Seismic Analysis of Multistoried RCC Building due to Mass Irregularity by Time History Analysis

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Abstract

From past earthquake it is observed that if the structures are not properly analyzed and constructed with the required quality, then it may lead great destruction and loss to human lives. It is proved that many of structure are totally or partially damaged due to earthquake. So it is necessary to determine seismic response of such buildings. There are different techniques of seismic analysis of structure. Among them time history analysis is one of the most important techniques for structural seismic analysis generally the evaluated structural response in non linear in nature. In this project work seismic analysis of multistoried building with mass irregularity at different floor level are carried out. Here a G+12 stories building with mass irregularity has been modeled for seismic analysis. In this thesis design of structure for this building is carried out by using ETABS software and computer-aided analysis. One regular building and three irregular buildings are compared. They have same plan size but mass irregularity is considered at 6th floor, 8th floor and 10th floor of the building. The stability checking such as storey drift, overturning moment and sliding are also checked in the building with static analysis and also with dynamic analysis (time history analysis). And then, after the models with and without change of mass and inter-storeyed height are being analyzed, structural response (storey drift, storey shear and storey moment) and member forces are compared.

KEY WORDS; Seismic Responses, Seismic Demands, Time History Analysis, Mass Irregularity, Storey Drift, Storey Shear, Storey Displacements, Story Moments, ETABS.

INTRODUCING

Our world is facing a threat of natural disasters from time to time. Earthquakes are one of the most unpredictable and devastating of all natural disasters. However the occurrence of earthquakes cannot be predicted and prevented but we can design the structures to resist such earthquake forces. Reinforced concrete building can adequately resist both horizontal and vertical load. During an earthquake, failure of structure starts at points of weakness. Generally weakness is due to geometry, mass discontinuity and stiffness of structure. The primary objective in designing an earthquake resistant structure is to ensure that the building has enough ductility to withstand the earthquake load. The performance of building during an earthquake depends upon several factors such as stiffness, ductility, lateral strength, Simple and regular configuration. My work focuses on study of multi storied RCC building with Mass irregularity.

The main parameters consider in this study are to compare the seismic performance of storey shear and storey displacement and storey moments.

OBJECTIVE

The objectives of this study are as follows:

1. To analyze a multistoried RC building (G +11 Storey) with change of mass and inter storey height by using Time History Analysis.
2. To compare seismic behavior of multistoried RC building for particular time history in terms of response.
3. To study the effects of seismic on performance of multistory building in term of seismic responses such as base shear and storey displacement.
4. To know the comparison results for dynamic analysis.
5. To compare the structural behavior of high-rise multistoried RC buildings with and without change of mass and inter-storied height

REGULAR AND IRREGULAR CONFIGURATION

Five types of **vertical structural** irregularities are -

1. Stiffness irregularity-soft storey
2. Weight (mass) irregularity
3. Vertical geometric irregularity
4. In-plane discontinuity in vertical elements resisting lateral force
5. Discontinuity in capacity-weak storey

Five types of **plan structural** irregularities are

1. Torsional irregularity
2. Re-entrant corners
3. Diaphragm discontinuity
4. Out-of-plane offsets
5. Nonparallel systems

DATA PREPARATION, MODELING AND ANALYSIS OF THE PROPOSED BUILDING

Structural Configuration and Material Properties of the Structure

1. Type of Structure : Twelve storey RCC building
2. Area of Building : Maximum length = 25m
   Maximum width = 18m
3. Height of Building :
   Ground Floor height = 4m
   Typical Floor height = 3m
   Total Height =37m
4. Shape of Building : Rectangular

Material properties used for proposed building

1. Yield strength of reinforcing bars, f_y = 500 N/mm^2
2. Compressive strength of concrete, f'_c = 30 N/mm^2
3. Yield strength of structural steel, F_y = 500 N/mm^2
4. Ultimate strength of structural steel,F_u=500 N/mm^2
5. Weight per unit volume of concrete = 24 kN/mm^2
6. Poisson's ratio = 0.2
7. Coefficient of thermal expansion = 9.9×10^{-6} mm/mm per °F

