SHEAR WALL DESIGN FOR HIGH RISE BUILDINGS

A

THESIS

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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(Professor)

And

Dr. Tanmay Gupta
(Assistant Professor)

by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

MAY, 2020

STUDENT' S DECLARATION

I hereby declare that the work presented in the Project thesis entitled **"SHEAR WALL DESIGN FOR HIGH RISE BUILDINGS"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at the **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Prof. Dr. Ashish Kumar** and **Dr. Tanmay Gupta**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Student

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Date: 25-05-20

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"SHEAR WALL DESIGN FOR HIGH BUILDINGS"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Shourabh Maanju (161673)** during a period from July 2019 to May 2020 under the supervision of **Prof. Dr. Ashish Kumar** and **Dr. Tanmay Gupta,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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ABSTRACT

Shear walls are one of the most appropriate and important structural components in multi-storied buildings. Therefore, it would be very interesting to study the structural response and their systems in multi-storied structures. Shear walls improve the strength and stiffness during earthquakes which is often neglected during the construction and design of the structure. This study has shown the effect of shear walls which significantly affect the vulnerability of structures. In order to test this hypothesis, a G+11 story building was considered with and without shear walls and analyzed for various parameters like base shear, story drift ratio, lateral displacement, bending moment and shear force. The significance of the shear wall has been studied with the help of two models. The first model is without shear wall i.e. bare frame and another model is with shear walls.

Currently, the simple design methods are available for greater heights in the respective design codes. Hence, the objective of this study is to thoroughly compare the high rise buildings using different codal provisions and under various combinations of design load using STAAD Pro. software. Firstly, making the structure at its normal conditions so that it can withstand the forces and does not collapse under its own weight and secondly, making it cost-effective.

The main advantage of shear walls is its merging in the wall which helps to reduce the cost of normal wall designing as compared to the other high rise structures in that particular area. Also if a shear wall is used it will automatically reduce the overall cost of installation as well as the future maintenance cost is significantly reduced.

Keywords: STAAD Pro., High Rise Buildings, Shear Wall

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LIST OF SYMBOLS

Abbreviation	Name	Page number
A_h	Design horizontal seismic coefficient	18
Z	Zone factor	18
I	Importance factor	18
S_a/g	Structural response factor	18
R	Response reduction factor	18
V_b	Base shear	18
W	Lumped weight	18

CHAPTER 1

INTRODUCTION

1.1.Background:

In the 21st century, there has been a huge growth in infrastructure development in most of the developing countries, especially India, in terms of the construction of bridges, buildings, and industries, etc. Due to the growing population and to fulfill their demands infrastructure development is undertaken. The land is scarce in urban cities, due to which the land is limited. To overcome this problem, tall and slender multi-storied buildings are often constructed. There is a high possibility that such structures are often subjected to huge lateral loads. These lateral loads are generated either due to wind blowing against the building or due to inertia forces induced by ground shaking (excitation) which tends to snap the building in shear and push it over in bending. In the framed buildings, the vertical loads are resisted by frames only, however, the lateral resistance is provided by the infill wall panels. For the framed buildings taller than 10-stories, frame action obtained by the interaction of slabs and columns is not adequate to give required lateral stiffness and hence the framed structures become an uneconomical solution for tall buildings. The lateral forces due to wind and earthquake are generally resisted by the use of a shear wall system, which is one of the most efficient methods of maintaining the lateral stability of tall buildings. In practice, shear walls are provided in most of the commercial and residential buildings up to thirty stories beyond which tubular structures are recommended. Shear walls can be provided in one plane or in both planes of the structure. Sometimes shear walls are provided with openings to improve functionality as well as the architectural requirement of the building. The present study is not concerned with the openings, but only with the position of the shear wall.

Fig 1.1: Design of shear wall

1.2. Classification of Shear Walls:

Based on experiments conducted, shear walls are mainly classified according to (i) Material (ii) Geometry.

1.2.1. Based on Material

Based on the material shear wall are of the following types (i) RC Shear Wall (ii) Plywood Shear Wall (iii) Steel plate Shear Wall (iv) RC Hollow Concrete Block Masonry Wall

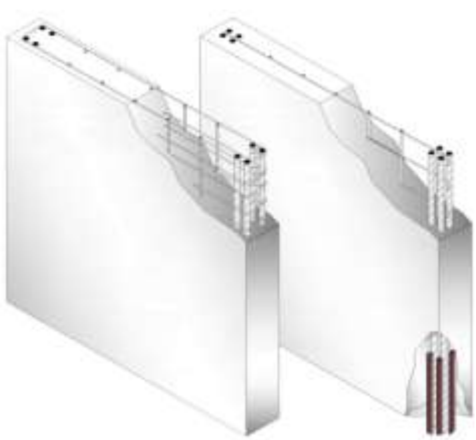
RC shear wall usually has a thickness varying from 140 to 500mm. Usually, these walls are continuous throughout the height of the building. RC shear walls are used in common buildings and complexes. Plywood Shear walls are not recommended for high rise buildings due to their limited strength. They can, however, be used in cold regions effectively. Steel Shear walls have high strength as compared to other types of shear walls but their use is also limited to high initial cost.

1.2.2. Based on Geometry

Based on geometry shear walls are classified as (i) Rectangular Shear wall (ii) Flanged Shear wall (iii) Coupled Shear wall (iv) Framed Shear Wall (v) Barbell Shear wall.

Rectangular shear is the simplest type of shear wall consisting of only vertical and horizontal reinforcement. Vertical reinforcement helps in controlling shear cracking and improves the ductility. Partial shear strength is due to horizontal reinforcement. When the shear wall is provided with extra reinforcement at the ends then it is a Rectangular shear wall with boundary elements, this helps in increasing the strength of shear walls. When the reinforcement to be provided at the boundary becomes large, the need for increasing the ends arises and this is done by shaping the shear wall in Bar Bell shape. This type of shear wall is stronger than a rectangular type of shear wall. Barbell Shear walls are frequently used in high rise buildings.

For use in nuclear power plants, Flanged Shear walls are used. They have been found better in resisting bending stresses as compared to rectangular shear walls.



R C Shear wall

Timber shear wall

Reinforced masonry shear wall   Steel shear wall

Fig 1.2: Different configurations of shear wall

1.3. Importance of Shear Walls:

When the structure is subjected to seismic loading or wind load, it leads the structure to deflect laterally and this deflection or deformation is usually significant to cause heavy damage or in some cases collapse of the structure. This not only puts the lives of many inside the building in danger but also its surrounding. To resist these large horizontal forces, the common elements used are shear walls. Shear walls are vertical members that transfer the lateral forces from roof, floors or external walls to the ground. Shear walls are placed where it will lead to least deflection. Usually it is at the center of external walls but this may not be possible every time. Other places include shear walls at the corner of a building. Shear walls can also be used at the core of a structure.

Shear Core: Shear walls provided in a type of box is known as a shear core. Shear core is usually provided at the core of structure. Shear core has made the construction of high rise buildings simple. Before the concept of shear core high rise buildings were designed with lots of columns and beams to stop it from deflecting significantly. This led to space restrictions inside the building. Also earlier buildings were designed with smaller windows. This led to minimum lighting inside the building. But with shear core, there is plenty of space inside the building as well as plenty of natural lighting. Shear core has led to cutting down of cost significantly as panels can be used on the periphery of elevators. This has made possible the construction of high rise buildings with complex design

1.4. Problem Statement:

Looking at the past records of earthquakes, the demand for earthquake resisting buildings has increased, which can be fulfilled by providing the shear wall systems within the building. Providing shear walls at adequate location results in a lesser displacement. More weightage has been given to the earthquake design of the structure.

1.5. Scope of the study:

- Verification of G+3 Building with Seismic Loading.
- Comparison of displacement of G+11 building with and without shear wall under seismic loading.
- Check and compare the seismic response of the G+11 building for different locations of the shear wall.

1.6. Significance of the study

The major significance for carrying out this analysis is to see how the shear walls affect the building with the increase in height, as the height of the building increases, the deflection goes on increasing due to either the wind load or seismic loading. The main advantage of the shear wall is the lateral force sustaining factor which helps it to keep the structure stable and reduce the deflection which increases the serviceability life of the structure.

The present research work involves the development of a high rise building and subjecting it to seismic loading using STAAD Pro with shear walls and comparing the deflection of building with and without the shear walls. Also, the location of the shear walls plays a key role in keeping the deflection of the building under control so shear walls in this study are placed in different locations and then deflection is checked.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

This chapter presents a summary of different studies on the design and analysis of the shear walls. It includes procedures and guidelines for the design of shear walls by different authors along with recently completed experimental and computational studies available in the published literature.

2.2 Previous Research:

- **Ms. Priyanka Soni, Mr. Purushottam Lal Tamrakar, Vikky Kumhar, 2016**

In this research paper, the authors have analyzed 3 buildings i.e. G+10, G+20, G+26. These buildings were analyzed with shear walls at different locations. In the end, it was concluded that G+10 generated less deformation. This is due to the increasing height of the building, as the height increases there is an increase in the deformation. Also, the optimum location that was found is at the corners of a building.

Also is was concluded that less obstruction will be there because of the reduced size of the column and provision of the shear wall. Building with a shear wall is constructed at a lower cost as compared to the structure without a shear wall.

- **Er. Raman Kumar, Er. Shagunveer Singh Sidhu, Er. Shweta Sidhu, Er. Harjot Singh Gill, 2014**

In this study, two reinforced concrete framed buildings with shear walls at different locations situated in seismic zone V have been analyzed, with four different locations of shear-walls i.e. at the central frame, external frame, internal frame, and combined external and internal frames. The size of the building in the plan is 31.5 m x 22 m. Story Height = 3m, Column Size = 600mm x 400mm, Beam Size = 500mm x 350mm, Slab Thickness = 120mm, Shear wall thickness = 230mm, Thickness of Floor Finish = 40mm, Concrete Mix Used = M30, All the supports are assumed to be fixed in nature. It was concluded that the story drift increases with an increase in the number of stories. Story drift decreases with the provision of shear walls. Story drift is minimum when shear walls are provided at the internal frame. A maximum decrease of 58% in story drift for ten storied building and 60% for fifteen storied building is observed when shear walls are provided at internal frames.

