3.1 Preamble

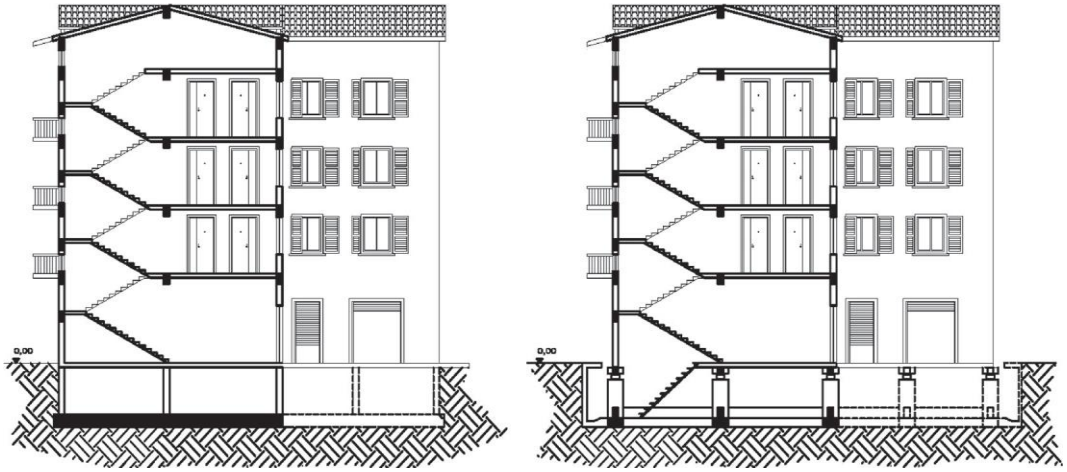
Chapter 3 contains the review of literature in the field of numerous kinds of base isolation system. The literature survey leading to the identification of research gaps and theresearch objectives along with the thesis hypothesis in brief are described in this chapter.

3.2 Literature Survey

Numerous studies have been conducted on various base isolation system types in order to understand their effects and to determine the best configuration and performance-improving methods. The necessary literature searches were conducted through national and international journals, periodicals, books, conferences, and online sources of recent data.

Regarding a multi-story reinforced concrete structure, Donato Cancellara and Fabio De Angelis [2016] studied the seismic behavior with two different base isolater. The base isolation systems were created in accordance with the EC2 and EC8 seismic codes in Europe. A fundamentally isolated structure is chosen, one that exhibits pronounced plan irregularity. The building chosen has a considerable irregularity in the layout and is a basic standalone structure. The structure's performance exposed to seismic occurrences is evaluated by a comparative analysis. The HDRB and LRB, both of which are simultaneously activated with FS, have been taken into consideration in the analysis (FS). The three-dimensional base isolated structure is subjected to an analysis that is dynamically nonlinear. For the assessment of the structure's seismic response, recorded accelerograms for ground motions in both directions that are consistent with the reference elastic response spectrum were employed. The dissipative capacity of LRB isolators is better than that of HDRB isolators, spanning from 15% to 30% more. The analysis's findings demonstrate the need to limit LRB's higher dissipative capacities because they could result in larger inter-storey drift values because other vibration modes contributed more than the initial one. Despite being predominantly maintained in the elastic zone in the layout, the overstructure, this must be taken into account when analysing the framework. It is recommended to take these factors into account while designing a system so that, by effectively avoiding the downsides, only the advantages

of the LRB's enhanced dissipative qualities are utilized. LRB isolators have very little dependence on the strain history. The LRB isolators' hysteretic cycles are significantly more robust and stable, which is a considerable advantage. When FS are used in parallel with FS isolators, which have low friction coefficient values, it has been possible to assess how much more the isolation system will dissipate. In order to achieve the goal of base isolating the structure effectively when quake, Friction Sliders (FS) positioned in the right location in the design correspond with elastomeric isolators looks to be a workable alternative in multi-story RC buildings. In comparison to other alternative solutions, this one is also distinguished by lower economically price (Cancellara & Angelis, 2016).



Fixed Base (FB) Isolated Base (IB)

Figure-7. Fixed & Isolated Base Structure Model.