Required Data for Loading

1. unit weight of concrete = 24 kN/mm^2
2. 230mm thick brick wall weight =14 kN/m
3. Live load on typical floor = 4 kN/m^2
4. Live load on roof = 2 kN/m^2
5. Live load on stair case = 4 kN/m^2

Earthquake Load

1. Seismic zone = Zone IV
2. Seismic zone factor, Z = 0.24
3. Soil profile type = II, medium
4. Allowable bearing pressure = 200 kN/m^3
5. Seismic important factor, I = 1.00
6. Response modification factor, R = 5
7. Seismic coefficient = 2.5
8. Structural system = Special moment-resisting frame system

Design load combinations for static analysis

1. 1.5 DL
2. 1.5 DL+1.5 LL
3. 1.2 DL+1.2 EQX+1.2 LL
4. 1.2 DL-1.2 EQX+1.2 LL
5. 1.2 DL+1.2 EQY+1.2 LL
6. 1.2 DL-1.2 EQY+1.2 LL
7. 1.5 DL+1.5 EQX
8. 1.5 DL-1.5 EQX
9. 1.5 DL+1.5 EQY
10. 1.5 DL-1.5 EQY
11. 0.9 DL+1.5 EQX
12. 0.9 DL-1.5 EQX
13. 0.9 DL+1.5 EQY
14. 0.9 DL-1.5 EQY

Design Load Combinations for Time History Analysis

Load Comb. Name	Load Case/ Load Factor			
	DEAD	LIVE	EQX	EQY
COMB1	1.05	1.275	1.4025	-
COMB2	1.05	1.275	-1.4025	-
COMB3	1.05	1.275	-	1.4025
COMB4	1.05	1.275	-	-1.4025
COMB5	0.9	-	1.43	-
COMB6	0.9	-	-1.43	-
COMB7	0.9	-	-	1.43
COMB8	0.9	-	-	-1.43

Design Results for Column & Beam Sections

C1 = 300x450 mm (all exterior columns)
C2 = 500x500 mm (all interior columns)
B = 300x450 mm (for the whole structure)

