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Structural Analysis of High-Rise Building in Different Shape

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Abstract: The existing seismic regulations act as a limiting factor and cannot cover specific behaviour of these buildings. Considering the increasing trend in their construction worldwide, additional investigations are necessary, particularly for structures in seismically active areas. It is necessary to elaborate official codes which will clearly prescribe methods, procedures and criteria for analysis and design of such type of structures. High-rise buildings are exposed to both static and dynamic loads. Depending on the method used and how the structure is modelled in finite element software the results can vary. The 3D-finite element software used for the analyses is Midas Gen. From the results it can be observed, when modelling a high-rise building in a finite element software, that one model is often not sufficient to cover all different aspects. To see the global behaviour, one model can be used, and when studying the detailed results another model with a fine mesh, that have converged, is often needed. The same principle applies when evaluating horizontal and vertical loads, different models or methods are usually needed analysis of building ETAB will be used.

In this project, we have to do the structural analysis of various multi-storied buildings with different plan configurations like C and H shaped configurations. The main aim of structural analysis is to determine the general shape and the dimensions of various elements of a structure which will be most suitable for the purpose for which the building has to be designed and will help the building to serve for its entire estimated life period without any severe damage.

Keywords: Midas Gen, 3D-finite element software, investigations, static and dynamic loads, global behaviour, fine mesh.

I. INTRODUCTION

Structural analysis means determination of the general shape and all the specific dimensions of a particular structure so that it will perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life. The process of designing high-rise buildings have changed over the past years. In the most recent years, it is not unusual to model full three-dimensional finite element models of the buildings. This due to the increased computational power and more advanced software. However, these models produce huge amount of data and results where possible errors are easily overlooked, especially if the model is big and complex.

If the engineer is not careful and have a lack of knowledge of structural behaviour and finite element modelling, it is easy to just accept the results without critical thoughts. Furthermore, different ways of modelling have a big influence on the force and stress distribution. This can lead to time consuming discussion and disagreements between engineers as they often have different results from calculations on the same building. Sweco AB were interested in initiating a Master's thesis that investigated different ways of modelling and how they affect the outcome. The Division of Structural Mechanics at Lund University were interested in a similar Master's thesis where the dynamics of high-rise buildings were to be analysed. Furthermore, investigations of how well analytical calculations by hand according to standards, codes and regulations of accelerations and resonance frequencies correspond to the results of large finite element models were to be conducted. For a high-rise building to have a successful security and fire safety program, it is important for the building owner or manager, the director of security, or the fire safety director to establish a liaison with various agencies in the public sector, including law enforcement and fire authorities. Developing and maintaining strong lines of communication and cooperation with these authorities will lead to a successful working relationship.

1.1 STAGES IN STRUCTURAL DESIGN

Every structure follows a specific path from its initiationto ultimate design as follows:
1) Structural planning of the building.
2) Model building in ETAB with assign material property and element
3) Calculation of assign loads cases and load combination.
4) Structural analysis of the building both building C shape and H-Shape of building
5) Design of the building as per analysis.

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6) Drawing and detailing of the structural members.
7) Preparation of tables and graphs.
8) It is the responsibility of the structural engineer to construct the building structurally good, considering all the loads acting on the building. There are so many methods of conducting this design we use E-tab software.

1.2 NEED OF RESEARCH

The purpose of this study is to evaluate the seismic properties and characteristics for multi storey residential high rise building structures. The main aspect of this analysis is to compare the results of the Analysis four different shapes of building. 1) C-shape 2) H-shape.

II. AIM AND SCOPE OF WORK

The RC framed Buildings are considered for the analysis by assuming regular in plan. The asymmetric buildings. The Flexibility of floor diaphragms are neglected and considered as rigid diaphragm. The base of the column is assumed to be fixed in the analysis. To compare the analytical results of High Rise (G+20) Building for different shape.
Like four different shapes for the same structure,
1. C-shape Plan
2. H-shape Plan

