A

Major Project on

DESIGN AND ANALYSIS OF G+4 RESIDENTIAL BUILDING

Submitted to

In partial fulfillment of requirements for the award of the degree of

Bachelor of Engineering
In
CIVIL ENGINEERING

Submitted by

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Under the esteemed guidance of

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STUDENTS DECLARATION

I hereby declare that the project entitled "**DESIGN AND ANALYSIS OF G+4 RESIDENTIAL BUILDING**" is the work done by me during the academic year 2016-2020 and is submitted in partial fulfillment of the requirements for the award of degree of **Bachelor of Engineering** in CIVIL ENGINEERING from **CSVTU, Bhilai**.

YASH NAGDEO (301402016075) - ___________________

CERTIFICATE

This is to certify that major project report titled **“Design and Analysis of G+4 Residential Building”** submitted by **YASH NAGDEO,** student of **B.E(Final Year) Department of Civil Engineering, SSGI(FET),** Bhilai in partial fulfillment of requirement for the reward of degree of Bachelor of engineering is Bonafide presentation of the work done by him under my guidance and supervision.

Approved By: -

Dr. Prabhat Giri

HOD(CIVIL)

Guided By: -

Dr. Umank Mishra

<u>CERTIFICATE BY THE EXAMINERS</u>

The thesis entitled **"Design and Analysis of G+4 Residential Building"** submitted by **YASH NAGDEO** – **301402016075,** has been examined by the undersigned as a part of the examination and is hereby recommended for the award of Degree of Bachelor of Engineering degree in **CIVIL ENGINEERING** of Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G).

________________	________________
Internal Examiner	External Examiner
Date:	Date:

ACKNOWLEDGEMENT

I would like to express my special thanks of gratitude to my lecturer as well as my HOD who gave me the golden opportunity to do this wonderful project on the topic, **“Design and Analysis of G+4 Residential Building.”**

It gives me an immense pleasure to express my gratitude to **Prof. Dr. Prabhat Giri**, Head of Department of Civil Engineering for his esteemed guidance and able supervision during the course of the project. His constant encouragement and co-operation made this project a success.

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I would also like to thank my institute and my faculty members without whom this project would have been a distant reality. I also extend my heartfelt thanks to my family, friends and well-wishers.

YASH NAGDEO (301402016075)

OBJECTIVES & SCOPE OF THIS PROJECT

The objectives of this project are as follows:

- Carrying out complete design and analysis of the main structural elements of multi-storey residential building including slab, column, footing and staircases.
- Getting familiar with structural softwares such as Staad.pro, Staad Foundation.

The scope of this project is if any additional modification is to be done in the structure during its future life, then designing using this software would be useful.

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NOTATIONS

ASCE	American Society of Civil Engineers
As	Area of Steel
A.	Attached
Auto	Automatic
b.m.d.	Bending Moment Diagram
BOTT.	Bottom
B	Breadth
c/c	Centre to Centre
CLR TYP.	Clear Type
Fc	Compressive Strength of Concrete
CAD	Computer Aided Design
Ø	Diameter of Bar
DL	Dead Load
D	Depth
Pu	Design Axial Force
Fe	Ferrous Iron
G	Ground
IS	Indian Standard
IJATIR	International Journal of Advanced Technology and Innovative Research
IJAIEM	International Journal of Application or Innovation in Engineering & Management
IJCE	International Journal of Civil Engineering
IJISRT	International Journal of Innovative Science and Research Technology
IJISET	International Journal of Innovative Science, Engineering and Technology
IRJET	International Research Journal of Engineering and Technology

ISSN	International Standard Serial Number
s.f.d.	Shear Force Diagram
Kmph	Kilometer per Hour
kN	Kilo-newton
LL	Live Load
MS	Microsoft
Mpa	Megapascal
m/s	Meter per Second
Mx	Moment in X Direction
Mz	Moment in Z Direction
N/mm	Newton per Millimeter
No.	Number
Pro	Program
RCC	Reinforced Cement Concrete
REINF.	Reinforcement
Vy	Shear Force in Y Direction
Sec	Secondary
Staad	Structural Analysis and Designing
UDL	Uniformly Distributed Load
WL	Wind Load
Fy	Yield Stress

ABSTRACT

In order to compete in the ever-growing competent market, it is very important for a structural engineer to save time. As a sequel to this, an attempt is made to design and analyze a Multistoried Building by using Software's such as AutoCAD, Revit and Staad.pro. Due to growing population and less availability of land, Multistory Buildings are constructed which can serve many people in limited area.