- **Sonali Pandey, Dr. Krishna Murari, Ashish Pathak, Chandan Kumar, 2017**

In this study, it can be concluded that providing shear walls at adequate locations reduces the displacement due to earthquake and shear wall along the periphery is most efficient among all the shear walls considered. By using shear walls, damages due to the effect of lateral forces due to an earthquake and high winds can be optimized. Story drift of building provided with openings in a shear wall is greater than shear wall without openings and also arrangement of shear walls influences material consumption and concrete consumption and steel. The shear wall is effective in reducing the soft story effect. The use of shear walls is more effective in high rise buildings than in low rise buildings.

- **Vivek Pal, Gaikwad Yogesh, Pawar Chetan, Vishwajeet Kadlag. Nikhil Maske, 2018**

In this research paper, the authors analyzed the G+15 building with Seismic loading in STAAD Pro. The building plan size is 24m × 24m. The building is in zone III. The seismic zone coefficient is taken as 0.16 as per IS code. There's more reduction in axial forces and bending moment in columns for a shear wall in opposite sides as compared to without shear wall, also for the center of the building. It was concluded that Shear wall construction will provide large stiffness to the building by reducing the damage to the structure. The location of the shear-wall on opposite sides has a significant effect on the seismic response than shear wall placed on any other location of the building. The seismic response of regular structure gives better in comparison with that of irregular structure, because of the discontinuities along with the height of the building.

- **Kanchan Rana, Vikas Mehta, 2017**

In this research paper, the authors analyzed the G+5 building. In total three models were generated i.e one having no shear wall, one having shear walls at the edges and one with shear walls at the center. It was concluded that Shear walls at the center of sides most effective as compared to corners

- **Prof. N. K. Meshram, Gauravi M. Munde, 2018**

In this research paper, the authors have thrown some light on the different types of shear walls, their function The authors have also analyzed a G+9 building with Seismic Loading. The height of the building is 30m. The spacing of frame along length and width is 4m. The materials used were of grades M35& Fe500 were used for the design. It was concluded that the time period decreases as the mode frequency increases for all models. Maximum lateral displacement increases as story height increases for all models.

- **Rajat Bongilwar, V R Harne and Aditya Chopade, 2018**

In this research paper, the authors have analyzed a G+8 Residential Building. It was concluded that

In multi-story buildings, the provision of shear walls is found to be effective in increasing the overall seismic response and characteristics of the structure. Shear walls are considered for analysis of the RC frame in which an equivalent static method can be effectively used. Shear wall ultimately increases the stiffness and strength of the structure and affects the seismic behaviour of the structure. From the analytical result, it is observed that base shear increases in the model with the shear wall when compared to the model without a shear wall. This is due to the increase in the stiffness of the building.

- **Ashwini A. Gadling, Dr. P. S. Pajgade, 2016**

In this study, RC shear walls with and without openings are analyzed. The dimension of the shear wall affects the load taken by them. When reinforcement is provided around openings, it highly affects the ductility and shear strength of the shear wall. It’s necessary to demonstrate work on the analysis, design and post effects of shear walls when seismic forces are applied. In this paper, a review is taken out over the analysis and design of RC shear walls with and without openings to study more detailed conclusions and results.

- **Mr. Ankur Vaidya, Mr. Shahayajali Sayyed, 2018**

In this study, Seismic Effect was compared on building with and Without- Shear wall. In this study, models are generated and shear walls are located at different positions in the building to find the least displacement of the elements due to shear walls.

- **Manjeet Dua, Er. Sumit Rana & Nitin Verma, 2018**

In this Study, the Effect on Deformation by using the Shear Wall in high rise Building with the Help of STAAD Pro is analyzed. By providing shear walls to the high rise buildings, Structural seismic behaviour will be affected to a great extent and also the stiffness and the strength of the buildings will be increased.

Literature Summary

In the above research papers, all the research has been carried out, focusing on the optimum location of the shear wall and also that how shear walls help in the minimization of the story drift due to earthquakes. the authors have analyzed 3 buildings i.e. G+10, G+20, G+26. These buildings were analyzed with shear walls at different locations. In the end, it was concluded that G+10 generated less deformation**.** The authors have also analyzed a G+9 building with Seismic Loading. The height of the building is 30m. The spacing of frame along length and width is 4m. The materials used were of grades M35& Fe500 for the design. It was concluded that the time period decreases as the mode frequency increases for all models. Maximum lateral displacement increases as story height increases for all models.

A maximum decrease of 58% in story drift for ten storied building and 60% for fifteen storied building is observed when shear walls are provided at internal frames. By providing shear walls to the high rise buildings, Structural seismic behaviour will be affected to a great extent and also the stiffness and the strength of the buildings will be increased. In this paper, a review is taken out over the analysis and design of RCC shear walls with and without openings to study more detailed conclusions and results. Our study is only constricted to the optimum location of the shear walls that leads to minimum deformation of the building and not whether openings are more efficient.

CHAPTER 3

METHODOLOGY

3.1 STAAD Pro.

STAAD Pro software can be used for a vast variety of work like to design structures and buildings, as well as to create simulations that test a structure's service life, load calculations, max absolute stresses, displacements, etc.

For the analysis of the shear wall, many analytical methods have been proposed by numerous researchers which range from a simplified standard approach to the subtle finite element approach. Due to the complexity of numerous factors that influence the overall behavior of RC shear walls, the validity of modeling and analysis techniques might solely be established by comparing the same with experimental results. In this chapter several experimental and analytical investigations are presented about the assessment of the shear walls of different aspect ratios with and without openings and subjected to different loading conditions. Furthermore, various codal provisions have also been reviewed to make a comparative study on design guidelines of shear walls with and without openings. In the end, the damping characteristics and the mathematical models are also discussed in detail.

During the past few decades, efforts have been directed towards the development of effective analytical techniques that can model the behavior of shear walls adequately. Simplified methods have been proposed by various researchers in the past: simplified methods such as equivalent column model, lumped plasticity models, equivalent frame model, Rosman - approach, method of relaxation, etc. are quite popular among the engineering fraternity. However, these simplified models apply only to shear walls with regular geometry and with linear elastic behavior. On the other hand, the finite element method is capable of analyzing shear walls of irregular geometry subjected to loads varying with time in the linear as well as non-linear regimes. The current section explains the various simplified methods and finite element methods.

3.2 STAAD RCDC

Staad RCDC is a software which is a part of Staad Pro Connect Edition. It can be used for the design of Pile cap, Footing, Column and Walls, Beams and Slab. This software requires the analysis file from Staad Pro. The model should be formed by using beams, columns or plate elements. Staad RCDC makes use of the latest codes for the design of Pile cap, Footing, Columns and Walls. By making use of Staad RCDC, the detailed drawings of the reinforcement design can be readily generated and it gives detailed information about the failed elements. There is option for changing the diameter of the reinforcement as per the requirement. After the design is complete, the software gives you the option to change the member sizes to let the user increase the reinforcement in the member. At last Staad RCDC is a powerful software that provides seamless design, drawing, detailing and estimation. RCDC is used for residential, high rise buildings, industrial projects.

3.3 Modeling considerations

For the dynamic response of shear walls, rectangular shear walls were considered under simulated earthquake ground motion applied at the base of the shear wall. The rectangular shear wall is of slender type. The shear wall was used at different locations as well as; it was used as a core for the elevator. It was found that the maximum displacement response, as well as the profile of time history response, was found to be satisfactory.

The focus of the present study is to investigate the influence of RC shear walls on the deflection of the G+11 Building with seismic loading. To determine the load-carrying capacity and ductility, the non-linear static analysis of shear wall was carried out considering material non-linearity. Since the ductility is an important parameter in the earthquake-resistant design, the present analyses focused on the comparison of the ductile response of the shear wall. Also after the frame was generated of the building, the percentage reinforcement was matched to what had been designed at the time of construction to see if any of the members would fail under seismic loading. The members that were used consisted of many shapes i.e. L shaped column, T shaped column, slender columns and rectangular columns.

To determine the displacement response of the shear wall under dynamic ground motions, the shear walls were subjected to the El Centro earthquake applied at the base of the shear wall. The maximum displacement response and base shear demand were computed for the structure with and without shear wall and also for different locations of the shear wall.

