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Research Paper

Seismic Design on a G+10 Rcc Residential Structure based on Performance

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Abstract
The performance-based design (PBSD) begins with defining performance goals. Performance-based seismic design accurately predicts the structure's performance during an earthquake. Recognizing and analyzing the structure's performance capacity is critical in performance-based design. This project was to do a PBSD on a (G+10) RCC construction. The building is first studied and built in STAAD PRO. Then, it was imported into the ETABS 2019 program to do a more detailed analysis of the displacement-controlled pushover analysis. The ETABS yields the structure's performance point, story displacement, capacity spectrum, Story drift, and demand spectrum. After the original design, a nonlinear pushover analysis is done to find out how well the building can withstand earthquakes and whether or not the goal was met, as well. In this research, we looked at the seismic code IS 1893 (Part 1) and the concrete design code IS 456: 2000 in order to make sure the building was safe. After obtaining all of the results, the structure's performance was compared for the various scenarios investigated and the optimal combination was determined.

Keywords: *Performance-based design, Non-linear pushover analysis, Displacement controlled Pushover Analysis, Demand Spectrum, Story Drift.*

1. INTRODUCTION

Earthquakes are natural occurrences that can cause catastrophic harm to structures and their occupants. As earthquake forces are also devastating and uncertain, the engineering technique should be enhanced to study and design alternative systems for earthquake load. The performance-based seismic design (PBSD) process assesses how a structure performs during an earthquake. However, future risk and its implications are rarely assessed using normal design methods. The performance-based design begins with selecting design criteria and one or more performance targets. Each performance objective assumes an acceptable risk of damage and eventual losses due to the seismic phenomenon. Thus, performance-based design is acceptable to all structures, non-structural elements, and members (Dilip & Chaudhari, 2016; Dimpleben & Sonwane 2015).

A structure developed using the PBSD method should meet the intended seismic performance objective. The performance-based seismic design effectively predicts how the structure will behave in an earthquake. Recognizing and analyzing a structure's performance capability is an important aspect of performance-based design.

We used nonlinear analysis (Yurizka & Rosyidah, 2020; Sumit & Gupta, 2019) to investigate a G+10 Story RCC construction. PBSD is a repeating process that begins with selecting a seismic performance objective, then designing and reviewing until the desired performance level is achieved. The performance-based design emerges when structural designers realize the standard code design process is not optimal. Varied structures have different performance goals, therefore developing them all isn't the best approach. The base shear is determined using the IS code recommended by keeping the average response acceleration coefficient (Sa/g), Importance factor ("I"), and Zone factor ("Z") as per the location. The base shear is distributed to all story

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levels based on the mass estimated for each story level based on height. The design forces and moments follow the lateral force. The dead and live loads, combined forces and moments are calculated using the seismic IS code1983 (part -1):2016. The structure is designed using concrete code IS456:2000, and then a pushover analysis is performed on the 14 structures. The PBSD predicts a building's performance during a seismic event (Ahmed, Abdo & Mohamed, 2021; Dilip & Chaudhari, 2016; Dimpleben & Sonwane, 2015).

Generally, performance requirements are classified as follows (Özuygur, 2016; Dya & Oretaa, 2015; Dubal, 2014): operational (the building can be used after the earthquake), immediate occupancy (the building was lightly damaged but can be used after minor repairs without affecting the structure's purpose), life safety (the building was damaged and needed repair after being emptied), and collapse prevention (building does not collapse but has many damages requiring demolition). The building's seismic performance during an earthquake indicates the maximum permitted non-structural or structural destruction for an expected seismic risk *Meghana Reddy & Srujana, (2022).* The performance target is divided into two parts: seismic risk and destruction. The maximum permitted destruction is determined by the seismic performance for a known seismic risk.

This project worked on a (G+10) RCC structure. After the original design, a nonlinear pushover analysis is performed to assess the building's seismic performance and determine whether the predetermined goal has been met. The 11-Story RCC frame building was evaluated and designed using IS 1893 (Part 1): 2016 and IS 456: 2000 for zone 5. The nonlinear static pushover analysis includes autoplastic hinges. STAAD PRO analyses and designs the building; ETABS 2019 examines the displacement-controlled pushover analysis. The pushover curve is calculated using ETABS software and ATC 40. The ETABS provides the structure's performance point, Story displacement, capacity spectrum, Story drift, and demand spectrum. After that, the structure's performance is compared for each situation to find the optimal combination.

2. REVIEW OF THE LITERATURE

This section highlights the updated literature review for performance-based seismic design. The inelastic design approach known as PBSD is used under the varied ground movements. Performance-based plastic design is an improved PBSD approach that is extensively utilized. It is a direct design approach in which the frame component and connector are designed in plastic to obtain the desired performance. So vast research is needed for PBSD and other structures.

Priestley (2000) performed PBSD analysis which is a relatively recent and strong technique for structural engineering generated from ongoing hard attempts to address gaps between actual, observed, and predicted structure performance. The major goal of this research is to evaluate building performance using performance-based seismic design. In the current research, several sets of reinforcement are created at different levels to analyze building performance due to earthquake forces. Finally, the most suited combination of reinforcement is offered, i.e., economical and whose damage is limited to achieve immediate occupancy level. Second, locate the building's performance point and compare its seismic response in terms of base shear, story drift, spectral acceleration, story displacement, and spectral displacements. If the resulting roof displacement is smaller than the goal displacement, the performance-based seismic design will be used. Performance-based design is contrasted with code-based design.

Momen Mohamed. M. Ahmed et al. (2021) suggest that Pushover analysis is advised to determine structures' seismic capability. Vertical buildings with uneven rigidity are susceptible to earthquakes. These buildings' earthquake capabilities must be re-estimated during design. In this work, we compare soft story and setback structures to ordinary (reference) buildings to measure their seismic performance. These forms of vertical irregularities are researched individually, combined in one story, and combined in two separate stories of building models, whereas earlier studies were satisfied with individual examples. Combined vertical irregularity creates weak places that change seismic capabilities, failure mode mechanism, and performance point position.

Three-dimensional numerical models are built to determine response requirements such as vibration period variation, lateral displacement, inter-story drift, pushover curve, and plastic hinge creation. Vertical irregular structures have reduced seismic capability and suffer early damage, according to the study. The basic time period is deceptive in seismic force calculations for vertical geometric irregular constructions and must be rethought. In vertical irregular structures, rapid stiffness changes cause additional lateral displacement and inter-story drift. Combinations of vertical irregularity situations result in negative pushover curves, ductility ratios, and plastic hinge development. According to their irregularity ratio, international regulations require extra structural design considerations for open soft ground story buildings with asymmetric setbacks. Response modification/reduction factor (R) may be reduced to accommodate negative seismic capacity.

Sardiwal et al. (2019) work updates the literature on the performance-based seismic analysis of non-linear multistory buildings using Soft Story. The performance-based seismic design is often called "performance-based plastic design". Overall structural capacity relies on component strength and deformation capacity. A soft story is a story in a structure with insufficient rigidity or flexibility to endure earthquakes. The soft Story is uncovered. A regular structure is better than irregular structure, according to the research. Geometrically uneven structures moved more than normal ones. New seismic design rules demand structural engineers to do both static and dynamic analyses to improve RCC building performance. But the present time and expanding population have led architects and engineers to construct irregular structures that need extensive structural research to assure acceptable behavior after a major earthquake. Regular and irregular media to high-rise structures need seismic analysis.

Rajan and Wankhade (2016) did a performance-based seismic analysis and design for a G+9 Story building structure. When you choose a structure, you have to think about how isolated bases and fixed bases work together to make it. In this study, the percentage of reinforcement increases in different cases when different combinations of beam and column reinforcement are used, and the PBSD is done. Reinforcement makes the inside column less likely to move, but the middle and corner columns move a lot. While the columns and beams have the same amount of reinforcement, the sectional sizes will be smaller, which will make the building less efficient. Changing the reinforcement of a column will make a big difference in how much base force it can hold. He has set the goal for the structure as being able to be used right away and keeping people safe, and this design principle can handle these goals for different levels of earthquake ground motion.

