Analysis and design of multi-storey residential building using Staad pro

Submitted in partial fulfilment of the requirement for the award of the degree of

Master of Technology

(Structural Engineering)

Submitted by

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Under the Guidance of Dr. Sushil Kr Singh

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CERTIFICATE

This is to certify that the project work entitled “analysis and design of multi-storey residential building by staad pro” being submitted by Mohit Tripathi to the School of Civil Engineering, Galgotias University, Greater Noida, for the award of the degree of Master of Technology is a bonafied work carried out by him under my supervision and guidance. The thesis work in my opinion has reached the requisite standard, fulfilling the requirements for the said degree.

The results contained in this report have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

Program Chair

Dean

School of Civil Engineering

M.Tech (Structural Engineering)

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APPROVAL SHEET

This project report entitled “analysis and design of multi storey residential building by staad pro” by Mohit Tripathi is approved for the degree of Master of Technology in Civil Engineering.

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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I am highly grateful to the Dr. Suprakash Vishwas (Dean of School of Civil Engineering) for giving me proper guidance and advice and facility for the successful completion of my thesis.

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My special thanks are going to all of the faculties for encouraging me constantly to work hard in this project. I pay my respect and love to my parents and all other family members and friends for their help and encouragement throughout this course of project work

ABSTRACT

This project involves the study of various aspects of analysis and design of multi storey residential building by using STAAD. Pro. Structural designing requires a detailed structural analysis on which the design of the structure is based. But it is not always possible to do in manual calculation hence the need for programming tools was found. For which several of power tools were formed, among which the most widely used one is STAAD. Pro, which allows the structural and seismic analysis prior to its construction. For high rise buildings its quite feasible to use STAAD. Pro for computing the loads and its combination and analysing the structure and designing the structure based on the analysis.

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INTRODUCTION

Infrastructure is the basic way to represent the level of development of a country, among which the major share is shared by the high rise buildings which are not possible without a structural designer. As the world is transforming the high rise buildings are in a great demand which is to be fulfilled without sacrificing any of the three factors, cost, time and safety. Achieving this is not possible with manual calculation hence to counter this we need highly advanced ways of computation, which can allow you to calculate and analyse the structural variables like shear force, nodal displacement, bending moment etc. The answer to such problems is Stadd.Pro which provides a much faster approach to structural analysis and designing with chances of minimum errors. There has been several research conducted comparing the results from Stadd.Pro to the manually calculated results, which all support the use of Stadd.Pro over manual the one. STAAD .Pro is a much better way to analyse the complicated load combinations and is quite versatile

Staad Pro

- STAAD or (STAAD . Pro) is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley Systems.
- STAAD . Pro is one of the most widely used structural analysis and design software products worldwide. It supports over 90 international steel, concrete, timber & aluminium design codes.
- STAAD can be used for analysis and design of all types of structural projects from plants, buildings, and bridges to towers, tunnels, metro stations, water/wastewater treatment plants and more.

Scope of STAAD. Pro in Civil Engineering

STAAD. Pro is a new means for Civil Engineering students which is in huge demand at this time. STAAD. Pro is structural analysis and design tool with applications mostly in the building and real estate industry like commercial building, bridges and highway structures, industrial structures, chemical plant structures, dams, turbine foundations, culverts, others embedded structures etc. Real Estate business is one of the profitable sectors of the market and there are huge no of scopes and opportunities for Civil Engineering students who want to pursue their career as a structural designer. Leading builders and colonizers are investing hugely in the real estate business to get maximum profit. [18]

Some other sofwtares

Auto CAD (Automatic Computer Aided Design) : This is the most popular software in the world of civil engineering. Designed by Autodesk, it helps in creating 2D and 3D designs, drafting, modeling workflows, architectural drawing, and more. It allows you to assess and understand the project performance, responds quickly to changes, and maintains data and processes consistently. Some of the important features it includes are:

- A powerful set of intuitive design and documentation tools to explore and visualize 3D concepts
- A user friendly interface that works across a range of integrated devices including desktop, mobile and cloud
- Eliminates the need of manual drafting to boost accuracy
- Provides the ability to share your work through trusted technology

SAFE: This software is mostly used in designing foundation slab systems and concrete floors. SAFE is a inclusive package that combines all the aspects of engineering design process – from creating layout to detail drawing production in a single, intuitive environment. It enables highly advanced local assessment of foundation systems within larger structures and imports files from CAD, ETABS, and SAP2000. Some of the other benefits it offers are:

- Wide-ranging templates to quickly initiate a model
- Post-tensioning
- Support conditions and loadings

RISA: This is another popular 3D analysis and design tool for creating general structures such as buildings, bridges, arenas, industrial structures, crane rails, and more. It is fast, productive and accurate. It has an intuitive interface that integrates with many other products like RISAFloor and RISA Foundation. It comes packed with the latest steel, cold-formed steel, concrete, aluminum, masonry and timber design codes. This, in turn, provides the tools you need to manage the multi-material projects with ease.

