Seismic Response of High Rise Building with Openings in Shear Walls

P. Vivek Reddy, G. Kamala Kumari

Abstract:Due to gradual development of metros and small towns and increasing population in India, the high rise buildings are constructed at a larger scale due to land scarcity and the commercial or cultural importance of a particular area. A high rise building should be architecturally viable and should have good light and air ventilation. In this project we compare and analyze the high rise buildings in three configurations.A high rise building is a structure which is more than 30m in height. In this project we consider a high rise building with story configuration of G+20. The three configurations of the high rise building are designed, configured and seismically analysed using ETABS software. Earthquake analysis in ETABS is carried out on Model (a)-Structure without a shear wall, Model (b)-Structure with shear walls and Model (c)-Structure with openings in shear walls resting in Type II soil and Type III seismic zone. The soil type and seismic zone considered for this project is specific for Amaravati the capital of Andhra Pradesh. Seismic analysis results for each configuration of the high rise building such as Base Shear, Time Period, Storey Drifts and Displacements are compiled and compared to find the suitable configuration of high rise structure.

Keywords: Time period, Storey Drifts, Base Shear, Displacements.

I. INTRODUCTION

Earth quakes are natural disasters which have adverse effect on the high rise buildings. To contain the adverse effects of the earth quake on the buildings, shear walls are considered as one of the measures to minimise the damage. Shear walls are the structural members that are designed so as to resist the earthquake and gravity loads.Shear walls are designed for high rise structures so as to provide stiffness to the structure.. In this high rise building the shear wall is provided for the complete height of the building. The high rise structure considered for this project has the no of stories as G+20 with a basement. The structure is rectangular in shape. The structure is provided with stairs and also two elevators are provided in the middle of the building. A retaining wall is provided for the base of the building. The brickwork considered for the buildings are light in weight compared to the conventional bricks. In the present scenario the shear walls are provided in L shape at the corners of the building. The openings in shear wall are provided considering them as window openings in the building. The openings are provided so that adequate light and air ventilation is provided in the high rise structure. The openings in the shear wall are provided on both the adjacent sides of the L shaped shear wall which is present at every corner of the high rise structure.The analysis of the building structures is done through ETABS-17 software. ETABS-17 software works on the procedure of Finite Element Analysis, by discretising the structure.

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The three models of the high rise structure are analysed through linear dynamic analysis as the structure is subjected to rapid applied forces such as earthquake and wind. The application ETABS calculates the structural responses based on the assumption that due to dynamic forces being applied on models the equilibrium dynamic analysis is done for the buildings. Dynamic analysis done for the models is Response Spectra Analysis. The Square root of the sum squares (SRSS) method is used to know the maximum modal responses of the structure.

II. RESPONSE SPECTRA ANALYSIS

It is the representation of spectrum of maximum responses during a given earth quake, ground motion of idealized SDOF systems having different time periods and damping. Response spectrum analysis is a linear dynamic analysis.

- Response spectrum method is used for earthquake engineering research and in applying the seismological knowledge of earthquake to the design of the structure.
- It is the extreme values from analysis that convey structural information. Maximum forces, displacement and deformation of the structure are known through response spectrum analysis.

III. BUILDING STRUCTURE DESCRIPTION

The high rise building has G+20 stories. The building can be designed and used for commercial or residential purpose. The building has dimensions in length and breadth as 32m x 14.5m respectively. The height of the high rise building is 67.2m.

IV. MODEL DETAILS OF THE STRUCTURE

- Type of frame : SDOF
- Column Size : 450mmx600mm
- Beam Size: 230mmx450mm
- Thickness of Slab : 150mm
- Thickness of Shear wall : 230mm
- Thickness of Brick wall : 230mm
- Height of the basement and ground floor : 3200mm
- Height of the each floor : 3200mm
- Grade of concrete : M 35
- Grade of steel : Fe 500
- Live Load : 3 kN/m^2
- Dead Load : 0.52 kN/m^2
- S.I.D.L : 0.5 kN/m^2
- SIDL on Brick Wall : 3.9
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- kN/m^2
- Supports for foundation : Fixed

