Performance, Evaluation of Various Shapes of Shear Wall in Symmetric Building under Static and Dymanic Loadings

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Abstract— Shear walls are the structural elements of the horizontal force resisting system. Shear walls have high influence stiffness and strength and provided to resist gravity load as well as lateral load caused by seismic and wind. So many literatures are available to analyze and design of shear wall. However the optimum location and its effects in high rise RC buildings is not much discussed in any literatures. In this project the main aim is to find the effective, efficient and optimum location of the shear walls in high rise irregular RC building. In this present study the optimum location of shear wall has been investigated with the help of three different Model 1 is bare frame structural system and other two models are dual type structural system with central core wall and corner shear wall. An earthquake load is calculated as per IS 1893(PART-1)-2002 and applied to (G+15) storey R.C building in zone-2 and zone-5. Based on the conventional wide column analogy, two different three-dimensional shear wall models. These approximate models are verified in comparison to not only the results available in the literature but also the ones obtained by using models containing shell elements. With the help of these new models three different groups of shear wall-frame structures such as L-shape, U-shape, rectangular shape with same floor plans and same heights are analyzed. The structure is analysed and design under static and dynamic loading conditions. The results of these computations are observed to be in good agreement with those obtained by detailed models containing shell elements.

Keywords: Shear walls, STAAD Pro V8i, stiffness, strength Bae frame

I. INTRODUCTION

Structural engineering is a most fundamental engineering discipline because it deals directly with the structural integrity and strength of building is a structure.

Structural engineering is a crucial because it directly impacts the safety and durability of buildings and structures. For example it is structural engineering that allows for an accurate estimation of safe weight maximums on bridges, the storm face winds a warehouse or facility can withstand or the magnitude of tremors skyscrapers can endure during an earthquake.

Structural engineering is extremely important in the design of a house or a building that is to be contracted on a site in mountains.

A. Commercial Constructions

Construction of a commercial buildings helps bring economic stability to an area. People generally want to see improvements made to their communities, including better infrastructure, which includes not only commercial buildings but roads, pipes, sidewalks and landscaping.

Commercial buildings are buildings that are used for commercial purposes and include office building ware houses and retail building (e.g. shopping walls).

In urban locations, a commercial building may combine functions, such as offices on level 2-10, with retail on floor 1.when space allocated to multiple functions is significant, these buildings can be call multi use.

Walls that mainly withstand lateral load due to the wind or earthquake acting on the building are called structural walls or shear walls. shear walls are the structural system use to increase the strength of RCC structures. in high rise buildings the shear wall are used to resist lateral loads that may be caused by wind and seismic motion. RC shear wall provide large strength and stiffness to the building in the direction of the orientation which considerably reduces lateral sway of the building and thereby reduces damage to the structure.

If a high rise RC structure is design without shear wall the beam and column size are large and so many problems arises at the joints. And due to this it is difficult to place and vibrate the concrete at such places and displacement is more which in turn induces heavy forces on structure therefore shear wall become essential from the point of view of economy.

By providing shear wall the structure become safe and durable and also more stable the function of shear wall is to increase rigidity for wind and seismic load resistance .the use of shear wall gains more popularity in the construction of service apartments or office.

Earthquake induced damages to the structures are unavoidable but it can be reduced by observance of seismic design provisions such as shear wall. Seismic design of structures often leads to construction of expensive structures. Thus it is reasonable to optimize the cost of the building constructions whereas the design criteria are satisfied economical design of structures can be performed via structural optimization clearly in this process objective functions most be selected in a way to lead to minimum structural cost ordinary objective functions are weight or cost of the structures obviously the cost of the structure usually in the function of structural weight.

The structure subjected to various load like concentrated loads, UDL, UVL, internal and earthquake load and dynamic forces which are consider during the design phase. The structure transfers it load to the support and ultimately to the ground. While transferring the loads the member of the structures are subjected to internal forces like axial forces, shearing forces, bending and torsion forces which are discuss while analyzing the structure.

Types of Shear Walls

Based on type of material used, shear walls are classified into following types.

1) Reinforced Concrete Shear Wall

2) Steel Shear WalL
3) Plywood Shear Wall
4) Mid-Ply Shear Wall

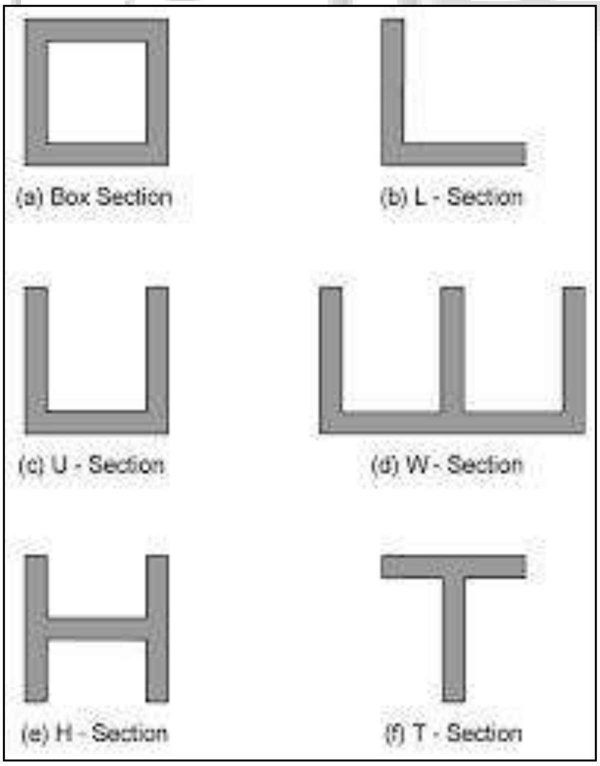
1) Reinforced Concrete Shear Wall

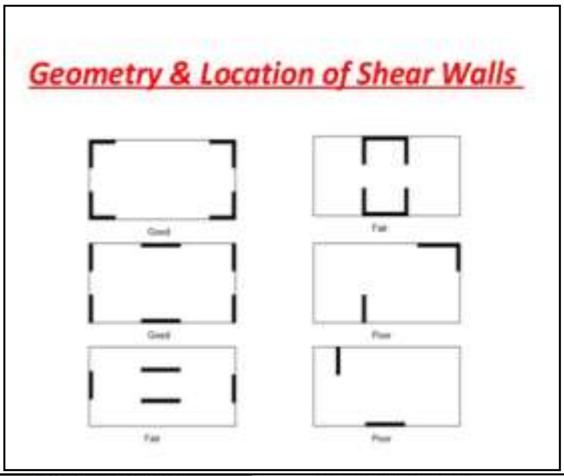
Reinforced concrete shear walls are widely used shear walls for residential buildings. The reinforcement is provided in both horizontal and vertical directions. But at the end of each wall, bars are closely spaced and anchored. So, the end zones of RC shear wall are called as boundary elements or barbells.