Dilip and Chaudhari (2016) designed a four-story RC building using performance-based seismic design and assessed it using the pushover SAP2000 v17 software. ATC 40 is used for tale drift, capacity spectrum curve, and performance point, while FEMA 273 is used for plastic hinges.

During an earthquake's ground motion, the critical component for nonstructural and structural damage is the Story drift of a multi-story building. Thus, in order to accomplish the building's established aim, the performance-based seismic design gives realistic methods for seismic upgrading the structure.

Dimpleben and Sonwane (2015) initially chose the performance target, then did a preliminary design and evaluation to see if the design fits the objective. After the RC frame construction was designed, it was examined using pushover. This was done in the SAP 2000 program, which changed the main reinforcements at different narrative levels for each component. A moment-resisting building was RC framed. Increasing the column reinforcement improved the building’s performance but reduced the roof displacement. The column’s strengthening increased the base shear. The performance of a building was lowered when the column’s reinforcement was the same as the beams. For asymmetrical buildings, increasing beam and column strengthening reduced roof movement.

Khan (2014) used the N2 technique in SAP 2000. It is used in G+4 symmetrical buildings built in STAAD PRO. This compares the structure’s capacity as measured by inelastic response spectra. The performance point is the two-curve junction. The building is in Zone-IV and is subjected to three Peak Ground Acceleration (PGA) levels. Changing the column beam reinforcement percentage and the beam and column sectional sizes separately produces different results. He found that when the structure is pushed towards higher PGA levels, the roof displacement rises. A higher proportion of reinforcement in the column leads to significant changes in base shear and displacement. With larger beam columns, the base shear rises and the roof displacement reduces. Elastic behavior becomes too inelastic as soil damping rises.

Shashi Shankar et al. (2020) studied the performance of a G+20 symmetrical building using non-linear pushover analysis. In this article, various structural components are reinforced in various ways. Their impact on the structure’s performance is shown. The study uses ETABS to compute the reinforcement and then uses SAP 2000 to calculate non-linearity. Increasing column reinforcements improves the structure’s performance, reduces max roof displacement, and increases base shear. However, reducing the cross-section size of beams and columns reduces the building’s performance. Retaining the reinforcement, when the roof reinforcement is enhanced, the building’s roof displacement is reduced. Hinge formation begins at beam ends, then spreads to upper stories, then to lower stories columns, and finally to upper levels.

The beams and e-columns have hinges, but they are life-safe.

Dubal (2014) **examined the bottom and upper soft stories in a G+9** Story **RCC structure. Initially, he determines the best portion to withstand an earthquake. The findings are nearly identical in all situations; however, the ninth floor has a 72.08 percent higher value. Aside from the final example, the base shear in the PBSD and IS 1893 2002 do not** exhibit any difference.

Panagopoulos (2004) utilize either the time history analysis or the inelastic static analysis euro code in their study for the 3D RCC construction and two distinct seismic loading tools. The most dependable and efficient software for time history analysis is needed, and there is a need for development in this software area. The direct displacement technique is the most accurate way to estimate the roof displacement of the structure for various earthquakes. The seismic activity of structures constructed using the proposed and other DBD techniques is deemed identical.

3. METHODOLOGY

The purpose of this research was to investigate different aspects of PBSD and to get to the root of the problem at hand. Thus, we employed the method outlined below where STAAD pro connection edition was used for the early design and modeling of several instances:

I. Original column section.

II. Increase column size in the x direction by 50mm.

III. Increase column size in the x direction by 100mm.

IV. Increase column size in the x direction by 150mm.

V. Increase column size in the x direction by 200mm.

VI. Increase column size in the y direction by 50mm.

VII. Increase column size in the y direction by 100mm.

VIII. Increase column size in the y direction by 150mm.

IX. Increase column size in the y direction by 200mm.

X. Increase column size in x and y directions by 50mm.

XI. Increase column size in x and y directions by 100mm.

XII. Increase column size in x and y directions by 150mm.

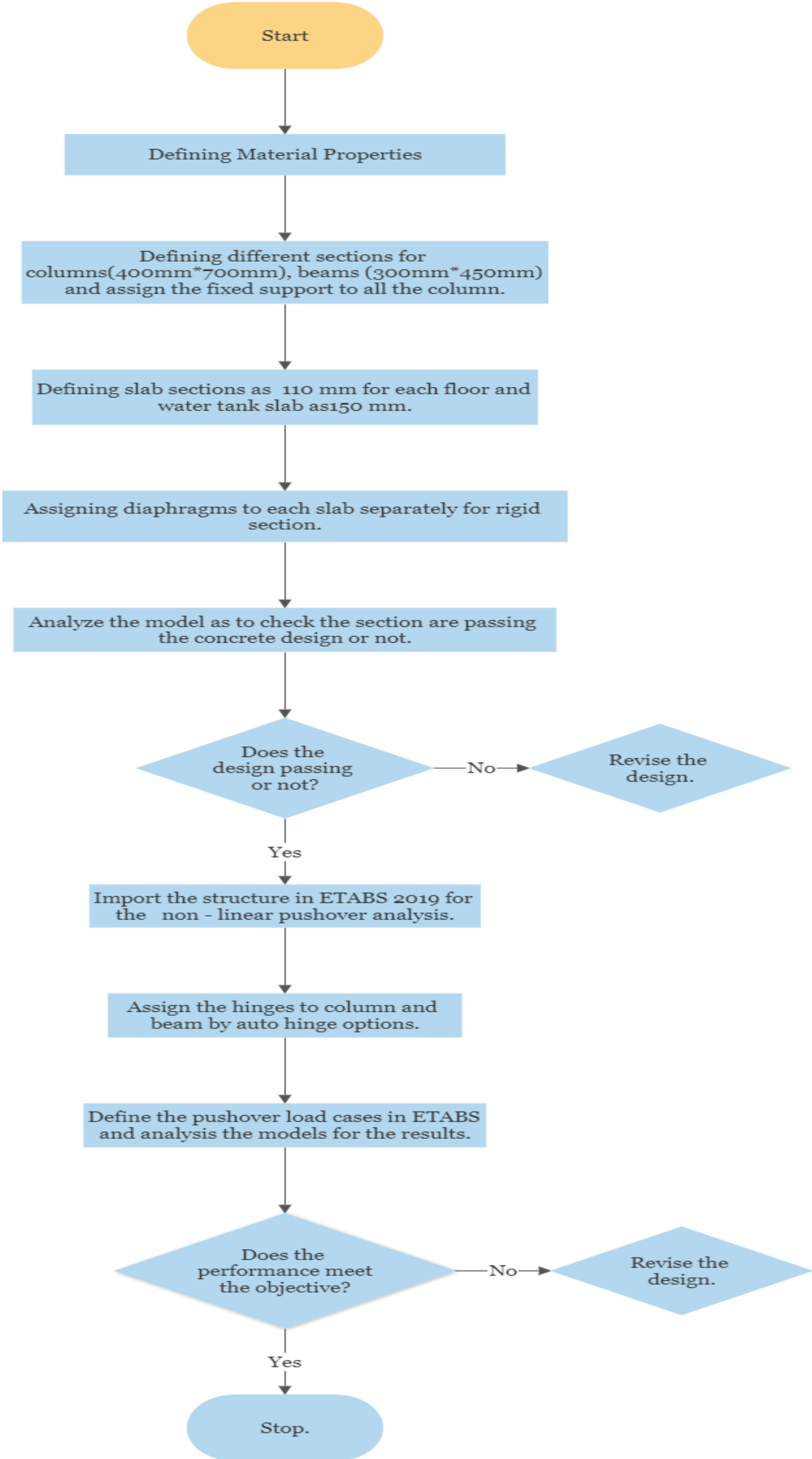
XIII. Increase column size in x and y directions by 200m

