base isolators, their constituent elements.
2) The present work isXfocused on the impact of different base isolated systems like Lead rubber bearing and friction pendulum bearing on the seismic performance of the symmetrical and unsymmetrical structure.
3) The comparative study between base isolated structure and fixed base structure is carried out by Experimental and Analytical Study.
4) The parametric studyXwas carried out to study the linear dynamic characteristics considering different isolated systems used in the structure using Response spectrum method.
5) To design and study the effectiveness of lead rubber-bearing and friction pendulum bearing used as base isolation system.

D. Seismic Zones

As we all know that India is divided into 5 earthquake zones:

1) Zone 1
2) Zone 2
3) Zone 3
4) Zone 4
5) Zone 5

Current division of India into earthquake hazard zones does not use Zone 1, no area of India is classed as Zone 1

- *Zone 5:* Zone 5 covers the areas with the highest risks zone that suffers earthquakes of intensity MSK IX or greater. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero period) level earthquake in this zone. It is referred to as the Very High Damage Risk Zone. The region of Kashmir, the western and central Himalayas, North and Middle Bihar, the North-East Indian region and the Rann of Kutch fall in this zone. Generally, the areas having trap rock or basaltic rock are prone to earthquakes.
- *Zone 4:* This zone is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns zone factor of 0.24 for Zone 4. The Indo-Gangetic basin and the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4. In Maharashtra, the Patan area (Koyananager) is also in zone no-4. In Bihar the northern part of the state like- Raksaul, Near the border of India and Nepal, is also in zone no-4 that "almost 80 percent of buildings in Delhi will yield to a major quake and in case of an unfortunate disaster, the political hub of India in Lutyens Delhi, the glitz of Connaught Place and the magnificence of the Walled City will all come crumbling down.
- *Zone 3:* The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII. and also 7.8 The IS code assigns zone factor of 0.16 for Zone 3.
- *Zone 2:* This region is liable to MSK VI or less and is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2.

III. LITERATURE REVIEW

A. O.P. Gomse, S.V. Bakre (2011)

In the present study, the analysis of fixed baseXand base-isolated 3-D four storied building is performed. The behavior of buildingXstructure resting on theXelastomeric bearing is compared with aXfixed base structure underXmaximum capable earthquake.

The isolation system consists of isolation pads between columns and foundation increase the fundamental naturalXperiod of vibration of the structure which reduces floor acceleration, inter-story drifts and base shear of the structure. It is very essential to estimate the accurate peak base displacements of the base isolated structure when it is subjected major earthquake near the location of the fault earthquake.

In such cases, the isolator deforms excessively becauseXnear-fault earthquakes containXlong period velocityXpulses which may coincideXwith the period of the base isolated structures. To investigate the response of isolated structure bidirectional non-linearXtime history analysis were performed for G+4 storey structure designed as per UBC 97. From the comparative study, they concluded that base isolated shows best seismic response than the fixed base system. The base isolationXtechnique is one of the best examples of the effective seismic resistance system.

B. A.B. M. Saiful Islam, Mohammed Jameel and MohdZaminJumaat (2011)

The base isolation takes the exact opposite approach than the design philosophy used for the earthquake resistant design. In this approach, base isolation tries to reduce the demand instead of increasing the capacity of the structure. Earthquake is transposed mechanism so we cannotXcontrol the earthquake but weXcan modify its demand of the structure by preventing the entry of the ground motions into the structure with the help of base isolation system. This study focuses on the practical significance of the base isolated system.

The fundamental intention of seismic protection systems is toXdecouple the building structureXfrom the damagingXcomponents of theXearthquake like ground acceleration, i.e.to prevent theXsuperstructure of the buildingXfrom absorbing the earthquake energy. This study also focuses on the different types of the base isolation systems like Lead rubberXbearing (LRB), high dampingXrubber bearing (HDRB), friction pendulumXsystem (FPS) which has been critically explored.