For analyzing a Multistoried Building, one has to consider all the possible loadings and see that the structure is safe against all possible loading conditions.

There are several methods for analysis of different frames like Cantilever method, Portal method, Matrix method.

The present project deals with the design and analysis of a Multistoried Residential Building of G+4 consisting of 4 apartments in each floor. The dead load and live loads are applied and design for beams, columns, footing is obtained. The project aims to give proper awareness to right designing and detailing of the building. Our project purpose is to give a complete experience in the field of design and to gain the knowledge in a practical way.

Staad.pro with its new features surpassed its predecessors and compotators with its data sharing capabilities with other major software like AutoCAD and MS-Excel.

We conclude that Staad.pro is a very powerful tool which can save much time and is very accurate in Design.

1. INTRODUCTION

Building construction is the engineering deals with the construction of building such as Residential Houses. In a simple word, Building can be defined as an enclose space by walls with roof, food, cloth and the basic needs of Human Beings. In the early ancient times, Humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun etc. as the times passed as Human Being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful Houses. Rich people live in sophisticated condition houses.

Buildings are the important indicator of social progress of the country. Every human has desire to own comfortable houses on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person does utmost effort and spend hard earned saving in owning houses.

Nowadays the house building is major work of the social progress of the country. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout etc. of the buildings. Draughtsman are responsible for doing the drawing works of building as for the direction of engineers and architects. The draughtsman must know his job and should be able to follow the instruction of the engineer and should be able to draw the required drawing of the building, site plans and layout plans etc., as for the requirements.

A building frame consists of number of bays and storey. A multi-storey, multi-paneled frame is a complicated statically indeterminate structure. A design of RCC building of G+4 storey framework is taken up. The building in plan consists of columns built monolithically forming a network.

The analysis is made using software on structural analysis design (Staad-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc. and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and wind load as per IS 875. The building is designed as two-dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS456-2000.

1.1. Early modern and the industrial age:

With the emerging knowledge in scientific fields and the rise of new materials and technology, architecture engineering began to separate and the architect began to concentrate on aesthetics and the humanist aspects, often at the expense of technical aspects of building design. Meanwhile, the industrial revolution laid open the door for mass production and consumption. Aesthetics became a criterion for the middle class as ornamental products, once within the province of expensive craftsmanship became cheaper under machine production.

Vernacular architecture became increasingly ornamental. House builders could use current architectural design in their work by combining features found in pattern books and architectural journals.

1.2. Modern architecture:

The Bauhaus Dessau architecture department from 1925 by Walter Gropius.

The dissatisfaction with such a general situation at the turn of the 20th century gave rise to many new lines of thought that served as precursors to modern architecture. Notable among these is detachers' deskbound, formed in 1907 to produce better-quality machine-made objects. The rise of the profession of industrial design is usually placed here. Following this lead, the Bauhaus school, founded in Weimar, Germany in 1919, redefined the architectural bounds prior set throughout history viewing the creation of a building as the ultimate synthesis—the apex—of art, craft and technology.

When modern architecture was first practiced, it was an avant-garde moment with moral, philosophical, and aesthetic underpinning. Immediately after world war I, pioneering modernist architects sought to develop a completely new style appropriate for a new post-war social and economic order, focused on meeting the needs of the middle and working classes. They rejected the architectural practice of the academic refinement of historical styles which served the rapidly declining aristocratic order.

2. LITERATURE REVIEW

- Sreeshna K.S, "Analysis and Design of an Apartment building", IJISET, Volume 3, Issue 3, ISSN 2348 – 7968, March 2016.
  This paper deals with structural analysis and design of G+4 storied apartment building. The work was completed in three stages. The first stage was modelling and analysis of building and the second stage was to design the structural elements and the final was to detail the structural elements. In this project Staad.Pro software is used for analysing 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.

- Amar Hugar, Sharanabasappa M Pujari, Beerappa G Pujari, Anaveerappa N Biradar, Gajendra, 'Analysis and Design of a Commercial cum Residential Building by Using STAAD Pro', IRJET, Volume 3, Issue 6, ISSN 2395-0056, ISSN 2395-0072, June 2016.
  It has discussed that the aim of the structural engineer is to design a safe structure. Then the structure is subjected to various types of loading. Mostly the loads applied on the structure are considered as static. Finite part analysis that exhibit the result of dynamic load like wind result, earthquake result, etc. The work is conducted using Staad.Pro software.