XIV. By increasing the column reinforcement by 5%

XV. By increasing the column reinforcement by 10%

XVI. By increasing the column reinforcement by 15%

It was then time to import the structure into ETABS 2019 for a nonlinear pushover analysis and look at how the roof moved. The following steps were used in the STAAD PRO V22 software for modeling and the first design of the building and design was only done for DEAD and LIVE load combinations which can be seen in the following flowchart:


Start
Defining Material Properties
Defining different sections for columns(400mm*700mm), beams (300mm*450mm) and assign the fixed support to all the column.
Defining slab sections as 110 mm for each floor and water tank slab as150 mm.
Assigning diaphragms to each slab separately for rigid section.
Analyze the model as to check the section are passing the concrete design or not.
Does the design passing or not?
No
Revise the design.
Yes
Import the structure in ETABS 2019 for the non - linear pushover analysis.
Assign the hinges to column and beam by auto hinge options.
Define the pushover load cases in ETABS and analysis the models for the results.
Does the performance meet the objective?
No
Revise the design.
Yes
Stop.

3.1. Working Model

Table 1. Building description of frame used

Typology	Ordr
Plan area	10.012m x 16.670m
No of story	11
Story height	3.35m
Slab thickness	For floor slab 110mm For water tank 150mm
Column section	400mmx 700mm
Beam section	250mm x 450mm
Secondary beam	150mm x 450mm
Grade of concrete	M20
Grade of steel	Fe500
Live load	As per is code 375 Part II
Dead load	As per calculation Mention in ANNEXURE
Importance factor	1
Response reduction factor	5
Seismic zone	V
Seismic zone factor	0.36
Soil type	Medium Soil
Damping ratio	0.05%

A version of STAAD PRO called Connect was used to make the structure. To run the nonlinear pushover analysis, it is first imported into the ETABS platform. The sectional size of the column is then changed to make the pushover analysis more accurate. In the first section, the column's width grows in the x direction. Then, the column's width grows in the Y direction. Then, the sectional size of the column grows in both directions at the same time, but the same amount of reinforcement is used. These changes were made after this percentage reinforcement was increased by 5%, 10%, and 15%, and then pushover tests were done to see what happens.

The building’s plan view showed that it was not symmetrical hence the structure’s elevation was modeled as indicated in Figure1.

Material properties are conferred on the structure. For instance, concrete characteristics are specified for each floor slab in a grade M20 structure, and sectional properties are assumed for members.

STAAD PRO allocated the following sections:

a) The columns are 400x700mm.

c) The main beams are 300x450mm.

c) Secondary beams are 250x450mm.

3.2. Enigma

This section aims to validate the project’s methods. The model was built in STAAD PRO using the paper’s description and comparing the reference model’s story displacement, capacity spectrum, and inter-story drift with each other as per DCM and CSM methods. The slab thickness at the floor level is 110mm, but at the water tank level it is 150mm, and the shear wall is also 150mm thick.

After then, the structure’s foundation was used as permanent support in this construction. Now all the slabs are chosen as a stiff action diaphragm. The slab should be placed independently at a common connection situated in the center of each slab. The superstructure is then assigned various load conditions as follows:

I. The structure’s self–weight was applied negatively.

II. The live load is applied as per IS code 375-part II 1987 for the bedroom and toilet, 3kN/m2 for the balcony, and 12kN/m2 for the lift and water tank.

III. The seismic load was determined in X and Z directions, and then applied to the structure as per IS code 1893:2016. Then the IS code 456:2000 load condition is made and the analysis is done. The model is then loaded into RCDC for concrete design following IS 456:2000 and, then the reinforcing detailing was done.

IV. The model is loaded into ETABS 2019 for the pushover analysis before the analysis hinges are allocated for the beam and column. M3 hinges are used on the beam. The column PMM hinges specify the load pattern for the pushover analysis. First, run the model and look for any warnings. Then run the model with simply gravity load and then with (DL +0.25LL < 3kN/m2 +0.5LL > 3kN/m2). A pushover analysis was then performed on the structure, pushing it to the desired displacement.

The following assumptions were made throughout the design process:

I. The material is isotropic, homogeneous, and linearly elastic in nature.

II. It is believed that the supports are fixed.

III. M3 hinges are assumed for the beam, whereas PMM hinges are assumed for the column.

IV. It is believed that the construction is built for immediate occupation. Since the structure is 39.650m tall thus as a result, roof displacement based on performance level will be 0.7 x 39.650 x 1000/100 = 277mm that means maximum roof displacement must be less than 277 mm.

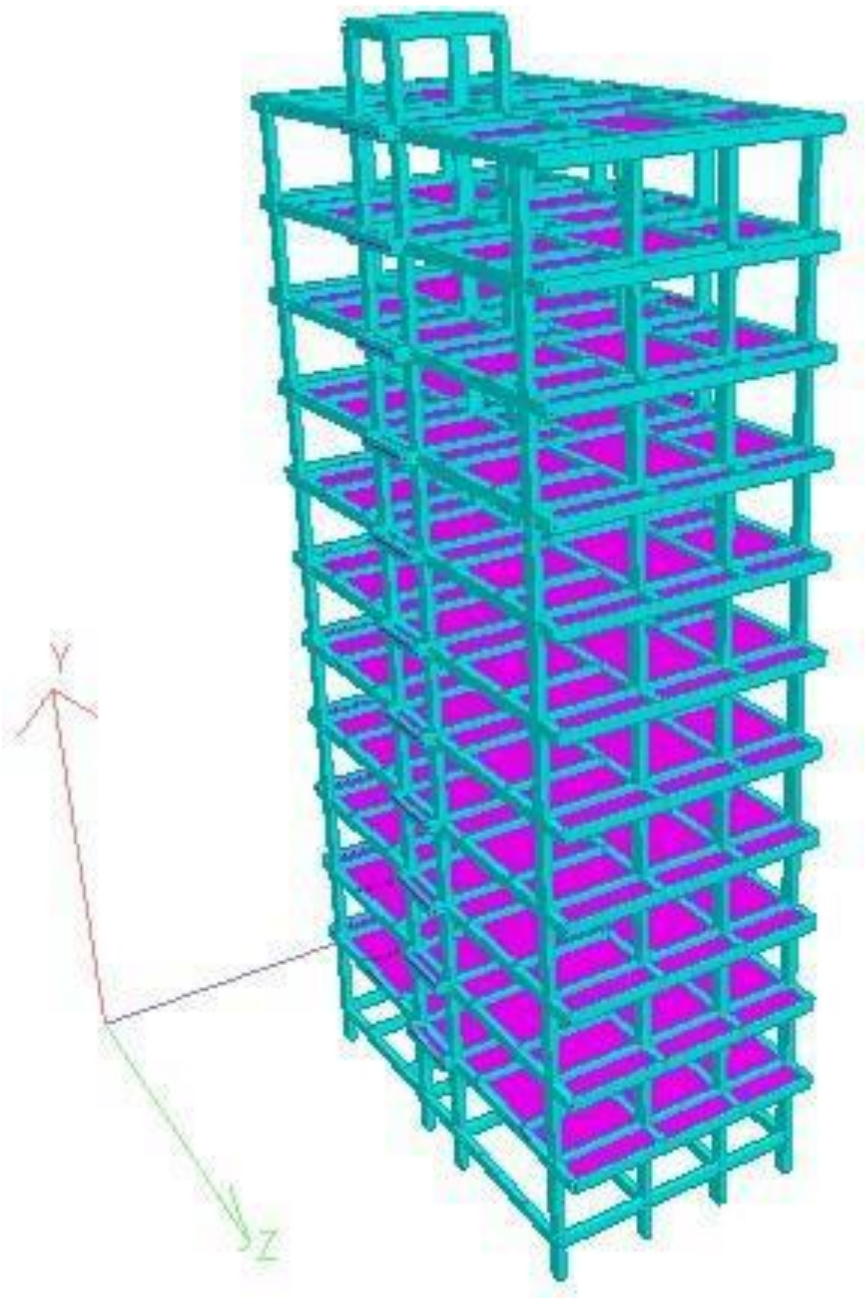


Fig 1. 3D figure of structure from Staad Pro

4. RESULTS

The structure's outcomes can be compared and studied against many parameters. In this project, ETABS 2019 simulates an eleven-story RCC framed building with a height-wise distribution of lateral force. The push curve between displacement and base shear is also derived for inelastic response spectra.