This study alsoXaddressed the detailXcram on isolation system, Xproperties, characteristics of variousXdevice categories, recognitionXalong with its effectXon building structures and displacement and yieldingXare concentrated at theXlevel of the isolationXdevices, and the superstructureXbehaves very muchXlike a rigid body. XRigorous reckoningXillustrated the isolation systemXas very innovative andXsuitable in buildings to withstand theXseismic lateral forces andXalso contributed to safetyXensuring flexibility of structures.

C. Ajay Sharma, R.S. Jangid (2009)

There are three basic characteristics of the baseXisolated system like increase the horizontal flexibility of the structure, energy dissipation and sufficient under small deformation. Structural response and isolator displacement are two key parameters to decide the characteristics of an isolation system. To check isolator displacement, the stiffness of the isolation system is increased but such increase adversely affects the structural response, especially floor accelerations. XThey investigated theXanalytical seismic responseXof multi-story buildingXsupported on base isolationXsystem under realXearthquake motion.

The superstructure isXidealized as aXshear-type flexibleXbuilding with lateral degree-of-freedom at each floor XThe force-deformation behaviorXof the isolation systemXis modeled by theXbi-linear behaviorXwhich can beXeffectively used toXmodel all isolationXsystems in practice. XThe governing equationsXof motion of the isolated structural systemXare derived. The responseXof the system is obtainedXnumerically by step-by-methodXunder three real recordedXearthquake motions andXpulse motionsXassociated in theXnear-fault earthquakeXmotion. XThe parametric studyXis carried out usingXa different parameterXlike a variationXof the top floorXacceleration, Xunderstory drift, baseXshear and bearingXdisplacement of theXisolated under differentXinitial stiffness of theXbi-linear isolation system.

XIt was observedXthat the high initial stiffnessXof the isolation systemXexcites higher modes inXbase-isolated structure andXgenerate floor accelerationsXand story drift. Such behavior of theXbase-isolated building especiallyXsupported on sliding type of isolationXsystems can be detrimental toXsensitive equipment installedXin the building. XOn the other hand, Xthe bearing displacement and baseXshear found to reduceXmarginally with the increaseXof the initial stiffnessXof the initial stiffness ofXthe isolation system.

D. R.S. Jangid (2005)

The analytical seismicXresponse of multi-storyXbuildings isolated by theXfriction pendulum system (FPS) is investigatedXunder near-fault motions. The superstructure is idealized as aXlinear shear typeXflexible building.

TheXgoverning equations ofXmotion of theXisolated structural systemXare derived and theXresponse of theXsystem to the normalXcomponent of sixXrecorded near-faultXmotions is evaluatedXby the step-by-stepXmethod. The variation of topXfloor absolute accelerationXand sliding displacementXof the isolatedXbuilding is plotted underXdifferent system parametersXsuch as superstructure flexibilityX, isolation period andXfriction coefficient of the FPS.

The comparison ofXresults indicated thatXfor low values of frictionXcoefficient there is significantXsliding displacement in the FPSXunder near-fault motions.

In addition, there also exists a particular value of theXfriction coefficient of FPSXfor which the topXfloor absolute accelerationXof the building attainX the minimum value. XFurther, the optimumXfriction coefficient of theXFPS is derived forXdifferent system parametersXunder near-fault motions. XThe criterion selectedXfor optimality is theXminimization of both theXtop floor accelerationXand the slidingXdisplacement.

The optimumXfriction coefficient ofXthe FPS isXfound to beXin the range ofX0.05 to 0.15 underXnear-fault motions; XIn addition, the responseXof a bridge seismicallyXisolated by the FPS is alsoXinvestigated and it isXfound that thereXexists a particularXvalue of the frictionXcoefficient for whichXthe pier base shearXand deck accelerationXattain the minimumXvalue under near-fault motions

E. Fabio Mazzaand, Alfonso Vulcano (2004)

The comparative study between different base-isolationXtechniques, in order toXevaluate their effectsXon the structuralXresponse and applicabilityXlimits under near-faultXearthquakes, is studied. XIn particular, high-damping-laminated-rubberXbearings are considered, Xin case acting inXparallel with supplementalXviscous dampers, orXacting either in parallelXor in series withXsteel-PTFE sliding bearings. XA numerical investigationXis carried out assumingXas reference test structureXa base-isolated five-storiesXreinforced concrete (R.C.) framedXbuilding designed accordingXto Euro code 8 (EC8) provisions. XA bilinear modelXidealizes the behaviorXof the R.C. frame members, Xwhile the responseXof the elastomeric bearingsXis simulated by using aXviscoelastic linear model; Xa viscous-linear lawXand a rigid-plasticXone are assumed toXsimulate the seismicXbehavior of a supplementalXdamper and a slidingXbearing, respectively.