The irregular seismic reactions of typical moment frame buildings upgraded with a number of passive protection devices are discussed in Ahmet Hilmi Dering and Esra Mete Guneyisi's [2020] study. For this purpose, base isolators such as LRB, FPB, and HDRB were taken into consideration. Friction damper (FD) was used as a mechanism for dissipating energy. Comparative research was done on the efficiency of the dampers and isolation systems. One of the study's key conclusions that a single control strategy couldn't always reach a level of performance equivalent to that of a fully functional system, but the base isolation and friction damper systems worked together to successfully achieve this goal within the case study framework. Due to the enormous horizontal stiffness of the friction device, the use of FD successfully reduced the

displacement demand, while base isolation methods, particularly elastomeric bearings, significantly increased horizontal displacement. For instance, FD resulted in a 65.6% reduction in average displacement. The largest average displacement increments, however, were produced by LRB and HDRB, at 67 and 74.5%, respectively. The biggest average base shear reductions were achieved by LRB and FD + LRB, both of which achieved reductions of nearly 84%, significantly higher than the 43.9% achieved by FD when used alone. LRB and HDRB may offer a more effective means of reducing structural vibration than FD and FPB. Extra lead core dissipation capacity and FD braking effect allowed for a clear observation of the dominance of FD + LRB on the nonlinear response (Deringol & Gunyesi, 2020).

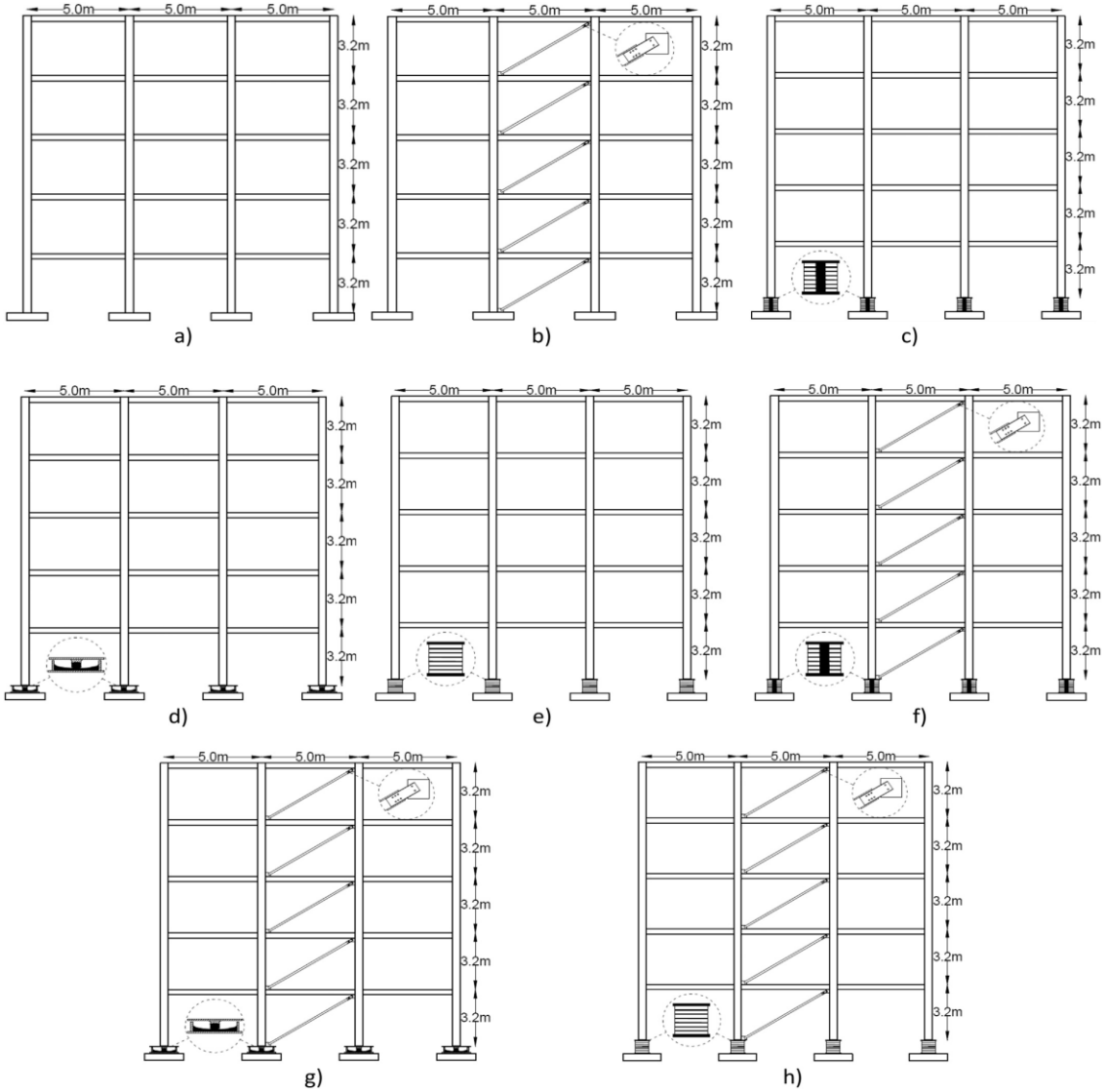


Figure-8. Elevation Views and Bare-Frame Case Study (Deringol & Gunyesi, 2020).