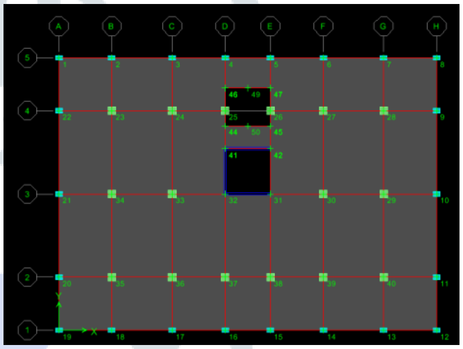

Fig.1. Typical Column Layout Plan

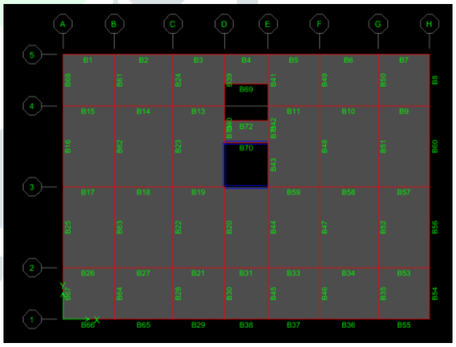

Fig.2. Typical Bean layout plan

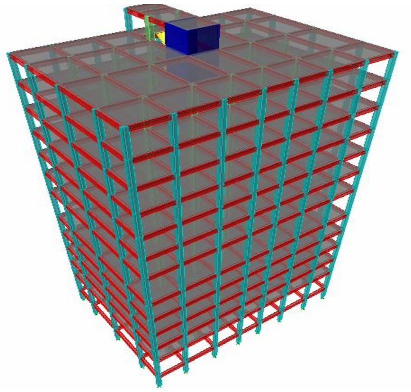

Fig.3.3D view of the building

DYNAMIC ANALYSIS AND COMPARISON OF STRUCTURAL RESPONSE

In this study, the structure is initially analyzed and designed with static analysis. The stability checks are also made in the proposed building with static analysis. It is found that the safety factor values are satisfied within allowable limits. The proposed building with and without change of mass and inter-storeyed height is also analyzed with dynamic analysis. For dynamic analysis, time history analysis is used in this study. After analyzing the model with and without change of mass and inter-storeyed height, the analysis results of the structures are compared.

Comparison of Storey Drift

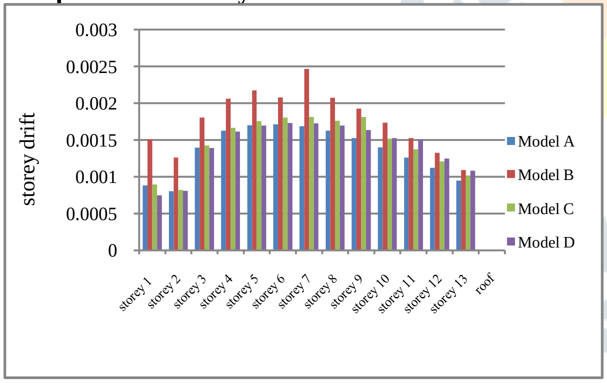

Fig.4. Comparison of Storey Drift in X-direction

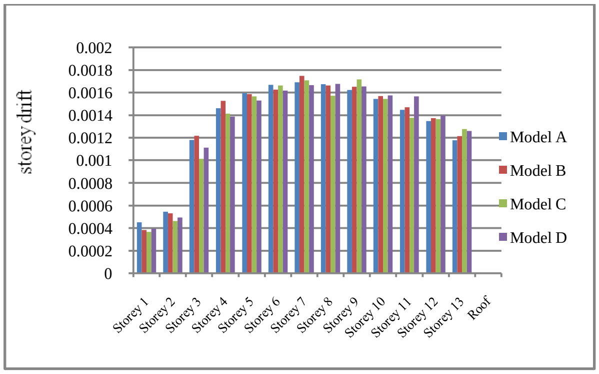

Fig.5. Comparison of Storey Drift in Y-direction

The maximum storey drifts occur in storey seven in X-direction and in storey seven in Y-direction. The values of storey drift in model B are the maximum in both directions.

Comparison of Storey shear

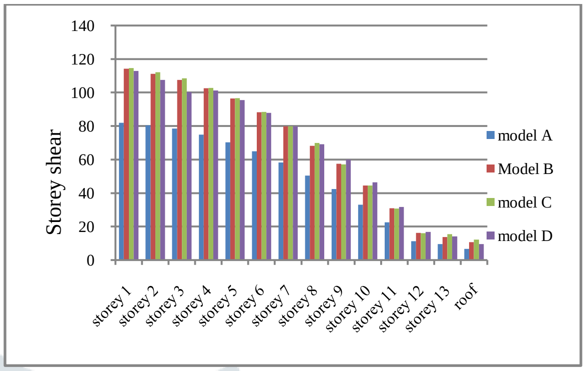

Fig.6. Comparison of Storey Shear in X-direction

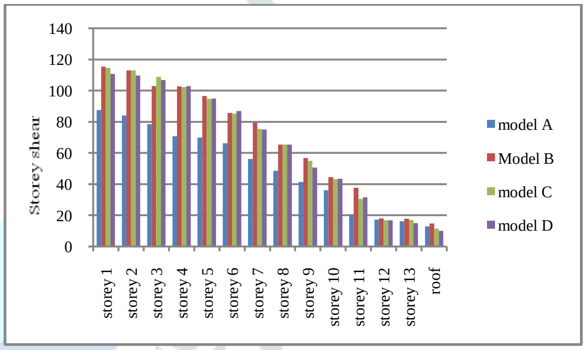

Fig.7. Comparison of Storey Shear in Y-direction

The maximum storey shear occurs in storey one in both X-direction and Y-direction displacement. In X-direction, the value of model C for storey one is larger than that of other models. The values of storey shear of model B and model C are nearly the same in both directions. The values of storey shear of model A and model C are 81.9 kN and 112.93 kN respectively in X-direction. In Y-direction, the values of model A and model D are 81.53 kN and 110.68 kN.