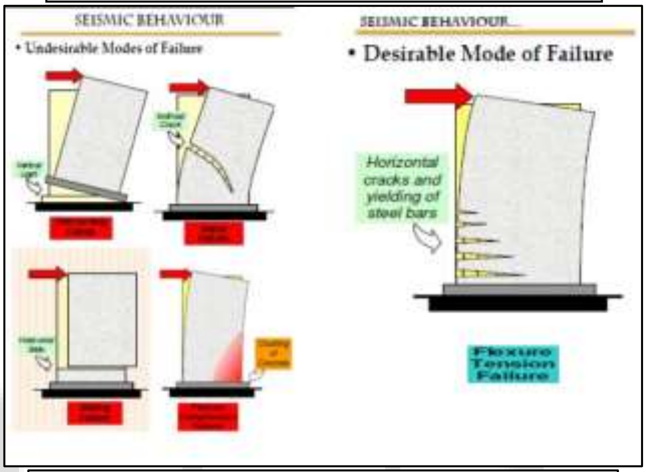
The wall thickness of RC shear wall is varied depending upon many factors like thermal insulation requirements of building, age of building, number of floors of building etc. It varies from 140 mm to 500 mm. In general, the provision of shear wall is continuous throughout the height of building. But sometimes it is discontinued where there is a building entrance or parking space etc.

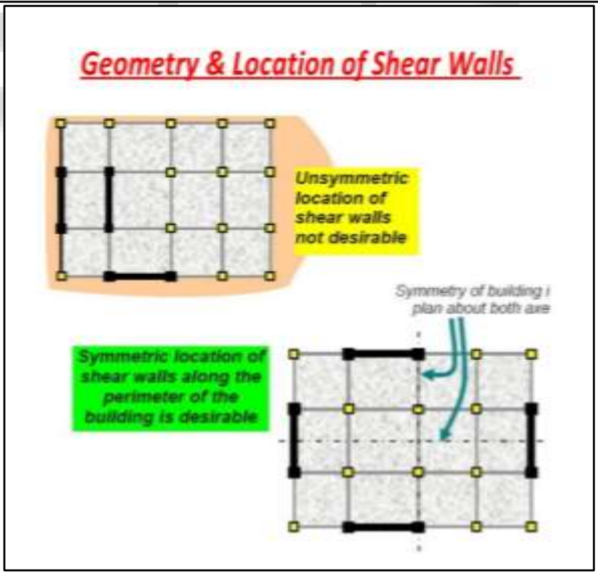
Fig. 1: Reinforced Concrete Shear Wall

a) Shapes of Shear Wall
- BOX-Section
- L-Section
- U-Section
- W-Section
- H-Section
- T-Section









II. METHODOLOGY

1) Geometry of the irregular buildings with various types of share walls at different locations.
2) Assessing different load combinations and analysis using Staad pro V8i software.
3) Designing and drawing of structural components like slab, beam, column, share wall etc by using limit state method and IS code provisions in Staad pro V8i software.

A. Design Methodology

1) Limit State Method

It uses the concept of the probability and based on the application of method of statistic to the variation that occurs in the practice in the loads acting in the structures or in the strength of material. The structures may reach a condition at which it becomes unfit for use for one of many reasons e.g. collapse, excessive deflection, cracking, etc. and each of these conditions is referred to a limit state condition. The aim of limit state design is to achieve an acceptable probability that the structure will not become unserviceable in its life time for the use of which it has been intended i.e. it will not reach a limit state. It means the structure should be able to withstand safely all loads that are liable to act on it throughout its life and it would satisfy the limitations of deflection and cracking.

a) Assumptions for flexural member:

1) Plane sections normal to the axis of the member remain plane after bending Structural Analysis and Design of Commercial Building for Earthquake Resistance.
2) The maximum strain in concrete at the outermost compression fiber is 0.0035.
3) The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoidal, parabola or any other shape which results in prediction of strength in substantial agreement with the result of test. For design purposes, the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor γm = 1.5 shall be applied in addition to this.
4) The tensile strength of concrete is ignored.
5) The design stresses in reinforcement are derived from representative stress-strain curve for the type of steel used. For the design purposes the partial safety factor γm = 1.15 shall be applied.

The maximum strain in the tension reinforcement in the section at failure shall not be less than:

$$\frac{fy}{1.15Es} + 0.002$$

Where,

fy= characteristic strength of steel

Es = modulus of elasticity of steel

Limit state of collapse for compression

b) Assumption:

- In addition to the assumptions given above from i) to v), the following shall be assumed:
  1) The maximum compressive strain in concrete in axial compression is taken as 0.002.
  2) The maximum compressive strain at highly compressed extreme fiber in concrete subjected to axial compressive and bending and when there is no tension on the section shall be 0.0035 minus 0.75 times the strain at the least compressed extreme fibre.
  3) The limiting values of the depth of neutral axis for different grades of steel based on the assumptions are as follows:

Structural Analysis and Design of Commercial Building for Earthquake Resistance Table 1: Limiting Value of Neutral Axis

c) Limit state of serviceability

This state corresponds to development of excessive deformation and is used for checking members in which magnitude of deformation may limit the use of the structure or its component. This limit may corresponds to

1) Deflection
2) Cracking
3) Vibration

The choice of the degree of reliability should be taken into account the possible consequences of exceeding the limit state of collapse which may be classified according to

1) Risk to life negligible and economic consequences small or negligible.
2) Risk to life exists and / or economic consequences considerable and
3) Risk to life great and / or economic consequences also great.