  - Seismic Zone : Zone III
  - Soil Type : Type II

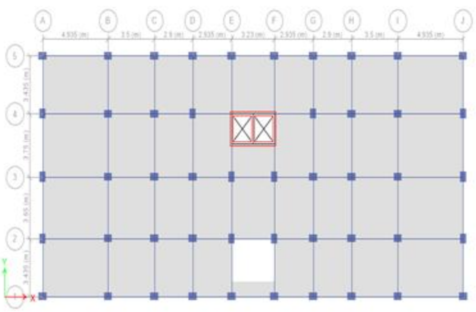
A.LOAD COMBINATIONS

- 1.5(D.L+SIDL) + 1.5L.L
- 1.2(D.L+SIDL) + 1.2L.L + 1.2E.LX
- 1.2(D.L+SIDL) + 1.2L.L – 1.2E.LX
- 1.2(D.L+SIDL) + 1.2L.L + 1.2E.LY
- 1.2(D.L+SIDL) + 1.2L.L – 1.2E.LY
- 0.9(D.L+SIDL) + 1.5E.LX
- 0.9(D.L+SIDL) + 1.5E.LY
- 0.9(D.L+SIDL) – 1.5E.LX
- 0.9(D.L+SIDL) – 1.5E.LY
- 1.5(D.L+SIDL) + 1.5E.LX
- 1.5(D.L+SIDL) – 1.5E.LX
- 1.5(D.L+SIDL) + 1.5E.LY
- 1.5(D.L+SIDL) – 1.5E.LY
- 1.5(D.L+SIDL) + 1.5W.LX
- 1.5(D.L+SIDL) – 1.5W.LX
- 1.5(D.L+SIDL) + 1.5W.LY
-

B.MODELING PROCEDURE IN ETABS

- The G+20 Story high rise building and also its two shear wall configurations are designed and analyzed in ETABS
- Enter Grid and Story Data
- Create reference lines. Enter center line data in ETABS.
- Define material property for steel and concrete
- Define section sizes for columns and beams
- Model the structure in ETABS
- Define Load Patterns and Load combinations. Load combinations are formed from the load patterns.
- Perform Model check
- Perform Analysis of the model
- Obtain results.

V. PLANS AND MODELS OF BUILDING



Model (a)

Fig 1:Plan of the building without shear wall

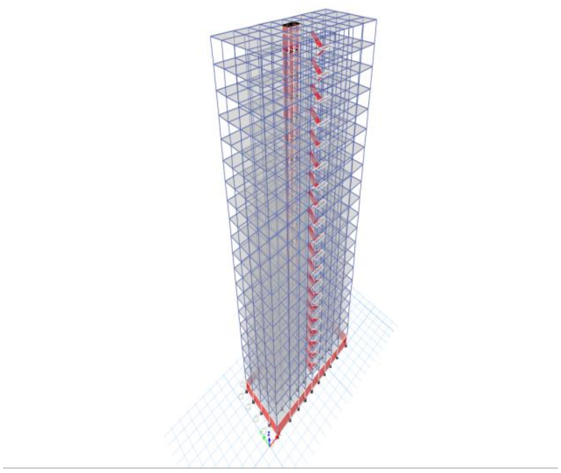


Fig 2:3D Model of the building without shear wall

Model (b)

