Earthquake Analysis and Retrofitting of Reinforced Concrete structures Utilizing Various Approaches

Vijay Kumar Pandit
Asst. Prof. Structures
Mid-West University, Graduate School of Engineering, Surkhet.
Correspondence Email: *vijay.pandit@mu.edu.np*

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Abstract

The appear consider focuses for the Seismic Retrofitting of RCC Buildings utilizing unmistakable retrofitting strategies. This mishap due to seismic tremor as well leads to the hardship of cash in various cases. Presently and after that disillusionment of the structure leads to the collapse of the structure which dangers people lives. So, Engineers focuses to arrange the buildings which can bear a repairable harm but collapse have to be not happened. Basically, retrofitting is done for the open properties like havens, clinics, points of interest conjointly for the private properties which are more defenseless to seismic powers. Seismic retrofitting is characterized as the strategy to make existing building more secure for seismic tremor qualities by unfeeling of counting a couple of essential people or by introducing certain contraptions which can stand up to the qualities delivered by seismic tremor. Inside the appear time there are various structures which are created having require inside the fortress indicating. Retrofitting is given to move forward the improvement quality and bearing capacity for outside stack capability. This consider deals with the esteem of utilizing particular retrofitting strategies such as bracing, jacketing, dampers, base division and shear divider utilized inside the RCC Building to make it stiffer. The retrofitting of building essentially comes almost inside the increase of strength, decreasing story coast and evacuating.

I. Introduction

Agreeing to the examination it is gathered that the shaking on the external layer of the ground is since of the creation of waves underneath the soil. These waves are known as seismic waves. There's entry of particular degree of vitality at the place of bursts within the deficiency, this vitality release is clarification for the age of seismic waves. The plenitude of seismic waves is diverse at different ranges and moreover the time taken by waves to reach at different range is one of a kind. Whereas shaking of ground happens the vibration or ready to say shaking is fundamentally characterized as speed increment, speed and expulsion. The impact of seismic tremor can be examined by the shaking of ground at different zones on the ground surface which can be surveyed as minor, direct ranges of quality for and. The minor seismic tremor comes routinely, direct shudder comes once in a long whereas and the strong tremors comes at times. The point of an architect isn't to form a development which is completely quake evidence. The structures which do not get small hurt whereas tremor costs

amazingly tall and since of critical cost of improvement it'll ended up uneconomical. In this way, by taking into consideration the put of cost of advancement plans for the foremost portion center around the arrange of structures which are shudder secure and can bear many hurts which later on gets settled. The Structures which restricts the seismic powers reasonably doesn't incite breakdown whereas tremor and due to non - breakdown component life of tenant of building subsequently remains secure and moreover taken a toll of redoing is spared. In this way, usually the basic way of considering utilized by and large for advancement of structures.

Earthquake Design Philosophy

From various a long time, there are beyond any doubt arrange thinking for structures amid seismic tremor

1. Amid minor tremors, it is supported that discretionary basic people from structures can have hurts which can be settled afterward however the fundamental essential people like shafts, sections, chunks shouldn't get hurt.
2. Amid direct tremors the discretionary people from the structure might incite genuine hurts as they can be supplanted after shake be that as it may the fundamental people from the structures which makes a difference in passing on burdens might incite a hurts since of seismic powers which can get settled after a few time.
3. Amid strong tremors, the elemental basis of a pro is that how much hurt it'll lead since of the seismic powers however the structure shouldn't get fallen.

It is contemplated that after minor seismic tremors, building will remain in total capability as hurts are especially unprecedented for which repairable time and fetched is greatly less. After direct Shake shaking, convenience of building takes time as differentiate with the minor seismic tremor building settle in light of the fact that the discretionary people needs substitution. Within the occasion of strong seismic tremor, building won't get fallen so such tenant's reality should to be secured be that as it may the convenience of building is gone in light of sad hurts as shown in figure 1.1.

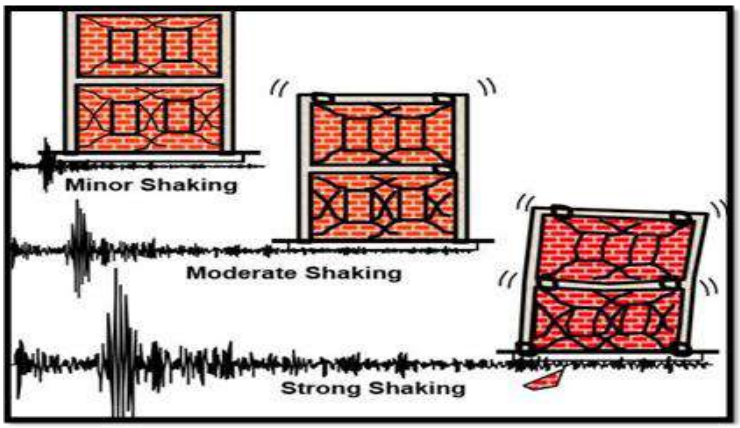

Figure 1.1: Execution targets beneath distinctive force of seismic tremor shaking

Seismic Retrofitting

Fundamental Concept of Retrofitting

From various past seismic tremors it is cleared that at anything point shake comes it brings around the passing toll of individuals, animals, property. Since of seismic tremor at a few point the plan or building will drop. Numerous examination has been done on the thoughts that how ready to make our development more secure in tremor. After diverse examinations a term called seismic retrofitting is displayed for making our current development less frail towards the tremor powers. For the course of seismic retrofitting there are distinctive strategies which are utilized to form our development more secure toward the seismic powers. Retrofitting is given to recover the advancement quality and bearing restrain with regard to exterior stack capacity. It is outrageous gigantic for open nostalgic properties and for the structures which are arranged within the zones that are more slanted to tremble. Extension within the sidelong quality of the structure: At the point when their comes tremor , seismic control acts in parallel heading which impacts in shaking of ground since of which vibration happens in building. By retrofitting structure, able to allow parallel solidarity to development to persevere seismic vibrations.