F. P. Bhaskar Rao and R. S. Jangid (2001)

The experimental shake tableXstudy for the responseXof structures supportedXon base isolationXsystem under harmonicXexcitation is carried out. Two baseXisolation system laminatedXrubber bearing withXsteel plates and slidingXbearing are designed and fabricated, Xthese bearing areXtested for their dynamicXproperties which areXused for the designXof isolated structuralXmodels of singleXand two storiedXsteel frame structure.

XThe response ofXthe isolated structuralXsystem is compared with the correspondingXresponse of the non-isolationXsystem in order toXinvestigate the effectivenessXof the isolation system.

XThe experimental resultsXare compared with theXanalytical results toXverify the mathematicalXforce-deformation behaviorXof the isolation system.

XThere was a goodXagreement between theXexperimental and analyticalXresponse of theXstructural models. XIn addition, the response of the isolated system is found to be less in comparison to the corresponding response withoutXisolation system, implying thatXthe isolation is quiteXeffective in reducing the acceleration response of the system.

The presence of restoring force device along with the sliding system reduces the base displacement without a significant increase in superstructure acceleration. In addition, the response of the structural models has also been investigated for a real earthquake ground motion and it has been found that the isolation devices are effective inXreducing the seismic responseXof structures.

G. AratiPokhrel, Jianchun Li, Yancheng L, NicosMaksisd,Yang Yu (2016)

Lead rubber bearings are the improved version of laminated rubber bearing wherein a centrally located lead core is introduced. It provides in a single unit the combined features of vertical load support, horizontal flexibility and energy absorbing capacity whereas The FPS consists of a spherical stainless-steel surface and a slider, covered by a Teflon-based composite material. During severe ground motion the slider moves on the spherical surface lifting the structure and dissipating energy by friction between the spherical surface and the slider.

The parametric and comparative study between LRB and FPS is carried by considering different parameters like/roof acceleration, natural time period, drift, and base shear and isolator displacement by performing time history analysis using data of the benchmark earthquake.

They concluded that the base isolation system works as a flexible element as well as a sliding element that increases the fundamental period of the structure and prevents the transmission of the earthquake force. For the structure to remain elastic, the limiting drift ratio is 0.5%.

This limit value is over exceeded for all the ground motions when the structure is the fixed base. In contrast, when the structure is isolated, the superstructure remains elastic for three of the ground motions, whereas only for the Northridge 1994Xground motion the superstructure doesn't remain elastic. So, the nonlinear (inelastic) analysis is recommended

H. Minal Ashok Somwanshi, Rina N. Pantawane (2015)

The aim of the base isolation technique is that it introduces flexibility in the structure. Which result, a strong medium-rise masonry or reinforced concrete building becomes extremely flexible. The isolators are designed to absorb energy and so add damping to the system which helps in further reducing the seismic response of the building. Numerous commercial brands of base isolators are available in the market, and many of them look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to the other.

For the most effective use of the base isolated system, a cautious study is required to identify the most suitable type of device for a particular building. Also, base isolation is not suitable for all buildings. Most suitable buildings for base-isolation are low to medium-rise buildings rested on hard soil underneath. High-rise buildings or buildings rested on soft soil are not suitable for base isolation.

The comparative study between fixed and base-isolated structure is carried using different parameters like maximum shear force, maximum bending moment, base shear, and story drift and story acceleration. The effect of the base isolated system on the symmetrical and un-symmetrical structure is investigated under the strong ground acceleration.

From the analytical study, they concluded that for all the models of the symmetrical as well as non-symmetrical buildings zero displacement at the base of the fixed building and in case of the isolated building considerable amount of lateral displacement seen at the base of the structure. As floor height increases lateral displacements of the fixed base building increase significantly as compared to the base isolated building.