Strengthening reinforcement lowers roof displacement by 2.27 percent for a 5% increase, 6.312 percent for a 10% increase, and 6.912 percent for a 15% increase in the column. Every 5% increase in roof reinforcement reduces roof displacement by 2.45%. The roof displacement is decreased by 5.92% and by 7.42% by adding 15% reinforcement. based on 5%, 10%, and 15% reinforcement modifications in the column The data reveal that adding reinforcement increases base shear by 5.13 percent per 5% and 8.42 percent per 10%. The base shear rises by 4.49 percent for a 5% reinforcement change, 9.43 percent for a 10% reinforcement change, and 18.46 percent for a 15% reinforcement change. The column size is raised by 50 mm, 100 mm, 150 mm, and 200 mm along X direction to lower the roof displacement by 3.97 percent, 6.58 percent, 8.58 percent, and 9.72 percent, respectively. It decreases roof displacement by 4.17 percent for 50mm, 6.89 percent for 100mm, 9.17 percent for 150mm, and 10.35 percent for 200mm. Using the DCM approach, the base shear rises by 5.15 percent for 50mm columns, 9.79 percent for 100mm columns, 14.25 percent for 150mm columns, and 19.15 percent for 200mm columns. It also increases roof displacement by 5.08 percent for 50mm adjustments, 9.64 percent for 100mm changes, 13.95 percent for 150mm changes and 28.13 percent for 200mm. The column size is raised by 50 mm, 100 mm, 150 mm, and 200 mm along the Y direction to lower the roof displacement by 1.68 percent, 2.01%, 3.53 percent, and 4.25 percent respectively. Roof displacements of 50mm, 100mm, 150mm, and 200mm are reduced by 1.50 percent using CSM. If the column size is increased by 50 mm, 3.86 percent, 4.59 percent, or 5.59 percent (using the DCM approach), the base shear increases by 1.65 percent. For 50mm, 100mm, 150mm, and 200mm alterations together along X and Y directions, the CSM technique increases roof displacement by 1.910 percent. The roof displacement lowers by 4.49 percent with a 50mm column increase, 8.022 percent with a 100mm increase, 10.210 percent with a 150mm increase, and 11.297 percent with a 200mm increase. The CSM technique decreases roof displacement by 4.24 percent for 50mm modifications, 6.96 percent for 100mm changes, 10.98 percent for 150mm changes, and 10.35 percent for 200mm changes, but increases roof displacement. The base shear rises by 6.25 percent for every 50mm column, 12.85 percent for every 100mm column, 19.627 percent for every 150mm column, and 26.71 percent for every 200mm column. It raises roof displacement by 7.51 percent for 50mm, 13.92 percent for 100mm changes, 19.44 percent for 150mm and 28.13 percent for 200mm.

Changing the reinforcement has a significant impact on the roof displacement and base shear as shown in Figure 2. Changing the sectional size of the column has a significant impact on the roof displacement and base shear as shown in Figure 6. These are all displacement-controlled results.

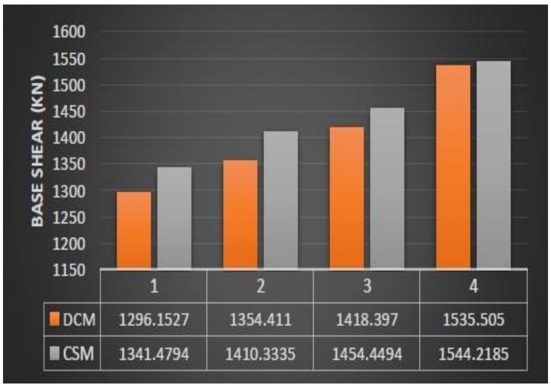
A change in reinforcement affects roof displacement and base shear, whereas a change in sectional size affects both. Figures 3 and 5 show the impact of changing reinforcement on roof displacement and base shear, respectively. These are all capacity spectrum results. The performance point and push-over curves are determined using acceleration displacement spectra. The performance point is when the structure's capacity and demand meet. The figure shows the base shear and displacement variation for each scenario.

4.1. Effects of change of reinforcement on the displacement in the roof and the base shea

The differences are seen in Figures 2 and 3.

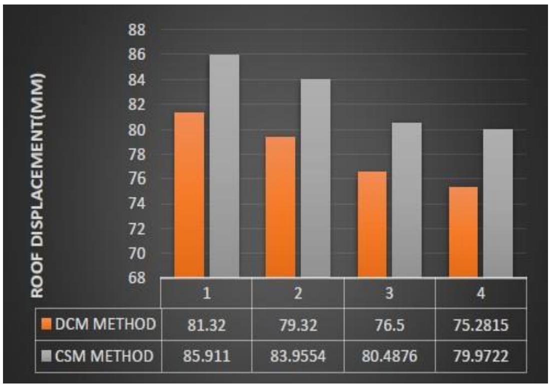
4.2. Effects of change of sectional size of the column in the X direction on the displacement in the roof and the base shear.

The differences are seen in Figures 4 and 5.



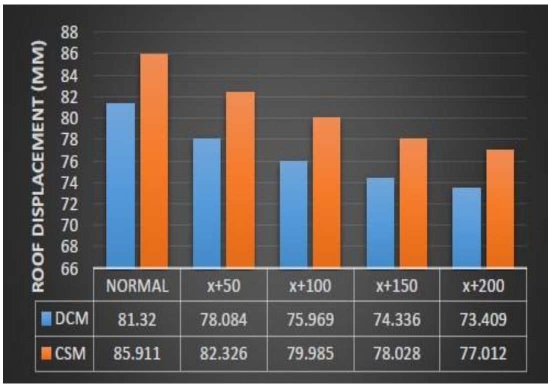
CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	85.911	--------	1341.479	---------
5%	83.9554	-2.276	1410.334	5.1326
10%	80.4876	-6.312	1454.449	8.4212
15%	79.9722	-6.912	1544.219	15.1130

Fig 2 Modifications to the base shear and Displacement in the roof and base shear as per DCM method



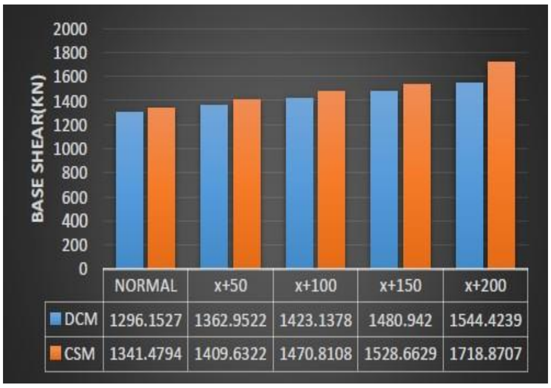
CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	81.32	-------	1296.153	--------
5%	79.32	-2.4594	1354.411	4.4947
10%	76.50	-5.9272	1418.397	9.4313
15%	75.2815	-7.4256	1535.505	18.4663