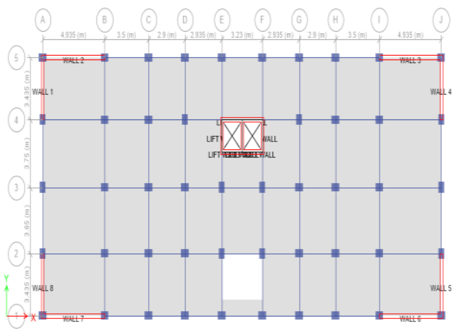


Fig3: Plan of the building with shear wall

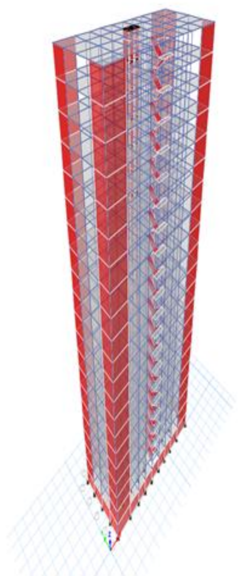


Fig 4: 3D Model of the building with shear wall

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Model

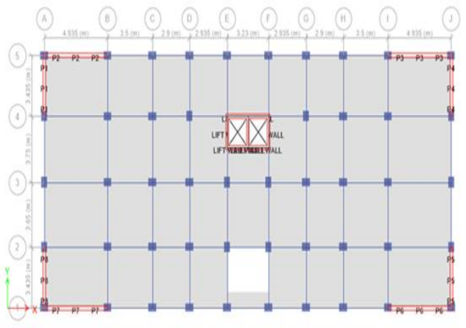


Fig 4:Plan of the building with openings in shear wall

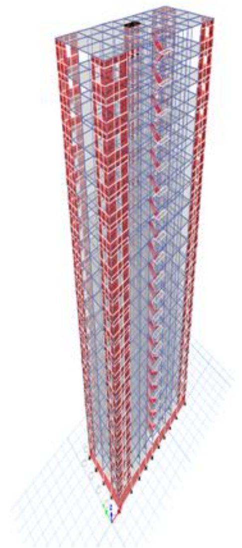
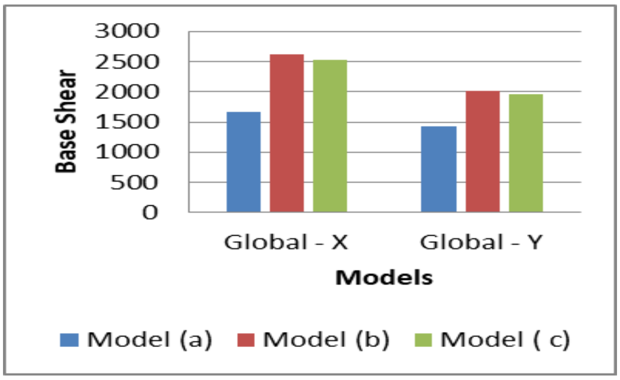


Fig 5:3D model of building with openings in shear wall

VI. RESULTS

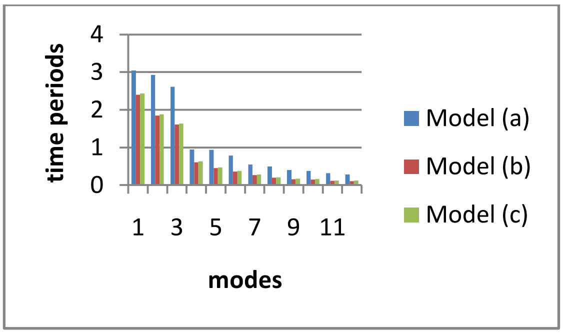
Table 1 Base Shear for different configurations



Graph 1: Model v/s Base Shear

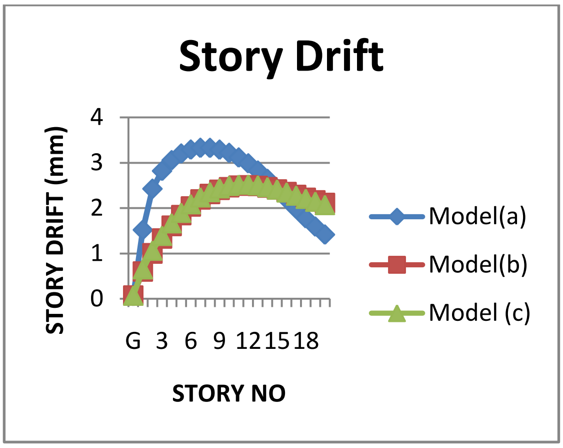
Mode Shape	Model (a)	Model (b)	Model (c)
1	3.049	2.401	2.436
2	2.927	1.85	1.882
3	2.611	1.606	1.637
4	0.948	0.606	0.628
5	0.933	0.451	0.469
6	0.783	0.356	0.376
7	0.548	0.267	0.284
8	0.494	0.195	0.207
9	0.404	0.154	0.168
10	0.378	0.148	0.161
11	0.319	0.113	0.122
12	0.281	0.103	0.115

Table 2 Time period for different mode shapes

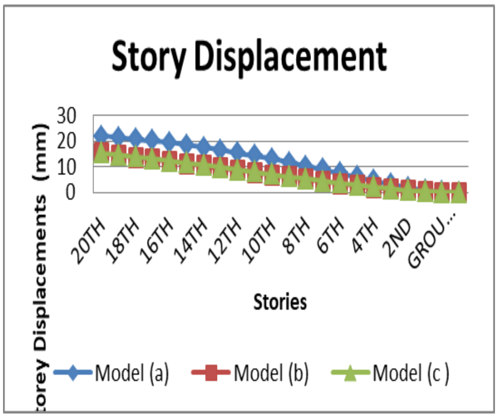


Graph 2: Modes v/s Time period

Model Type	Base Shear (X direction) (kN)	Base Shear (Y direction) (kN)
Structure without shear wall	1672.1692	1432.07
Structure with Shear Wall	2610.3502	2010.8434
Structure with opening in shear wall	2532.328	1955.880



Graph 3:story v/story drift



Graph 4 : Story Displacement

VII. RESULT ANDDISCUSSION

- Base shear of the structure is the amount of shear the base will contain in the event of earthquake. The percentage of decrease of shear between base shears of model (b) and model (c) is 1.45%.
- The model (a) also has higher time period than model (b) and model (c). The model (b) and model(c) have identical time periods.
- Story drifts for the model (a) have more deviations observed than from model (b) or model(c)
- Story shear is decreased from model (b) to model (c) by 2.06%
- Story displacement is almost identical for model (b) and model (c). Model (a) displaces further than the other two models.
- The base shear and story drifts of the three building orientations are studied and can be found that there is minimal performance difference between the building with shear walls and with openings in shear walls**.**

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