SAP 2000 software was used to analyse Nitya M and Arathi S's [2016] plus-shaped G+6 storey with friction isolation and rubber isolation. With and without base isolation conditions, nonlinear seismic Time History data are used for the analysis. On the earthquakes in EL Centro, 1940, It has been done to analyze time history. Therefore, the effectiveness of RC buildings in dynamic conditions is examined in this work with base isolation, and the results are compared with those of buildings without base isolation. Base isolation, it has been found, lengthens the building's lifespan and correspondingly reduces base shear. The base isolation significantly lengthens the building's lifespan and, as a result, minimizes the base shear. Up to 75% less base shear than a fixed one exists. The lengthening of the time for structures with isolated bases ensures that the structure is entirely excluded from the earthquake's resonance range. Analysis reveals that for the isolated structure, the basic period is about doubled. The maximum acceleration and, consequently, the earthquake-induced stresses on the structure are reduced as the fundamental cycle increases. It is evident from the graph & tables that the storey displacements are significantly longer for isolated buildings and that they are nearly identical for all storeys. In comparison to a friction isolator, the rubber isolator has a larger displacement (Nitya & Arathi , 2016).

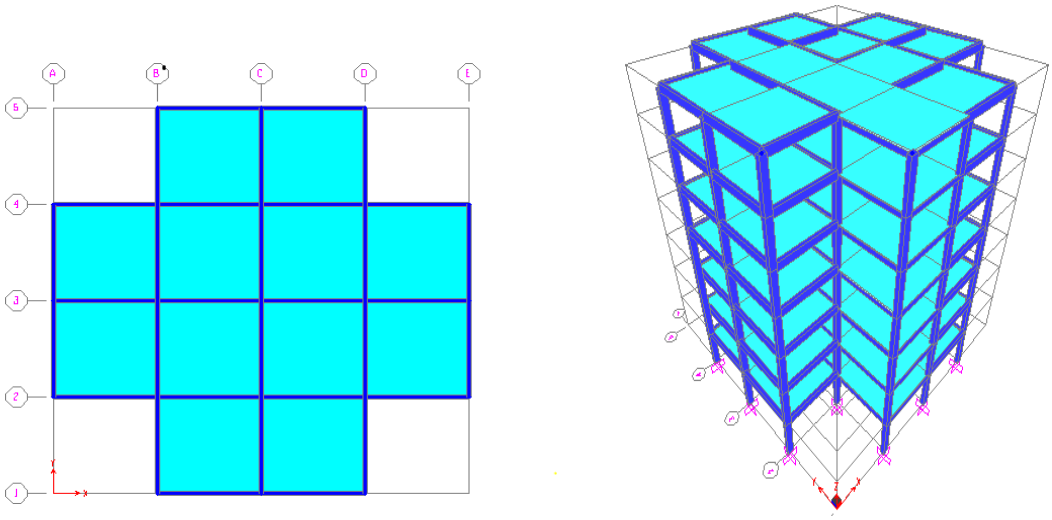


Figure-9. Plan & Elevation G+6 Storey Model

Tessy Thomas and Dr. Alice Mathai [2016] conducted research utilising the ANSYS 14.5 software's finite element base isolator model. Analysis was also done on the friction pendulum's behaviour as a base isolator. For various storey load levels, the base

isolator's nonlinear static analysis is conducted. Conclusion: Stress intensity value increases along with the load value of number of storey. The stress intensity value up to 30 stories is within acceptable bounds, hence a base isolator can be constructed for a building with 22 to 30 stories. This investigation clearly shows that the slider's movement generates an introduce uncertainty force that functions as the necessary damping to absorb the energy of the earthquake (Thomas & Mathai , 2016).

Using SAP 2000 software, M. Vijayakumar, Mr. S. Manivel, and Mr. A. Arokiaprakash [2016] assess a G+25 storey building square in plan. Buildings using the base isolation technique perform substantially better than those with fixed bases. Analysis has been done on the parameters, including displacement and drift. Therefore, it can be shown that base isolation has a bigger displacement than fixed base. The building's story drift is the key regulating factor. The study demonstrates that base isolation significantly reduces drift. Despite the fact that base isolation is more expensive to instal, its effectiveness shows that it is necessary in hospitals, public spaces, and important structures. It was discovered that the usage of base isolation in seismically active areas improved the performance of various bracing systems (Vijaykumar, Manivel, & Arokiaprakash, 2016).