1. Development in pliability of building: Flexibility infers that when burdens are moving toward on the improvement it'll divert to a particular level in any case after the removal of burden plan will recoup its one of a kind shape. Along these lines, by outfitting retrofitting development can be fulfilled with satisfactory pliability amid seismic powers so it can't drop quickly.
2. Extension in quality and flexibility: There are various seismic retrofitting procedures by which development can continue on through parallel powers and besides avoidances amid shudder.

Require of Retrofitting

1. Since of tremor: Amid tremor ground shakes inferable to which level powers takes after up on the development and building shakes which prompts breaks in structure portions, dissatisfaction or settlement of building and reasonably other sort of unmistakable hurt to structure. To diminish this impact of seismic tremor ready to utilize such methods which can help our structure with persevering that impacts of shudder.
2. Lacking significant creation: On the off chance that considerable creation whereas conceivably deficiently it'll provoke drop in quality of plan since of which plans are not that much defenseless against bear stack or may get hurt besides.
3. Terrible execution handle: It is basic that the way in which we are designating our significant amid improvement of development as compaction is moreover required on the off chance that we do not negligible or put concrete suitably it won't obtain tolerable quality. By giving retrofit we are able include solidarity to structure.
4. Arrange botch already and after advancement: Some time recently improvement botches infers not getting authentic nuances like not having suitable consider or status of building arrange suitably and after improvement recalls afterward impacts for building.

5. Since of nonattendance of itemizing: Within the occasion that back indicating are not appropriate during advancement at that point it'll lead of plan having less quality which lead to implode of development or having tall quality which prompts uneconomical improvement.

Objective of Retrofitting

1. Structure unaffected: By retrofitting we are able lessen the occurrence and harmed of house.
2. Structure survivability: At the point when the tremor comes the fundamental point is that improvement will affirm to require off or exit.
3. Structure esteem: Central structures are secured and the structure is completely in offer help for its key application. A lifted degree of retrofit, this endorses that any fundamental fixes are moving forward.
4. Life Thriving: One of the imperative objectives of retrofitting is to secure lives of individuals by making structure more tireless in seismic tremor so there's no breakdown of amplifying on its occupants or individuals standing, passing by the structure in the midst of shiver.

Retrofitting Strategies

Retrofit plot comments to choices of total or progress the consistent quality by extending the solidness of building. The structure can moreover make tremor secure by enhancement within the pliability of plan and by extension in parallel quality of building. In straightforward words we are able say that the foremost common way of retrofitting may be a well-informed method to create structures more relentless so they can persevere seismic powers in a really well way. The retrofit approaches can be requested beneath around the world and adjacent strategies. There are basically two sorts of seismic retrofitting strategies named as around the world retrofitting methodology and nearby retrofitting method. The around the world retrofitting and neighborhood retrofitting which are talked approximately underneath as takes after.

Worldwide retrofitting strategies

This strategy of retrofitting is utilized to offer the common development within the parallel quality of the structure. At the point when this strategy of seismic retrofitting is utilized, building won't fail or drop. There are different strategies for around the world retrofitting like shear divider development in building, infill dividers, utilization of bracings, Mass Dampers, base detachment and so on. Seismic retrofitting of working by including shear divider within the structure is one of best procedure as shown in figure 1.2. This procedure makes a difference in working on the obstacle of the structure whereas building will experience any sort of seismic powers. In a general sense shear divider helps in reducing bend that's the reason this divider is suited total level of construction in an even way.

Figure 1.2: Seismic retrofitting by expansion of shear divider

Utilization of steel bracings are moreover one of the compelling strategy for growing the quality and robustness of the structure as shown in figure 1.3. The bracings helps with reducing the pile way for the level seismic powers as the load goes through the bracings to the foundation.

Figure 1.3: Seismic retrofitting by expansion of bracings

Base Separation: When it comes to seismic, the thought is to utilize a segregating framework to keep ground movement from entering the structure. This is often finished by the utilize of heading as appeared in figure 1.4. These are commonly found between the establishment and the superstructure within the storm cellar.

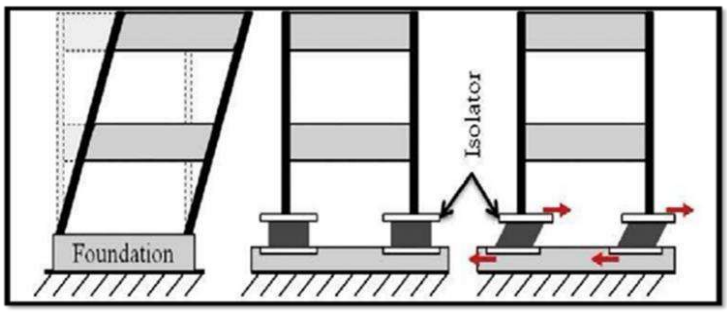

Figure 1.4: Misshapening in Settled Upheld Vs Seismic Separated Building in Seismic tremor

Concept of base segregation: The essential arrange thought shown in figure is to grow the vital time of the structure so the honest to goodness seismic interest on the development isn't precisely that can safely be spurned by the plan as shown in figure 1.5. Base isolation is ordinarily fitting for brief to center rising structures, by and expansive up to 10-12 stories tall. Superstructure highlights like level, width, and immovability are basic in characterizing the congruity and efficiency of seismic separation.

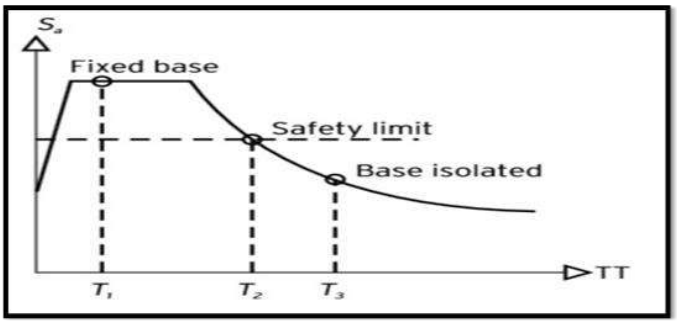

Figure 1.5: Ghostly Reaction for a Commonplace Base Separation Framework.