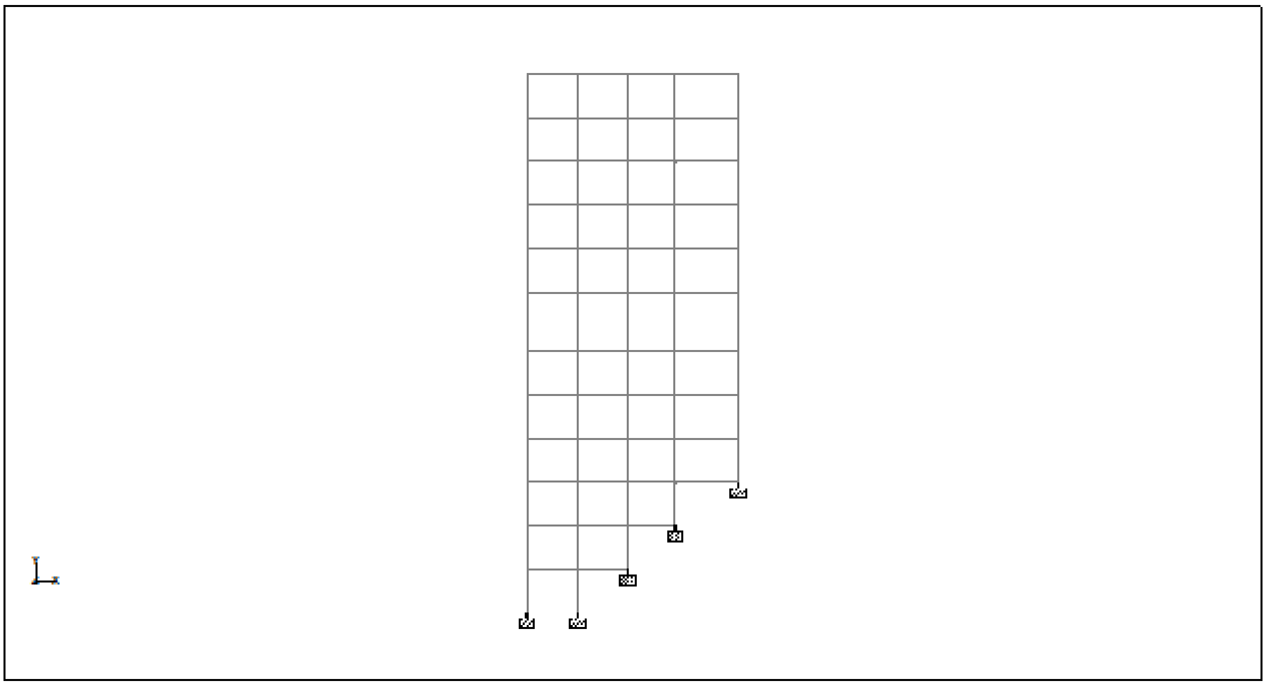


Fig 3.1: Cross-sectional view of Hostel no. 05

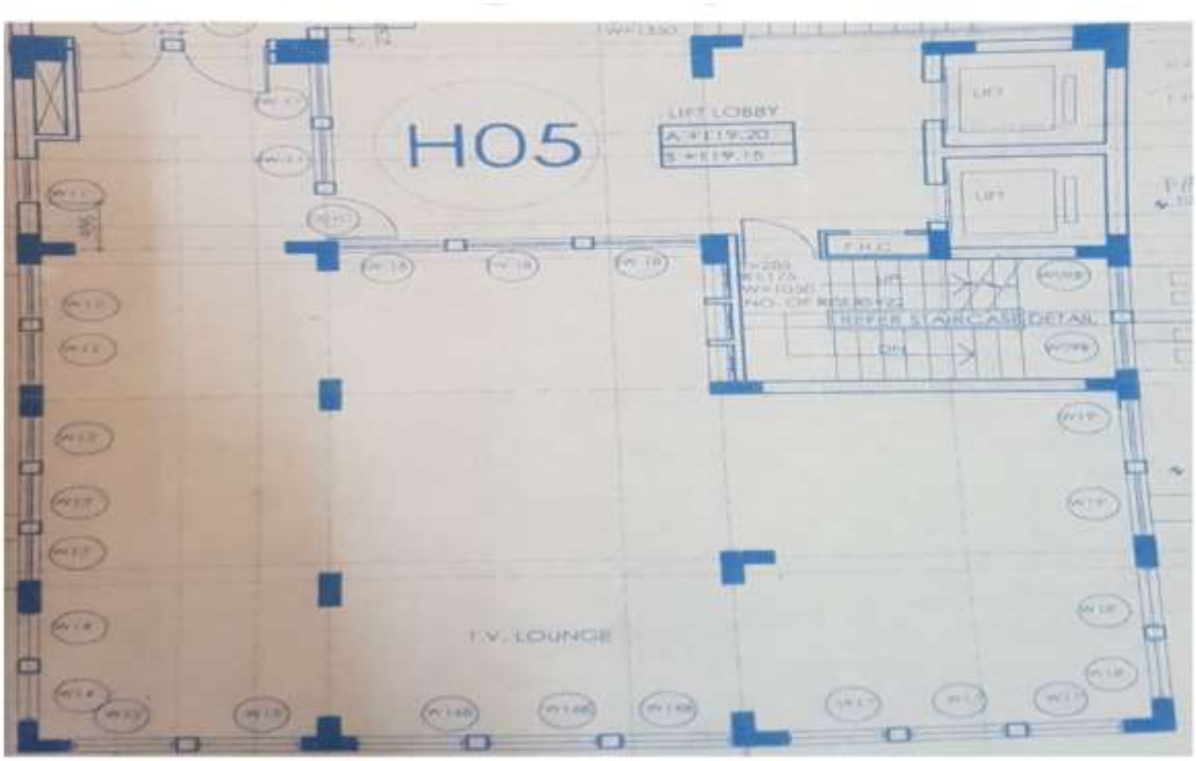


Fig 3.2: Plan of Hostel no. 05

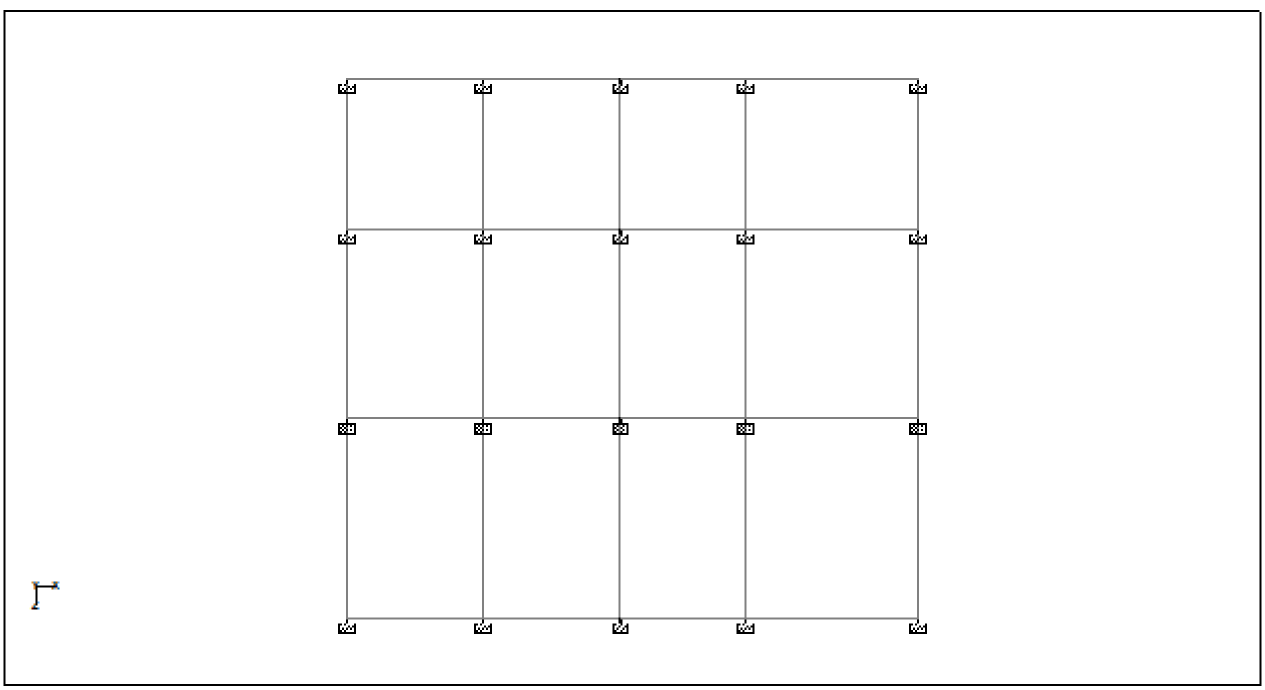


Fig 3.3: Top view of Hostel no. 05

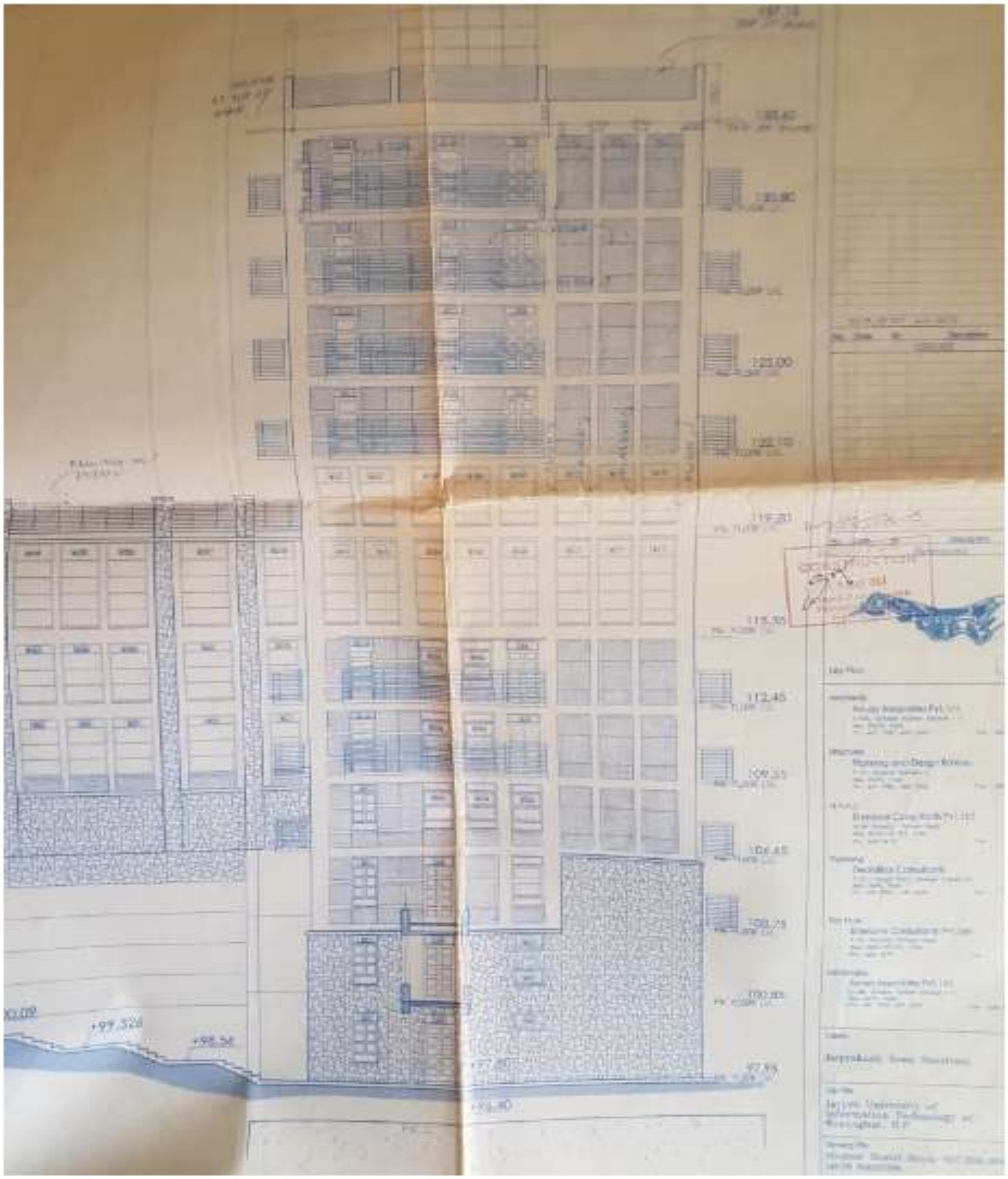


Fig 3.4: Front view of Hostel no. 05

3.4 Work Plan

The tasks undertaken to complete the stated objectives:

Task-1: Literature review

Task-2: Learning expertise of STAAD Pro.

Task-3: Basic model creation and analysis in STAAD pro.

Task-4: Modeling of live high rise buildings in STAAD Pro (H5 Hostel)

Task-5: Load Calculations

Task-6: Calculation of reinforcement using RCDC with and without shear walls

Task-7: Comparing various parameters of the structure with and without shear Walls

Task-8: Using shear walls at different locations to obtain optimum results

A brief description of the work done in each task is as follows:

Task-1: Literature Review

The research activities require a thorough understanding of the literature work done so far to understand the problem so that previous research will not be duplicated. All the objectives were formed based on the research conducted, to solve a few problems.

Task-2: Learning expertise of STAAD Pro.

Learning some important tools and commands of the software, to properly model the shear wall and analyze the structure to get the appropriate results.

Task-3: Basic model creation and analysis in STAAD pro

- **Explanatory Examples on Indian Seismic Code IS 1893 (Part I)**

Consider a four-storey reinforced concrete office building shown in Fig. 1.1. The building is located in Shillong (seismic zone V). The soil conditions are medium stiff and the entire building is supported on a raft foundation. The R. C. frames are infilled with brick-masonry. The lumped weight due to dead loads is 12 kN/m^2 on floors and 10 kN/m^2 on the roof. The floors are to cater for a live load of 4 kN/m^2 on floors and 1.5 kN/m^2 on the roof. Determine design seismic load on the structure as per new code.

[Problem adopted from Jain S.K, "A Proposed Draft for IS:1893 Provisions on Seismic Design of Buildings; Part II: Commentary and Examples", Journal of Structural Engineering, Vol.22, No.2, July 1995, pp.73-90]

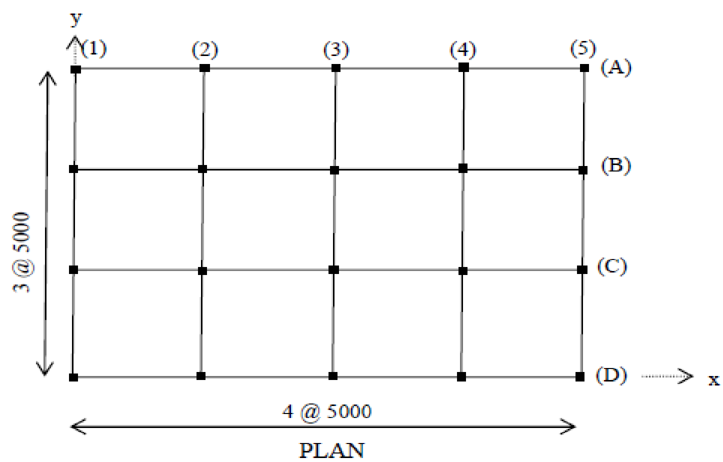


Fig 3.5: Plan of G+3 Building for Seismic Design

Task-4: Modeling of live high rise buildings in STAAD

A single unit of the structure is made by assigning the nodes and then each levels are separately designed to construct the whole structure. The structure is generated by using the plans of the building to figure out the dimensions. Firstly, the structure without the shear wall is prepared and then a structure with the shear wall is prepared.

Step 1: Modeling the frame of the building

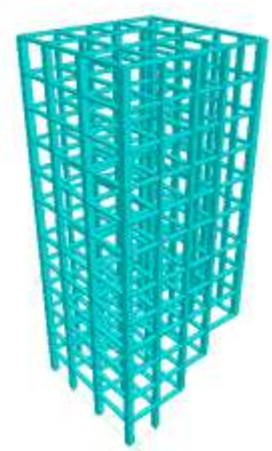


Fig 3.6: Isometric view of Hostel no. 05

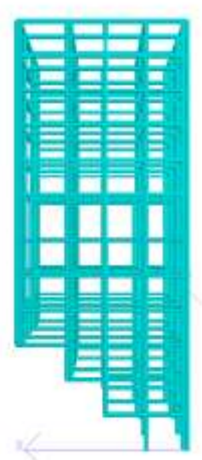


Fig 3.7: Side view of Hostel no. 05

Fig 3.8: Front view of Hostel no. 05

Fig 3.9: Top view of Hostel no. 05

- **Different types of concrete sections**

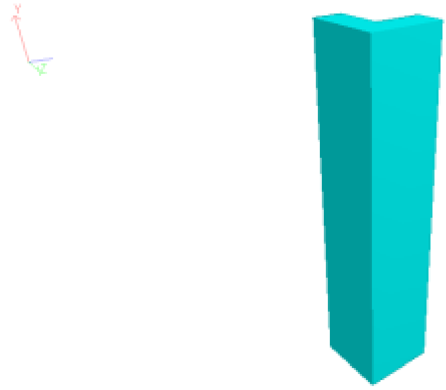


Fig 3.10: L shaped column

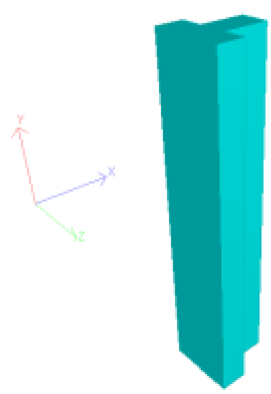


Fig 3.11: T shaped column

Step 2: Assigning supports:

- Twenty fixed supports are assigned, four at each end section of the structure and all twenty are attached to the ground.

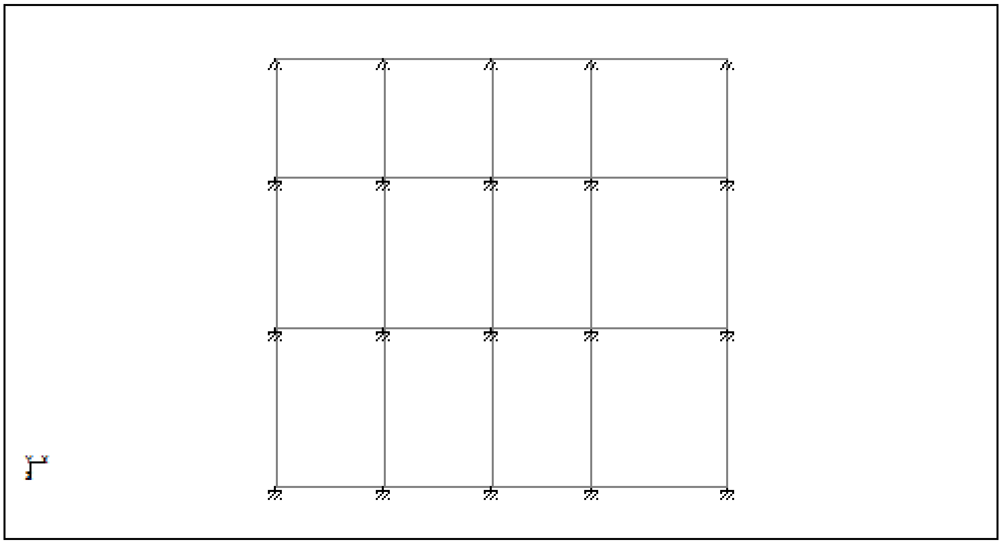


Fig 3.12: Supports of the Building

Step 3: Assigning members:

- Seven types of sections are implemented for the structure.

Ref	Section	Material
1	Rect 0.23x0.75	CONCRETE
2	Rect 0.23x0.60	CONCRETE
3	Rect 0.23x0.40	CONCRETE
4	L1	CONCRETE
5	L2	CONCRETE
6	T	CONCRETE
7	Rect 0.30x0.60	CONCRETE

Fig 3.13: Properties assigned to the members

Step 4: Adding specification to the members

- Concrete grade shall be M25; unless noted otherwise.

- Clear cover to the main bar shall be as follows:
  - Footings- 50mm
  - Columns- 40mm
  - Slab- 15mm
  - Beam- 25mm

- At any section not more than 50% bars shall be lapped and lap length shall be 50 * dia. of smaller bar lapped.

- Net soil safe bearing capacity has been taken as 20T/sq. mtr.

Task-5: Load Calculations

According to IS:875-1987 various types of loads were considered in the seismic design of the building. Loads acting on the building are Dead Loads, Live Loads, Earthquake Loads.