III. OBJECTIVE

1) To examine a G+20 storey residential building for distinctive loads combinations using ETABS software.
2) Study of displacement, drift, overturning, shear forces, Reactions and bending Moments.
3) Compare the analysis different shape of model with software calculations
4) To analyse the building using IS code 1893 (part 1): 2002 for seismic analysis.
5) To develop, design and analysis model of the High-rise structure in ETABS.
6) To verify deflection obtained by ETABS with IS code Limit.
7) Modelling of G+20-storey building and application of different loads on ETABS, load calculations due to different loading combinations, analysis and design of structure on ETABS.
8) Analyse the structural result of different shape of high-rise building.
9) To study the behaviour of different shape of high-rise building structures.
10) To learn structural analysis and design of different shape of high-rise buildings.
11) To study design criteria for different shape of high-rise building structures.
12) Analyse different methods, codes and guidelines used when performing calculations on high-rise buildings.
13) Structural analysis of multi-storied building before construction work using ETABs software.

IV. OBJECTIVE

A. MODELING PROCEDURE

Step-1:
Modelling: With respect to the consideration of type of structure modelling has been done using Geometry and Structural Wizard tool.

Step-2:
Generation of grid Point: As per the planning with respect to the positioning of column in building, their respective grid point has been created on that model.

Step-3:
Property Definition: Using General-Property command define the property as per size requirement to the respective building on ETABS. So, beam and columns, slab, wall have been generated after assigning to selected property.

Step-4:
Create and Assign Support & Member Property: After column definition at supports have been provided as fixed below each column and its cross-section assigning based on load calculations and property definition.

Step-5:
Load Assignment:

I. Dead load
The dead load contains of the weight of walls, partitions floor finishes, false ceilings, floors and the other permanent standing construction in the buildings. The dead load loads are estimated from the dimensions of various members of building and their unit weights. The unit weights of plain concrete and reinforced concrete taken as25kN/m3. The unit

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weight of masonry taken as 20 kN/m3. As per IS: 1893 (Part 1)-2002, the dead load has been assigned on the basis of member load, floor load, self-weight of the beam's definition.

II. Live Load

Imposed loads or live load is the load put up on the structure by movable entities. It is calculated by occupancy of the building and weight of movable partitions, distributed and concentrated loads. For example, combined weight of all machines or instruments or materials in a building, furniture etc.

As per IS: 875 (part 2)-1987, live load 2.0 kN/m has been assigned to the members.

III. Seismic Load

Seismic load or the Earthquake load/loading is the load generated when an earthquake is in action. It is very much important for areas near volcanoes or areas with high earthquake intensity (or ZONES). These zones are more prone to high intensity earthquake than the other areas into consideration.

After defining the seismic load as per requirement of IS: 1893 (Part 1): 2002, the seismic load has been assigned with respect to +X, -X, +Y, and –Y directions with their respective appropriate seismic factor.

IV. Wind Load

As per IS: 875 (part 3)-1987, wind load area averaging factor (K_a) 0.8 has been assigned to the members.

Table 1. Area averaging factor (Ka)

Tributary Area (A) (m^2)	Area Averaging Factor (K_a)
≤ 10	1.0
25	0.9
≥ 100	0.8

IV. Load combination

Required load combinations cases for seismic analysis have been assigned to the model based on specified loading combinations provided in the Indian standard CODES that are also available in ETABS.

Step-7:

Structural analysis on ETABS. After adding Analysis/Print, using Run Analysis Command, the structure is analyzed and detailed study of drift and displacement is undertaken through the Post processing mode to recognize their base shear strength diagrams to it check is safe or not.

Step-8:

The analysed model is checked for the drift, displacement, overturning and base shear from the output of ETABS.

Step-9:

Output Generation. After that output file is generated which containing the structural design of each individual beam and column member of structure.

VI. PROBLEM STATEMENT

A building having plan dimension 36 X 28m, Floor to floor height is 3m, having 35 storied building. Column spaced at 4m centre to centre. For this study different size of column use at different stories of building such as 1 to 10 stories column size 600x600mm, 11 to 15 stories columns size 500x500mm and 16 to 20 stories column size is 400x400mm. For this analysis various loads are considered such as dead load, live load and wind load respectively. The combination of loads consider according to IS 875(Part 5)-1987. Shape of building is 1. C-Shape Plan, 2. H-shape Plan.