Dynamic load analysis methods:

1) Equivalent static analysis
2) Response spectrum analysis
3) Linear dynamic analysis
4) Non linear static analysis
5) Non linear dynamic analysis

B. Method of Wind Analysis:

From IS875 (Part3), the basic wind speed (V) depends upon Terrain roughness, height and size of structure, and location of the structure. It can be mathematically expressed as follows:

$$V=V_bK_1K_2K_3$$

V_b = design wind speed at any height z in m/s

K_1 =risk coefficient

K_2 = height and structure size factor and

K_3= topography factor

The wind load on a building shall be calculated for:

1) The building as a whole,
2) Individual structural elements as roofs and walls For calculating wind load on individual member, the wind load, F, acting in a direction normal to the individual structural element or cladding unit is

$$F= (C_{pe}-C_{pi})Ap_d$$

Where,

C_{pe}=external pressure coefficient,

C_{pi}=internal pressure- coefficient,

A=surface area of structural or cladding unit,

and p_d= design wind pressure element

1) Description of Building Structure

The details of the building is given in below Table 1

STRUCTURE	DESCRIPTION
No of Stories	G+15
Typical height of one storey	3m
Soil Type	Medium Soil
Plinth height	1.5m
Grade of Concrete	M40
Grade of Steel	Fe 500
Slab Thickness	150 mm

Dead Load	3.75 KN/m^2
Live Load on Roof	3 KN/m^2
Floor Finish	1 KN/m^2
External wall	230 mm
Partition wall	100 mm

III. OBJECTIVES

1) To select a typical plan of a building using shear walls locations.
2) To assess different combination of loads on the structure
3) To analyze the structural elements like beam, column, slab, shear wall etc.
4) To design and draw detailing of all the structural elements using IS code specifications
5) To compare analysis results between models with and without shear walls

IV. MODELING, ANALYSIS, DESIGN AND DETAILING

A. Isometric views of structure:

The main output obtained from AutoCAD and STAAD Pro V8i after performing analysis.