- **Dead Loads**

  First Load considered is the dead load. Dead load is due to the self-weight of the structural elements, boundary walls, partition walls, and different materials.
  Self-weight of the slab = 0.15 x 25 = 3.75 kN/m^2
  External wall (2.9m) = 0.23 x 2.35 x 20 = 10.8 kN/m
  Internal wall (2.9m) = 0.15 x 2.35 x 20 = 7 kN/m
  External wall (3.85m) = 0.23 x 3.3 x 20 = 15.2 kN/m
  Plaster (Both Sides) = 0.02 x18 x 2 = 0.7 kN/m^2
  Due to openings present in the building the load will reduce, so Final Loads are

Dead Load due to external wall of 2.9m height = 10 kN/m
Dead Load due to external wall of 3.85m height = 12 kN/m
Dead Load due to internal wall of 2.9m height = 5 kN/m

- **Live Load**

Live load can be described for different levels, so
For 2.9m to 17.4m Live Load = 4 kN/m^2
For 17.4m to 24.15m Live Load = 3 kN/m^2
For 24.15m to 32.85m Live Load = 4 kN/m^2

The loads considered above are in accordance with IS:875-1987

- **Seismic Load**

The Lumped weight due to dead and live load with act in the form of member weight and floor weight.

Member Weight:

Member weight will simply be the dead load considered above,
External wall (2.9m) = 10 kN/m
Internal wall (2.9m) = 5 kN/m
External wall (3.85m) = 12 kN/m

Floor Weight:

Floor weight will consist of the self-weight of slab, and 0.5LL or 0.25LL
It is taken as 0.5LL if the live load is 4 kN/m or above, whereas it is taken as 0.25LL if the live load is 3 kN/m or below.
For 2.9m to 17.4m, Floor weight = 0.5LL = 0.5 x 4 = 2 kN/m^2

For 17.4m to 24.15m, Floor weight = 0.25LL = 0.25 x 3 = 0.75 kN/m^2

For 24.15m to 32.85m, Floor weight = 0.5LL = 0.5 x 4 = 2 kN/m^2

Task-6: Calculation of reinforcement using RCDC with and without shear walls

After load calculation, the structure is analyzed using Staad RCDC, this software is used for the calculation of percentage steel and to see if any of the members fail under seismic loading. It will also help in comparing the reinforcement of the structure with and without shear walls.

Task-7: Comparing various parameters of the structure with and without shear Walls

After reinforcement design, the structure is analyzed in Staad Pro. and various parameters such as design base shear, lateral displacement and story drift are determined. These parameters are determined for both structures with and without shear walls.

Design Base Shear: Design Base shear is the total lateral force at the base of the structure. The value of design base shear increases as the structure becomes heavy i.e. with the use of shear walls. The structure becomes stiff with the use of shear wall and it is expected that this value will be higher for structure with shear walls.

Lateral Displacement: It is the average displacement for each story in both directions i.e. X and Y.

Story Drift: Story drift can be defined as the difference of lateral displacement between two successive stories divided by the height of the story.

Task-8: Using shear walls at different locations to obtain optimum results

After the comparison of the above parameters, the structure is again analyzed in Staad Pro by using shear walls at different locations i.e. shear walls at corners of the structure, shear walls at center of external walls.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 STAAD Pro Analysis of Explanatory Example:

$A_h = ZIS_a/2Rg$

$= 0.36x1x2.5/2x5$

$= 0.09$

Design base shear

$V_B = A_hW$

$= 0.09x15600$

$= 1440$ kN

Design Base shear is the total lateral force at the base of the structure. The above example was just to get an idea about how the seismic loading is to be applied and to obtain the desired results as obtained by manual calculations. For the above example, the displacement of each node is also shown below with the help of table. Some of the terms used above are also explained below.

Zone factor (Z): It is a factor for seismic risk which will be maximum based on the zone in which the building is located.

Response Reduction factor (R): If the building remains elastic during earthquake then there is a reduction in the base shear.

Structural Response factor (S_a/g): Denotes the acceleration response of the building due to seismic response.

Importance factor (I): It is a factor which is used to calculate the design seismic force depending on the use of the structure.

4.2 Analysis of the structure (H5 Hostel) in Staad Pro:

4.2.1. Reinforcement design without shear walls:

Firstly, the structure (H5 Hostel) was analyzed without the shear walls and columns were designed using "Staad Pro Advance Concrete Design" to see if any of the members failed under the loading used and to compare the reinforcement design between structure without shear walls and with shear walls.

The design was carried out using IS:456 + IS:13920-1993. The following design settings were used for the reinforcement design:

Load Combination

1.5 (LOAD 3: D.L) +1.5 (LOAD 4: L.L)

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) +1.2 (LOAD 1: EQX)

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) +1.2 (LOAD 2: EQZ

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) -1.2 (LOAD 1: EQX)

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) -1.2 (LOAD 2: EQZ)

1.5 (LOAD 3: D.L)

1.5 (LOAD 3: D.L) +1.5 (LOAD 1: EQX)

1.5 (LOAD 3: D.L) +1.5 (LOAD 2: EQZ)

1.5 (LOAD 3: D.L) -1.5 (LOAD 1: EQX)

1.5 (LOAD 3: D.L) -1.5 (LOAD 2: EQZ)

0.9 (LOAD 3: D.L) +1.5 (LOAD 1: EQX)

0.9 (LOAD 3: D.L) +1.5 (LOAD 2: EQZ)

0.9 (LOAD 3: D.L) -1.5 (LOAD 1: EQX)

0.9 (LOAD 3: D.L) -1.5 (LOAD 2: EQZ)

Ductile Design – Yes

Shear Walls with boundary elements – No

Columns Braced – No

Column % Reinforcement

Minimum – 0.8

Maximum – 4

Longitudinal Bar Spacing

Minimum – 75mm

Maximum – 250mm

<u>Link Spacing</u>

Minimum – 100mm

Maximum – 300mm

<u>Available Rebar</u>

Rebar used – 8,10,16,20,25

<u>Column Rebar</u>

Minimum – 16

Maximum – 25

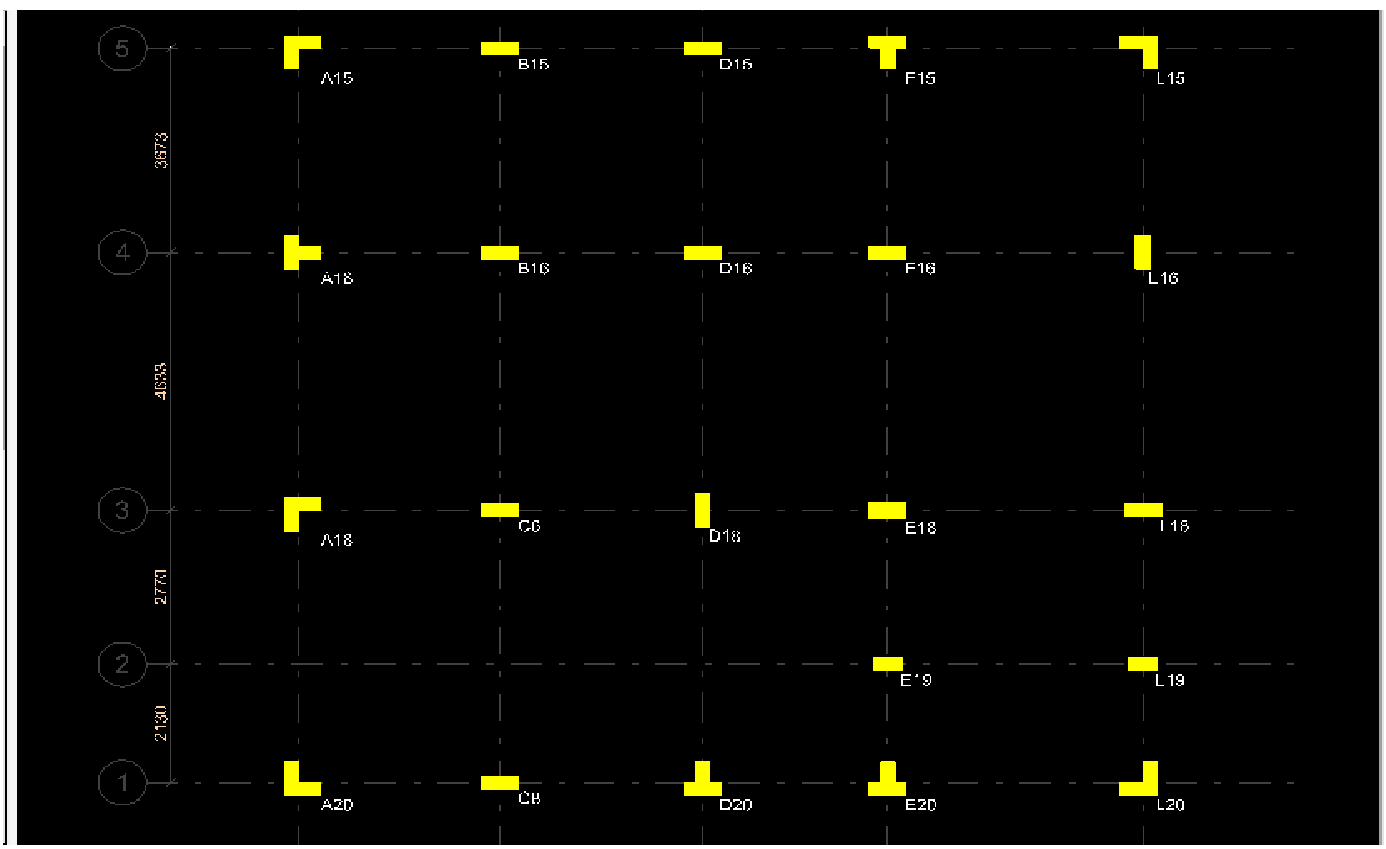


Fig 4.1: Layout of Columns

Table 4.1: Percentage Steel for columns A15,A16,A18,A20,B15,B16,C18

COLUMN MARK	A15	A16	A18	A20	B15	B16	C18
0m to 2.9m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.44%	1.26%	1.44%	1.44%	1.17%	2.42%	1.85%
2.9m to 5.8m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.85%	1.97%	1.85%	1.64%	1.49%	2.42%	2.05%
5.8m to 8.7m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08%	1.77%	1.08%	1.08%	1.17%	2.16%	1.85%
8.7m to 11.6m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08&	1.26%	1.08%	1.08%	1.17%	1.43%	2.57%
11.6m to 14.5m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.85%	2.76%	2.48%	2.16%	1.17%	1.17%	2.25%
14.5m to 17.4m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	230 X 600
	1.64%	1.77%	1.64%	1.64%	1.17%	1.17%	3.30%
17.4m to 21.25m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	3.52%	3.33%	**FAILED**	3.13%	1.17%	1.17%	1.17%
21.25m to 24.15m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.64%	1.08%	1.17%	1.17%	1.17%
24.15m to 27.05m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
27.05m to 29.95m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
29.95m to 32.85m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
32.85m to 35.75	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%

