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Seismic Analysis of Multistorey Building with Shear Wall using STAAD Pro

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***Abstract*—In present era, development of tall buildings preferred due to scarcity of space. This scarcity has led to the vertical construction growth of low rise, medium rise, tall buildings. These buildings general used RCC framed structures subjected to vertical as well as horizontal loads. But for the buildings taller than 15 to 20 stories this system is not adequate because it does not provide the required lateral stiffness. By providing shear wall at suitable locations the required stiffness can be provided. This paper focuses on the study of the effect of seismic forces on 50 storey RCC building with shear wall provided.**

Keywords—Seismic; analysis; multi-storey; shear wall; STAAD Pro

I. INTRODUCTION

Any sudden shaking of the ground caused by the passage of seismic waves through earth's rocks causes earthquake. This shaking may cause building damage. When the ground shakes, the building foundation vibrate in a manner that's similar to the surrounding ground. The Indian subcontinent has a history of devastating earthquakes.

Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which reduces lateral sway of the building and thereby reduces damage to the structure and its contents. Shear wall is a vertical structural element that resists lateral forces in the plane of the wall through shear and bending. The behavior of shear walls depends on the material used, the wall thickness, length & position of the wall in the building frame. Their thickness can be above 150 mm or below 400 mm in tall buildings; they are like vertical-oriented wide beams that carry the earthquake load towards the foundation.This wall resists the lateral loads that are imposed on the structure due to wind, earthquake, or sometimes due to hydrostatic or lateral earth pressure. Shear wall buildings are a common choice in many earthquake-prone countries. They are efficient in reducing construction costs. Also reduces earthquake damage in structural and non-structural elements such as glass windows and construction materials. Buildings with shear walls have shown very good performance during earthquakes in high seismic areas. Shear walls designed to resist gravity/vertical loads and earthquake/wind lateral loads. These types of walls are structurally combined with the roof or floor. These walls resist the shear forces that try to push the walls up and the lateral forces of air that push the walls in and out of the structure.

II. AIM

Aim of the present study is to compare the behavior of multi-storey building with shear wall to analyze the effect of building height on the performance under earthquake forces.

III. RESEARCH OBJECTIVES

1) To study the effectiveness of shear wall to resist seismic forces.
2) To analyze the building using seismic analysis method in STAAD Pro software.
3) To study the results of various parameters such as displacement, torsion and deflection.

IV. METHODOLOGY

Various IS Codes like IS 1893:2016(Part 1) and IS 456:2000 was referred for design purpose. The required architectural plan, sizes of beams and columns for analysis and design purpose is collected from a construction site of a multistorey building.

Following data is used for modelling of RC framed building:
Structure type: Residential Building, commercial building
Number of stories: 50
Seismic zone: 4
Floor height: 3m
Size of the column: 700 mmX500 mm
Size of the beam: 500 mmX500 mm

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Thickness of slab: 150 mm
Masonry wall thickness: 150 mm
Live load: 4.5 KN/m2
Floor finish: 1.5 KN/m2
Types of soil considered: type II – Medium soil.
All the columns are assumed to fix at base
Characteristic compressive strength, fck: 50 N/mm2
Steel grade: 500N/mm2
Modulus elasticity: 2000N/mm2
Concrete density: 26N/mm2
Density of brick masonry, ρ: 19.4 KN/m3
Poison's ratio of concrete, μ: 0.3
Modulus of elasticity of brick masonry: 14100 N/mm2
Poison's ratio of brick masonry: 0.2
Damping ratio: 5%

A. Following are the steps used for modellig

- First the grid line is prepared in STAAD Pro.
- The materials like concrete and steel are defined.
- Frame sections as beams, columns, shear walls, slab are defined.
- Properties of beams, columns, slabs, shear wall are designed.
- Define the load cases.
- Assign the loading as Dead load, Live load, Wind loads, Seismic loads.
- Assign the support conditions as fixed and Analyze the model.

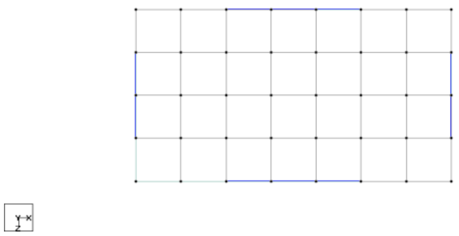

Fig.Grid Plan of Building

B. Load Bearing Shear Wall

The key difference between the conventional framed system (with or without shear wall system) and the RCC LBSW system is the significant inclusion of more load bearing walls. Due to the presence of longer walls with higher stiffness in response to lateral loads, a well-detailed RCC LBSW system provides exceptional rigid buildings at satisfactory ductility. Several structures with RCC LBSW System have performed exceptionally well around the world during times of natural calamities by providing the expected structural integrity and life safety.