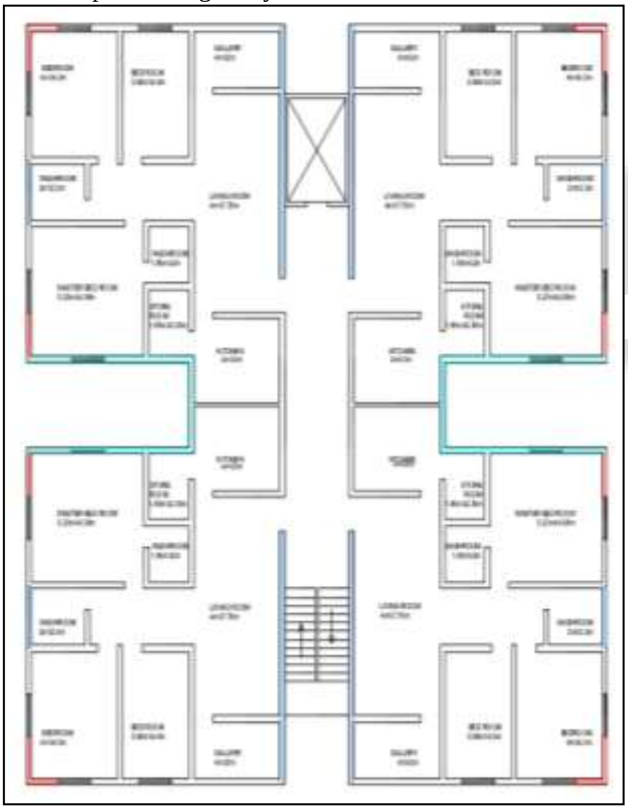


Fig. 1: 2D plan with various shapes of shear walls

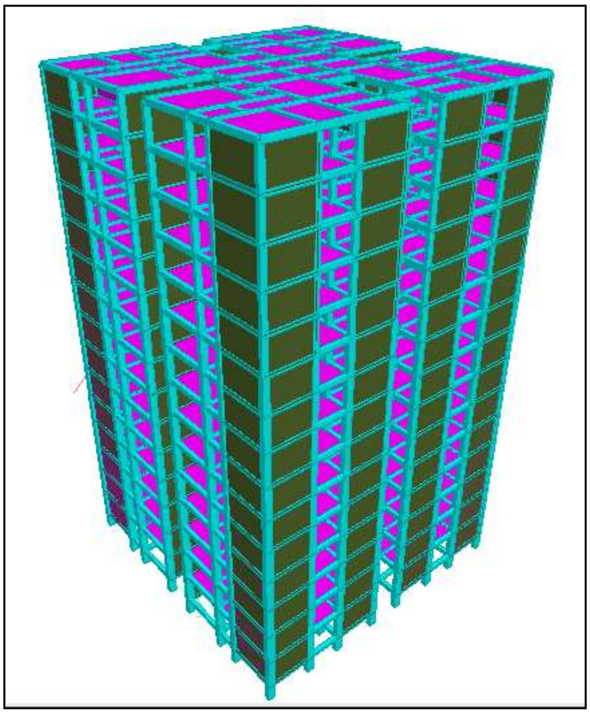


Fig. 3: 3D view of structure with various shapes of shear walls

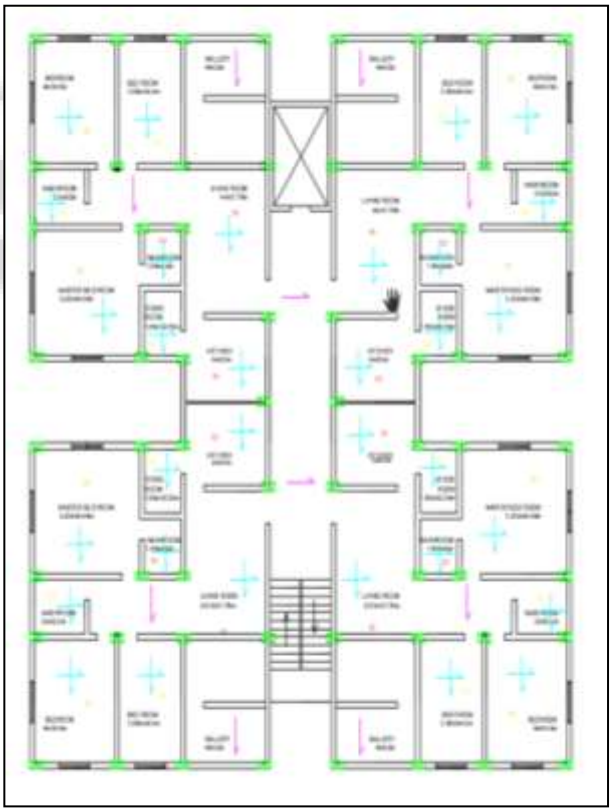


Fig. 2: 2D plan without shear walls

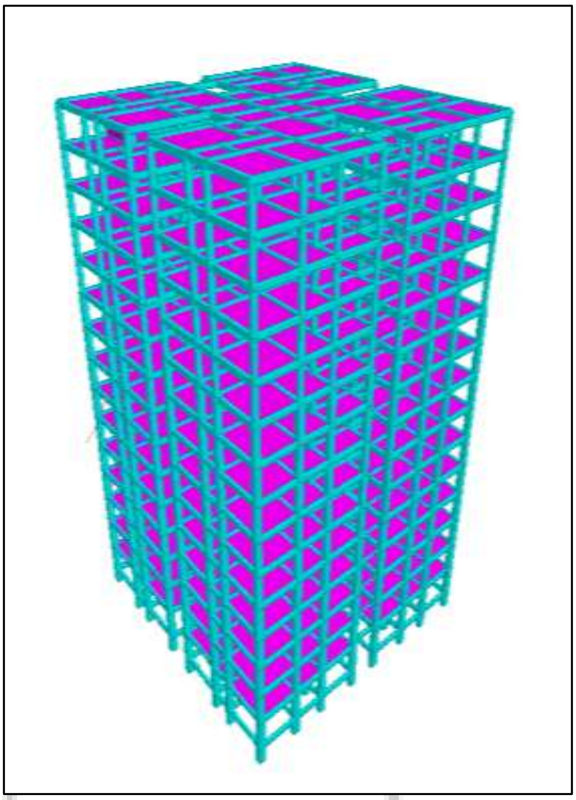


Fig. 4: 3D view of structure without shear walls

V. RESULTS

A. *Analysis with various shapes of shear walls.*

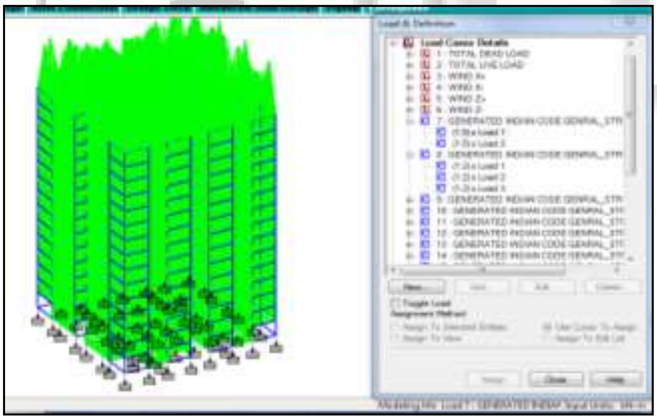


Fig. 1: Combinations of Loads (1.5(DL+LL))

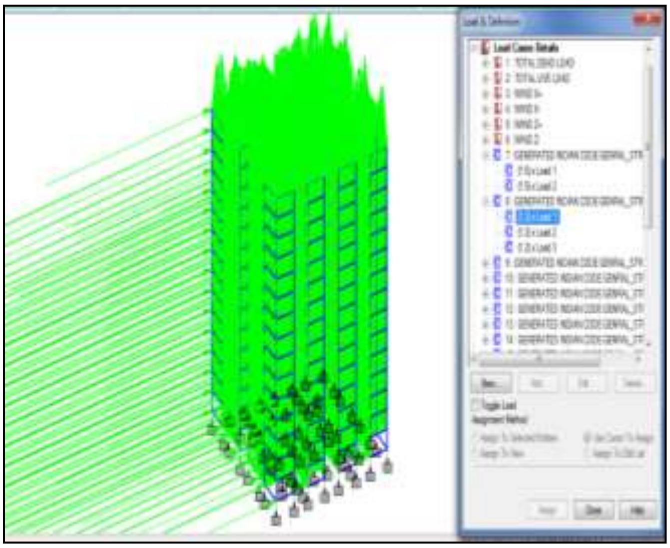


Fig. 2: COMBINATIONS OF LOADS (1.2(DL+LL+WL))