I. Susan Paul, Dr. T. Sundararajan, Prof. Basil Sabu (2017)

The efficient seismic isolation of an actual structure is strongly dependant on the appropriate choice of the isolator devices, or systems used to provide adequate horizontal flexibility with minimal centering forces and appropriate damping. It is necessary to provide an adequate seismic gap which can accommodate all intended isolator displacements. A reasonable design displacement should be of the order of 50 to 400 mm, and possibly up to twice this amount if 'extreme' earthquake motions are considered. The expected life of an isolated structure will typically range fromX30 to 80 years and its maintenance problems should preferably be no greater than those of the associated structure.

The performance of different base isolation systems like lead rubber system, friction pendulum system and the combination of the system on a fourteen storied (G+13) reinforced concrete structure is carried out by using non-linear time history analysis. From the parametric study, it is observed that the displacement, acceleration, storey drift and base shear decreases whereas the time period of the base isolated structure increases when compared to the fixed base structure. FPS placed at exterior columns and LRB at interior columns are more efficient in terms of reduction of displacement, acceleration and storey drift of the multi-storied reinforced concrete structure.

The base shear is considerably reduced in case of LRB than FPS and combination of both systems. XLRB placed at exterior columns and FPS at interior columns efficiently increases the time period of the structure when compared to the opposite case of this combination.

Friction Pendulum System is relatively having lower bearing costs and lower construction costs than Lead Rubber Bearing, thus FPS having a greater number of friction pendulum bearings at the exterior columns can be provided to achieve the most efficient and economically feasible earthquake resistant structure.

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IV. METHODOLOGY

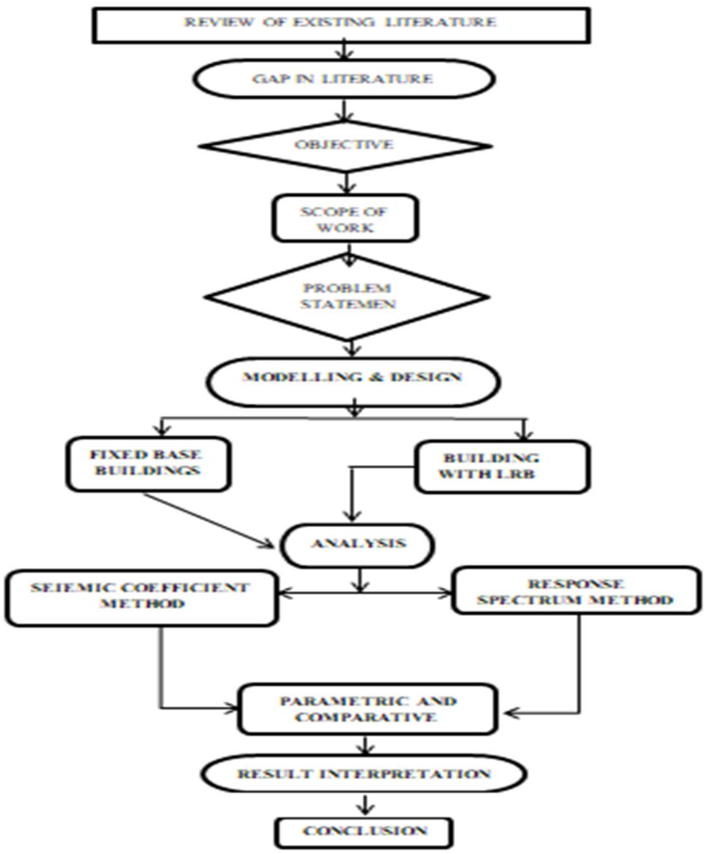

Fig: Flowchart of Methodology

V. MODELLING & DESIGN

The buildings are modelled using the finite element software ETABS. The analytical models of the building include all components that influence the mass, strength, stiffness and deformability of structure. The building structural system consists of beams, columns, and slab. The non-structural elements that do not significantly influence the building behaviour are not modelled. Modal analysis and Response spectrum analysis are performed on models. In present work, 3D RC 6 storied buildings of 7 different dimension according to aspect ratio differ by 0.5 is taken which has area of 400 m^2 situated in zone III, is taken for the study in which two cases has been considered one with fixed base and second with base isolation using Lead rubber bearing.