Mital Desai and Prof. Roshni John [2015] Utilizing the Response Spectrum Method, an eight-story skyscraper has been examined. Software called STAAD Pro has been used for dynamic analysis. Variables that are compared between isolated and non-isolated buildings. Comparing the base isolated building to the fixed base building, frequency has decreased. In seismic analysis, fundamental mode is much more effective. In fundamental mode, frequency is lowest in the LRB structure compared to HDRB and LDRB. When isolators are present, acceleration is decreased. In comparison to the other two types of isolators, LRB construction provides the least acceleration. When a base is isolated, the base shear is significantly reduced. When a structure is LRB isolated as opposed to a fixed base framework, the base shear is reduced by 47%. When the structure is separated with HDRB and LDRB as opposed to the fixed base structure, the variation in base shear is 33% and 34%, respectively. Compared to the non-isolated structure, displacement has increased in each of the three isolators. In comparison to

HDRB and LDRB, Lead Rubber Bearing has the highest average displacement. Due to the isolator's presence, storey drift has significantly decreased. In comparison to a non-isolated building, HDRB, LDRB, and LRB constructions all experienced a reduction in storey drift at a height of 9 metres of 13%, 13%, and 15%, respectively. We can draw the conclusion that isolated buildings perform better than non-isolated ones. In comparison to high- and low-damping rubber bearings, lead rubber bearings perform better (Desai & John, 2015).

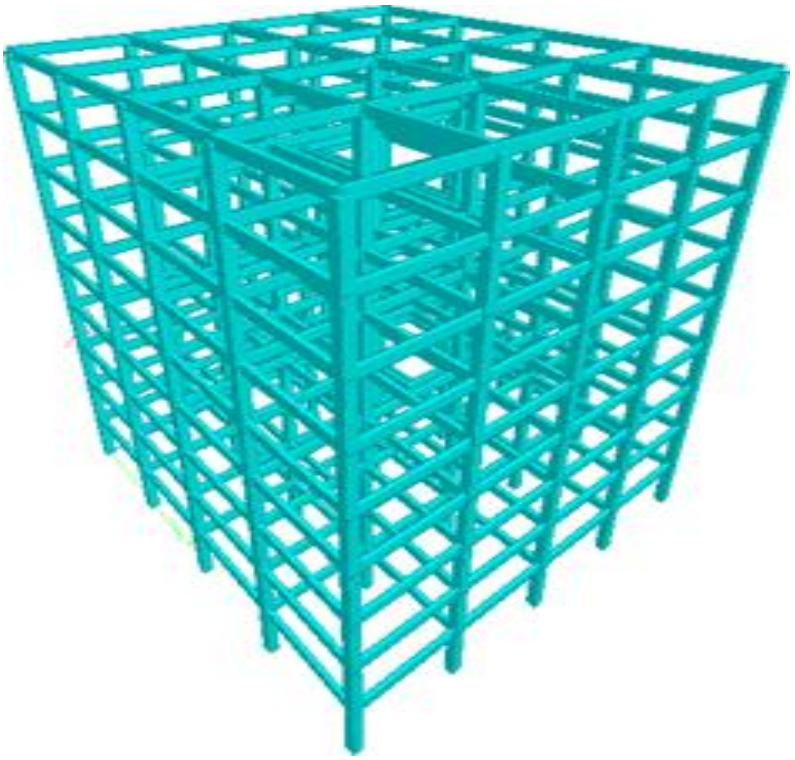


Figure-10. 3D Model of 8-Storey Office Building

A G+9 storey square building was examined using SAP 2000 software by Naveen K, Dr. H.R. Prabhakara, and Dr. H. Eramma [2015]. According to the results of the time history study for the El Centro earthquake, top storey lateral displacement is reduced by 35% for ten-story regular buildings and by 36% for ten-story mass irregular buildings. A building's mass irregularity creates torsion, as may be demonstrated by examining the outcomes in both horizontal displacements X and Y axes. It has been discovered that base separated buildings do not have inter-story drifts. This indicates that when base isolators are used, the structure moves rigidly. Inter-storey drifts for mass irregular buildings are bigger than for regular buildings (Naveen, Prabhakara, &

Eramma, 2015).