Fig 3. Changes in the displacement of the roof and Displacement in the roof and base shear as per CSM method



CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	81.32	-------	1296.153	--------
X+50	78.084	-3.97	1362.952	5.1536
X+100	75.969	-6.58	1423.138	9.7970
X+150	74.336	-8.58	1480.942	14.2567
X+200	73.409	-9.72	1544.424	19.1544

Fig 4. Changes in the displacement of the roof and Displacement in the roof and base shear as per DCM method



CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	85.911	-------	1341.4794	--------
X+50	82.326	-4.17	1409.6322	5.08
X+100	79.985	-6.89	1470.8108	9.64
X+150	78.028	-9.17	1528.6629	13.95
X+200	77.012	-10.35	1787.07	28.13

Fig 5. Modifications to the base shear and Displacement in the roof and base shear as per CSM method

4.3. Effects of change of sectional size of the column in the Y direction on the displacement in the roof and the base shear

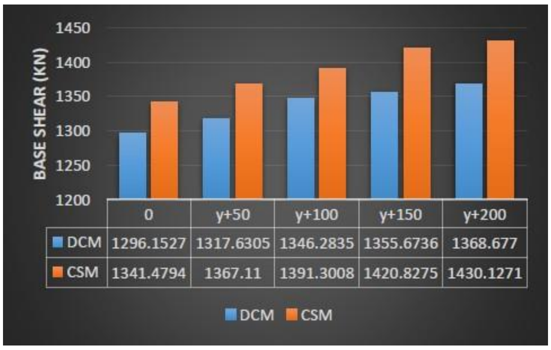
The differences are seen in Figures 6 and 7.

4.4. Effect of change of sectional size of the column in X and Y directions on the displacement in the roof and the base shear

The differences are seen in Figures 8 and 9.

CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	81.32	------	1296.153	-------
Y+50	79.948	-1.68	1317.63	1.65
Y+100	79.681	-2.01	1346.28	3.86
Y+150	78.447	-3.53	1355.67	4.59
Y+200	77.86	-4.25	1368.677	5.59

Fig 6. Changes in the displacement of the roof and Displacement in the roof and base shear as per DCM method



CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	85.911	------	1341.479	-------
Y+50	84.619	-1.50	1367.11	1.910
Y+100	83.942	-2.19	1391.301	3.710
Y+150	83.81	-2.44	1420.828	5.914
Y+200	82.917	-3.485	1430.127	6.608

Fig 7. Modifications to the base shear and Displacement in the roof and base shear as per CSM method

CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	81.32		1296.153	
X+50,Y+50	77.281	-4.966	1377.247	6.256
X+100,Y+100	74.796	-8.022	1462.715	12.850
X+150,Y+150	73.017	-10.210	1550.559	19.627
X+200,Y+200	72.133	-11.297	1642.364	26.710

Fig 8. Changes in the displacement of the roof and Displacement in the roof and base shear as per DCM method

CASES	DISPLACEMENT IN ROOF (mm)	% CHANGE IN DISPLACEMENT IN ROOF	BASE SHEAR(kN)	%CHANGE IN BASE SHEAR
NORMAL	85.911	------	1341.479	-------
Y+50	82.261	-4.24	1442.267	7.51
Y+100	79.928	-6.96	1528.286	13.92
Y+150	76.47	-10.98	1602.384	19.44
Y+200	77.012	-10.35	1781.871	28.13

Fig 9. Modifications to the base shear and Displacement in the roof and base shear as per CSM method

5. CONCLUSION

After looking over the results for the various situations of the model discussed in this work, the conclusion is made, and the following points may be interpreted:

1) Increased column strengthening results in a reduction of roof displacement and shear at the base as seen in Figures 10-12.

2) Due to the fact that the moment of inertia is greater in the X direction than in the Y direction, when the sectional size is raised, only the X direction is enlarged. As a result, the roof displacement is decreased by 9.72 percent, while the roof displacement is reduced by just 4.25 percent whereas the base shear is enhanced by 19.154 percent in the higher moment of inertia direction, but only by 5.59 percent in the lower moment of inertia direction, when the sectional size is raised in the Y direction as seen in Figures 13-16.

3) According to the CSM technique, when the column size is raised in both directions, the roof displacement decreases, and when the base shear is increased, the roof displacement increases. However, when the column size is increased in both directions above 150 mm, the roof displacement increases as seen in Figures 17-18.

4) The pushover is the ideal instrument for analyzing the structure since it pushes the structure to its limit value under the given earthquake, providing valuable information for the structure's design. The figure in the section Base Shear vs. Monitored Displacement details the hinges at each step during various analytical courses. The rooftop's maximum displacement was 277mm.