With the advancement of innovation their comes a auxiliary component known as seismic dampers which makes a difference in lessening uprooting of the structure or building by retaining the seismic vitality produced amid the shaking of ground. Thick dampers: In this sort of damper, vitality is captivated by silicone based liquid temporal between cylinder barrel courses of action as appeared in figure 1.6.

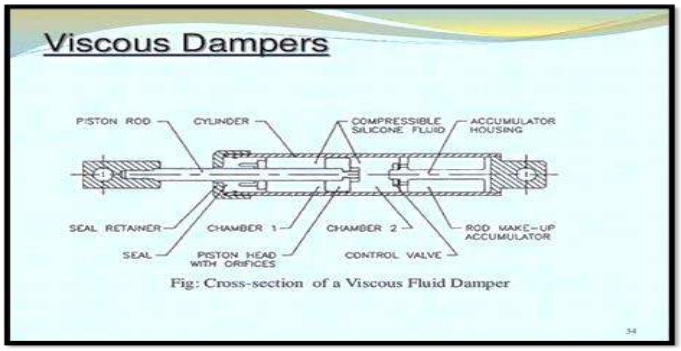

Figure 1.6: Cross section of Viscous Damper.

Sorts of dampers: A few of the sorts of gooey dampers are thought underneath

i. Yielding dampers: The vitality is engaged by metallic components that yields.
ii. Contact dampers: vitality is charmed by surfaces by contact between them rubbing against each other.
iii. Tuned mass damper: This one could be a gadget connected on the building to diminish the adequacy of mechanical vibrations.

Nearby retrofitting methods: Neighborhood retrofit approaches are utilized to avoid the collapse of the auxiliary components. It makes a difference in progressing the execution of the building by dodging the collapse of the basic components.

Jacketing of pillars and columns: It is most extreme common strategy for improving the quality by fortifying of building column as appeared in figure 1.7.

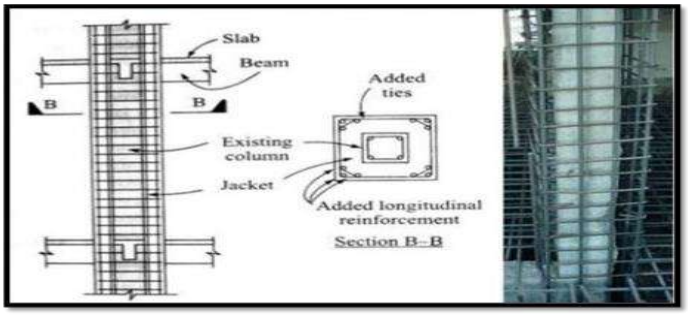

Figure 1.7: Retrofitting by Jacketing of bar and column.

Jacketing of shafts and sections by FRP: A fiber backed polymer could be an essential bracing system which utilized to increase or work on the constrain of built up emanates. FRP upsurges a conclusive burden passing on restrain of built-up significant people and recovers the shear constrain of backed significant component. The pliability of a built-up significant fragment is extended in a general sense. The FRP jacketing will be utilized for revealed locale segments as shown in figure 1.8.

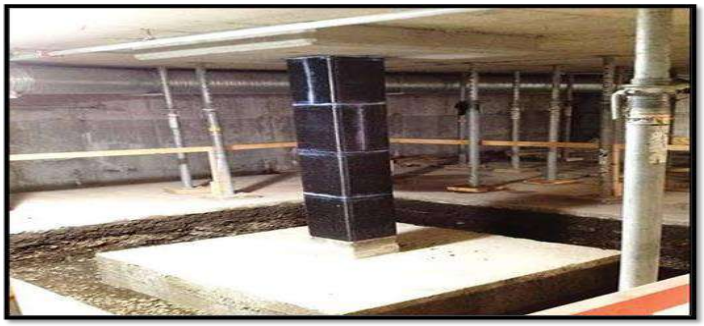

Figure 1.8: Retrofitting by Composite Fiber Wrap

Objective of the consider

- **i.** The seismic examination and retrofitting of RCC (Invigorated Concrete) buildings point to achieve a couple of key objectives, all centered around moving forward the fundamental keenness and security of buildings inside the stand up to of seismic occasions.
- **ii.** The examination and retrofitting shapes point to protect or make strides the assistant insightfulness of RCC buildings. This incorporates fortifying essential essential components to stand up to the powers made by seismic events without basic mutilation or disillusionment.
- **iii.** Retrofitting makes a difference minimize hurt to the building's essential components and non-structural components, ensuring property and minimizing repair costs. Ordinarily essential for both private and commercial structures.
- **iv.** The objective is to diminish the defenselessness of RCC buildings to seismic threats, in this way bringing down the danger of hurt or disillusionment in the midst of a seismic tremor.

II. Methodology

Methodology of Study

The essential period of the technique incorporates the examination of the plans for occasion examination of arrange of plans and the information given for its outlining. The Plan is at that point appeared and analyzed utilizing ETABS 18 programming. After the evaluation the plans are at that point organized by utilizing Arrange Reach Procedure. With the apex of the course of action communication resulting arrange is to assess the introduction of the plan which need to be conceivable by utilizing Sucker examination. With the assistance of weakling evaluation it is seen that where the plastic turns progression happens to begin with as a result of the involvement of seismic powers. Since the unmistakable prove of frail individuals or districts is done plans are at that point retrofitted by utilizing distinctive seismic retrofitting techniques. The organize I procedure is appeared in figure 2.1.