Table 2. General Data for Design

BUILDING DESCRIPTION	
Plan Dimension	Length=36, Width=28
Total Height of Building	57.9
Height of each storey	3m
Periphery Beam Dimension	450x650
Main Beam Dimension	400x400
Column Dimension for 1to 15 Storey	600x600

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Column Dimension for 16 to 30 Storey	500x500mm
Column Dimension for 31 to 35 Storey	400x400mm
Support conditions	Fixed
Type of structure	2
Seismic zone	V
Slab thickness	225mm
Thickness of main wall	230mm
Height of parapet wall	0.90m

Table 3. General Data for Material Specification

MATERIAL SPECIFICATIONS	
Grade of Concrete, M40	fck= 40N/mm2
Grade of Steel	fy= 415N/mm2
Density of Concrete	ϒc= 25kN/m3
Density of Brick walls considered	ϒbrick= 20kN/m3

V. LOAD CASES AND LOAD COMBINATION

a) LOAD CASES

1. Dead Load
2. Live Load
3. Earthquake Load On X-Direction
4. Earthquake Load On Y-Direction
5. Wind Load On X-Direction
6. Wind Load On Y-Direction

b) LOAD COMBINATION

1. 1.5(DL+LL)
2. 1.2(DL+LL+WX)
3. 1.2(DL+LL+WY)
4. 1.2(DL+LL+EQX)
5. 1.2(DL+LL+EQY)
6. 0.9(DL+LL+WX)
7. 0.9(DL+LL+WY)
8. 0.9(DL+LL+EQX)
9. 0.9(DL+LL+EQY)

VI. SEISMIC SELF WEIGHT LOAD CALCULATION

SELF-WEIGHT

1. Weight of typical slab (Floor)
Self-weight of slab = 5.625 kN/m²

2. Weight of periphery Beam
Self-weight of beam = 25 X 0.45 X 0.65 = 7.3125 kN/m

3. Weight of main Beam
Self-weight of beam = 25 X 0.40 X 0.40 = 4 kN/m

4. Weight of Columns per m Load
a. Column 600x600mm
Self-weight of Column = 25 X 0.60 X 0.60 = 9KN/m
b. Column 500x500mm
Self-weight of Column = 25 X 0.50 X 0.50 = 6.25KN/m
c. Column 400x400mm
Self-weight of Column = 25 X 0.40 X 0.40 = 4KN/m

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VII. TYPICAL LAYOUT OF PROBLEM STATEMENT