- Madhurivassavai, V. Bhargavi, E.V. Raghava Rao, 'Analysis and Design of Multi-storeyed Building with G+8 Floors by Using Staad.pro', IJATIR, Volume 8, Issue 2, ISSN 2348–2370, February 2016.
  He says that the one of the major problems the country is facing 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.

- T. Subramani, S. Prakash, D. Arumugaperumal, V. Kandasamy, R. Ramesh Kumar, "Planning, Analyzing and Designing of Marriage Hall Building by using Staad.pro", IJAIEM, Volume 8, Issue 3, march 2019.
  Through our study concluded that application of software in civil industry plays important role in our study. In our Marriage hall building project, adopted limit state method for analysis and design of our structure. Time taken for doing this project is very less due to the application of the software. We bring extra accuracy in dimension and analysis part through our study.

- A.D. Bhosale, Archit Pradip Hatkhambkar, Rupesh Vinayak Katkar, Shubham Balasaheb Babar, Sunny Pramod Gorivale, "Analysis and Design of Multi-Storey Building by using Staad.pro", IJISRT, Volume 3, Issue 4, ISSN 2456-2165, April 2018.

Unique structures need more time for its time-consuming calculations, if we use manual methods. STAAD Pro provides us a quick result. It is easy to use for analyse and design any structure for more accuracy. STAAD Pro is accurate structural design software. It also provides economical design of the structure. The difference in steel error is due to human error.

- T. Dinesh Kumar, Mohammed Ibrahim, Mohammed Ismail Pasha Quadri, Mohammed Sohail Ali, Syed Abdul Rahman, Mohammed Akbar Khan, "Design and Analysis of High-Rise Building using Staad.pro", IJCE, Volume 6, Issue 6, June 2019.
  In case of rectification, it is simple to change the values at the place where error occurred and the obtained results are generated in the output.

3. SOFTWARES USED

This project is mostly based on software and it is essential to know the details about these softwares.

List of softwares used are as follows:

- Revit
- Staad.pro V8i
- Staad Foundations V8i (ver 5.3)

3.1. Revit

Fig.1: Revit Logo

Autodesk Revit is a building information modelling software for architects, landscape architects, structural engineers, mechanical, electrical, and plumbing engineers, designers and contractors. The software allows users to design a building and structure and its components in 3-Dimensional, annotate the model with 2-Dimensional drafting elements, and access building information from the building model's database. Revit is 4-Dimensional building information modeling capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later maintenance and/or demolition.

3.2. Staad.Pro V8i

Fig.2: Staad.pro Logo

Staad is powerful design software licensed by Bentley. Staad stands for Structural Analysis and Design. Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, whereas analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis. To calculate s.f.d and b.m.d of a complex loading beam it takes about an hour. So, when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just an hour. Staad is a best alternative for high-rise buildings. Now a days most of the high-rise buildings are designed by Staad which makes a compulsion for a civil engineer to know about this software. These softwares can be used to carry RCC, steel, bridge, truss etc according to various country codes.

Limitations of Staad pro:

- Huge output data.
- Even analysis of a small beam creates large output.
- Unable to show plinth beams.

3.3. Staad.foundation V8i

Fig.3: Staad Foundation Logo

Staad foundation is a powerful tool used to calculate different types of foundations. It is also licensed by Bentley. All Bentley softwares cost about 10 lakhs and so all engineers can't use it due to heavy cost. Analysis and design carried in Staad and post processing in staad gives the load at various supports. These supports are to be imported into this software to calculate the footing details i.e., regarding the geometry and reinforcement details.

This software can deal different types of foundations such as:

SHALLOW (D<B)

1. Isolated (Spread) Footing

2.Combined (Strip) Footing

3. Mat (Raft) Foundation

DEEP (D>B)

1.Pile Cap

2. Driller Pier

- Isolated footing is spread footing which is common type of footing.
- Combined Footing or Strap footing is generally laid when two columns are very near to each other.
- Mat foundation is generally laid at places where soil has less soil bearing capacity.
- Pile foundation is laid at places with very loose soils and where deep excavations are required.

So, depending on the soil at type we have to decide the type of foundation required. Also, lot of input data is required regarding safety factors, soil, materials used should be given in respective units. After input data is give software design the details for each and every footing and gives the details regarding:

1. Geometry of footing

2. Reinforcement

3. Column layout

4. Graphs

5. Manual calculations

These details will be given in detail for each and every column. Another advantage of foundations is even after the design; properties of the members can be updated if required.