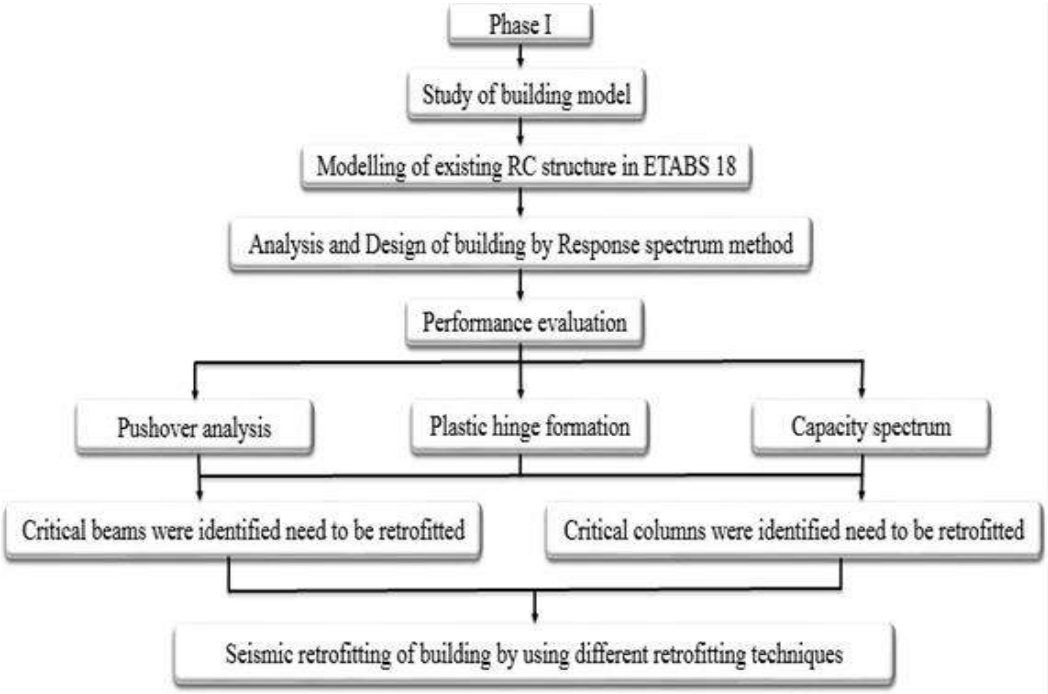

Figure 2.1: Methodology (phase 1)

The arrange II starting stages with the appraisal of plans taking after retrofitting. In this way, the results for the two cases for illustration retrofitted and without retrofitted structures are gotten by utilizing ETABS 18, the going with organize is to form assessment between the story response plots of the plans. Fair ensuing to isolating the story reaction plots of the plans the most excellent retrofitted framework is proposed for express sort of building. The moment season of the approach is shown in figure 2.2.

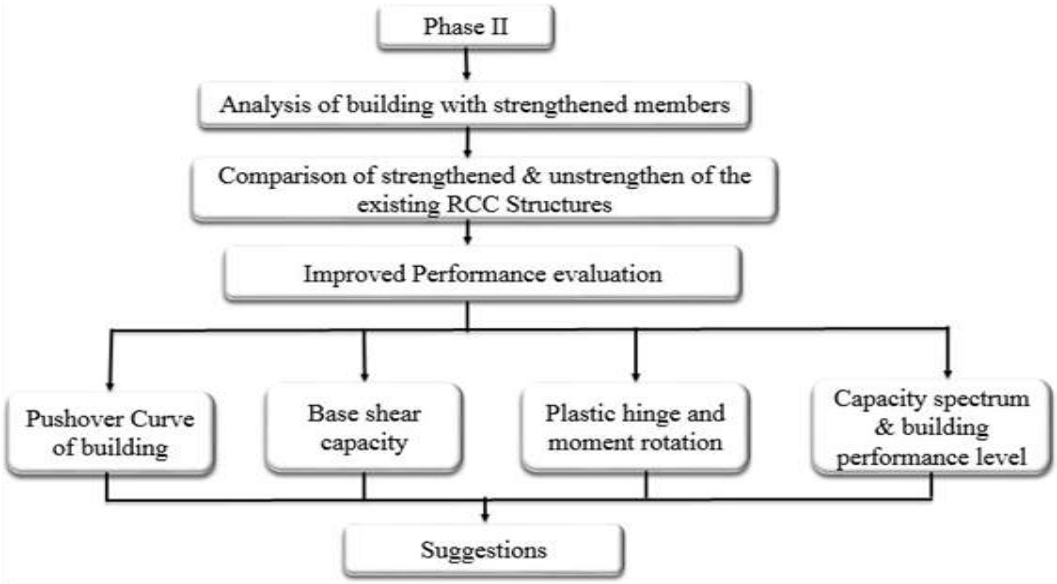

Figure 2.2: Methodology (phase II)

Strategy of examination utilized in this Consider

The evaluation strategy utilized in this think about is essentially indistinguishable inactive procedure or coordinate inactive method to calculate the story reaction plots of the plans and sucker appraisal to select the turn diversion arrange and plans execution examination in different stages in structures fundamental individuals for occasion bolster focuses and ranges.

Identical Inactive Strategy of examination

In a comparative inactive strategy, the development reaction is famous by the arrangement of capacities circling back to the plan and gives the diverse mode shapes as the reaction of the development. The reaction of the plan is famous by the plots of the development after the course of action reaction extend.

Pushover Examination

Since the technique is fantastically prompt and appraisals post versatile approach to acting, nonlinear inactive examination, for the most part called sissy examination, has changed into the slanted within the course of appraisal for arrange and seismic execution examination purposes. In any case, since the method combines different approximations and partitions for the suspicion for seismic intrigued. The non-direct inactive cycle, frequently known as push over evaluation, may be a sensible technique for enrolling post-flexible quality constrain. This participation incorporates circling a ordained sidelong weight arrange at by and large level of the improvement. The distortion point of the development is come to in see of the expansion of capacities within the level course with the removal control. As the relocation and weights are growing, a colossal lessening within the sidelong removal is taken note.