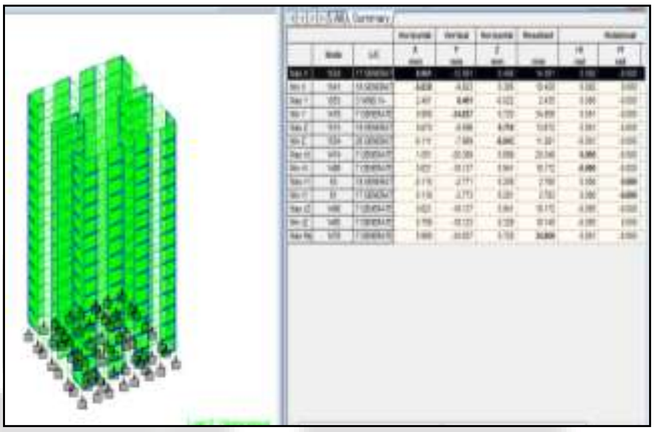


Fig. 3: NODE DISPLACEMENT DIAGRAM

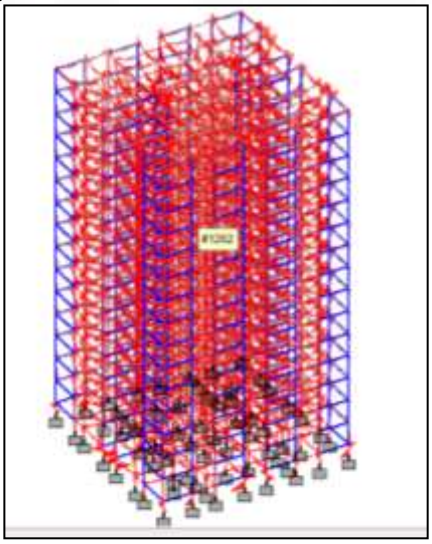


Fig. 4: BENDING MOMENT DIAGRAM

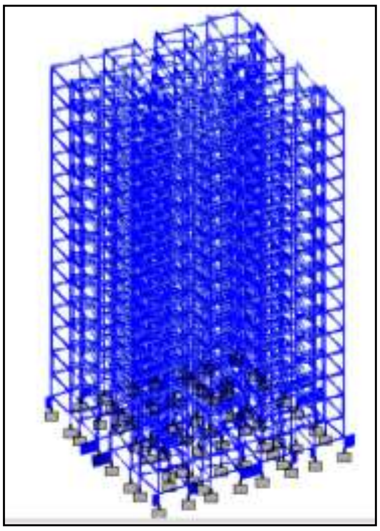


Fig. 5: SHEAR FORCE DIAGRAM

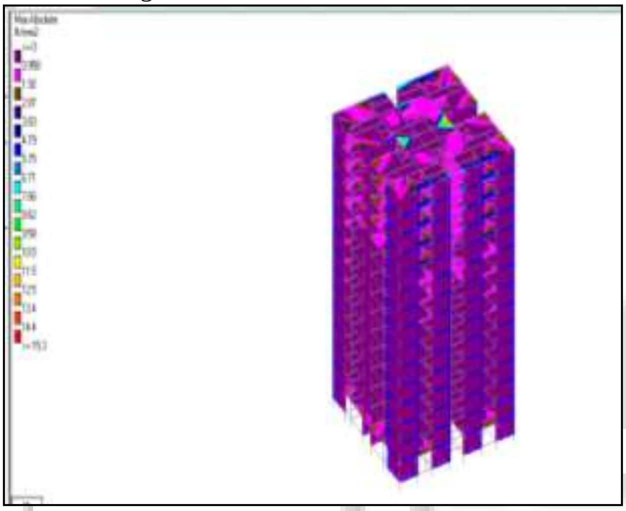


Fig. 6: PLATE STRESSES DIAGRAM

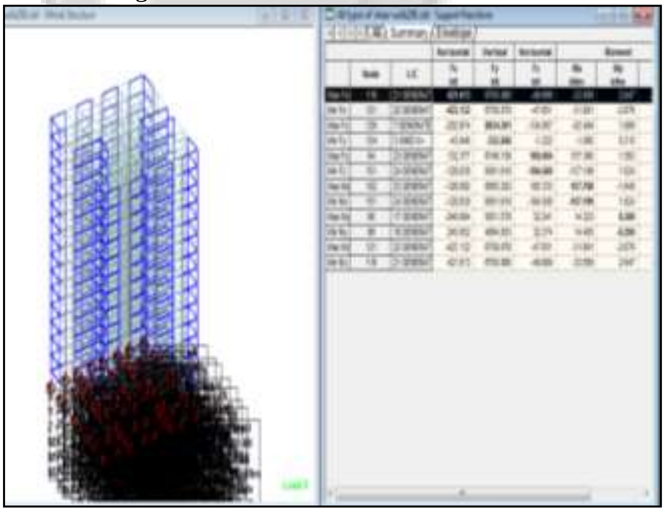
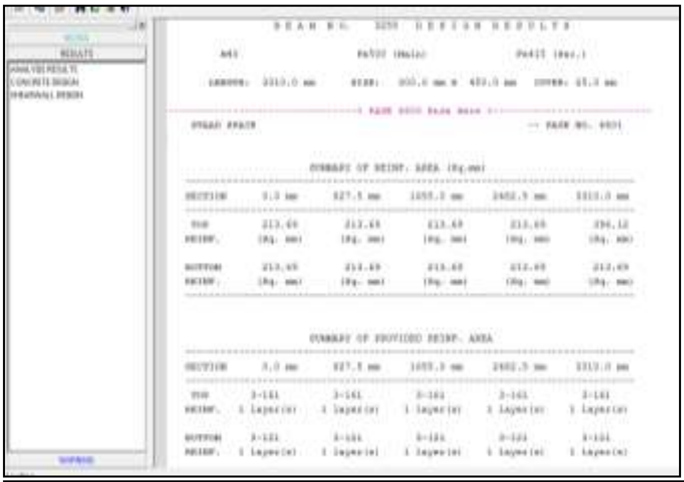


Fig. 7: SUPPORT REACTIONS AT SUPPORTS



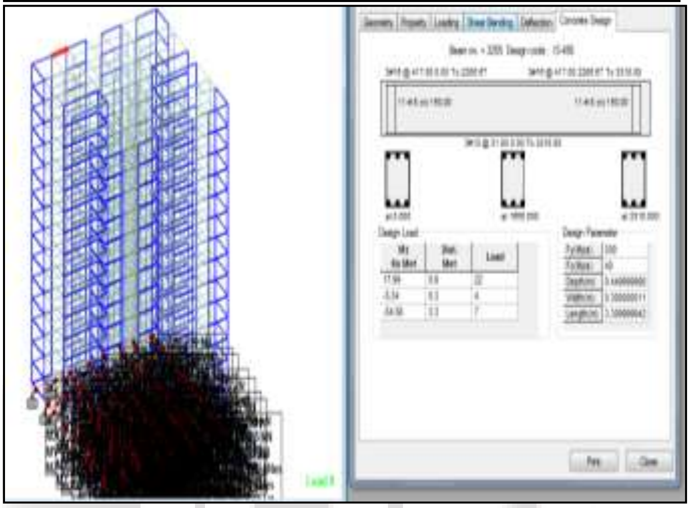
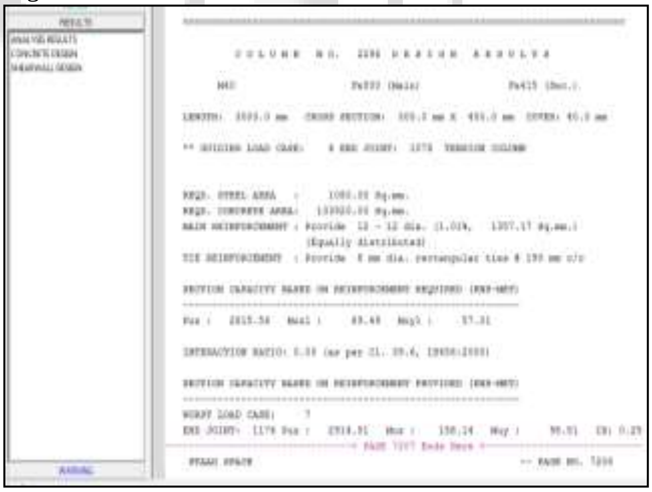