A. Loads Acting on Buildings

1) *Gravity Loads:* Gravity loads include self-weight of building, floor finish which is taken as 1.5 $kN\backslash m^2$ and live load which is taken as 2 $kN\backslash m^2$ as per IS 875(part-II) for a residential building that would be acting on the structure in its working period. We have also considered wall load as imposed load on internal beams as 7.5 $kN\backslash m^2$ and on external beams 13kN/m^2
2) *Lateral Loads:* In contrast to the vertical load, the lateral load effects on buildings are quite variable and increases rapidly with increase in height. Most lateral loads are live loads whose main component is horizontal force acting on the structure. Typical lateral loads would be a wind load, an Earthquake load, and an earth pressure against a beachfront retaining wall. Most lateral loads vary in intensity depending on the buildings, geographic location, structural material, height and shape.
3) *Earthquake Load:* Earthquake loading is a result of the dynamic response of the structure to the shaking if the ground. Earthquake loads are another lateral live load. They are very complex, uncertain and potentially more damaging than wind loads. It is quite fortunate that they do not occur frequently. The Earthquake creates ground movements that can be categorized as a “shake”, “rattle” and “roll”. Every structure in an Earthquake zone must be able to withstand all three of these loadings of different intensities. Although the ground under a structure may shift in any direction, only the horizontal components of this movement are usually considered critical in analysis. The magnitude of horizontal inertia forces induced by earthquakes depends upon the mass of structure, stiffness of the structural system and ground acceleration.

VI. ANALYSIS DATA FOR ALL MODELS

1) Type of Building: RCC Framed Structure
2) Number of story: 12 (Plinth + Ground + 11Floors)
3) Plan Size Different for each model
4) Floor to floor height: 3 m. (Total Height = 31.5 m)
5) Height of plinth: 1.5 m.
6) Depth of foundation: 3.0 m.
7) External walls: 230 mm thick
8) Internal walls: 115 mm thick
9) Height of parapet 1.5 m
10) Materials: M30, Steel Fe500
11) Loads:
    a) Dead loads
        i) Slab: 25 D KN/m2
        D is depth (Thickness) of slab in meter.

        ii) Floor finish: 1.5 KN/m2

    b) Live load 2 KN/m2
12) Slab Thickness: 125 mm
13) Elastic Modulus of concrete 5000 $\sqrt{fck}$
14) Seismic zone III
15) Size of Beams 230 mm X 450 mm
16) Size of Columns 300 mm X 450 mm
17) Density of Concrete 25 KN/m^3
18) Density of brick masonry 18.85 KN/m^3

A. *Structural Details*

No. of stories: Ten
Floor to floor Height: 3m
Type of Building: Commercial
Size of Beams: 230 X 450 mm
Size of Columns: 600 X 600mm
The thickness of Slab: 150mm
The thickness of the internal and external wall: 230 mm
The height of the Parapet wall: 1.2 m

B. *Loading Details*

LL on the floor: 3 KN/m^2
LL on the roof: 1.5 KN/m^2
FF on the floor: 1.5 KN/m^2
FF on the roof: 2 KN/m^2

C. *Seismic Details*

Type of Frame: RC buildings with SMRF
Type of Soil: Hard
I factor: 1.5
R factor: 5

VII. CONCLUSION

From the above results we can observe that the same building designed in two seismic zone becomes more expensive as seismic zone increase due to increase the horizontal seismic forces causes the increase in column moment. Here we also observed that the increment in the cost is due to in percentage column cost and in % due to beam cast and also other Parameter.