Navisworks: This is a comprehensive project review solution mainly used by design, engineering and construction management professionals to gain detailed insight into the project and enhance productivity and quality. It is developed and marketed by Autodesk and allows users to open, combine, review and share Detailed 3D Design Models in various file formats. It lets you import all file formats and merge all the files to create a model.

Advantages of STAAD.Pro

- Covers all aspects of structural engineering
- It has a pre built collection of most used structures , such as trusses, buildings, and many more and can be altered as per the requirement

- It includes the design of concrete and steel together and also includes the features for bridge and pipe designing
- It provides fast and reliable method of designing durable structures
- Eliminates the need for any manual collection
- Stadd.Pro gives hardly any variation in results compared to the results computed manually
- Stadd.Pro allows you to follow the criteria of several design codes for eg. The Indian standards relating to loads, designs, analysis etc.
- Stadd.Pro is a much easier and faster way of analysing and designing a structure when compared to manual computation.
- Stadd.Pro is a user-friendly way to analyse the structure as its GUI is very easy to work with and the software is quite versatile.

Building

A building is a structure with a roof and walls standing more or less permanently in one place, such as a house or factory. Buildings come in a variety of sizes, shapes, and functions, and have been adapted throughout history for a wide number of factors, from building materials available, to weather conditions, land prices, ground conditions, specific uses, and aesthetic reasons.

Classification of Building

Every building or portion of land can be classified according to its use or the character of its occupancy as a building of occupancy. [6]

They are categorized into the following types

Agricultural buildings

Residential buildings

Commercial buildings

Educational buildings

Industrial buildings

Government buildings

Military buildings

Religious buildings

Transport buildings

Based on the type of construction buildings are classified into five categories.

Fire resistive buildings

Non-Combustible buildings

Ordinary Buildings

Heavy timber buildings

Wood framed buildings

Components of building

The basic components of a building structure are the foundation, floors, walls, beams, columns, roof, stair, etc. These elements serve the purpose of supporting, enclosing and protecting the building structure.[7]

Roof

Parapet

Lintels

Beams

Columns

Damp proof course (DPC)

Walls

Floor

Stairs

Plinth Beam

Foundation

Plinth

1. Roof

The roof forms the topmost component of a building structure. It covers the top face of the building. Roofs can be either flat or sloped based on the location and weather conditions of the area.

2. Parapet

Parapets are short walls extended above the roof slab. Parapets are installed for flat roofs. It acts as a safety wall for people using the roof.

3. Lintels

Lintels are constructed above the wall openings like doors, windows, etc. These structures support the weight of the wall coming over the opening. Normally, lintels are constructed by reinforced cement concrete. In residential buildings, lintels can be either constructed from concrete or from bricks.

A lintel or lintol is a structural horizontal block that spans the space or opening between two vertical supports. It can be a decorative architectural element, or a combined ornamented structural item. It is often found over portals, doors, windows and fireplaces.

4. Beams and slabs

Beams and slabs form the horizontal members in a building. For a single storey building, the top slab forms the roof. In case of a multi-storey building, the beam transfers the load coming from the floor above the slab which is in turn transferred to the columns. Beams and slabs are constructed by reinforced cement concrete (R.C.C).

5. Columns

Columns are vertical members constructed above the ground level. Columns can be of two types: Architectural columns and structural columns. Architectural columns are constructed to improve the building's aesthetics while a structural column takes the load coming from the slab above and transfers safely to the foundation.

6. Damp Proof Course (DPC)

DPC is a layer of waterproofing material applied on the basement level to prevent the rise of surface water into the walls. The walls are constructed over the DPC.

7. Walls

Walls are vertical elements which support the roof. It can be made from stones, bricks, concrete blocks, etc. Walls provide an enclosure and protect against wind, sunshine, rain etc. Openings are provided in the walls for ventilation and access to the building.

8. Floors

The floor is the surface laid on the plinth level. Flooring can be done by a variety of materials like tiles, granites, marbles, concrete, etc. Before flooring, the ground has to be properly compacted and leveled.

9. Stairs

A stair is a sequence of steps that connects different floors in a building structure. The space occupied by a stair is called as the stairway. There are different types of stairs like a wooden stair, R.C.C stair etc.

10. Plinth Beam

Plinth beam is a beam structure constructed either at or above the ground level to take up the load of the wall coming over it.