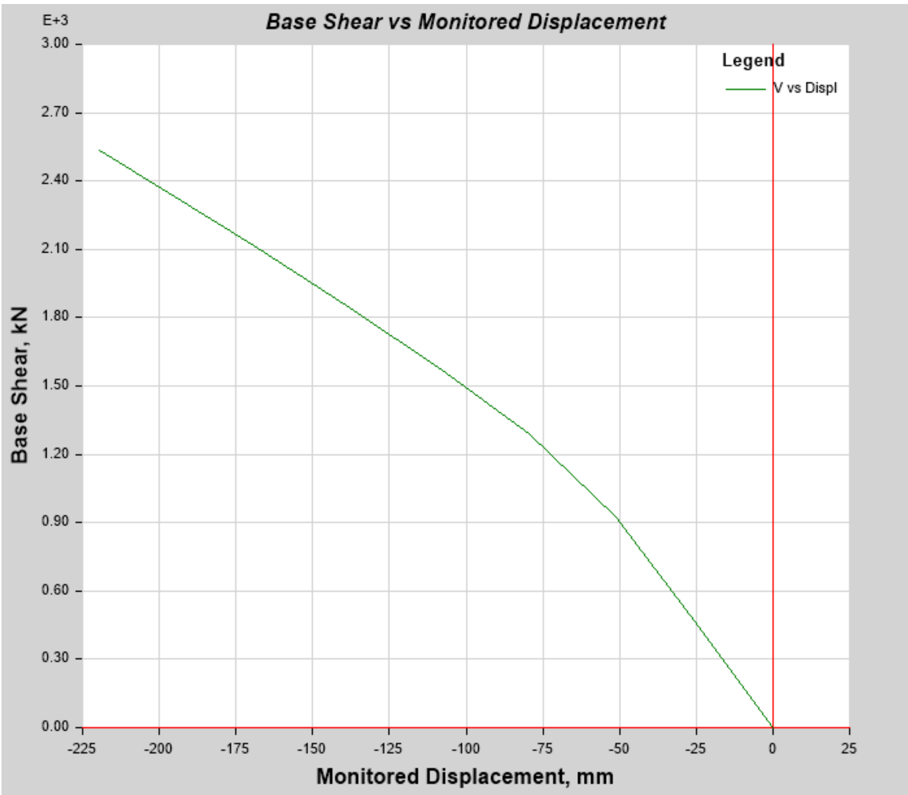


Fig 10. Base Shear vs Monitored Displacement when reinforcement is changed by 5%

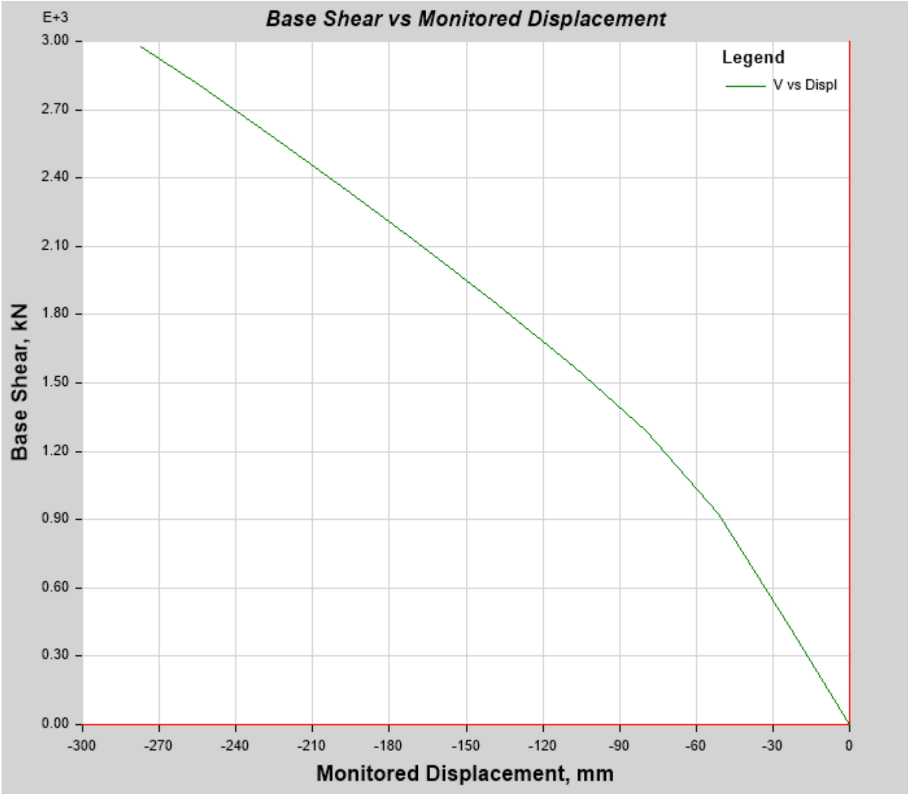


Fig 11. Base Shear vs Monitored Displacement when reinforcement is changed by 10%

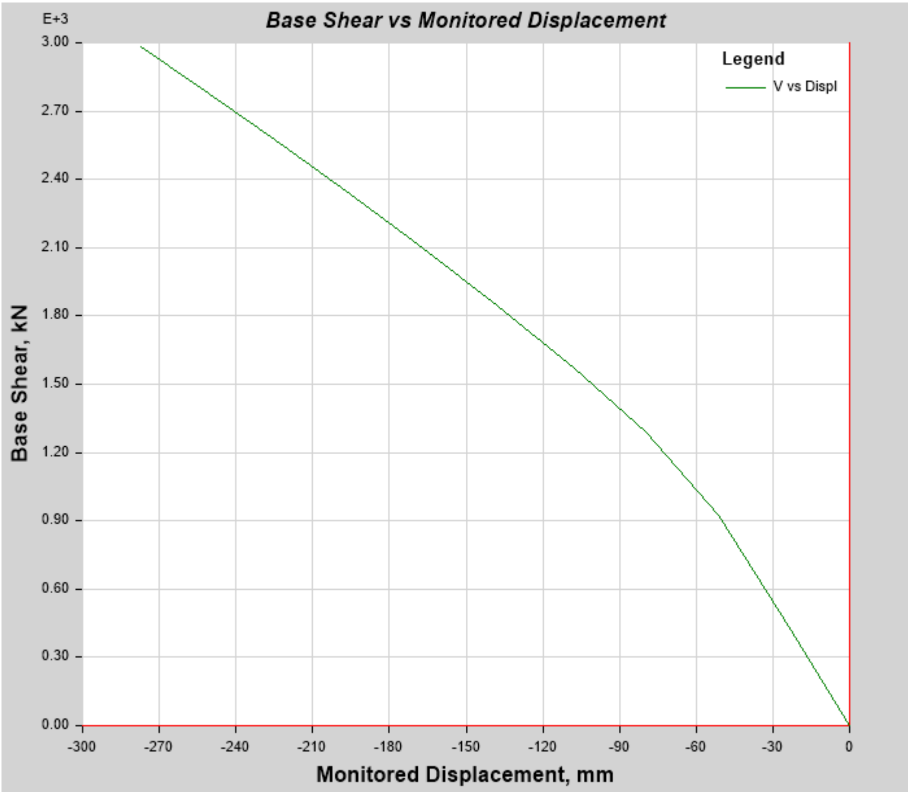


Fig 12. Base Shear vs Monitored Displacement when reinforcement is changed by 15%

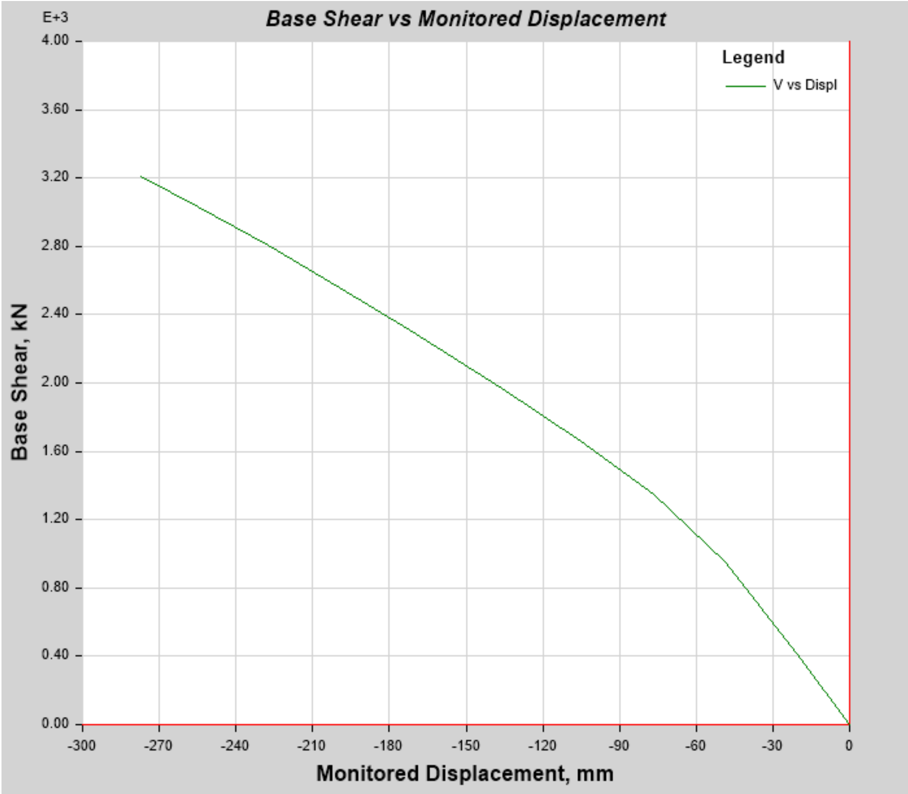


Fig 13. Base Shear vs Monitored Displacement when column section in X direction is changed by 50mm