Comparison of Storey Moment

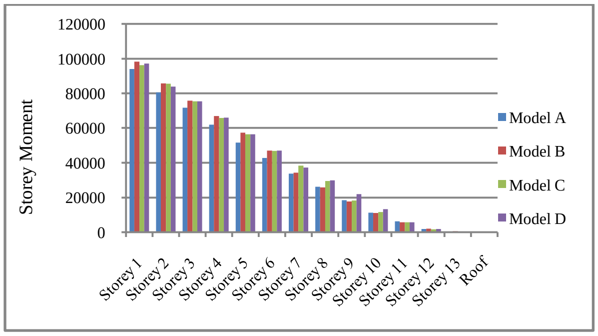

Fig.8. Comparison of Storey Moment in X-direction

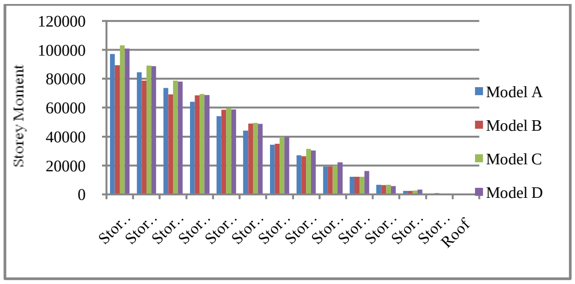

Fig.9. Comparison of Storey Moment in Y-direction

The maximum storey moments occur in storey one in both X-direction and Y-direction displacement. The maximum storey moment in X-direction occurs at model B and that in Y-direction at model C.