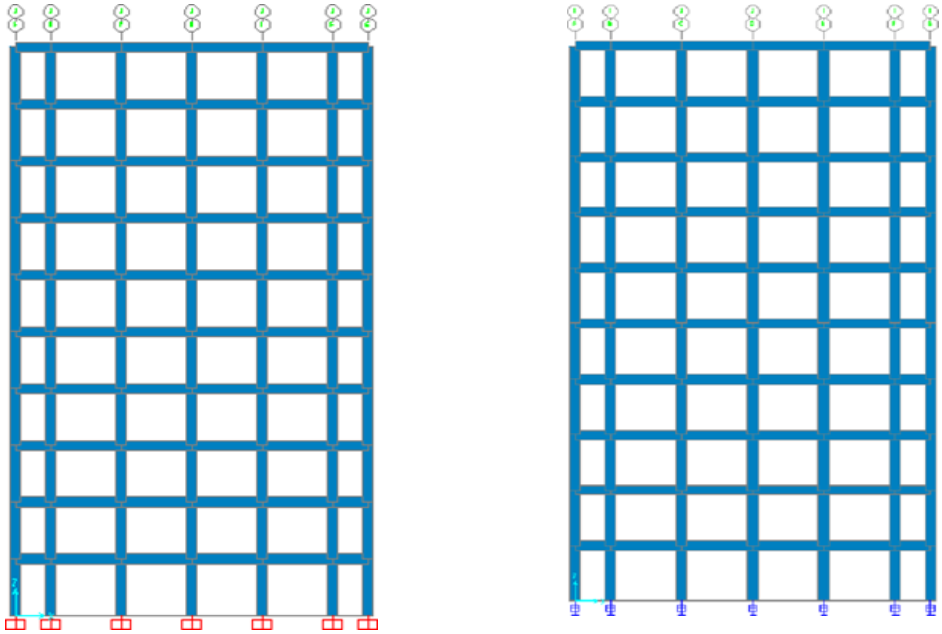
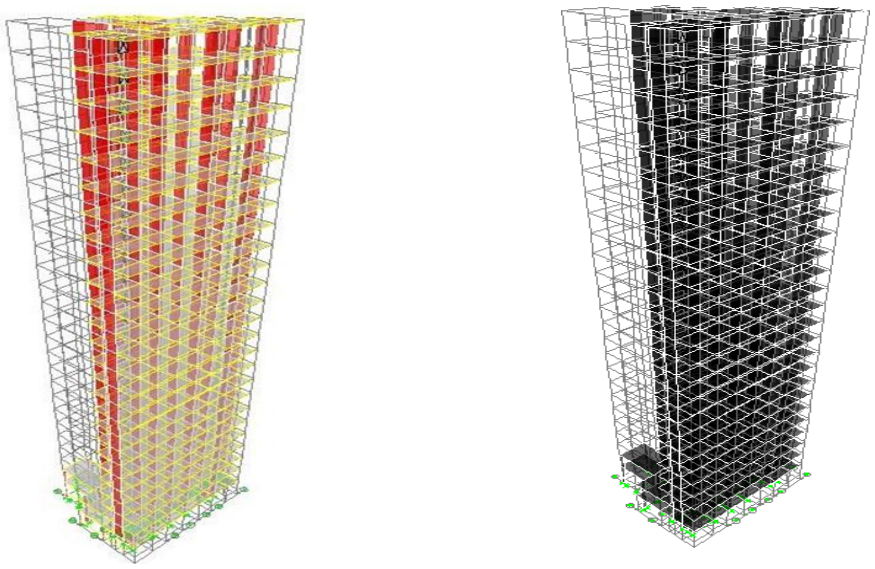


Figure-11. Buildings Elevation with and without Base Isolators.

Meena Noorzai, M.N. Bajad and Neha Dodal [2015] The seismic impact of a G+25 story frame building is compared with a fixed base building vs an isolated building. The G+25 story RCC frame structure is designed with base isolation using the ETAB programme. LRB is utilized as an isolator, and the report demonstrates that the values for lateral loads are significantly reduced when using lead rubber. Base-isolated structures have lower lateral deflection and lower moment values than fixed base structures because the lateral displacement at the base never equals zero. The base separation separates the structure from the load caused by earthquakes while maintaining a longer fundamental lateral period than a fixed basis. A method known as base isolation shields a structure from the potentially harmful effects of a seismic movement. The ground may be moving during an earthquake, but the structure will remain still if it separates from the ground. The ETABS programme was used to create the G+25 storeys frame structure with base isolation. LRB is used as the isolator since it produces better results for the frame structure over the fixed base structure than any other isolation method (Noorzai, Bajad, & Dodal, 2015).



Fixed Base Isolated Base

Figure-12. Analytical Model – Fixed & Isolated Base.