Table 4.2: Percentage Steel for columns C20,D15,D16,D18,D20,F15,F16

COLUMN MARK	C20	D15	D16	D18	D20	F15	F16
0m to 2.9m	T 600 X 600	-	-	-	-	-	-
	1.26%	-	-	-	-	-	-
2.9m to 5.8m	T 600 X 600	**FAILED**	**FAILED**	L 600 X 600	T 600 X 600	-	-
	2.76%			2.89%	3.08%	-	-
5.8m to 8.7m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 750 X 750
	2.76%	1.17%	1.17%	2.05%	2.76%	3.33%	2.88%
8.7m to 11.6m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 750 X 750
	1.77%	1.17%	1.43%	1.85%	2.76%	2.76%	1.69%
11.6m to 14.5m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 750 X 750
	2.09%	1.17%	1.17%	2.48%	2.76%	2.76%	2.64%
14.5m to 17.4m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	**FAILED**
	1.46%	1.17%	1.17%	1.64%	1.17%	1.77%	
17.4m to 21.25m	T 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	**FAILED**
	2.09%	1.17%	1.17%	2.79%	3.64%	3.33%	
21.25m to 24.15m	230 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	L 600 X 600
	2.79%	1.17%	1.17%	1.17%	1.08%	1.08%	1.64%
24.15m to 27.05m	230 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	L 600 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.08%
27.05m to 29.95m	230 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	230 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.17%
29.95m to 32.85m	230 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	230 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.17%
32.85m to 35.75	230 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	230 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.17%

Table 4.3: Percentage Steel for columns E18,E19,E20,L15,L16,L18,L19,L20

COLUMN MARK	E18	E19	E20	L15	L16	L18	L19	L20
0m to 2.9m	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
2.9m to 5.8m	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
5.8m to 8.7m	**FAILED**	-	**FAILED**	-	-	-	-	-
		-		-	-	-	-	-
8.7m to 11.6m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	L 750 X 750	L 750 X 750	230 X 600	L 600 X 600
	2.09%	2.11%	2.76%	1.85%	1.69%	1.84%	1.17%	2.89%
11.6m to 14.5m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 750	230 X 750	230 X 600	L 600 X 600
	1.59%	1.17%	1.77%	2.37%	1.43%	1.17%	1.17%	2.89%
14.5m to 17.4m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 600	230 X 750	230 X 600	L 600 X 600
	1.37%	1.49%	1.26%	1.85%	1.49%	1.17%	1.49%	1.85%
17.4m to 21.25m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 600	230 X 750	230 X 600	L 600 X 600
	1.12%	1.17%	1.77%	3.45%	1.49%	1.17%	1.17%	3.13%
21.25m to 24.15m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600	L 600 X 600
	1.12%	1.17%	1.08%	1.64%	1.17%	1.17%	1.17%	1.08%
24.15m to 27.05m	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 450	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
27.05m to 29.95m	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 450	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
29.95m to 32.85m	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 450	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
32.85m to 35.75	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 450	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%

As the maximum percentage of steel allowed was 4%, the columns shown below failed. Due to the frame being a “sway” type of frame, the effective length factor had a range from 0.1 to 5. To design the failed columns, either the percentage steel should be increased or the cross section of the column is modified.

Table 4.4: Failed Column Report

Column No.	Level	Location	Pt(%)	Failure Type
A18	21.25m	TOP	5.77%	Detailing
D15	5.8m	TOP	6.53%	Detailing
D16	5.8m	-	6.53%	Detailing
E18	8.7m	TOP	5.36%	Detailing
E20	8.7m	-	5.05%	Detailing
F16	17.4m	-	5.77%	Detailing
F16	21.25m	-	5.77%	Detailing

4.2.2. Reinforcement design with shear walls:

For the reinforcement design of structure with shear wall, the effective length factor becomes “1” as the frame becomes a “non-sway” type of structure. The design was carried out using IS:456 + IS:13920-1993. The following design settings were used for the reinforcement design:

Load Combination

1.5 (LOAD 3: D.L) +1.5 (LOAD 4: L.L)

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) +1.2 (LOAD 1: EQX)

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) +1.2 (LOAD 2: EQZ

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) -1.2 (LOAD 1: EQX)

1.2 (LOAD 3: D.L) +1.2 (LOAD 4: L.L) -1.2 (LOAD 2: EQZ)

1.5 (LOAD 3: D.L)

1.5 (LOAD 3: D.L) +1.5 (LOAD 1: EQX)

1.5 (LOAD 3: D.L) +1.5 (LOAD 2: EQZ)

1.5 (LOAD 3: D.L) -1.5 (LOAD 1: EQX)

1.5 (LOAD 3: D.L) -1.5 (LOAD 2: EQZ)

0.9 (LOAD 3: D.L) +1.5 (LOAD 1: EQX)

0.9 (LOAD 3: D.L) +1.5 (LOAD 2: EQZ)

0.9 (LOAD 3: D.L) -1.5 (LOAD 1: EQX)

0.9 (LOAD 3: D.L) -1.5 (LOAD 2: EQZ)

Ductile Design – Yes

Effective length factor - 1

Shear Walls with boundary elements – Yes

Columns Braced – No

Column % Reinforcement

Minimum – 0.8

Maximum – 4

Longitudinal Bar Spacing

Minimum – 75mm

Maximum – 250mm

Link Spacing

Minimum – 100mm

Maximum – 300mm

Available Rebar

Rebar used – 8,10,16,20,25

Column Rebar

Minimum – 16

Maximum – 25

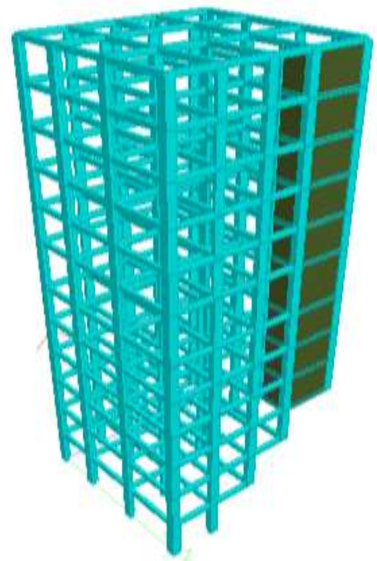


Fig 4.2: Isometric view of Hostel no. 05 with Shear Walls

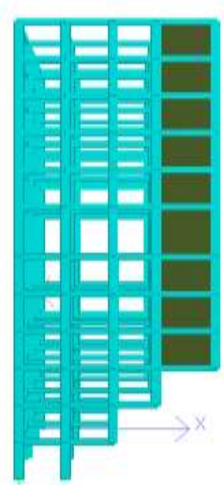


Fig 4.3: Side view of Hostel no. 05 with Shear Walls

Table 4.5: Percentage steel for columns A15,A16,A18,A20,B15,B16,C18

COLUMN MARK	A15	A16	A18	A20	B15	B16	C18
0m to 2.9m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	2.42%	1.85%
2.9m to 5.8m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.66%	1.64%
5.8m to 8.7m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.43%	1.08%
8.7m to 11.6m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.08%
11.6m to 14.5m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	L 600 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.08%
14.5m to 17.4m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 750	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.49%
17.4m to 21.25m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
21.25m to 24.15m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
24.15m to 27.05m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
27.05m to 29.95m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
29.95m to 32.85m	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%
32.85m to 35.75	L 600 X 600	T 600 X 600	L 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600
	1.08%	1.08%	1.08%	1.08%	1.17%	1.17%	1.17%

Table 4.6: Percentage steel for columns C20,D15,D16,D18,D20,F15,F16

COLUMN MARK	C20	D15	D16	D18	D20	F15	F16
0m to 2.9m	T 600 X 600	-	-	-	-	-	-
	1.08%	-	-	-	-	-	-
2.9m to 5.8m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	-	-
	1.08%	1.17%	1.17%	1.08%	1.08%	-	-
5.8m to 8.7m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 750 X 750
	1.08%	1.17%	1.17%	1.08%	1.08%	1.08%	1.53%
8.7m to 11.6m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 750 X 750
	1.08%	1.17%	1.17%	1.08%	1.08%	1.08%	1.10%
11.6m to 14.5m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 750 X 750
	1.08%	1.17%	1.17%	1.08%	1.08%	1.08%	1.10%
14.5m to 17.4m	T 600 X 600	230 X 750	230 X 750	L 600 X 600	T 600 X 600	T 600 X 600	L 600 X 600
	1.08%	1.17%	1.17%	1.08%	1.08%	1.08%	1.08%
17.4m to 21.25m	T 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	L 600 X 600
	1.08%	1.17%	1.17%	1.17%	1.08%	1.08%	1.08%
21.25m to 24.15m	L 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	L 600 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.08%
24.15m to 27.05m	L 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	L 600 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.08%
27.05m to 29.95m	L 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	230 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.17%
29.95m to 32.85m	L 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	230 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.17%
32.85m to 35.75	L 600 X 600	230 X 600	230 X 600	230 X 600	T 600 X 600	T 600 X 600	230 X 600
	1.17%	1.17%	1.17%	1.17%	1.08%	1.08%	1.17%