Comparison of Member Forces for Change of Mass and Inter-storeyed Height

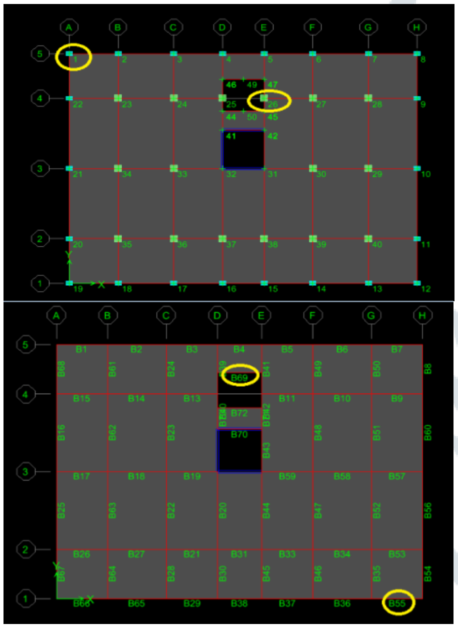

Fig.10. Location of Selected Columns and Beams

Comparison of member forces for columns

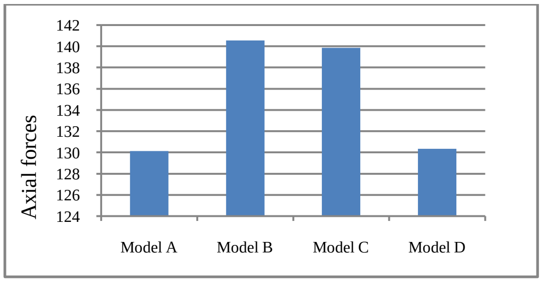

Fig.11. Maximum Axial Forces for Corner Column C1

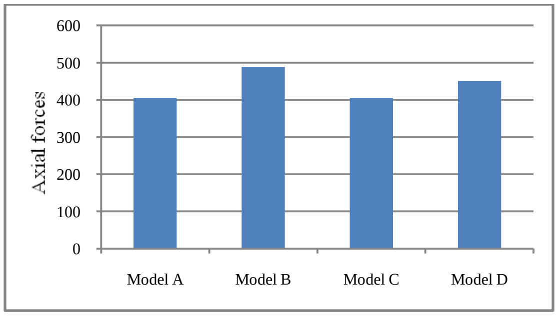

Fig.12. Maximum Axial Forces for Interior Column C26

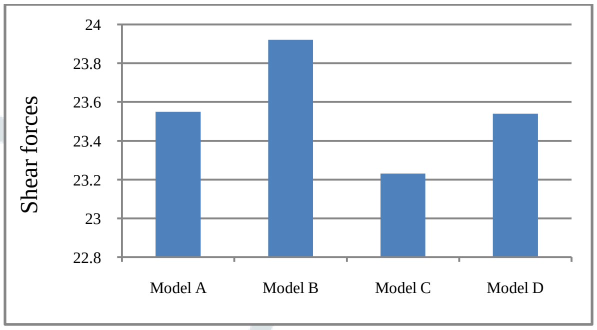

Fig.13. Maximum Shear Forces for Corner Column C1

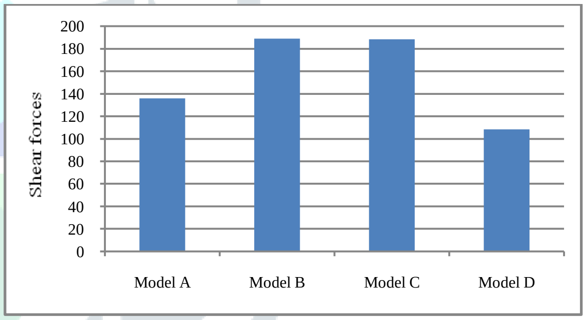

Fig.14. Maximum Shear Forces for Interior Column C26