Nonlinear Plastic Pivot Properties

This requires the change of a control mutilation turn for basic parts of bars and portions utilizing the FEMA 356 measures (2000). The flexure drive misshapening turns are gotten from supporting subtleties and relegated to all bars and parts. The parcel organizer was utilized to dissect the nonlinear properties of shafts and portions, which were at that point managed to the PC demonstrate in ETABS 18. At the two terminations of the bars, flexural default turns (M3) and shear turns (V2) were dispersed. The areas' by and large upper and lower closes have working together (P-M2-M3) turns. Figure 2.2 appears the affiliation between the rise to control on a advancement and the level twisting of the plan's roof. This bend is known as the 'push over' bend. The sissy turn, as appeared in Figure 2.3, can be utilized to conclude the show point and position of turns at different stages. The control redirection lead of the turn is depicted by five consigned A, B, C, D, and E. From point A to point B Versatile state is there, From direct B toward point IO the state of beneath rapid inhabitance, from coordinate IO toward point LS there's a organize between brief inhabitance and life success, from direct LS toward point CP the organize is between life security and breakdown desire, from coordinate CP toward point C the arrange is between breakdown avoidance and over the top cut-off, from coordinate C toward point D the organize is between over the top cut-off and remaining quality, from coordinate D toward point E the arrange is between additional quality and breakdown, and more noteworthy than point E arrange is breakdown.

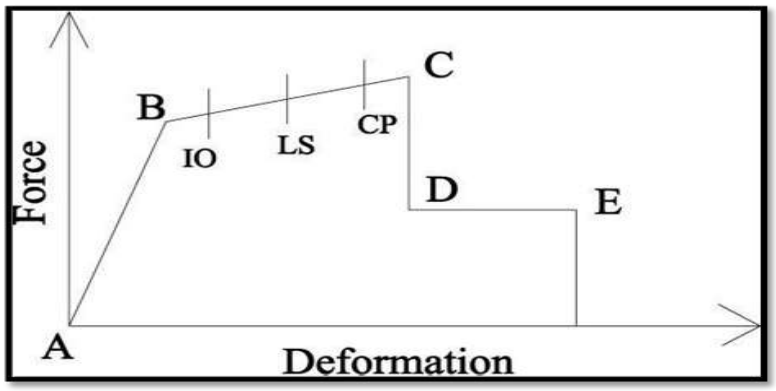

Figure 2.3: Various Phases of Plastic Hinge Formation

III. Structural Modelling, Analysis, and Retrofitting of a G+3 Building

Details of the G+3 Building

The analysis focuses on a four-story reinforced concrete (RCC) structure designed in accordance with the Indian seismic code IS 1893 (Part 1): 2016. The yield strength of the reinforcing steel used is 415 MPa, and the concrete grade is M25 (25 MPa). Steel bracings incorporated into the structure have a yield strength of 250 MPa. A response reduction factor of 5 is adopted, and the structure is analyzed for seismic Zone V.

The building features five bays in total, with three bays arranged along both the X and Y directions. Each bay spans 5 meters. The height of the ground floor is 4 meters, while the upper three floors each have a height of 3 meters, introducing a vertical irregularity in the structure.

Figure 2.3 illustrates the building's layout and elevation. The slab thickness is specified as 120 mm. A live load of 3 kN/m² is applied. Beam dimensions are 250 mm × 300 mm, and column cross-sections are 300 mm × 300 mm.

1. A plan and 3D view of the structure are shown in Figure 3.1.

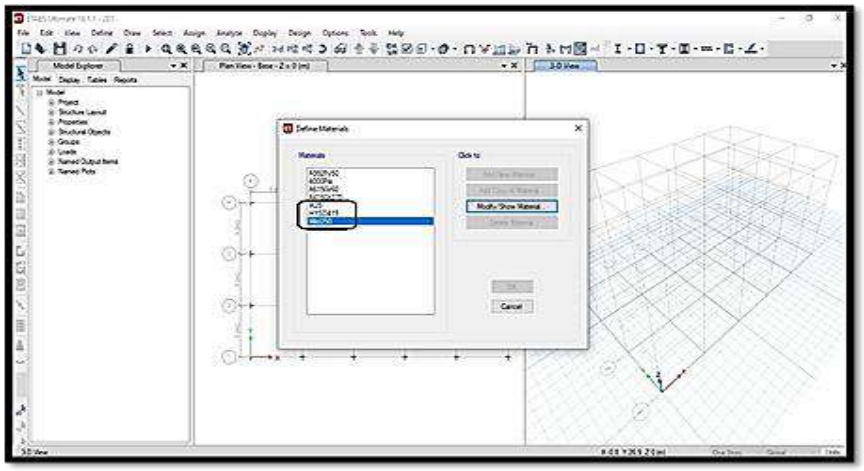

Figure 3.1: Plan and 3D Representation of the G+3 Building

2. Navigate to **Define > Material Property** to open the "Add New Material Property" dialog box. Select the material grades as follows: concrete grade M25, reinforcing steel as HYSD 415, and mild steel with a yield strength of 250 MPa, as illustrated in Figure 3.2.