Fig. 8: REINFORCEMENT DETAILS IN BEAM NO.3255



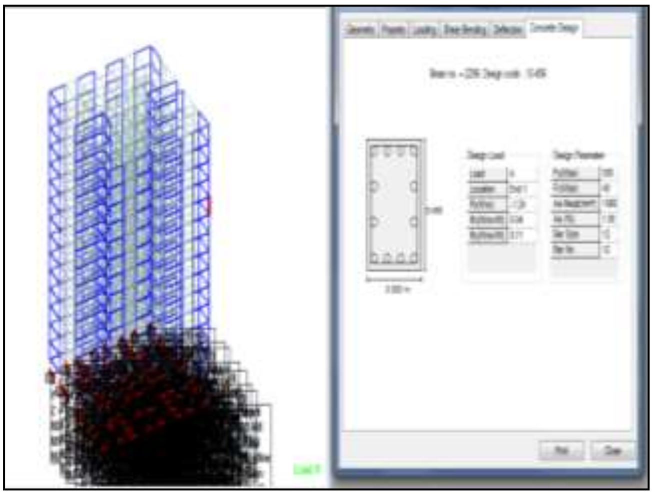


Fig. 9: REINFORCEMENT DETAILS IN COLUMN 2296

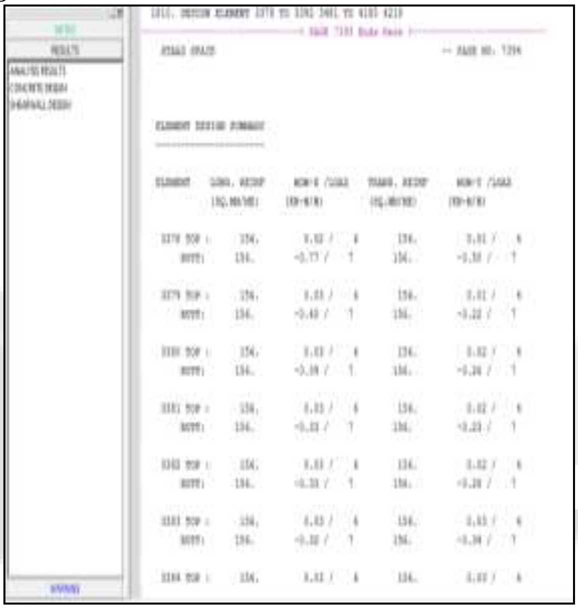
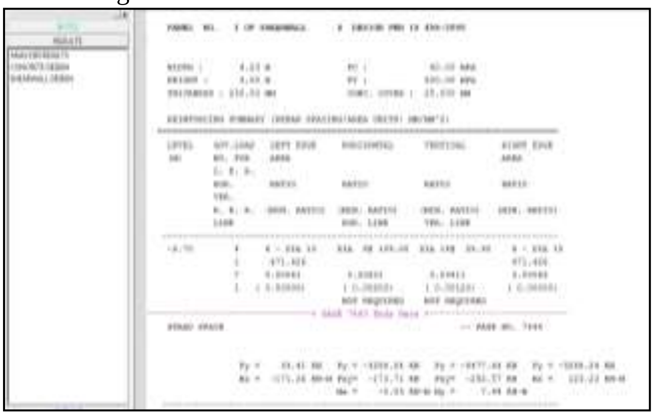