Step-1: Modeling:

With respect to the consideration of type of structure modeling has been done using Geometry and Structural Wizard tool.

Step-2: Generation of Nodal Point :

As per the planning with respect to the positioning of column in building, their respective nodal point has been created on that model.

Step-3: Shear wall surface :

Design shear wall by using Add Surface tool at specified locations.

Step-4: Property Definition:

Using General-Property command define the property as per size requirement to the respective building on STAAD-Pro. So, beam and columns have been generated after assigning to selected beams and columns.

Step-5: Create and Assign Support & Member Property:

After column definition at supports have been provided as fixed below each column by selecting columns using Node Cursor and its cross- section assigning based on load calculations and property definition.

Step-5:3-DRendering:

After assigning the member property to structure the 3-D view of the structure can be shown using 3-D Rendering command.

Step-6: 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 as 50kN/m3. As per IS:1893 (Part 1)-2016, the dead load have been assigned on the basis of member load, floor load, self-weight of the beams definition.

ii. Live Load

As per IS:875 (part 2)-1987, live load 4.5kN/m has been assigned to the members.

iii. Seismic Load

After defining the seismic load as per requirement of IS: 1893 (Part 1): 2016, the seismic load has been assigned with respect to +X, -X, +Z, and –Z directions with their respective appropriate seismic factor.

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 STADD-Pro.

Step-7: Structural analysis on STADD-Pro.

After adding Analysis/Print, using Run Analysis Command, the structure is analyzed and detailed study of forces and

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bending moment is undertaken through the Post processing mode to recognize their shear forces, bending moment diagrams to it check is safe or not.

Step-8: Design of Structure on STADD-Pro
The design is undertaken as per IS 456:2000 for RCC. M50 concrete and Fe500 is used as design parameters. Percentage steel of 1.2% has been specified as per IS Code standards and the design parameters have been assigned to respective every beam and column to get the final design.

Step-12:Output Generation.
After that output file is generated which containing the structural design of each individual beam and column member of structure.

Table 2 Zone Factor, *Z*
(*Clause* 6.4.2)

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

I=1; Importance factor given in IS 1893 (part1-5) for the corresponding structures; when not specified, the minimum value of I shall be,
a) 1.5 for critical and lifeline structure,
b) 1.2 for business continuity structures,
c) 1.0 for the rest.
R=3; response reduction factor given in IS 1893 (Table-9) for the corresponding structures.
$\frac{Sa}{g}$ = The design acceleration coefficient considered as per Indian Standards for design, as per IS 1893 (Part 1): 2016.

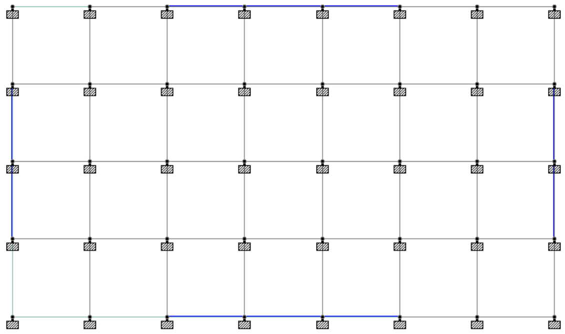

Fig. STAAD Plan

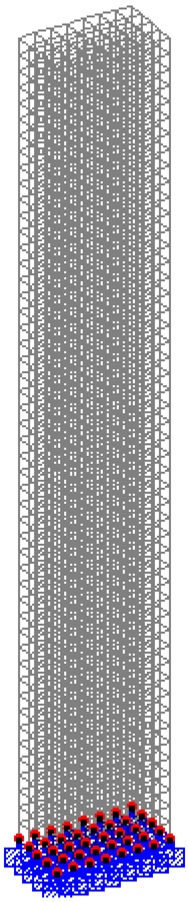

Fig. STAAD Model

The STADD-Pro plan and model for the considered G+49 building is shown below.