G+5 storey building is studied using SAP 2000 software by Prof. R.B. Ghodke and Dr. S.V. Admane [2015] increases with building height, but displacement in base-isolated buildings and displacement in permanent base isolation decreases. Additionally, base isolation results in less displacement as compared to fixed bases (Ghodke & Admane, 2015).

According to Dia Eddin Nassani and Mustafa Wassef Abdul majeed [2015], quake effect on fixed-base and Isolated base structures are evaluated in their study. The SAP 2000 software is used to examine two different G+4 story structures, the first of which is a regular structure and the second of which is an irregular structure. Based on their findings, base isolation can be used to lessen the structure's reactivity. The base isolation system increases displacement while decreasing base shear force and story drifts, according to a comparison of the findings of the base-isolated condition and the fixed-base condition (Dia & Mustafa, 2015).

Mazhar Khan and S.V. Bakre [2015] A G+5 steel frame building was used to evaluate how it responded to seismic loading under both standard fixed base conditions and base isolation conditions. The four kinds of isolators listed above were created based on the weight and natural cycle of the superstructure. In SAP2000, the building was modelled.

It was modelled in the same programme using the isolators' design values. The structure was then designated for the four various types of isolated and stationary bases. On the building underneath the permanent base and the several isolator bases, a time history analysis was done. The time history analysis in SAP2000 utilized two alternative time histories that were chosen for use. In comparison to fixed base structures, base isolated structures have a longer time duration. The framework is more adaptable as a result. Because of its flexibility, the structure is less affected by seismic forces as storey displacement rises. This lessens the strong impact of the seismic force's impulse, which would otherwise inflict more damage to fixed base framework. For a fundamentally isolated framework, the relative displacement of the joint has decreased. Thus, it will contribute to minimizing the negative impacts of the seismic force. Base Due to the more flexible material used in base isolators, deformation is larger. Base shear for an independent has significantly decreased (Khan & Bakre, 2015).

S. Keerthana, K. Balamonica, and K. Sathish Kumar [2015] One of the effective methods for designing earthquake-resistant constructions is base isolation. If base isolation is applied, the structure's acceleration time history is regulated, but the structure's displacement is increased. By designing the isolator in a nonlinear form that is simple to implement, the massive displacements seen in the isolated structure may be controlled. There was a 58% decrease in acceleration and an 85% rise in displacement. When the non-linear characteristics of the isolators were taken into account, a further 38% decrease in displacement could be seen (Keerthana, Sathish Kumar, & Balamonica, 2015).

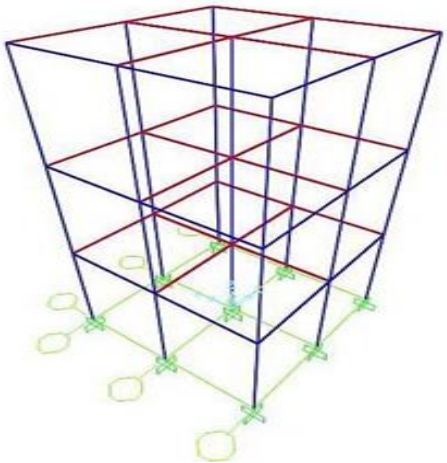
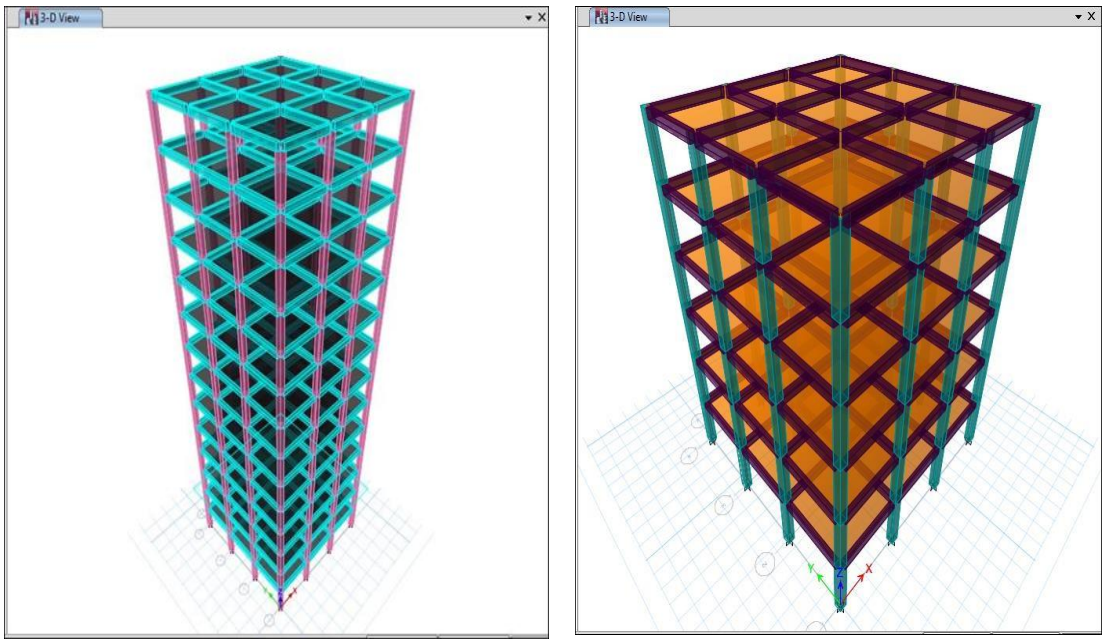