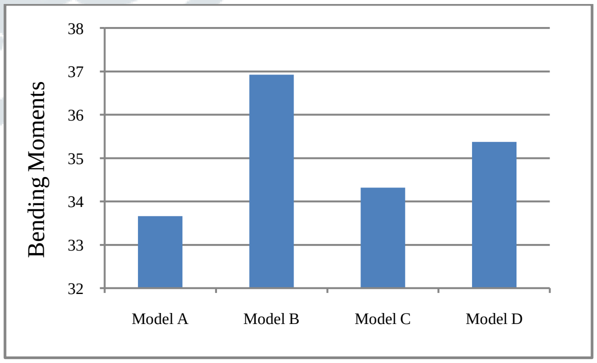

Fig.15. Maximum Bending Moment for Corner Column C1

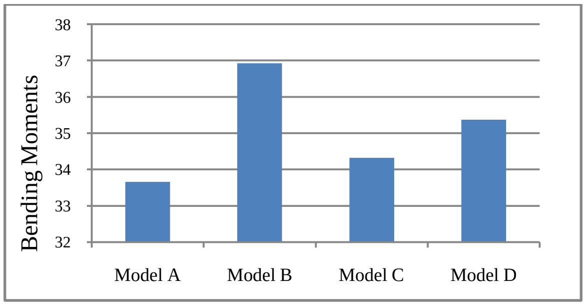

Fig.16. Maximum Bending Moment for Interior Column C26

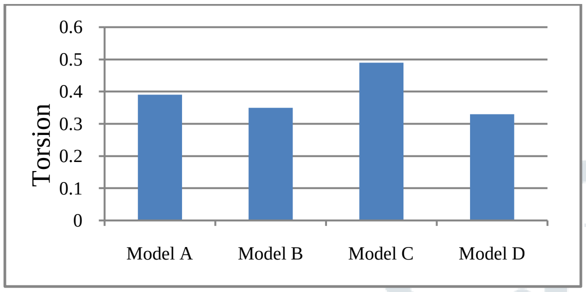

Fig.17. Maximum Torsion for Corner Column C1

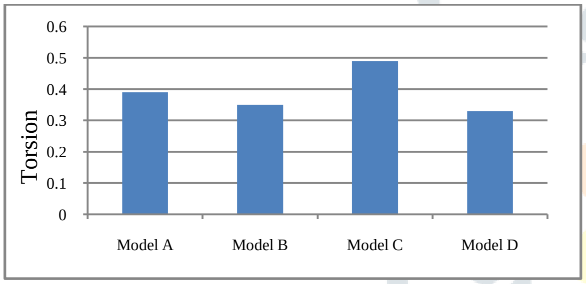

Fig.18. Maximum Torsion for Interior Column C26

In comparison of axial forces, shear force and bending moment, the values of C1 are greater than that of C26. All values of axial forces, shear forces, and bending moment for C1 are the maximum at model B.