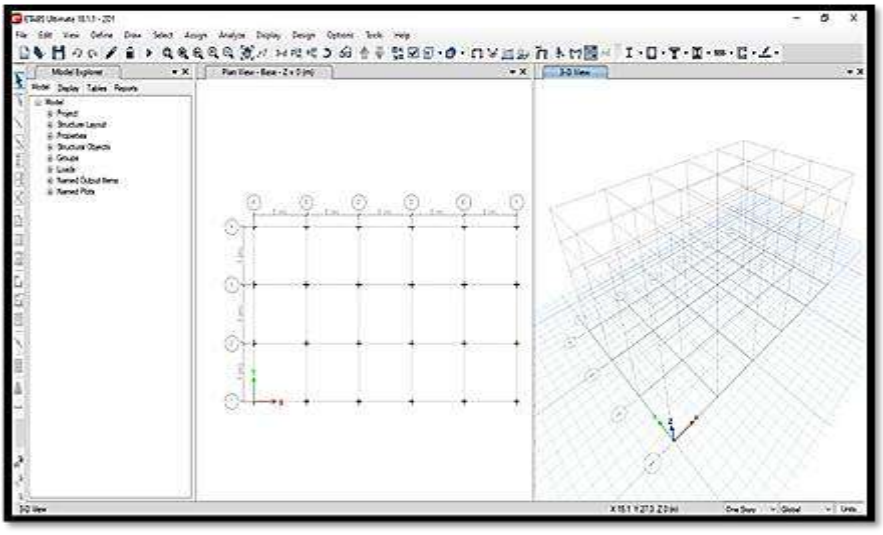

Figure 3.2: Defined Material and Section Properties for the G+3 Building

3. Navigate to **Define > Section Property > Frame Sections and Slab Sections**. This will open the frame and slab property dialog boxes. Click on **Add New Property** to define the following dimensions: beam size as 350 mm × 350 mm, column size as 450 mm × 450 mm, and slab thickness as 120 mm, as shown in Figure 3.3.

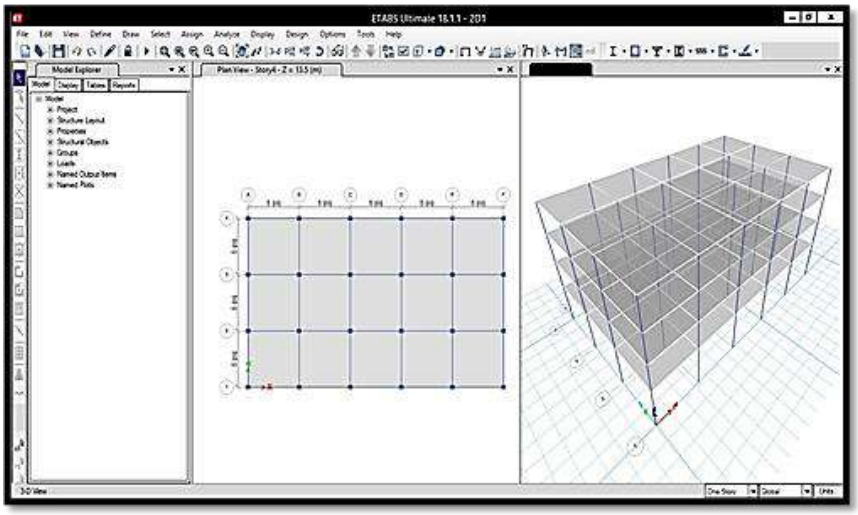

Figure 3.3: Assigned Section Properties for the G+3 Building

4. Go to **Define > Load Patterns** to open the Load Patterns dialog box. Click on **Add New Load** to define load types such as Dead Load, Live Load, Wind Load, and Earthquake Load, as illustrated in Figure 3.4.

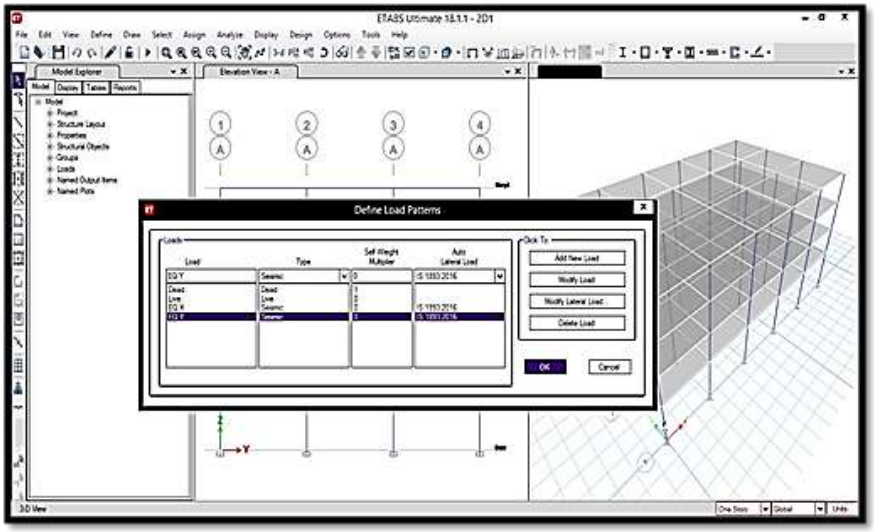

Figure 3.4: Load Patterns for the G+3 Building

5. **Load Assignments** – After applying the self-weight of the structure, an additional load of 1 kN is assigned at the joints. The applied joint loads are shown in Figure 3.5.

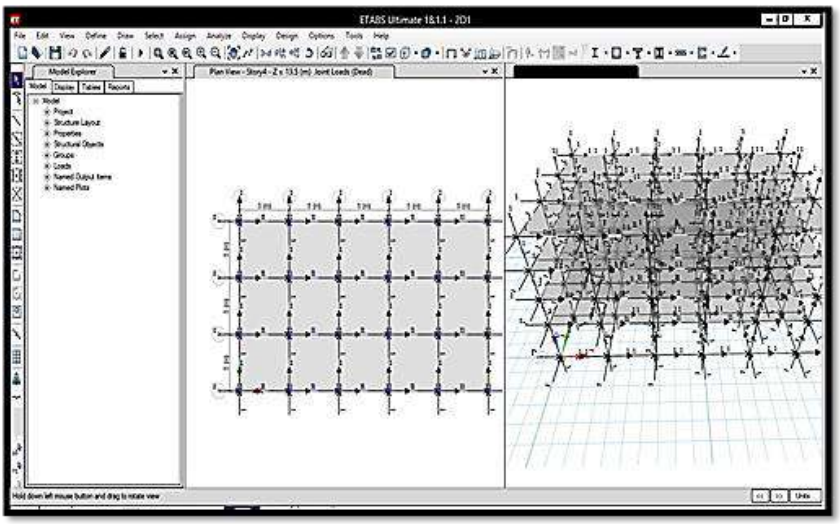

Figure 3.5: Assigned Self-Weight Load for the G+3 Building

6. The slab dead load is calculated by multiplying the slab thickness with the unit weight of concrete, i.e., 120 mm × 25 kN/m³ = 3 kN/m². An additional floor finish load of 1.5 kN/m² is also applied. Once the dead load is assigned to the slabs, the distribution of loads is shown in Figure 3.6.