11. Plinth

The plinth is constructed above the ground level. It is a cement-mortar layer lying between the substructure and the superstructure.

12. Foundation

The Foundation is a structural unit that uniformly distributes the load from the superstructure to the underlying soil. This is the first structural unit to be constructed for any building construction. A good foundation prevents settlement of the building.

TYPES OF LOADS

The loads which are considered for analysis are,

Dead loads

Live loads

Wind loads

DEAD LOAD : All permanent loads in the building are considered as dead loads. The dead loads comprise of selfweight of the building, weight of wall, weight of slab, floor finish and permanent materials placed on the building. Dead loads are specified in IS 875 (Part 1)

LIVE LOAD Imposed load is created by the meant use or occupancy of a building together with the load of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Live loads are specified in IS 875 (Part 2)

WIND LOAD These loads rely on the rate of the wind at the situation of the structure, permeableness of the structure, height of the structure etc. They will be horizontal or inclined forces. Wind loads are specified in IS 875 (Part 3).

P-Delta Effect on Building

When the seismic lateral loading acts on a building, leading to it to deflect, the gravity loading on such laterally deformed structure may cause the lateral displacements to increase. The second order effect of vertical loads acting upon a laterally displaced structure is termed the P-Δ effect, where P is the total vertical load, and Δ is the lateral displacement relative to the ground. Figure 1 shows the P-Δ effect on a SDOF system. The P-Δ effect refers to the mass of the structure with a weight P,moving through a displacement Δ, causing a moment at the base of the structure. [17]

Push Over Analysis on Building

Pushover analysis is a static procedure that uses a simplified nonlinear technique to estimate seismic structural deformations. Structures redesign themselves during earthquakes. As individual components of a structure yield or fail, the dynamic forces on the building are shifted to other components.

Chapter:2

LITERATURE REVIEW

B. Gireesh [1] studied the structural and seismic analysis of G+7 structure using the Staad. Pro software. In his study he followed Indian standard codes: IS 1893 (Part 1) – 2007, for the design of base shear. IS 1893:2002 for the earthquake resistant criteria which stated the different analysis criteria based on Zone of area, the height of building and Importance of the building. After starting the project various dead load, live load, wind load, snow load and earthquake load was imposed for which the analysis will run. The building was designed for Heydrabad area whose zone was II. From the analysis, it was concluded that the steel quantity was increased by 1.517% compared to the conventional concrete design. The earthquake load was more dominant than wind load in the selected area but still, there was no need for a shear wall and braced column as the base drift at every storey is 0.0 hence the structure was safe under the drift condition.

Aman et.al [2] The analysis and design of C+G+5 residential cum commercial building based on the criteria defined by the IS codes on Stadd.Pro software. The load imposed were only dead and live load hence the load combination generated was 1.5(D.L. + L.L.) after which the analysis of the building was done for the frame and the resulting bending moments and shear forces were studied. The detail of all the building members was represented along with the functions of slab, beam, column, footing and staircase. From which it was concluded that the horizontal deflections were within 20mm and the structure was safe and economical in this way results obtained from Kani's method and Stadd.Pro do not exhibit much variation.

Mahesh et.al [3] This study was focused on the analysis of the structure in the effect of wind load on the sloping ground by the software Stadd.Pro. The design of wind was based on the Indian standard code IS 875 part- III. The study stated that as the height increases the Bending moment, shear force and joint displacement all show an approx directly proportional relationship with the height. Hence it was concluded that the zone IV was the most critical one as the values of bending moment, shear force and joint displacement was highest in the IV zone and was least in the Zone I.

Anoop et.al [4] A project to design a G+5 floor structure at Kalakode, 4km from Paravoor. The planning of the building was done using the software Revit 2011 with the help of AutoCAD 2014, and the structural analysis was done in Stadd.Pro.V8i The project considered the load cases on basis of the Indian standard codes IS1893:2002 for seismic load, IS 875 Part 3 for wind loads, IS 875 Part 1 for dead loads and Part 2 for live loads. The combinations of these loads were generated on the basis of IS 875 Part 5. And the design was done on the basis of IS 456:2000. After analysis, it was concluded that the graphical input generation provided by Stadd. Pro allows the generation of a graphical model of the structure.

D. R. Deshmukh et.al [5] Analysis and design of G+19 Story building using Staad. Pro The design was based on Indian Standards on Staad. Pro and then compared by was then compared by manual calculation. The design loads considered were dead load, live load, seismic load and wind load and were calculated on the basis of Indian Standards. It was seen that the load was maximum when applied in the x-direction (parallel to shorter span) and the deflection increases as the height of building increases. The data regarding take off for material was provided. The results obtained for base shear was 5% more in the case of Stadd.Pro as compared to manually. It was concluded in the study that Stadd.Pro is versatile software which can be used to analyse a building and compute reinforcement.