Table 4.7: Percentage Steel for columns E18,E19,E20,L15,L16,L18,L19,L20

COLUMN MARK	E18	E19	E20	L15	L16	L18	L19	L20
0m to 2.9m	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
2.9m to 5.8m	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
5.8m to 8.7m	300 X 600	-	T 600 X 600	-	-	-	-	-
	2.49%	-	1.08%	-	-	-	-	-
8.7m to 11.6m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	L 750 X 750	L 750 X 750	230 X 600	L 600 X 600
	1.59%	1.78%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
11.6m to 14.5m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 750	230 X 750	230 X 600	L 600 X 600
	1.12%	1.49%	1.08%	1.08%	1.17%	1.17%	1.49%	1.08%
14.5m to 17.4m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 600	230 X 750	230 X 600	L 600 X 600
	1.12%	1.49%	1.08%	1.08%	1.17%	1.17%	1.78%	1.08%
17.4m to 21.25m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 600	230 X 750	230 X 600	L 600 X 600
	1.12%	1.49%	1.08%	1.08%	1.17%	1.17%	1.49%	1.08%
21.25m to 24.15m	300 X 600	230 X 600	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.49%	1.08%
24.15m to 27.05m	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
27.05m to 29.95m	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
29.95m to 32.85m	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%
32.85m to 35.75	300 X 600	230 X 450	T 600 X 600	L 600 X 600	230 X 600	230 X 600	230 X 600	L 600 X 600
	1.12%	1.17%	1.08%	1.08%	1.17%	1.17%	1.17%	1.08%

It can be seen that none of the columns failed with the use of shear walls. Percentage steel for the columns is also less than the percentage steel for columns without shear walls.

4.3 Comparing various parameters of the structure with and without Shear Walls:

4.3.1. Design Base Shear

- **Without Shear Walls**

TIME PERIOD FOR X 1893 LOADING = 1.09652 SEC

S_a/G PER 1893 = 0.912,

LOAD FACTOR = 1.000

V_B PER 1893 = 0.0219 X 26666.71 = 583.66 KN

TIME PERIOD FOR Z 1893 LOADING = 1.09652 SEC

S_a/G PER 1893 = 0.912,

LOAD FACTOR = 1.000

V_B PER 1893 = 0219 X 26666.71 = 583.66 KN

- **With Shear Walls**

TIME PERIOD FOR X 1893 LOADING = 1.09652 SEC

S_a/G PER 1893 = 0.912,

LOAD FACTOR = 1.000

V_B PER 1893 = 0.0219 X 27745.11 = 607.27 KN

TIME PERIOD FOR Z 1893 LOADING = 1.09652 SEC

S_a/G PER 1893 = 0.912,

LOAD FACTOR = 1.000

V_B PER 1893 = 0219 X 27745.11 = 607.27 KN

Design Base shear is the total lateral force at the base of the structure. If the building is provided with shear walls, the building becomes stiff. A flexible structure will experience lower acceleration. Since the flexible building will be hard to excite, that's why it will have a lower base shear value as compared to a stiff building.

4.3.2. Lateral Displacement

Table 4.8: Lateral Displacement without Shear walls

Without Shear Walls				
Story	Height(m)	Load	Average Displacement(cm)	
			X	Z
1	0	0.9DL+1.5EQX	0.0000	0.0000
		0.9DL+1.5EQZ	0.0000	0.0000
2	2.9	0.9DL+1.5EQX	**-0.0012**	0.0014
		0.9DL+1.5EQZ	-0.0001	**0.1428**
3	5.8	0.9DL+1.5EQX	**-0.0024**	-0.0016
		0.9DL+1.5EQZ	0.0002	**0.3824**
4	8.7	0.9DL+1.5EQX	**0.0372**	-0.0005
		0.9DL+1.5EQZ	-0.0025	**0.6322**
5	11.6	0.9DL+1.5EQX	**0.3365**	-0.0086
		0.9DL+1.5EQZ	-0.0110	**1.1546**
6	14.5	0.9DL+1.5EQX	**0.7799**	-0.0238
		0.9DL+1.5EQZ	-0.0276	**1.7915**
7	17.4	0.9DL+1.5EQX	**1.2812**	-0.0382
		0.9DL+1.5EQZ	-0.0460	**2.4928**
8	21.25	0.9DL+1.5EQX	**2.0574**	-0.0587
		0.9DL+1.5EQZ	-0.0687	**3.5134**
9	24.15	0.9DL+1.5EQX	**2.5380**	-0.0657
		0.9DL+1.5EQZ	-0.0846	**4.1488**
10	27.05	0.9DL+1.5EQX	**2.9324**	-0.0694
		0.9DL+1.5EQZ	-0.1008	**4.6921**
11	29.95	0.9DL+1.5EQX	**3.2397**	-0.0741
		0.9DL+1.5EQZ	-0.1172	**5.1467**
12	32.85	0.9DL+1.5EQX	**3.4537**	-0.0780
		0.9DL+1.5EQZ	-0.1336	**5.4811**
13	35.75	0.9DL+1.5EQX	**3.5792**	-0.0811
		0.9DL+1.5EQZ	-0.1497	**5.6928**

Table 4.9: Lateral Displacement with Shear walls

With Shear Walls				
Story	Height(m)	Load	Average Displacement(cm)	
			X	Z
1	0	0.9DL+1.5EQX	0.0000	0.0000
		0.9DL+1.5EQZ	0.0000	0.0000
2	2.9	0.9DL+1.5EQX	**-0.0007**	-0.0335
		0.9DL+1.5EQZ	0.0001	**0.1122**
3	5.8	0.9DL+1.5EQX	**-0.0013**	-0.0870
		0.9DL+1.5EQZ	0.0002	**0.3003**
4	8.7	0.9DL+1.5EQX	**0.0091**	-0.0618
		0.9DL+1.5EQZ	-0.0228	**0.3051**
5	11.6	0.9DL+1.5EQX	**0.1068**	-0.1618
		0.9DL+1.5EQZ	-0.0900	**0.6606**
6	14.5	0.9DL+1.5EQX	**0.2566**	-0.2484
		0.9DL+1.5EQZ	-0.1633	**1.0662**
7	17.4	0.9DL+1.5EQX	**0.4369**	-0.3219
		0.9DL+1.5EQZ	-0.2324	**1.5020**
8	21.25	0.9DL+1.5EQX	**0.7251**	-0.4155
		0.9DL+1.5EQZ	-0.3187	**2.1178**
9	24.15	0.9DL+1.5EQX	**0.9222**	-0.4633
		0.9DL+1.5EQZ	-0.3717	**2.5545**
10	27.05	0.9DL+1.5EQX	**1.0983**	-0.5075
		0.9DL+1.5EQZ	-0.4182	**2.9656**
11	29.95	0.9DL+1.5EQX	**1.2510**	-0.5485
		0.9DL+1.5EQZ	-0.4594	**3.3460**
12	32.85	0.9DL+1.5EQX	**1.3762**	-0.5854
		0.9DL+1.5EQZ	-0.4957	**3.6861**
13	35.75	0.9DL+1.5EQX	**1.4727**	-0.6177
		0.9DL+1.5EQZ	-0.5276	**3.9836**

The lateral displacement due to the application of seismic load is shown above. The lateral displacement is calculated for structure without shear walls and structure with shear walls. For the calculation of lateral displacement and story drift, load combination of 0.9DL+1.5EQ is used. Due to the use of shear walls, the lateral stiffness of the building increases. It can be seen above that lateral displacement of building with shear is lesser than building without shear wall.

4.3.3. Story Drift

Table 4.10: Story Drift without Shear walls

Without Shear Walls				
Story	Height(m)	Load	Drift(cm)	
			X	Z
1	0	0.9DL+1.5EQX	0.0000	0.0000
		0.9DL+1.5EQZ	0.0000	0.0000
2	2.9	0.9DL+1.5EQX	**0.0012**	0.0014
		0.9DL+1.5EQZ	0.0001	**0.1428**
3	5.8	0.9DL+1.5EQX	**0.0012**	0.0002
		0.9DL+1.5EQZ	0.0003	**0.2395**
4	8.7	0.9DL+1.5EQX	**0.0396**	0.0011
		0.9DL+1.5EQZ	0.0027	**0.2499**
5	11.6	0.9DL+1.5EQX	**0.2992**	0.0090
		0.9DL+1.5EQZ	0.0085	**0.5224**
6	14.5	0.9DL+1.5EQX	**0.4434**	0.0153
		0.9DL+1.5EQZ	0.0166	**0.6369**
7	17.4	0.9DL+1.5EQX	**0.5013**	0.0144
		0.9DL+1.5EQZ	0.0184	**0.7013**
8	21.25	0.9DL+1.5EQX	**0.7762**	0.0205
		0.9DL+1.5EQZ	0.0227	**1.0206**
9	24.15	0.9DL+1.5EQX	**0.4806**	0.0070
		0.9DL+1.5EQZ	0.0159	**0.6354**
10	27.05	0.9DL+1.5EQX	**0.3944**	0.0037
		0.9DL+1.5EQZ	0.0162	**0.5433**
11	29.95	0.9DL+1.5EQX	**0.3073**	0.0047
		0.9DL+1.5EQZ	0.0164	**0.4546**
12	32.85	0.9DL+1.5EQX	**0.2140**	0.0039
		0.9DL+1.5EQZ	0.0163	**0.3344**
13	35.75	0.9DL+1.5EQX	**0.1255**	0.0031
		0.9DL+1.5EQZ	0.0161	**0.2118**