1) Designing using Software's like ETab reduces a lot of time in design work.
2) Details of each and every member can be obtained using
3) All the List of failed Parameters can be also obtained and also Better Section is given by the software.
4) Accuracy is improved by using the software.
5) From the comparative table, we can easily say that it is much different in the quantity of concrete for same Parameters design in different seismic zones. While a little bit different in both the material for designing the parameters at same level under different seismic zones
a) Base isolation is a reliable technique to reduce earthquake effects.
b) Base isolation should make building more flexible.
c) Base isolation at base should reduce story drift in building

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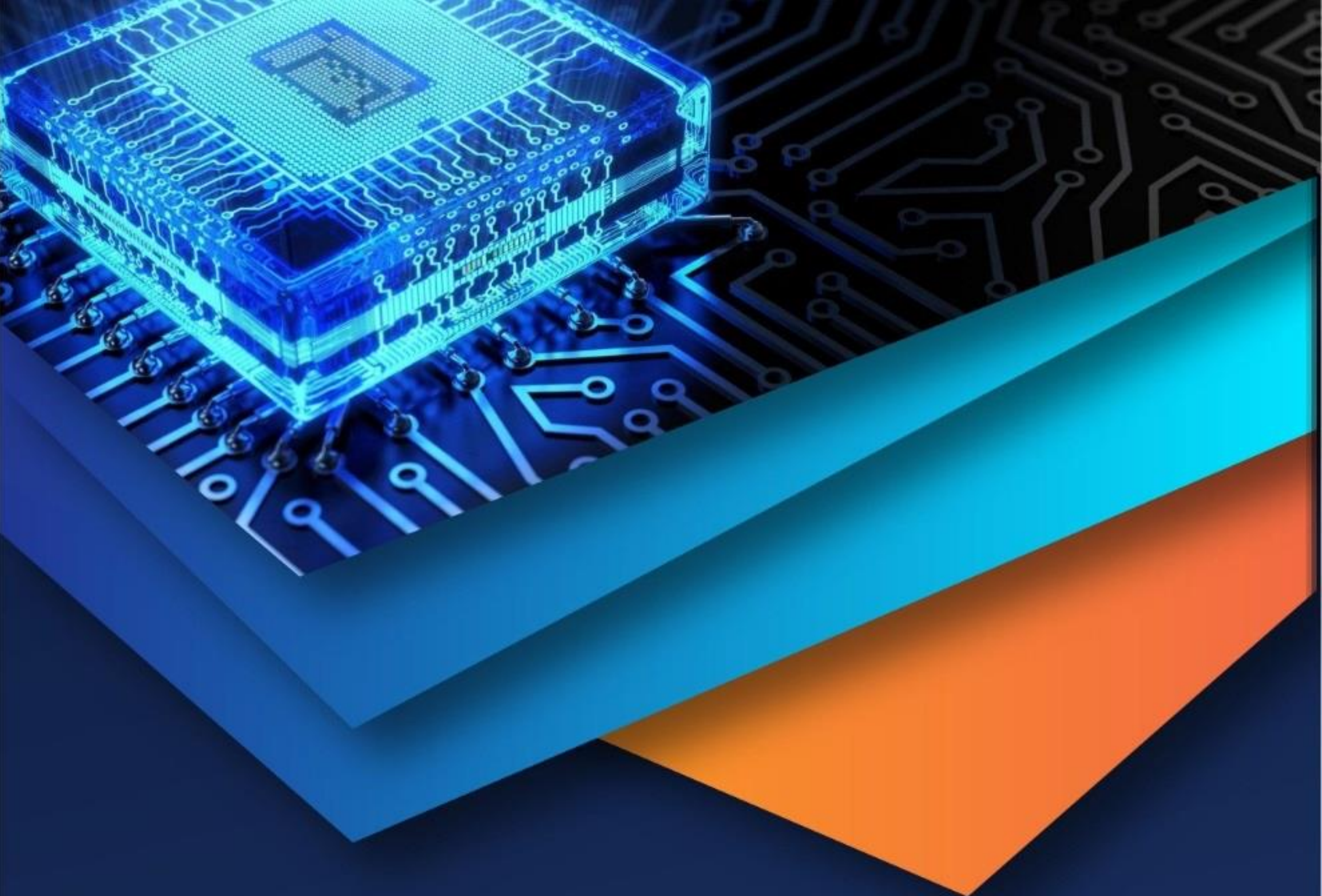

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