V. Varalakshmi [8] The design and analysis of multistoried G+5 building at Kukatpally, Hyderabad, India. The study includes design and analysis of columns, beams, footings and slabs by using well known civil engineering software named as STAAD.Pro. Test on safe bearing capacity of soil was obtained.

P. Jayachandran [9] The design and analysis of G+4 building at salem tamilnadu India. The study includes analysis and design of footings, columns, beams and slabs by using to softwares named as STAAD. Pro and RCC Design Suit.

L.G. Karulkar [10] The design and analysis of G+5 building using composite structure at earthquake zone-3 A three dimensional modeling and analysis of structure are carried out with the help of SAP 2000 software. Equivalent static method of analysis and response spectrum analysis method are used for the analysis of both composite and RCC structures the results are compared and found that composite structure are more economical.

Madhurivassavai et al., (2016) [11] he says that the one of the major problem country facing is the growing population. Because of the less availability of land, multi-storey building can be constructed to serve many people in limited area. Efficient modelling is performed using STAAD.Pro and AutoCAD. Manual calculations for high rise buildings are tedious and time consuming. STAAD . Pro provides us a quick, efficient and correct platform for analysing and coming up with structures.

Sreeshna K.S (2016)[12] this paper deals analysis and design of B+G+4 storied apartment building. The work was completed in three step. The first stage was modelling and analysis of building and the second stage was to design the structural component and the final was to detail the structural components. In this STAAD . Pro software is used to analyse the building. The IS: 875 (Part 1) and (Part 2) were referred for dead load and live load. Design of structural elements like beam, column, slab, staircase, shear wall, retaining wall, pile foundation is done according to IS Codes.

P.P. Chandurkar et. al. (2013) [13] Had presented study of G+9 building having three meters height for each storey. The whole building design had carried out according to IS code for seismic resistant design and the building had considered fixed at base. Structural element for

design had assumed as square or rectangular in section. They had done modelling of building using ETAB software in that four different models were studied with different positioning of shear walls.

Mohit Sharma et.al. (2015) [14] considered a G+30 storied regular reinforced concrete framed building. Dynamic analysis of multi-storeyed Building was carried out. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS:1893-2002 Part-1 for the zones- 2 and 3. It was concluded that not much difference in the values of Axial Forces as obtained by static and dynamic analysis.

M. S. Aainawala et. al. (2014) [15] He did the comparative study of multi-storeyed R.C.C. Buildings with and without Shear Walls. They applied the earthquake load to a building for G+12, G+25, G+38 located in zone II, zone III, zone IV and zone V for different cases of shear wall position. They calculated the lateral displacement and story drift in all the cases. It was observed that Multistoreyed R.C.C. Buildings with shear wall is economical as compared to without shear wall. As per analysis, it was concluded that displacement at different level in multistoreyed building with shear wall is comparatively lesser as compared to R.C.C. building without shear wall. Which is important for building design and use of shear walls.

M. Mallikarjun et. al. (2016) [16] Carried study on analysis and design of a multi-storied residential building of ung-2+G+10 by using most economical column method and the dead load and live load was applied on the various structural component like slabs, beams and found that as the study is carried using most economical column method this was achieved by reducing the size of columns at top floors as load was more at the bottom floor. The economizing was done by means of column orientation in longer span in longer direction as it will reduce the amount of bending and the area of steel was also reduced

Chapter: 3

Methodology

Proposed Tool and Methodology

This project involves the study of various aspects of analysis and design of multi storey residential building by using STAAD. Pro. Structural designing requires a detailed structural analysis on which the design of the structure is based. But it is not always possible to do in manual calculation hence the need for programming tools was found. For which several of tools were formed, among which the most widely used one is STAAD. Pro, which allows the structural and seismic analysis prior to its construction. For high rise buildings its quite feasible to use STAAD. Pro for computing the loads and its combination and analysing the structure and designing the structure based on the analysis

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PROBLEM DESCRIPTION

Utility of building :Residential Building

No of storeys :(G+6)

Shape of the building : rectangular

Type of construction :RCC Framed Structure

Type of Wall : Brick Wall

GEOMETRIC DETAILS

Ground floor :3.0M

Floor height :3.0M

Height of plinth :1.5M from below foundation

Depth of foundation :500MM

MATERIAL DETAILS

Concrete Grade : M25

All steel grade : Fe500 grade

Type of steel bars : HYSD

Bearing capacity of Soil : >180 KN/M2

STRUCTURAL DESIGN

For slab, depth is 125 mm provided.