Table 4.11: Story Drift with Shear walls

With Shear Walls				
Story	Height(m)	Load	Drift(cm)	
			X	Z
1	0	0.9DL+1.5EQX	0.0000	0.0000
		0.9DL+1.5EQZ	0.0000	0.0000
2	2.9	0.9DL+1.5EQX	**0.0007**	0.0335
		0.9DL+1.5EQZ	0.0001	**0.1122**
3	5.8	0.9DL+1.5EQX	**0.0006**	0.0535
		0.9DL+1.5EQZ	0.0001	**0.1880**
4	8.7	0.9DL+1.5EQX	**0.0104**	0.0252
		0.9DL+1.5EQZ	0.0230	**0.0048**
5	11.6	0.9DL+1.5EQX	**0.0615**	0.0685
		0.9DL+1.5EQZ	0.0049	**0.2285**
6	14.5	0.9DL+1.5EQX	**0.1356**	0.0832
		0.9DL+1.5EQZ	0.0240	**0.2613**
7	17.4	0.9DL+1.5EQX	**0.2135**	0.1047
		0.9DL+1.5EQZ	0.0480	**0.2910**
8	21.25	0.9DL+1.5EQX	**0.3408**	0.1472
		0.9DL+1.5EQZ	0.0847	**0.3542**
9	24.15	0.9DL+1.5EQX	**0.4013**	0.1706
		0.9DL+1.5EQZ	0.1037	**0.3578**
10	27.05	0.9DL+1.5EQX	**0.4486**	0.1906
		0.9DL+1.5EQZ	0.1181	**0.3655**
11	29.95	0.9DL+1.5EQX	**0.4795**	0.2069
		0.9DL+1.5EQZ	0.1277	**0.3638**
12	32.85	0.9DL+1.5EQX	**0.4919**	0.2173
		0.9DL+1.5EQZ	0.1334	**0.3448**
13	35.75	0.9DL+1.5EQX	**0.4858**	0.2214
		0.9DL+1.5EQZ	0.1360	**0.3018**

Story drift can be defined as the difference of lateral displacement between two successive stories divided by the height of the story. IS:1893-2002 puts a limitation on story drift, it is given by L/40. For the calculation of lateral displacement and story drift, load combination of 0.9DL+1.5EQ is used. Both the buildings with and without shear walls are well below the allowable drift i.e. L/40.

4.4 Using shear walls at different locations to obtain optimum results:

4.3.1. Shear Walls at corner

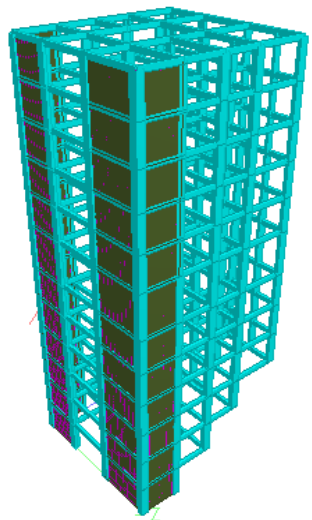


Fig 4.4: Isometric view of Hostel no. 05 with Shear Walls at corner

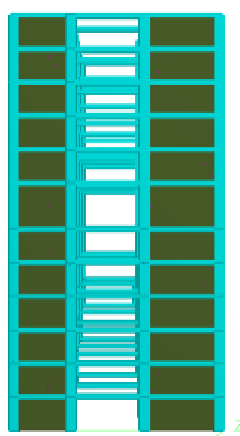


Fig 4.5: Front view of Hostel no. 05 with Shear Walls at corner

- **Design Base Shear**

V_B PER 1893 = 0219 X 29232.9 = 639.83 KN

- **Average Lateral Displacement**
    - Table 4.12: Lateral Displacement with Shear walls at corner

Shear Walls at corner				
Story	Height(m)	Load	Average Displacement(cm)	
			X	Z
1	0	0.9DL+1.5EQX	0.0000	0.0000
		0.9DL+1.5EQZ	0.0000	0.0000
2	2.9	0.9DL+1.5EQX	**-0.0005**	-0.0027
		0.9DL+1.5EQZ	-0.0017	**0.0391**
3	5.8	0.9DL+1.5EQX	**0.0282**	-0.0089
		0.9DL+1.5EQZ	-0.0025	**0.1133**
4	8.7	0.9DL+1.5EQX	**0.0943**	-0.0168
		0.9DL+1.5EQZ	-0.0019	**0.2217**
5	11.6	0.9DL+1.5EQX	**0.2622**	-0.0309
		0.9DL+1.5EQZ	0.0001	**0.4056**
6	14.5	0.9DL+1.5EQX	**0.4841**	-0.0488
		0.9DL+1.5EQZ	0.0056	**0.6401**
7	17.4	0.9DL+1.5EQX	**0.7358**	-0.0685
		0.9DL+1.5EQZ	0.0147	**0.9074**
8	21.25	0.9DL+1.5EQX	**1.1201**	-0.0981
		0.9DL+1.5EQZ	0.0334	**1.3005**
9	24.15	0.9DL+1.5EQX	**1.4042**	-0.1173
		0.9DL+1.5EQZ	0.0530	**1.5751**
10	27.05	0.9DL+1.5EQX	**1.6800**	-0.1356
		0.9DL+1.5EQZ	0.0769	**1.8310**
11	29.95	0.9DL+1.5EQX	**1.9429**	-0.1546
		0.9DL+1.5EQZ	0.1046	**2.0678**
12	32.85	0.9DL+1.5EQX	**2.1861**	-0.1732
		0.9DL+1.5EQZ	0.1353	**2.2726**
13	35.75	0.9DL+1.5EQX	**2.4041**	-0.1908
		0.9DL+1.5EQZ	0.1687	**2.4403**

4.3.2. Shear Walls at center of the external walls

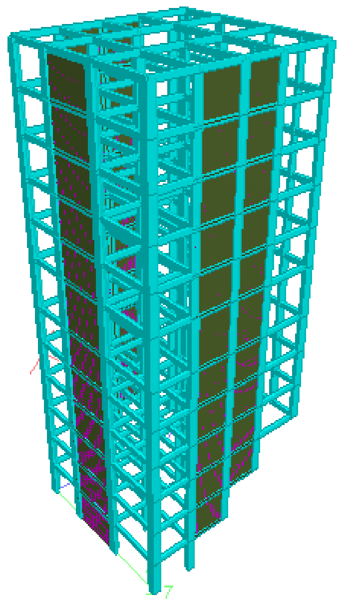


Fig 4.6: Isometric view of Hostel no. 05 with Shear Walls at center

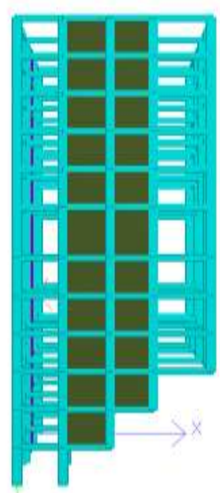


Fig 4.7: Side view of Hostel no. 05 with Shear Walls at center

- **Design Base Shear**

V_B PER 1893 = 0219 X 29340.53 = 642.19 KN

- **Average Lateral Displacement**
  - Table 4.13: Lateral Displacement with Shear walls at center

Shear Walls at center of external walls				
Story	Height(m)	Load	Average Displacement(cm)	
			X	Z
1	0	0.9DL+1.5EQX	0.0000	0.0000
		0.9DL+1.5EQZ	0.0000	0.0000
2	2.9	0.9DL+1.5EQX	**-0.0075**	0.0003
		0.9DL+1.5EQZ	-0.0032	**0.0424**
3	5.8	0.9DL+1.5EQX	**0.0066**	-0.0011
		0.9DL+1.5EQZ	-0.0126	**0.1306**
4	8.7	0.9DL+1.5EQX	**0.0145**	-0.0035
		0.9DL+1.5EQZ	-0.0270	**0.3307**
5	11.6	0.9DL+1.5EQX	**0.0727**	-0.0092
		0.9DL+1.5EQZ	-0.0517	**0.6453**
6	14.5	0.9DL+1.5EQX	**0.1583**	-0.0159
		0.9DL+1.5EQZ	-0.0773	**1.0276**
7	17.4	0.9DL+1.5EQX	**0.2624**	-0.0215
		0.9DL+1.5EQZ	-0.1013	**1.4549**
8	21.25	0.9DL+1.5EQX	**0.4292**	-0.0325
		0.9DL+1.5EQZ	-0.1310	**2.0760**
9	24.15	0.9DL+1.5EQX	**0.5543**	-0.0336
		0.9DL+1.5EQZ	-0.1483	**2.4914**
10	27.05	0.9DL+1.5EQX	**0.6750**	-0.0315
		0.9DL+1.5EQZ	-0.1629	**2.8663**
11	29.95	0.9DL+1.5EQX	**0.7883**	-0.0297
		0.9DL+1.5EQZ	-0.1751	**3.1983**
12	32.85	0.9DL+1.5EQX	**0.8903**	-0.0278
		0.9DL+1.5EQZ	-0.1847	**3.4601**
13	35.75	0.9DL+1.5EQX	**0.9802**	-0.0247
		0.9DL+1.5EQZ	-0.1914	**3.6480**

CHAPTER - 5

CONCLUSION

5.1 Conclusions

The main objective of this study has been the Comparison of displacement of G+11 building with and without shear wall under seismic loading and to check and compare the seismic response of the G+11 building for different locations of the shear wall. To achieve this objective, the structure was analyzed using Staad Pro. and various parameters such as Design Base Shear, Lateral Displacement and Story Drift were determined and compared for structure with and without shear walls. Since the behavior of RC shear walls is highly complex under the influence of severe lateral loads arising due to wind and earthquake, the response of shear walls no longer remains elastic and therefore, Staad Pro. was needed to predict the behavior of shear walls under static and dynamic loading conditions. After performing the analysis on the structure, the following conclusions are drawn:

- Reinforcement required for structure with shear walls is considerably less than for structure without shear walls.
- Design Base Shear for structure with shear walls is higher than that for structure without shear walls.
- Lateral Displacement for structure with shear walls is considerably less than for structure without shear walls.
- Story Drift of structure with shear walls also decreased as compared to structure without shear walls.
- Design Base Shear for structure with shear walls at center of external walls is greater than design base shear for structure with shear walls at corner.
- Average lateral displacement for structure with shear walls at center of external walls is less than that for structure with shear walls at corner.

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