- The building plan is of size 20m x 25m.
- Height of the building (h) = 150 m
- Width of the building (dx) = 25 m
- Width of the building (dz) = 20 m

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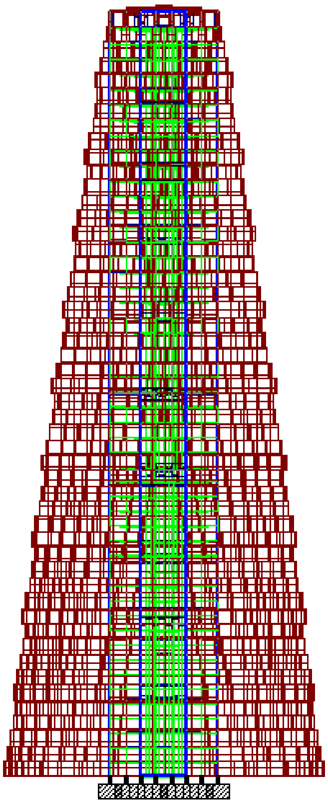

Fig. Axial Force

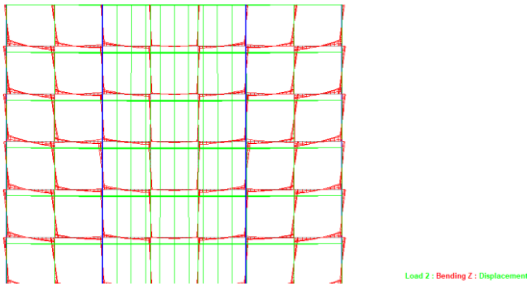

Fig. Bending

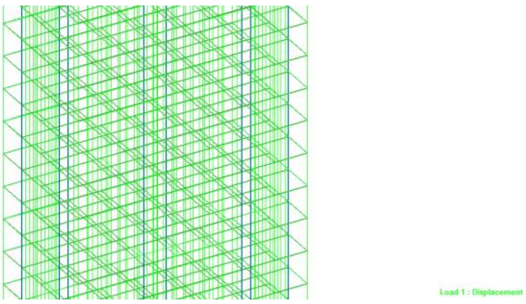

Fig. Displacement

Ta = 3.02sec.,
$\frac{Sa}{g}$ =4.5.
Load Factor =1,
Ah=0.0308,

STAAD-Pro model Load to make the structure seismic force resistant, the fundamental period of the building while vibration should be calculated and procure as input to STADD-Pro for seismic analysis. The considered building is in zone IV. These values are derived as input to the seismic definition in STADD-Pro and seismic forces are calculated. The earthquake force acting on the structure is represented below.

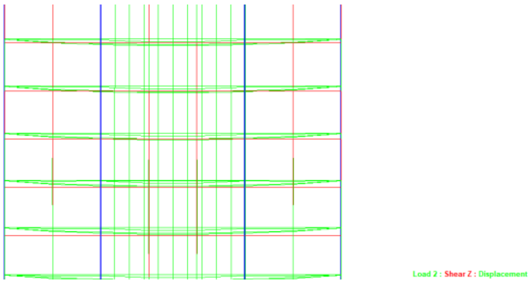

Fig. Shear in Z direction

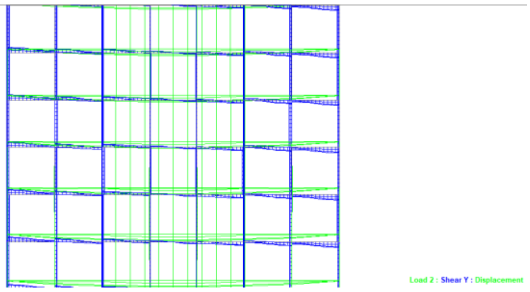

Fig. Shear in Y direction

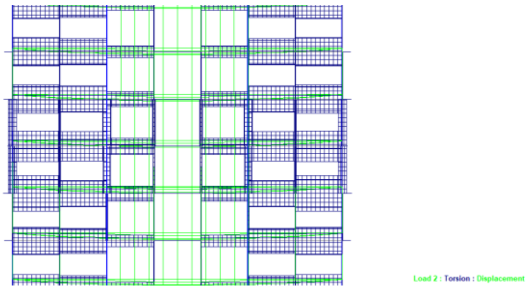

Fig. Torsion

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V. CONCLUSION

To analyze the effect of shear wall on the response of multi storey RC framed building the Seismic Analysis carried out, based on the results following points are concluded:
From the results of the Seismic Analysis, it was concluded that the RC framed building with Shear wall has good resistance to earthquake and can sustain the vibrations due to earthquake.
Based on the study of seismic analysis, following points are summarized:
1. It can be observed that the maximum displacement against earthquakes is very less because of shear walls as compared to the bare frames.
2. STADD. Pro is versatile software having the ability to determine the reinforcement required for any concrete section based on its loading and determine the nodal deflections against lateral forces.
3. It experiences static as well as dynamic analysis of the structure and gives accurate results which are required.

Thus, the Shear Walls in RC framed buildings make the structure more stiff for Earthquake excitations and can be used to reduce the lateral deflection.

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