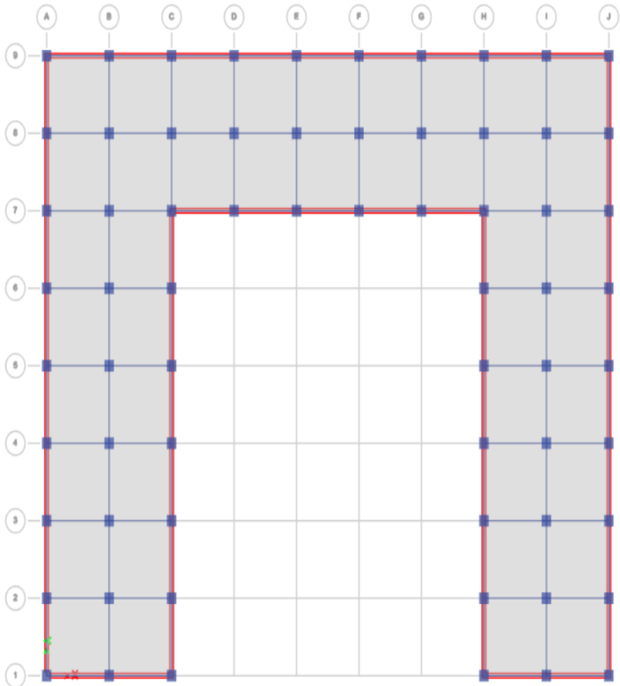

Fig. 1 C-Shape Plan View

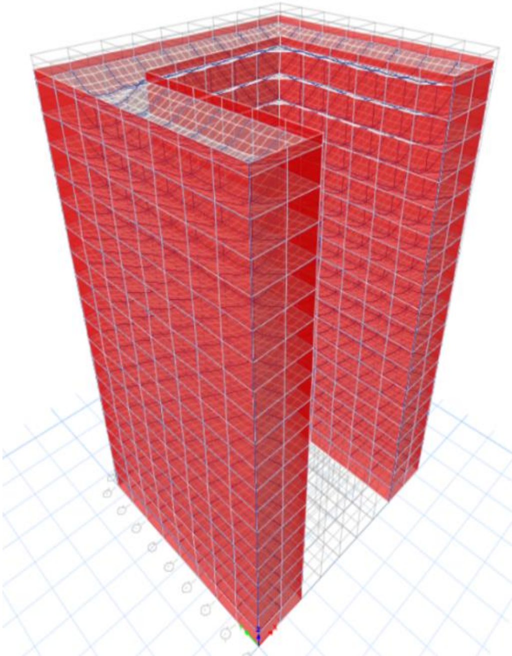

Fig 2. C-Shape 3D View

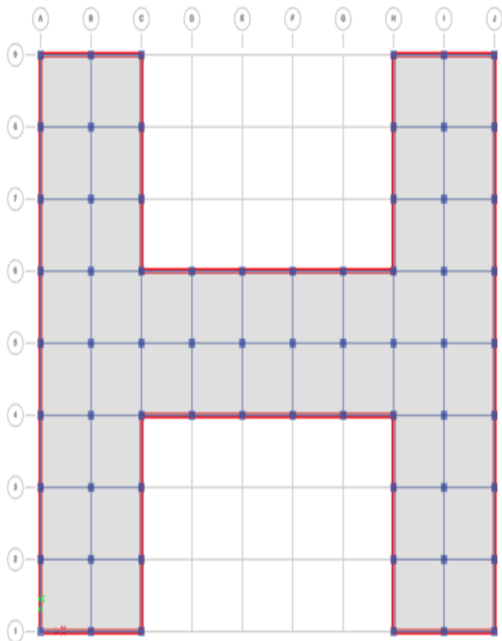

Fig 3. H-Shape Plan View

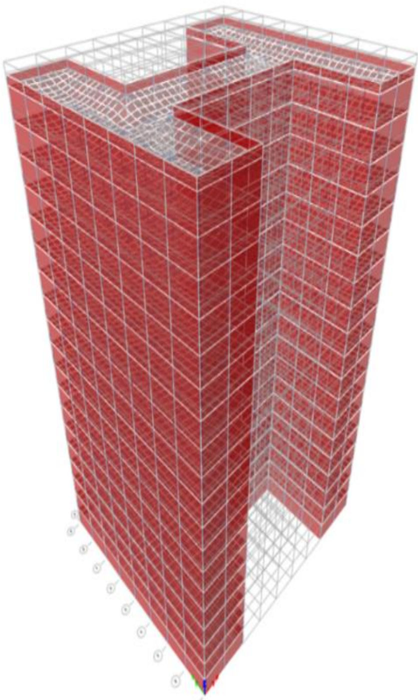

Fig 4. H-Shape 3D View

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VII. RESULT

1. MAXIMUM STORY DRIFT

Table.4 Maximum Story Drift

BUILDING SHAPE	STORY	STORY DRIFT
C- Shape	Story 8 to story 14	3.217
H- Shape	Story 6 to story 8	2.397