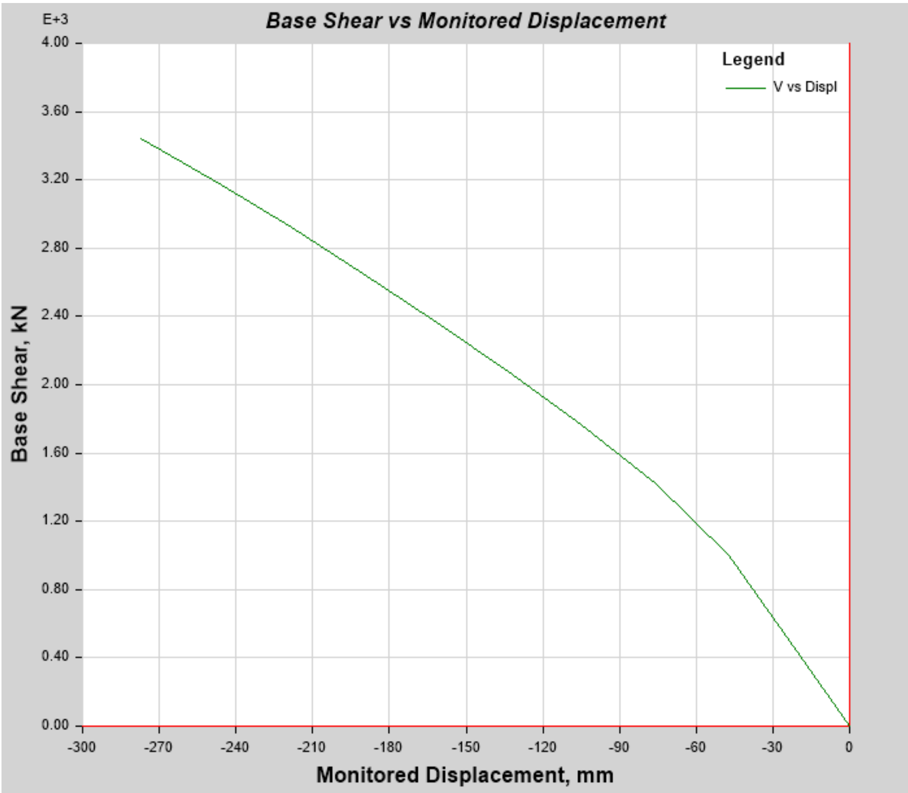


Fig 14. Base Shear vs Monitored Displacement when column section in X direction is changed by 100mm

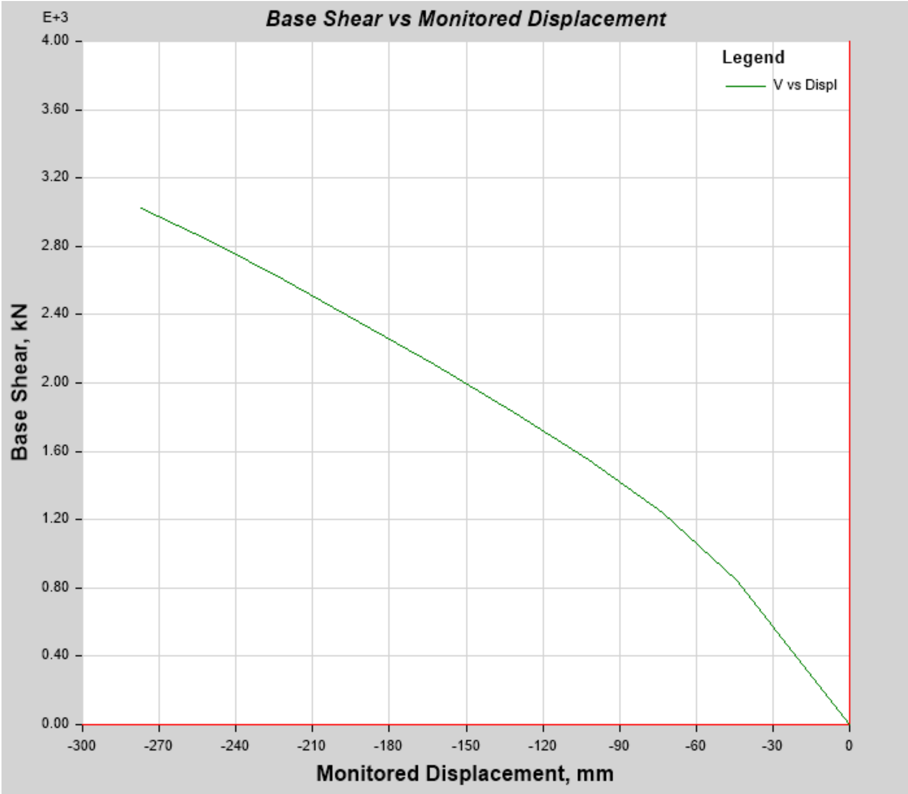


Fig 15. Base Shear vs Monitored Displacement when column section in Y direction is changed by 50mm

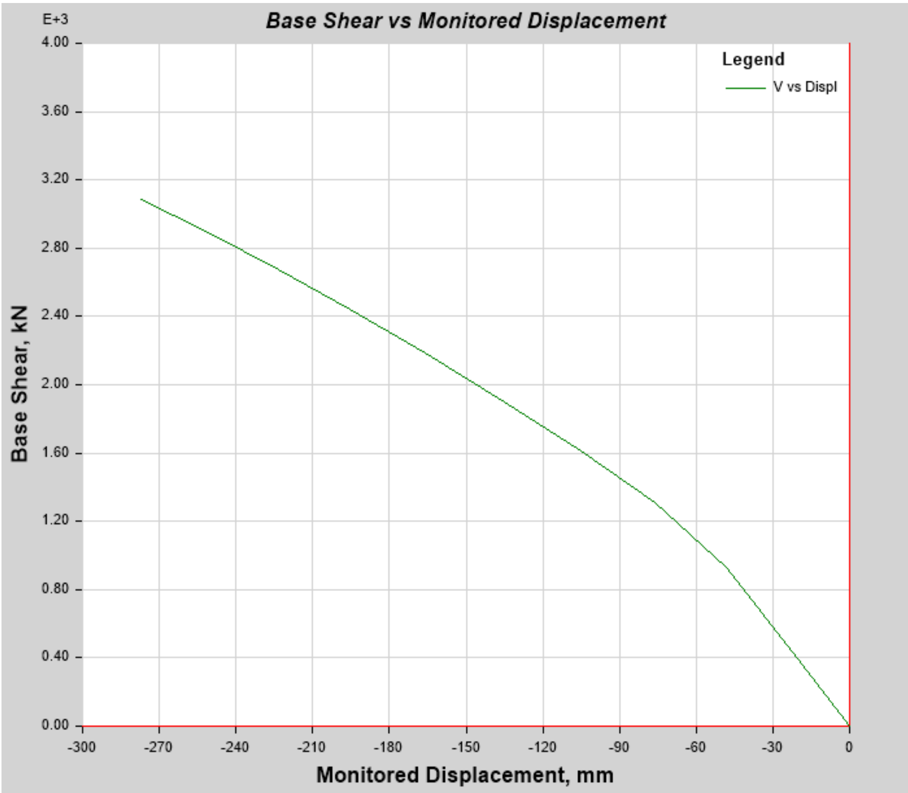


Fig 16. Base Shear vs Monitored Displacement when column section in Y direction is changed by 100mm

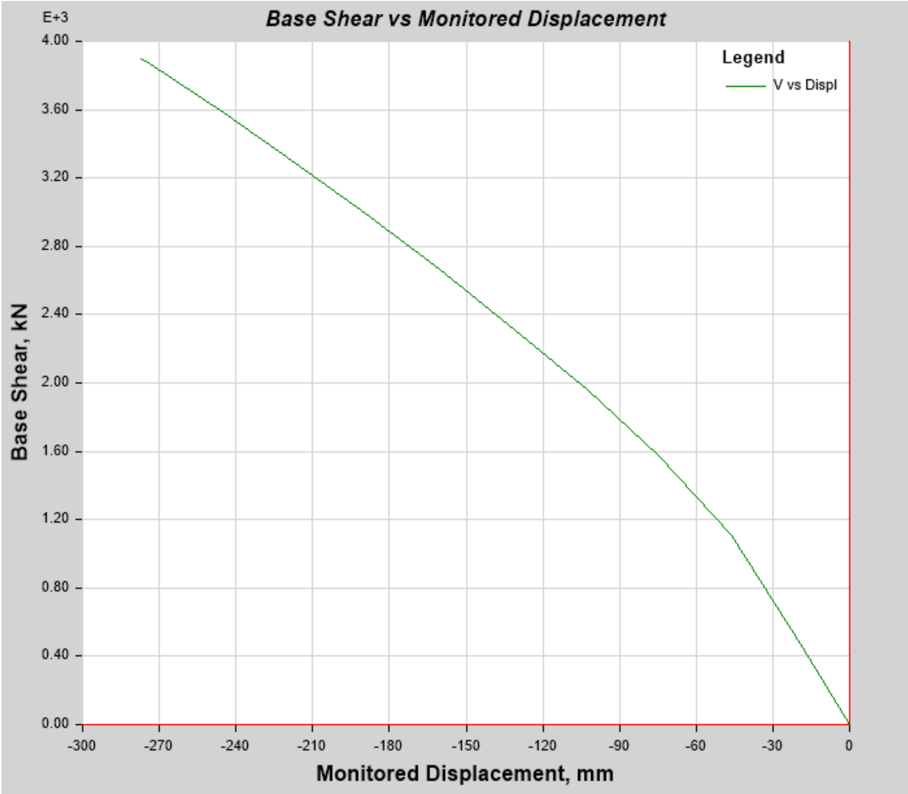


Fig 17. Base Shear vs Monitored Displacement when column section in X & Y direction is changed by 150mm