Figure-13. 2-Storey Sample Model

Ganga Warrier A, Balamonica K, Sathish Kumar K and Dhanalakshmi [2015] The installation of isolators modifies acceleration on buildings and displacement. The building's displacement grows as its acceleration decreases. If the isolator is made of a non-linear material, the displacement rise can be decreased. The non-linear isolator additionally adds more damping to the system (Warrier, Balamonica , & Sathish Kumar , 2015).

Anusha R Reddy and Dr. V Ramesh [2015] two structures are taken into consideration: a G+13-story building and a G+5-story building that were both planned and assessed using ETABS. Both structures are given lead rubber isolators, and under zone v and soil type II, assessments of the time history and linear response spectra in both case were conducted. After installing a rubber base isolator, G+13 and G+5 storey structures' mode periods rose by 19% and 47%, respectively. It has been determined that the rubber isolator's flexible nature, which was provided, extended the mode period (Reddy & Ramesh , 2015).



Fixed Base Isolated Base

Figure-14. 3D Model of G+ 5 Storeys

Pallavi Wamanrao Taywade and Madhuri Narayan Savale [2015] Seismic base isolation has shown to be a dependable technique for designing earthquake-resistant structures. The efficiency of this approach is greatly influenced by the design of isolation mechanisms and meticulous planning. Extensive study has been done on a variety of isolation device types that have been proposed. They are capable of serving the objective in practically all circumstances. Systems for effective isolation must be flexible enough to respond to different seismic events. In addition, the current devices are pricey, so work is needed to design devices that are affordable in order to make isolation practical for common buildings (Taywade & Savale, 2015).

Khloud El-Bayoumi [2015] Using concrete slab pieces that were 0.2 meter wide and IPE300 column and beam sections, a prototype model of a (25*15) m, 10-story skyscraper was constructed. In earlier iterations of SAP2000, TFPB was typically modelled as a set of friction bearings, seeking to approximate the behaviour of the isolator as closely as possible. However, after utilising the new TFPB feature, it is now clear that new versions of SAP2000 v-16.0 and later are more moderate for the analysis of base-isolated framework since these versions have an actual model of TFP bearing, so we can get results with actual isolator behaviour (El-Bayoumi , 2015).

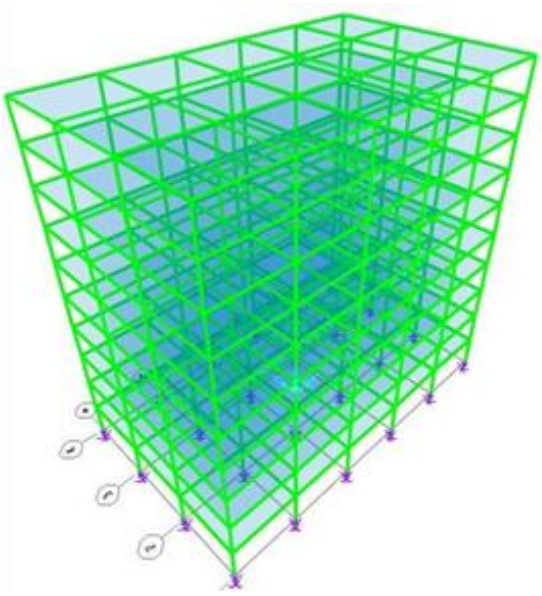


Figure-15. 3D View of G+10 Storey in SAP2000 Model

G. Arya, Alice T.V and Alice Mathai [2015] ANSYS was used to model the HDRB and conduct nonlinear finite element analysis. The largest displacement that the isolator can experience without losing stability is equal to 350% of the rubber layer's thickness. Although the isolator can withstand a 400% shear strain, the bearing may be damaged if the tensile tension is too high. The isolator can be employed for accelerations of about 0.3 g and can tolerate cyclic displacements. The induced stresses were discovered to be within the acceptable range (Arya, Alice, & Mathai, 2015).