For beams, after calculations are done the dimensions of beam is 230*530mm factored load on beam is 15.87kn/m

Shape of column is rectangular

For columns, the dimension of column is 300*600mm

Factored load on column 1090.10kn

For footings, the bearing capacity of soil is 175kn/m2

To provide the dimensions of footing is 12.5m*2.7m

ANALYSIS

Analysis is done using STAD PRO developed by BENTLEY

Once the loads and load combinations are assigned to the structures, analysis is to be done

Analysis is done for RCC structure

Code is assigned as IS:456-2000

The parameters are assigned to the structure

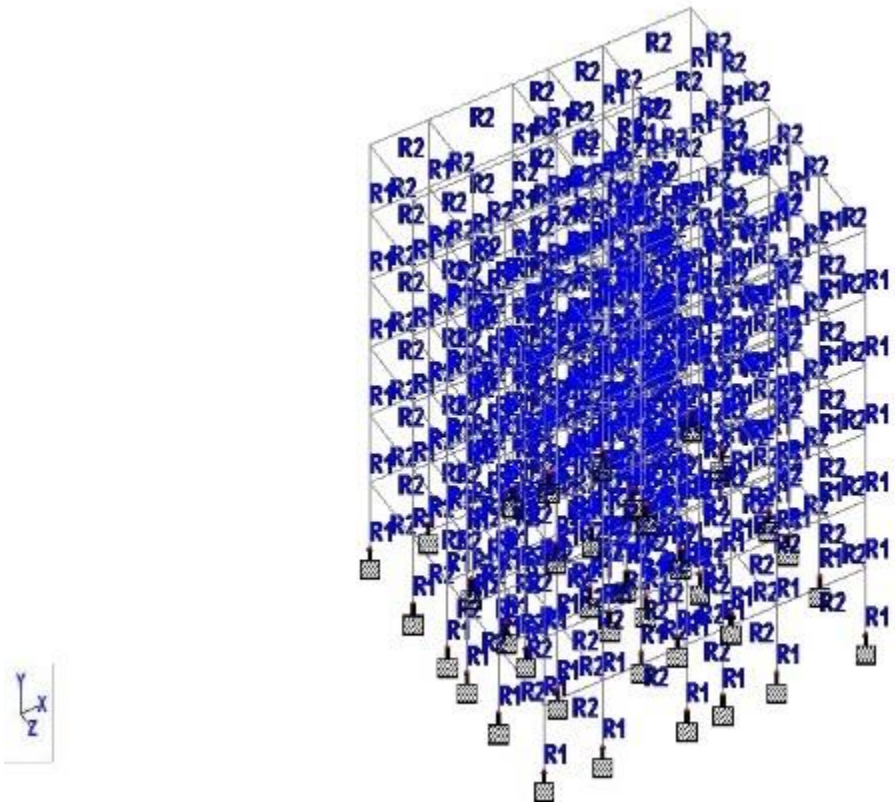
Commands to be given are

1. concrete design

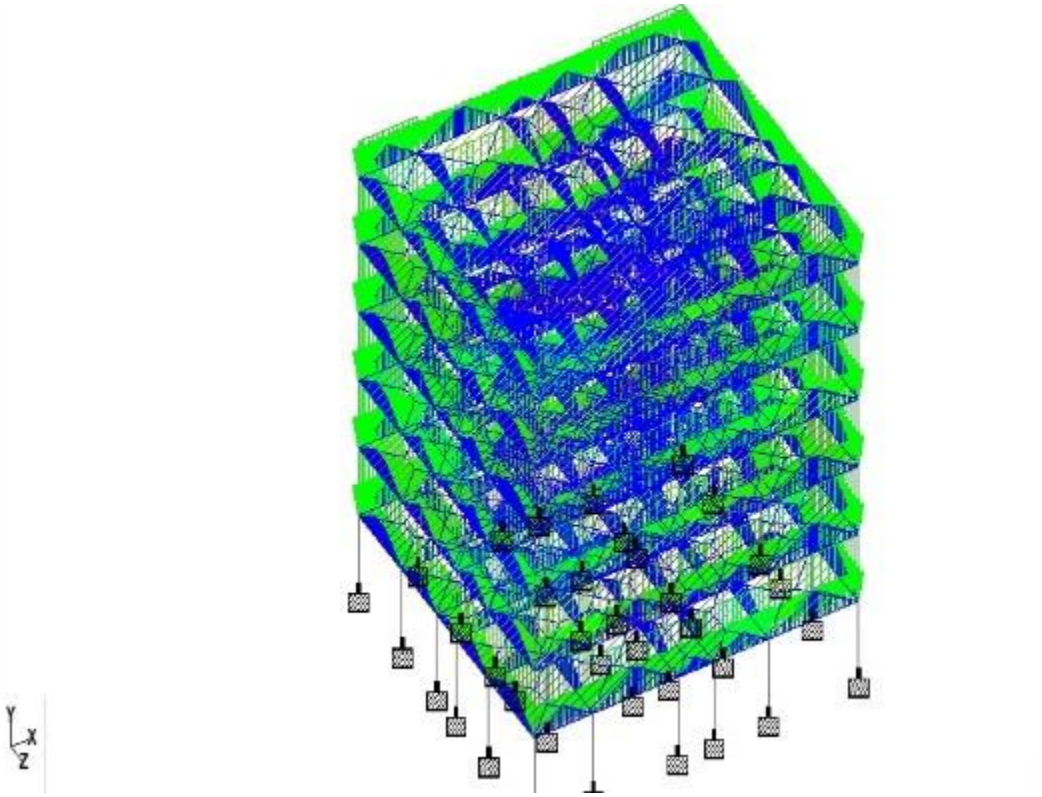
2. define parameters

3. command

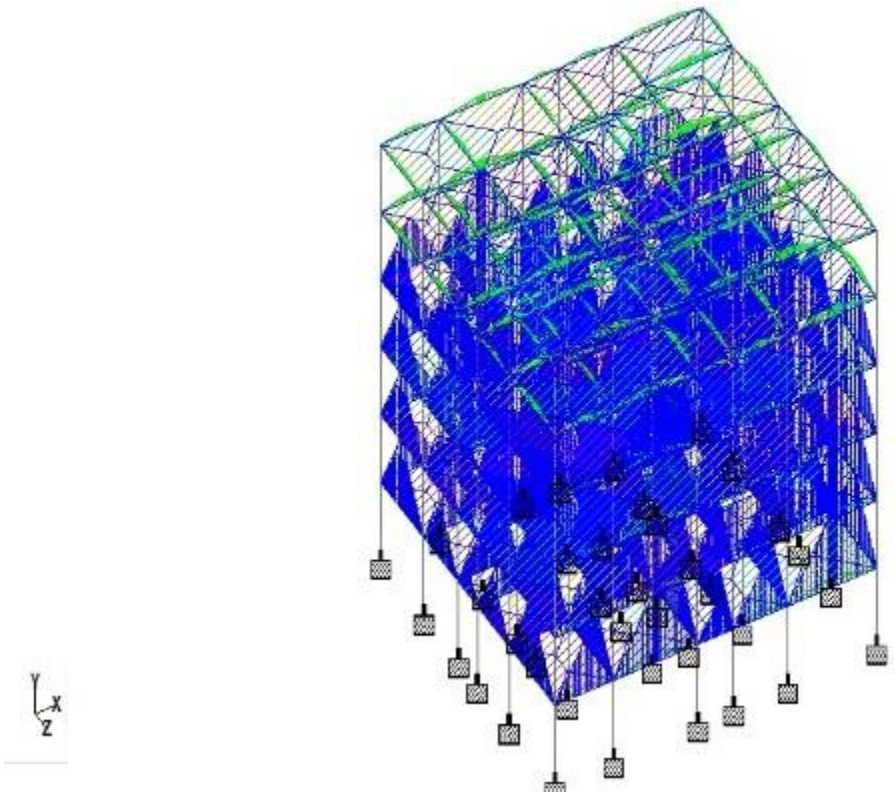
ASSIGN THE PROPERTIES OF STRUCTURES



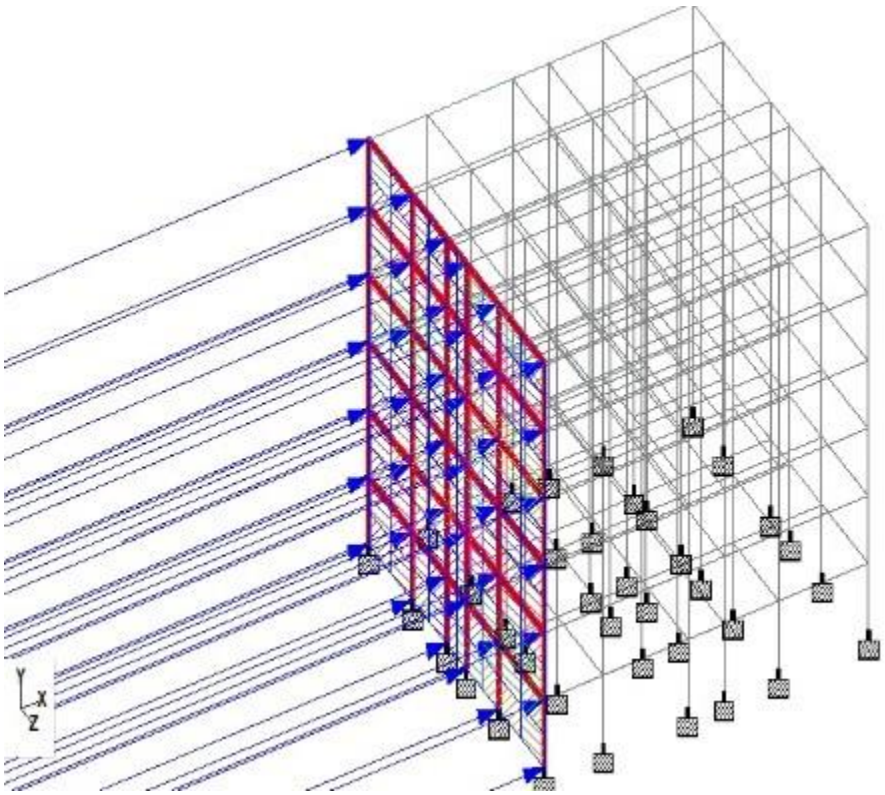
ASSIGN LOADS ON THE SLAB



LOAD ASSIGN ON THE WALLS



ASSIGN WIND LOAD ON THE STRUCTURES (X+VE DIRECTION)