Comparison of member forces for beams

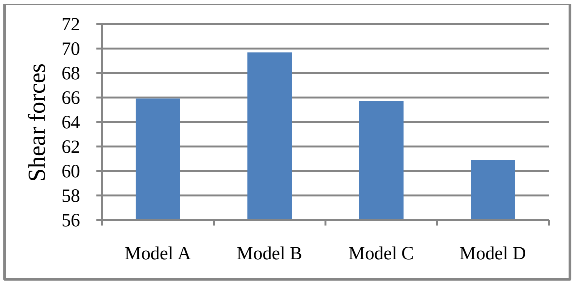

Fig.19. Maximum Shear Forces for Exterior Beam B55

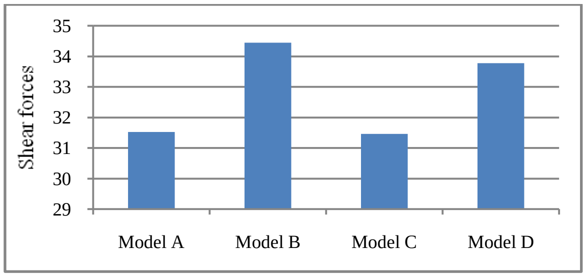

Fig.20.Maximum Shear Forces for Interior Beam B69

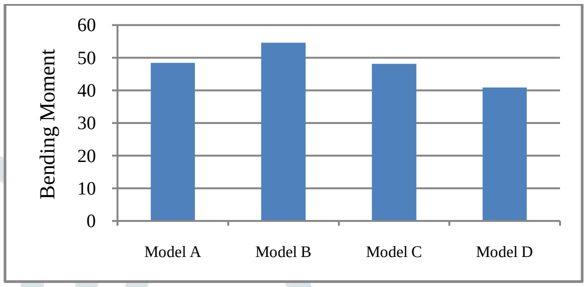

Fig.21. Maximum Bending Moment for Exterior Beam B55

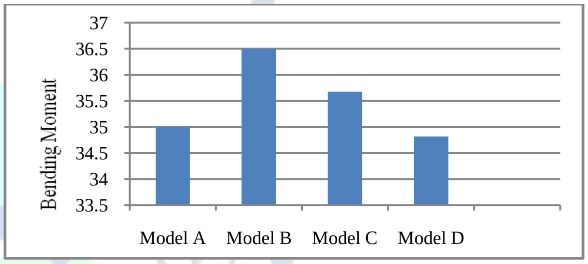

Fig.22. Maximum Bending Moment for Interior Beam B69

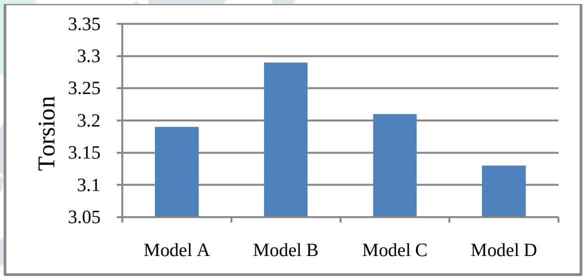

Fig.23. Maximum Torsion for Interior Beam B55

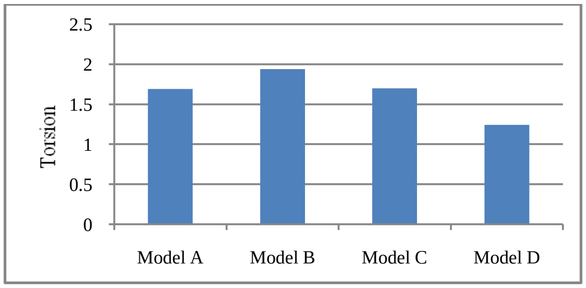

Fig.24. Maximum Torsion for Interior Beam B69

In comparison of shear forces with bending moment, the maximum values for exterior beam B55 are greater than that of interior beam B69. All values of shear forces and bending moment of B55 are the maximum at model B. Torsion forces of B69 are greater than that of B55 because B69 has longer span. So, the values depend on locations of the selected members and structural configuration.

It occurs that structural behavior and member forces of proposed RCC building due to change of mass and inter-storeyed height are different based on the structural configuration although the member sizes are the same.

Discussions and Conclusion

In this study, twelve-storeyed vertical irregular RCC building is selected to analyze the behavior of the structural members due to change of mass and inter-storeyed height. This building is situated in seismic zone IV. It is composed of special moment-resisting frame system. The superstructure is designed with ETABS software. The structure is initially analyzed and designed with static analysis. It is found that the safety factor values are satisfied within allowable limits. And then, this structure is analyzed with dynamic (time history analysis) based on change of mass and inter-storeyed height. The results of column size in dynamic analysis are greater than that in static analysis.

The *maximum storey drifts* are occurred in storey seven in X-direction and in storey three in Y-direction. The values of storey drift of model B are the maximum in both directions. The *maximum storey shears* are occurred in storey one in both directions. The maximum storey shear in X-direction is absolutely equal to Y-direction. The *maximum storey moments* occur in storey one in both directions. The maximum storey moment in X-direction occurs at model B. In Y-direction, the maximum storey moment occurs at model C. In comparison of column forces, corner column C1 and interior column C26 are selected for all models. The values of corner column C1 are greater than that of interior column C26 .The maximum axial forces, shear forces and bending moment occur at corner column C1 because it is the exterior corner column and it is mostly applied by the lateral load. In comparison of beam forces, exterior beam B55 and interior beam B69 are selected for all models. The maximum values of shear forces, torsion and bending moment of exterior beam B55 are occurred at model B.It can be observed that model B has the maximum structural responses because change of mass and inter-storeyed height of model B is at the sixth storey of the building. In this study, the effects of change of mass and inter-storeyed height have more influence than the regular building because of the effect of vertical irregular structure. So, the conclusion can be drawn that the buildings with vertical structural irregularity have lower performance than the regular building. It is observed that if change of inter-storeyed height and load mass are at the middle of the building, the building can affect more seismic effects and can have more damage than that of change of mass in another storey level. So change of that height and mass is more suitable at the top.

Recommendations

From this thesis, it is recommended that the following additional study can be carried out for further study.

1. High-rise RC building should be analyzed with response spectrum and push-over analysis.
2. Design of substructure should be carried out to get complete design for the whole building.
3. Seismic weight and base shear values can be calculated by the manual analysis and compared with software analysis.
4. Determining the earthquake response of high rise irregular building structures by considering different shapes and sizes of shear wall at different locations.
5. This work can be compared with an irregular structure by using STADD.Pro software.

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