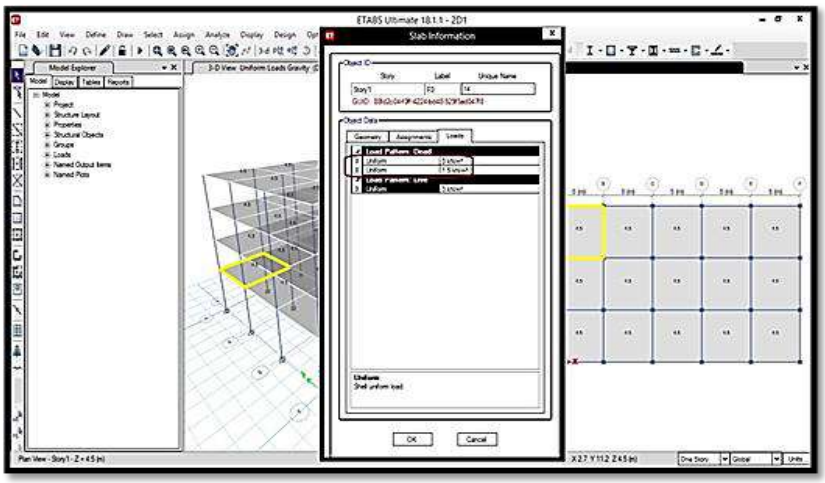

Figure 3.6: Total Slab Dead Load Assigned for the G+3 Building

7. The wall dead load is calculated by multiplying the thickness of the brick wall by the unit weight of brick masonry and the floor height. For floors 2 to 4, the load is:

$$0.21 \times 19 \times 3 = 12 \text{ kN/m}.$$

For the ground floor, the height is greater, so the load becomes:

$$0.21 \times 19 \times 4.5 = 17.955 \text{ kN/m}.$$

After assigning the wall load to the beams, the applied loads are illustrated in Figures 3.7 and 3.8.

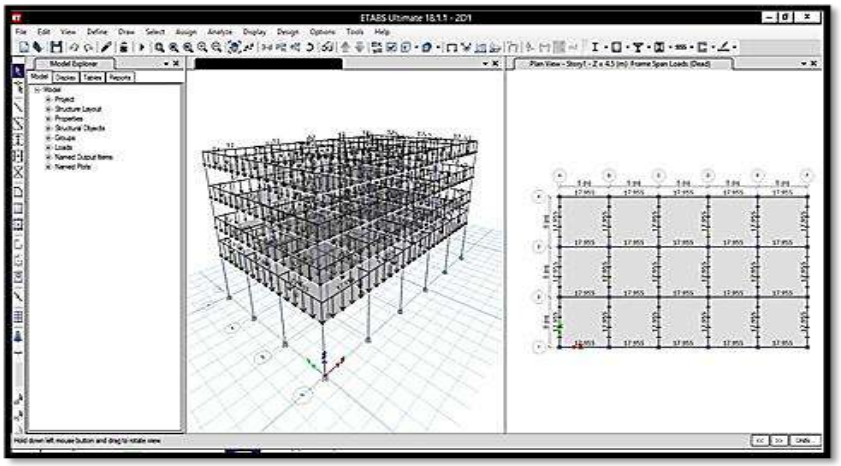

Figure 3.7: Wall Load Applied on Beams at Ground Floor of the G+3 Building

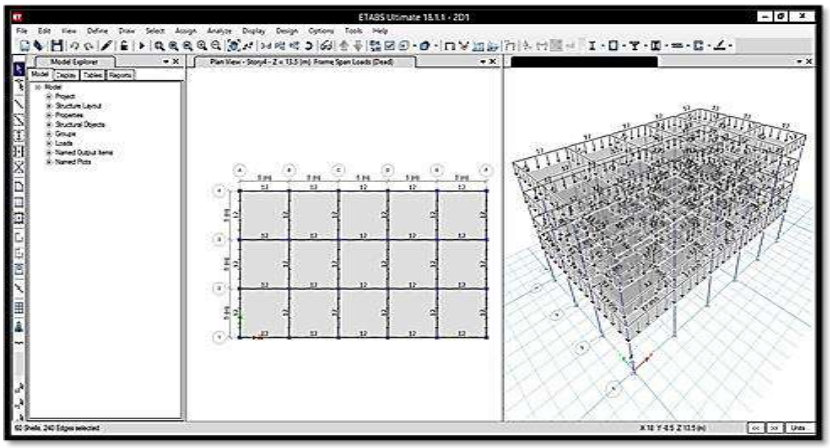

Figure 3.8: Wall Load Applied on Beams for Upper Floors of the G+3 Building

8. A live load of 3 kN/m² is applied to all floors. Once the live load is assigned to the slabs on all floors, the resulting loads are shown in Figure 3.9.