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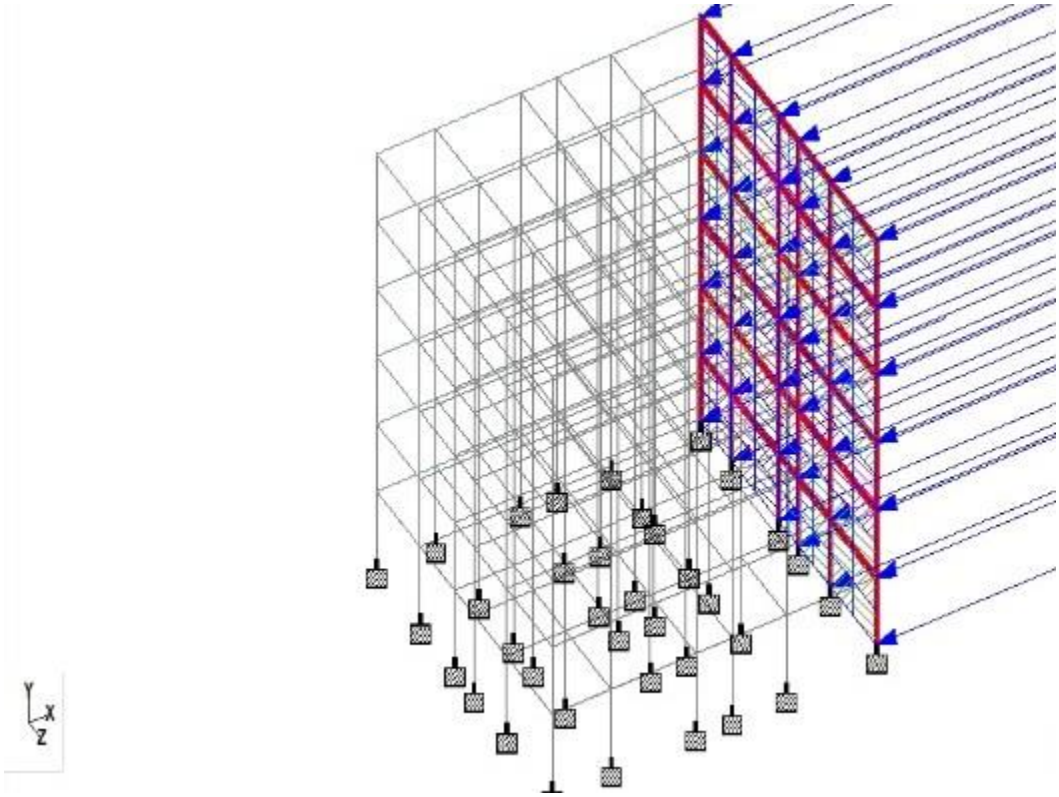
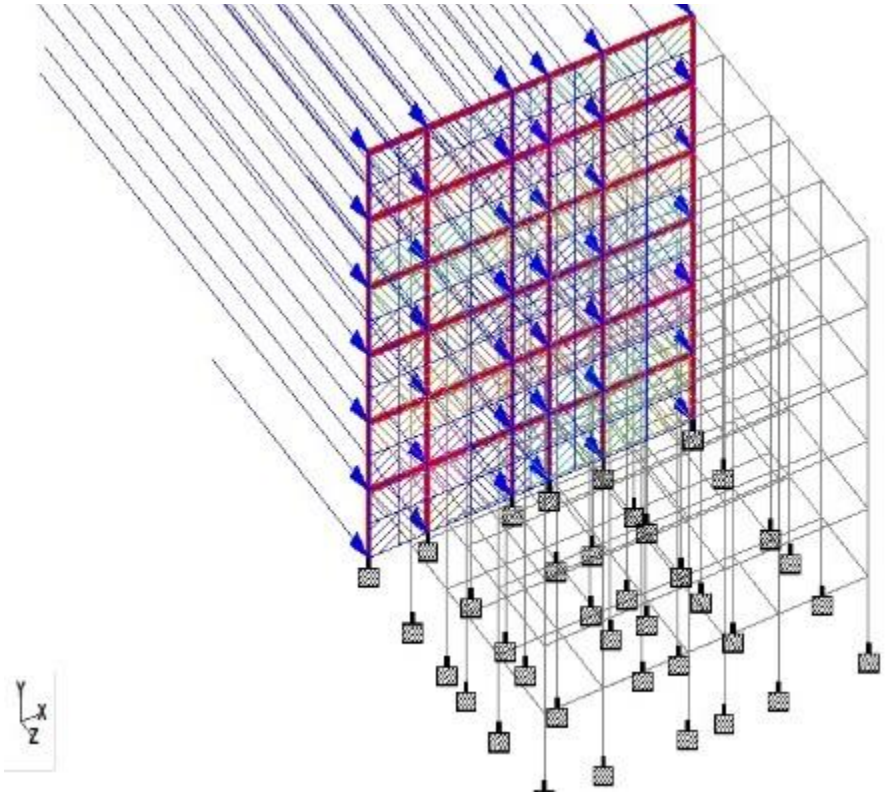
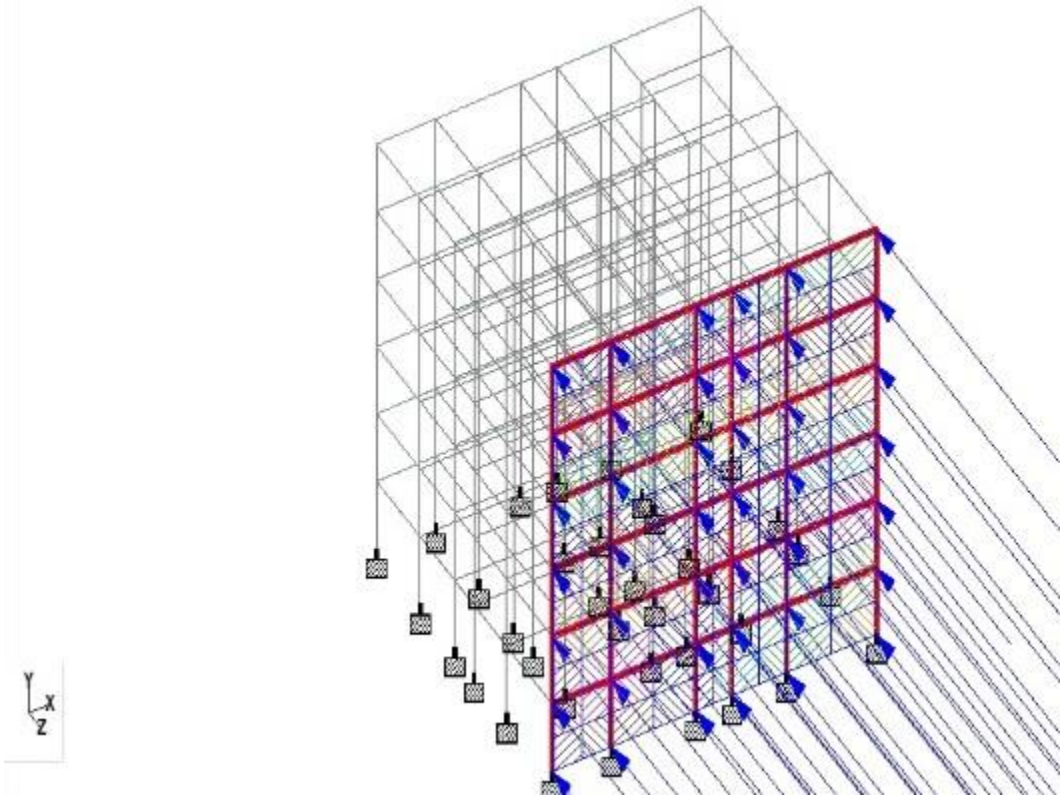


ASSIGN WIND LOAD ON THE STRUCTURES (Z +VE DIRECTION)



ASSIGN WIND LOAD ON THE STRUCTURES (Z -VE DIRECTION)



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