Fig. 10: DESIGN ELEMENT SUMMARY



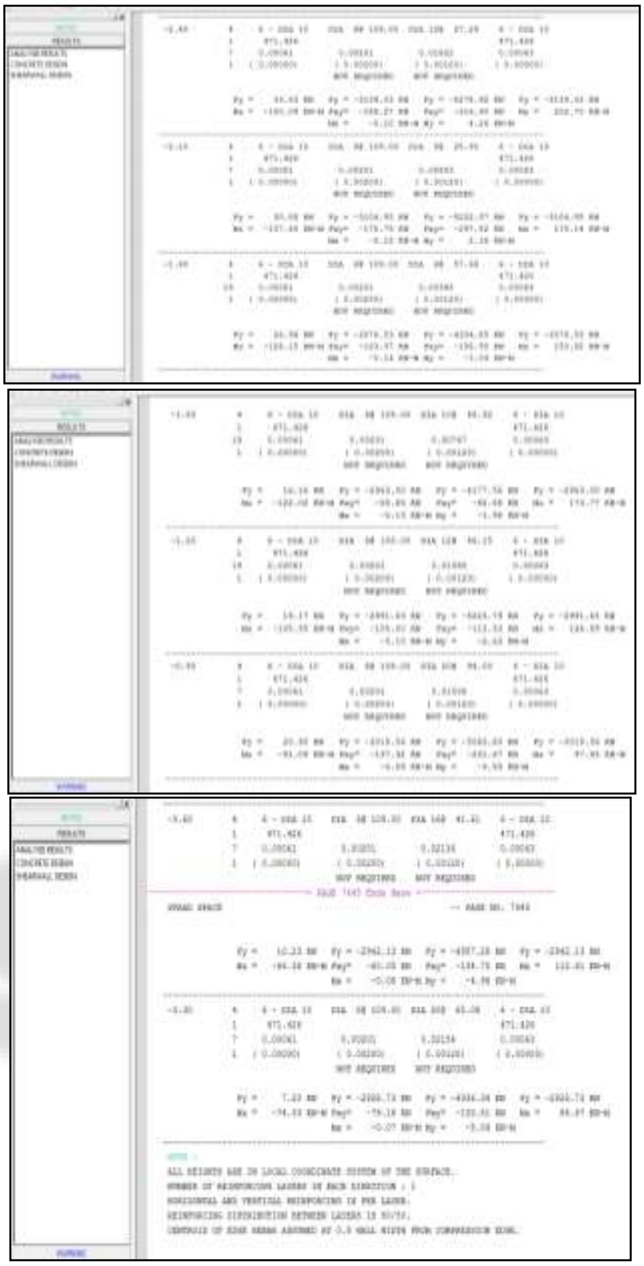


Fig. 11: SHEAR WALL PANEL NO.4 DESIGN DETAILS

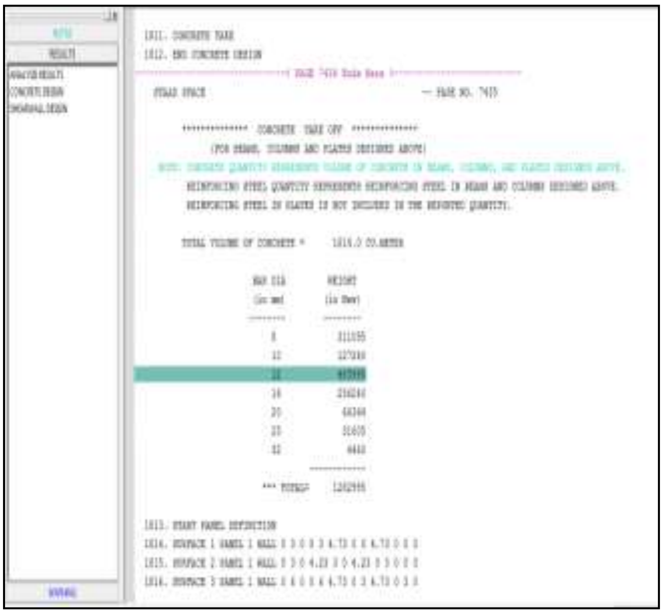


Fig. 12: Total Volume of Concrete in Beam, Columns and Plates Designed In Cubic Meters and Total Weight of Steel Bars in Newtons

B. Analysis without shear wall.

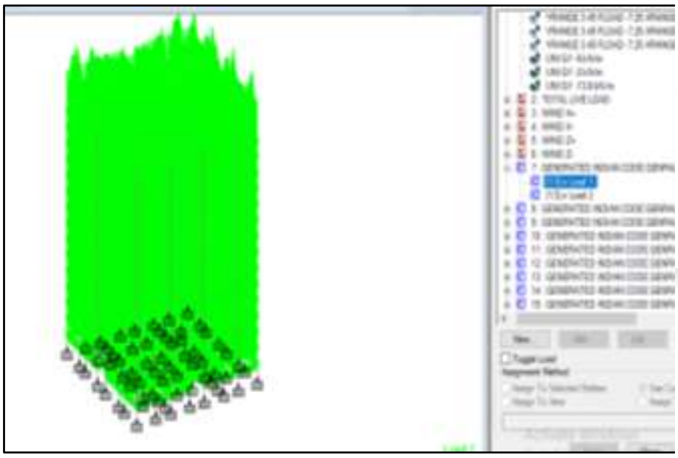


Fig. 1: COMBINATIONS OF LOADS (1.5(DL+LL))

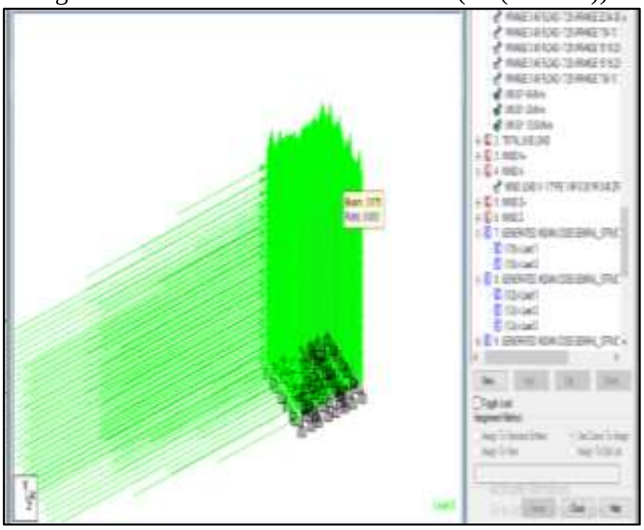


Fig. 2: COMBINATIONS OF LOADS (1.2(DL+LL+WL))