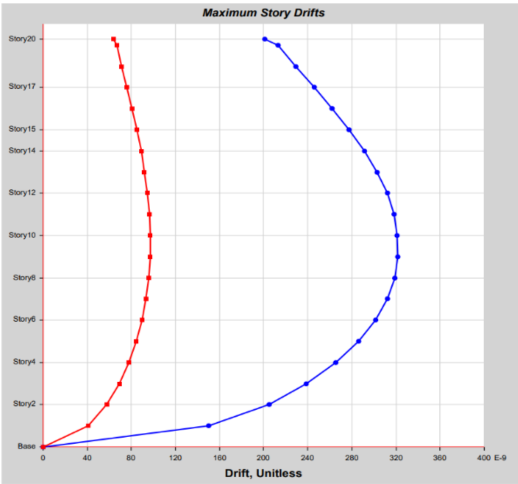

Fig. 5 C-Shape Maximum Story Drift

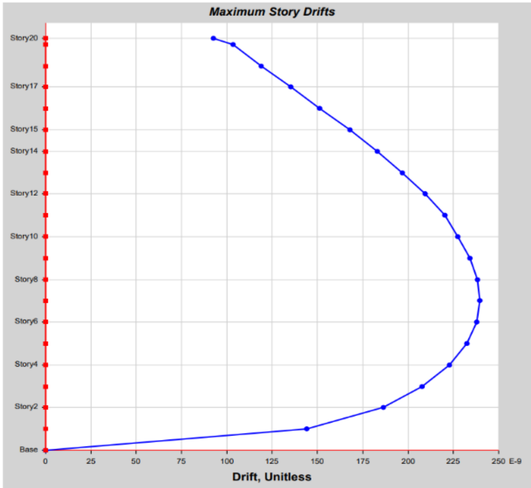

Fig. 6 H-Shape Maximum Story Drift

2. MAXIMUM STORY DISPLACEMENT

Table 5. Maximum Story Displacement

BUILDING SHAPE	STORY	STORY DISPLACEMENT (MM)
C- Shape	Story 20	0.015696
H- Shape	Story 20	0.011054

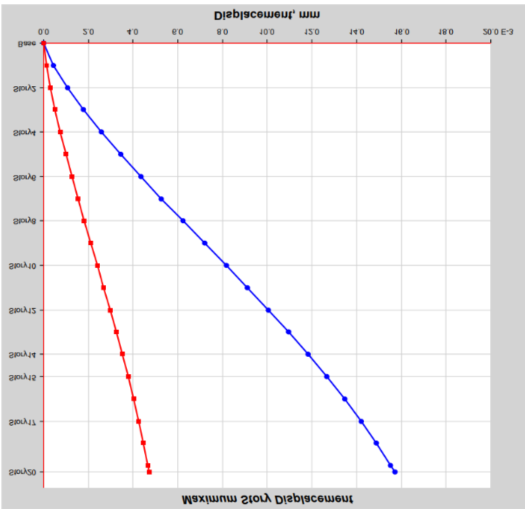

Fig. 7 C-Shape Maximum Story Displacement

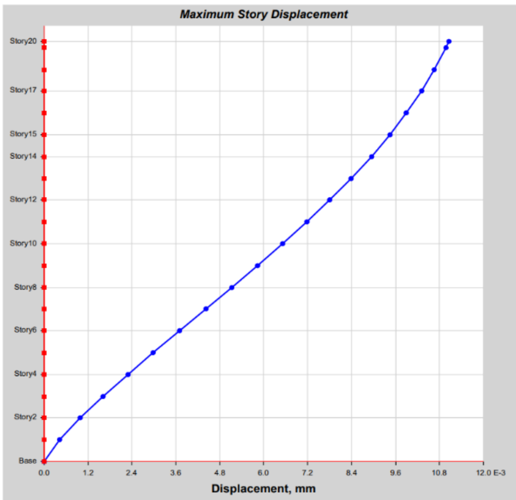

Fig. 8 H-Shape Maximum Story Displacement

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3. STORY OVERTURNING MOMENT

Table 6. Story Overturning Moment

BUILDING SHAPE	STORY	MAX. OVERTURNING (KN/M)	MIN. OVERTURNING (KN/M)
C- Shape	Story 8 to Story 10	579.9245	-3.737
H- Shape	Story 15 to Story 17	0	-839.2168