Sarah Moretti, Alba Trozzo, VesnaTerzic, Gian Paolo Cimellarol and Stephen Mahin [2014] G+2, the base isolated system dramatically reduces average harm and recovery time in two Oakland, California, buildings: a healthcare institution and a school. The results are decrease significantly that occurs at the building's base when an isolated system is used. The range of the repair cost savings for the hospital occupancy with an average of 85%, and for the school with an average of 76%. This significant decrease in the price of base-isolated system impact restoration is primarily attributable to the prevention of damage to costly structural elements and accessories in addition to the avoidance of damage to non-structural components. Compared to fixed-base buildings, repair times for standalone buildings are 3–6 times shorter. A base-isolated building's resilience will be higher and its downtime will be greatly reduced as a result of the drastic reduction in maintenance time (Moretti, Trozzo, Terzic, Cimellaro, & Mahin , 2014).

Sima Rezaei, Gholamreza Ghodrati Amiri and Pejman Namiranian [2014] To assess the system's seismic response during near-field motions, three alternative TFPB geometry configurations and FS are evaluated. The findings reveal a notable decrease in isolated structure reaction when compared to fixed base structures, but a striking rise in displacement induced at the ground level of isolated structures during near-fault earthquakes. Additionally, the results demonstrate that base displacement will increase with corresponds to period, acceleration, inter-story drifts & base shear will decrease (REZAEI, AMIRI, & NAMIRANIAN, 2014).

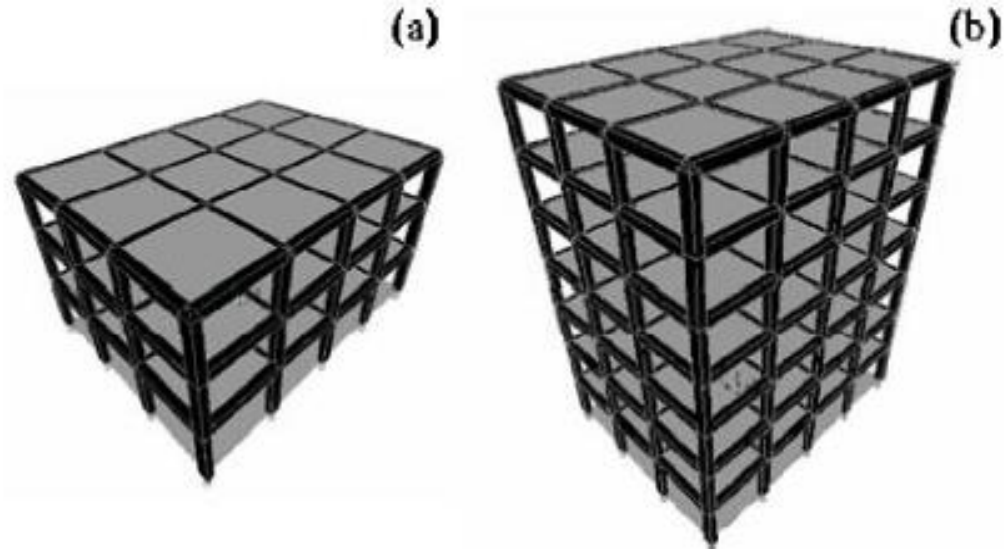


Figure-16. Building A & Building B Model

Prerna Nautiyal, Saurabh Singh and Geeta Batham [2014] The Indian standard offers various expressions for estimating the building structure's natural period while taking or ignoring the stiffness of the infill wall. When masonry infill stiffness is taken into account, the structure becomes more rigid, which decreases the natural period and increases response acceleration and, in turn, seismic forces (base shear and corresponding lateral forces at each storey) (Nautiyal, Singh, & Batham , 2013).

3.3 Observations from Literature Survey

- Base isolation greatly lengthens the building's lifespan and hence lowers base shear.
- Base isolation approach significantly improves a building's performance over fixed base one.
- LRB's performance is superior than that of HDRB and LDRB.
- When compared to other isolation systems, LRB is employed as an isolator because it produces effective results for frame structures over fixed base structures.
- Increases with height of building displacement decreases in base- isolated framework and displacement in fixed base isolation.
- The displacement is increased while the base shear and story drifts are decreased.
- The main factors that contribute to a significant decrease in the cost of base-isolated system damage repairs are the prevention of damage to costly technology and

structural parts as well as the reduction of non-structural component damage.

3.4 Summary

In current chapter, the research gaps are identified by means of the literature survey and the observation are identified from the literature survey.