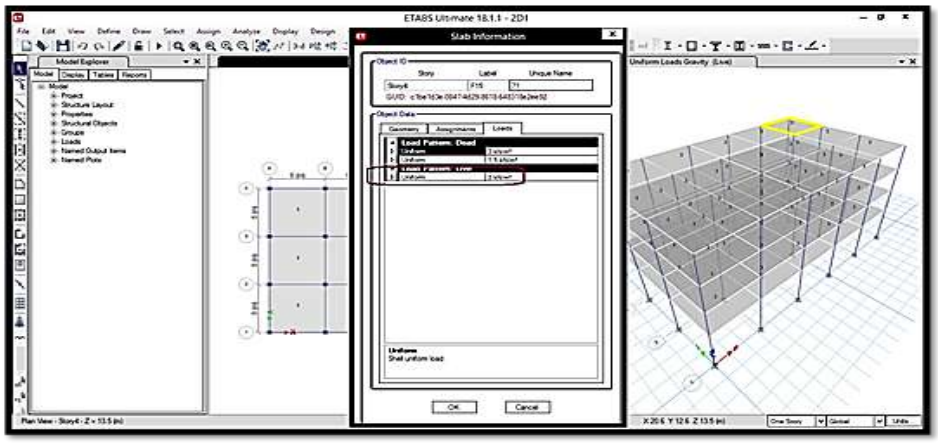

Figure 3.9: Assigned Live Load for All Floors of the G+3 Building

9. The seismic load is applied according to IS 1893:2016 for Zone V, with a zone factor of 0.36 and soil type III. The importance factor (I) is taken as 1, and the response reduction factor (R) is set to 5 for both the X and Y earthquake load directions, as shown in Figures 3.10 and 3.11.

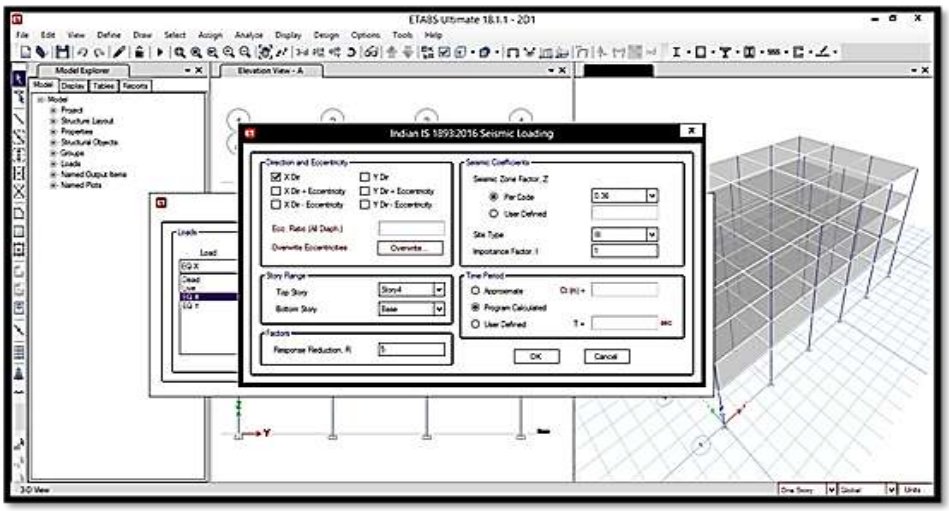

Figure 3.10: Defined Seismic Load in the X Direction for the G+3 Building

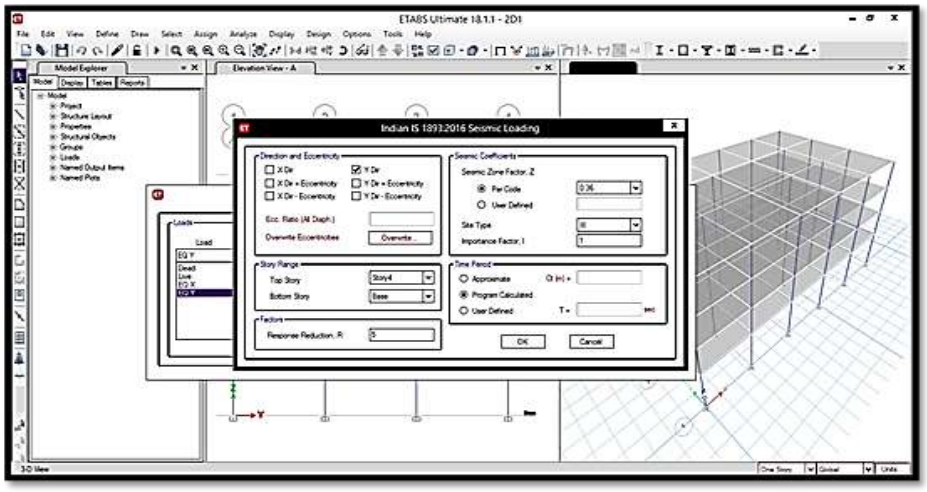

Figure 3.11: Defined Seismic Load in the Y Direction for the G+3 Building

IV. Conclusion

This research focuses on RCC buildings that were initially assessed using ETABS software, performing both static and dynamic studies. Following that, numerous retrofitting approaches are used, and the most successful retrofitting method is chosen for practical use in the field. This chosen retrofitting strategy improves the building's stability, reduces story drift, and limits displacement, as determined by ETABS simulations.

V. Future Scope

- **i.** Advancements in computational strategies and recreation strategies will empower more exact and point by point seismic investigation of structures.
- **ii.** Ongoing inquire about into modern materials, such as shape memory amalgams and progressed composites, may lead to the improvement of more successful retrofitting arrangements.
- **iii.** These materials offer upgraded quality and adaptability, making strides a structures capacity to resist seismic powers.
- **iv.** The future of seismic investigation and retrofitting of RCC buildings will include a multidisciplinary approach, combining mechanical progressions, inventive materials, maintainability, worldwide collaboration, and a centre on moving forward both auxiliary versatility and open security.
- **v.** In this extend, I will illustrate and analyse G+19 and G+3 buildings in ETABS beneath seismic stacking conditions in both the X and Y bearings.

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