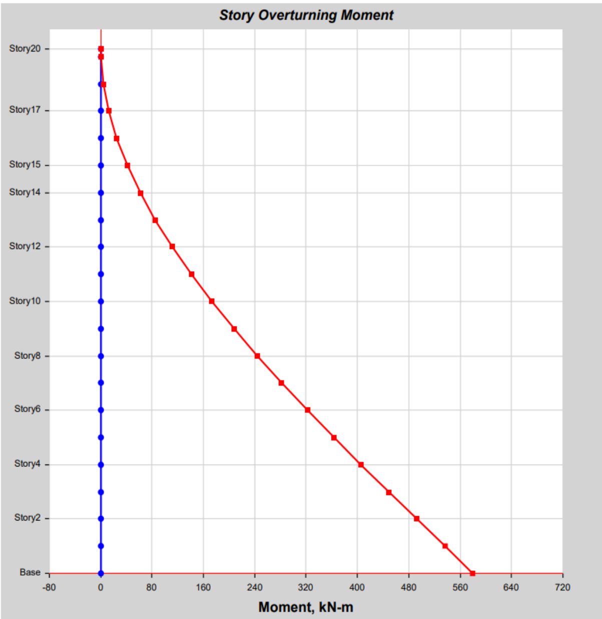

Fig. 9 C-Shape Story Overturning Moment

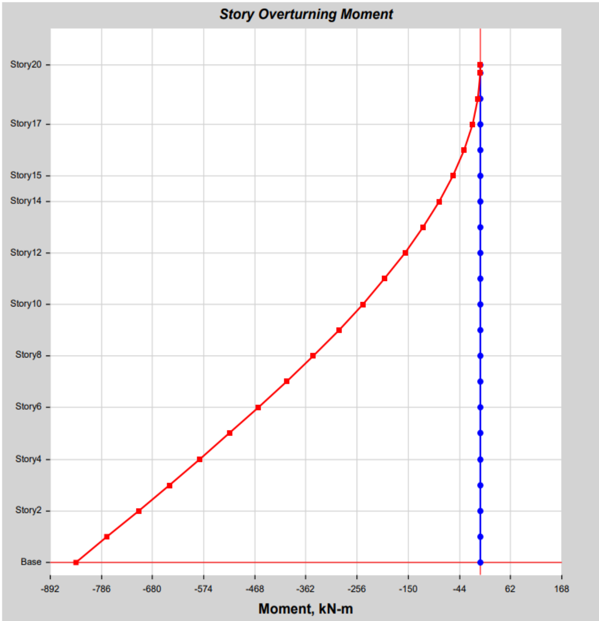

Fig. 10 H-Shape Story Overturning Moment

4. RECTANGLE SHAPE MAXIMUM SHEAR BASE

Table 7. C-Shape Maximum Shear Base

Output Case	FX (KN)	FY (KN)	FZ (KN)	MX (KN)	MY (KN)	MZ (KN)
Dead	-2016	-2016	347175.3701	7547904.229	-4476780	15120
Live	0	0	102000	2203200	-1264800	0.000005922
EQ_X	-48291.9127	-9.484E-07	0	0.00004059	-1656853	1030888.649
EQ_Y	-0.000001162	-48017.6674	0	1644559.074	-0.0000474	-610385.0568
WIND LOAD_X1	-136183.3971	-0.000002033	0	0.0001	-4130445	2885533.953
WIND LOAD_Y1	-6.922E-07	-40118.6972	0	1224132.5	-0.00002921	-536798.9497

5. L-SHAPE MAXIMUM SHEAR BASE

Table 8. H-Shape Maximum Shear Base

Output Case	FX (KN)	FY (KN)	FZ (KN)	MX (KN/m)	MY (KN/m)	MZ (KN/m)
Dead	-1366	-1366	433852.5543	8045326.872	-7850995	-1146
Live	0	0	51072	963072	-919296	0.000001137
EQ_X	-64505.4174	0	0	-0.000001212	-2155231	1178427.475
EQ_Y	0	-64828.0518	0	2169338.397	0	-1166905
WIND LOAD_X1	-2941.0971	0	0	0	-94106.0212	47057.5533
WIND LOAD_Y1	0	-5169.8972	0	165420.7403	0	-93058.1499

VII. CONCLUSION

- The G+20 Building has been analysed and designed using E-tab.
- The G+20 residential building of C-shape an H-shape has been analysed and deigned using ETABS. Seismic forces have been considered and the structure is designed as an earthquake resistant structure.
- To conclude,

a) minimum Storey drift in H-shape of building on Story 6 to story 8 Story 6 to story 8 is less as compared to C-shape of building
b) Maximum storey dis in H-shape of building is less
c) Maximum storey overturning moment in H-shape of building is less Story 15 to Story 17
d) for rectangle shape of building maximum shear base and for L-shape of building maximum shear base is shown in Table 7. C-Shape Maximum Shear Base and Table 8. H-Shape Maximum Shear Base

for different load case

- Details of each and every member and component can be obtained from ETABS.
- Seismic forces have been considered and the structure is designed as an earthquake resistant structure.

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