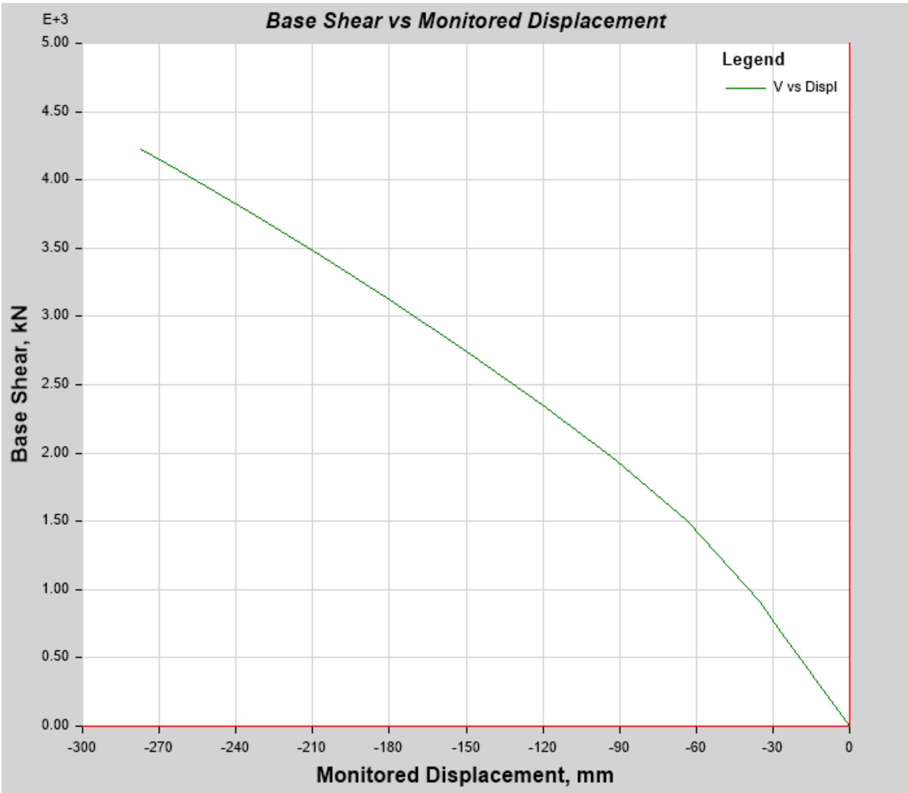


Fig 18. Base Shear vs Monitored Displacement when column section in X & Y direction is changed by 200mm

APPENDIX

Dead Load Calculation for the Building

Wall load = [(floor ht. - beam depth) *density of the brick*wall thickness] = (3.5 - 0.5) * 0.254 *18 = 13.72 *kN/m*

Balcony wall load = [(balcony ht.*wall thickness*density of the brick)] = 1 * 0.125 *18 = 2.25 *kN/m*

Parapet load = [parapet ht.*density of the brick*wall thickness] =1 ∗ 0.125 ∗ 18 = 2.25 *kN/m*

REFERENCES

Ahmed, M., Abdo, M., & Mohamed, W. (2021). Vertical Geometric Irregularity Effect on Performance-Based Seismic Design for Moderate Rise RC Moment Resisting Frame Buildings. *Arabian Journal For Science And Engineering*. doi: 10.1007/s13369-021-06376-y

Dya, A., & Oretaa, A. (2015). Seismic Vulnerability Assessment of Soft Story Irregular Buildings Using Pushover Analysis. *Procedia Engineering*,r*125*, 925-932. doi: 10.1016/j.proeng.2015.11.103

Meghana Reddy, E., & Srujana, N. (2022). Performance Assessment of RCC Structure Using Nonlinear Analysis.h*IOP Conference Series: Earth And Environmental Science*,O*982*(1), 012077. doi: 10.1088/1755-1315/982/1/012077

Priestley, M. J. N. (2000). Performance based seismic design. *Bulletin of the New Zealand society for earthquake engineering*, *33*(3), 325-346.

Sardiwal, D., Shinde, R., & Victor, O. (2019). A performance based seismic analysis of irregular multi-Story building with soft-Story: A review. i*PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON SUSTAINABLE MATERIALS AND STRUCTURES FOR CIVIL INFRASTRUCTURES (SMSCI2019)*. doi: 10.1063/1.5127132

Seismic Analysis of Multi-Story Rcc Building and STEEL Building using Etabs. (2017). N *International Journal Of Advance Engineering And Research Development*, n*4* (07). doi: 10.21090/ijaerd.86590

Sumit, & Gupta, S. (2019). Performance-Based Seismic Evaluation of Multi-Story R.C.C. Building with Addition of Shear Wall. *Lecture Notes in Civil Engineering*, 49-61. doi: 10.1007/978-981-13-6717-5_6

Yurizka, H., & Rosyidah, A. (2020). The Performance of Irregular Building Structures Using Pushover Analysis. *Logic: Jurnal Rancang Bangun Dan Teknologi*, o*20*(2), 65-72. doi: 10.31940/logic.v20i2.1456

Ö2), 65-72. doi: 10.31940/logic.v20i2.1456rformance of Irregular Building Structures Using Pushover *Structures*, t*5*, 112-122. doi: 10.1016/j.istruc.2015.10.001

Awasthi GGJ (2016)

Dilip J, Chaudhari GO (2016) Performance-Based Seismic Design of. Open Journal of Civil Engineering 6: 188–194

Dimpleben P, Sonwane PD (2015) Seismic Performance-based Design of Reinforced Con- crete Buildings using Nonlinear Pushover Analysis. International Journal of Engineering Research & Technology

Dubal GNR (2014) Application OF Performance-Based Seismic Design Method To Rein- forced Concrete Moment Resistant Frame With Vertical Geometric Irregularity With Soft Story. American Journal of Engineering Research.

Khan DR (2014) Performance-Based Seismic Design of Reinforced Concrete Building.

International Journal of Innovative Research in Science Engineering and Technology Leslie R (2018) The Pushover Analysis is explained in its Simplicity. Assistant Director,

Buildings Design, DRIQ Board. Kerala PWD, Trivandrum

Mr, Ingale PMC (2017) PERFORMANCE-BASED SEISMIC DESIGN OF RCC BUILD-

ING. International Research Journal of Engineering and Technology

Panagopoulos AJ (2004) PERFORMANCE-BASED SEISMIC DESIGN OF 3D R/C

BUILDINGS. Journal of Earthquake Technology

Rajan L, Wankhade AB (2016) Performance-Based Analysis and Design of Building Frames with Earthquake. International Journal of Engineering Research Shankar S, T M (2020) Themelis S (2008)

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