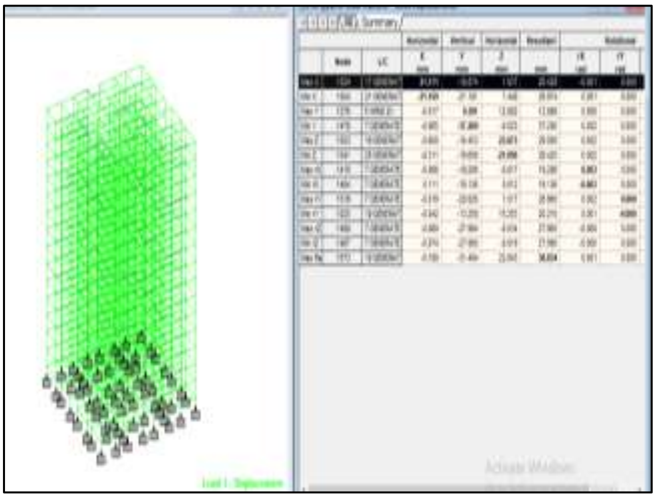


Fig. 3: NODE DISPLACEMENT DIAGRAM

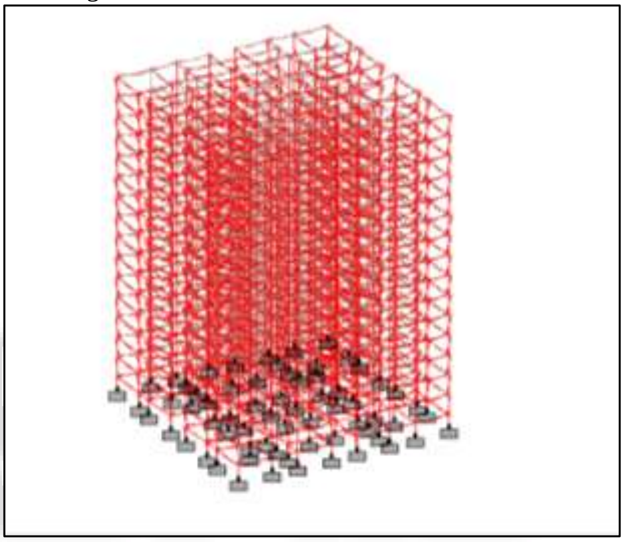


Fig. 4: BENDING MOMENT DIAGRAM

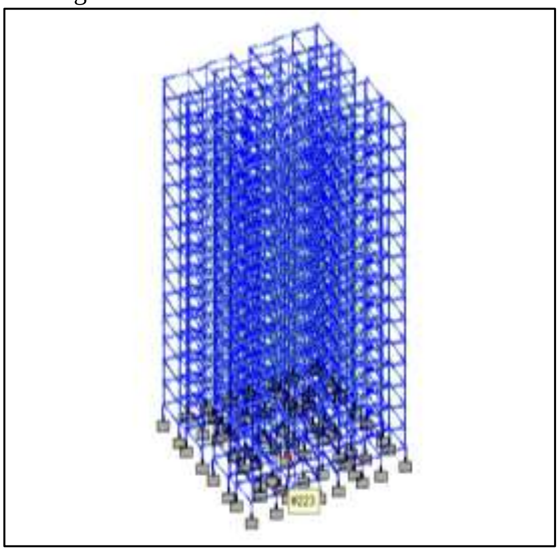


Fig. 5: SHEAR FORCE DIAGRAM

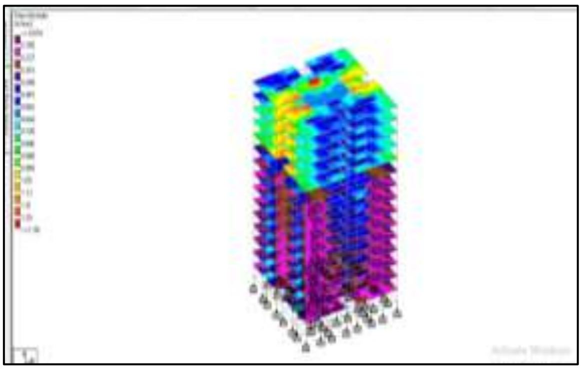


Fig. 6: PLATE STRESSES DIAGRAM

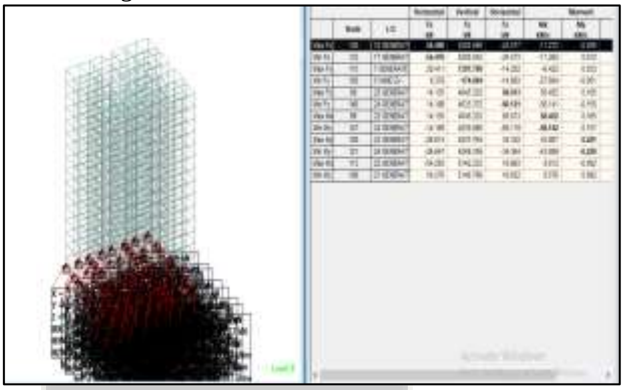


Fig. 7: SUPPORT REACTIONS AT SUPPORT

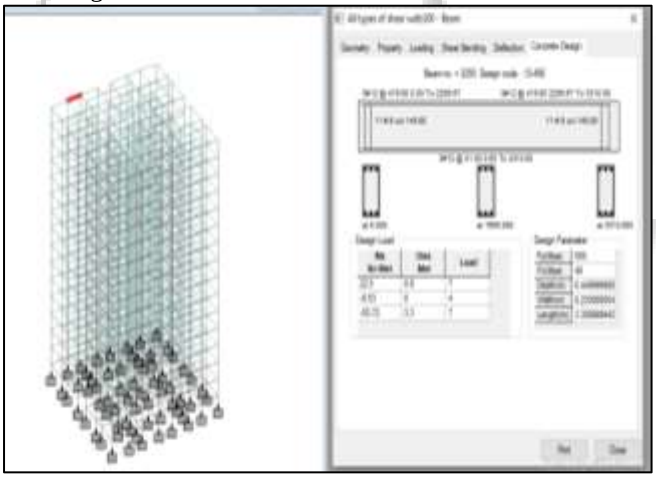


Fig. 8: REINFORCEMENT DETAILS IN BEAM NO.3255

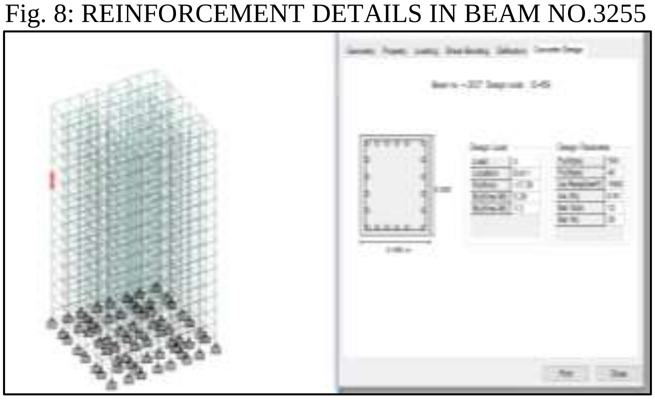


Fig. 9: REINFORCEMENT DETAILS IN COLUMN NO.2037

VI. CONCLUSIONS

1) Modeling of entire structural frame is completed with various shapes of shear wall and without shear walls.
2) Assessment of all combination of loads have been completed for both models (with and without shear walls) using IS 875-1987 in STAAD pro.
3) Complete analysis of all structural elements for models in STAAD pro is completed such as shear force diagram, bending moment diagram, deflection diagram, stresses diagram etc.
4) Design and detailing of all structural element is being carried out in STAAD pro such as for beams, columns, slabs, shear walls using IS code specifications.
5) Comparision of analysis results is being carried out for the models with and without shear walls.
6) From above conclusions it is clear to us that STAAD pro V8i software is user friendly software can be used for analysis and design of many civil engineering structure such as for public buildings, residential buildings, industrial buildings, commercial buildings etc.

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