The following properties can be updated:

- Column Position
- Column Shape
- Column Size
- Load Cases
- Support List

It is very easy to deal with this software and we don’t have any best alternative to this.

4. DESIGN OF MULTI-STOREYED RESIDENTIAL BUILDING

A structure can be defined as a body which can resist the applied loads without appreciable deformations. Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and the construction of structures. Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system. The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution.

The objective of the design is

1. Foundation design

2. Column design

3. Beam design

4. Slab design

These all are designed under limit state method.

4.1. Limit state method:

The acceptable limit for the safety and serviceability requirements before failure occurs is called a limit state. The object of design based on the limit state concept is to achieve an acceptability that a structure will not become unserviceable in its life time for the use for which it is intended. It will not reach a limit state. In this limit state method, all relevant states must be considered in design to ensure a degree of safety and serviceability.

4.1.1. Limit state of Collapse:

This correspond to the maximum load carrying capacity. Violation of collapse limit state implies failures in the source that a clearly defined limit state of structural usefulness has been exceeded. However, it does not mean complete collapse.

This limit state corresponds to:

a) Flexural

b) Compression

c) Shear

d) Torsion

4.1.2. Limit state of Serviceability:

This state corresponds to development of excessive deformation and is used for checking member in which magnitude of deformations may limit the rise of the structure of its components.

a) Deflection

b) Cracking

c) Vibration

Assumptions in design:

- Using partial safety factor for loads in accordance with clause 36.4 of IS-456 2000 as 1.5
- Partial safety factor for material in accordance with clause 36.4.2 of IS-456 2000 is taken as 1.5 for concrete and 1.15 for steel.
- Using partial safety factors in accordance with clause 36.4 of IS-456 2000 for combination of loads:
  D.L + L.L > 1.5
  D.L + L.L + W.L > 1.2

Assumptions Regarding Design:

- Slab is assumed to be continuous over interior support and partially fixed on edges, due to monolithic construction and due to construction of walls over it.
- Beams are assumed to be continuous over interior support and they frame in to the column at ends.

Assumptions on Design:

- M25 grade is used in designing unless specified.
- For steel, Fe415 is used for main reinforcement.
- For steel, Fe415 is used for distribution reinforcement.
- Mild steel Fe250 is used for shear reinforcement.

5. ANALYSIS OF MULTI-STOREYED RESIDENTIAL BUILDING

Method of analysis of statistically indeterminate portal frames are as follows:

5.1. Method of flexibility coefficients:

The method of analysis is comprises reducing the hyper static structure to a determinate structure form by removing the redundant support or introducing adequate cuts or hinges. It is not applicable for degree of redundancy>3.

5.2. Slope deflection method:

It is advantageous when kinematic indeterminacy < static indeterminacy. This procedure was first formulated by axle bender in 1914 based on the applications of compatibility and equilibrium conditions. The method derives its name from the fact that support slopes and displacements are explicitly comported. Set up simultaneous equations is formed the solution of these parameters and the joint moment in each element are computed from these values. A solution of simultaneous equations makes method tedious for manual computations. This method is not recommended for frames larger than too bays or two storeys.

5.3. Moment Distribution Method:

In the moment distribution method, every joint of the structure to be analyzed is fixed so as to develop the fixed-end moments. Then each fixed joint is sequentially released and the fixed-end moments (which by the time of release are not in equilibrium) are distributed to adjacent members until equilibrium is achieved. The moment distribution method in mathematical terms can be demonstrated as the process of solving a set of simultaneous equations by means of iteration.

5.4. Cantilever Method:

The cantilever method is an approximate method for calculation of shear forces and moments developed in beams and columns of a frame or structure due to lateral loads. The applied lateral loads typically include wind loads and earthquake loads, which must be taken into consideration while designing buildings. The assumptions used in this method are that the points of contraflexure (or points of inflection of the moment diagram) in both the vertical and horizontal members are located at the midpoint of the member, and that the direct stresses in the columns are proportional to their distances from the centroidal axis of the frame. The method is quite versatile and can be used to analyze frames of any number of storey or floors.

5.5. Portal method:

Portal frame can be defined as two-dimensional rigid frames that have the basic characteristics of a rigid joint between column and beam. Portal frame construction is a method of building and designing structures. Because of these very strong and rigid joints, some of the bending moment in the rafters is transferred to the columns. The main objective of this form of design is to reduce bending moment in the beam, which allows the frame to act as one structural unit. Portal frames are designed for roof load and wind load. While designing, care should be taken for proper joints and foundation.

Assumptions:

- Point of contra-flexure occurs at the middle of all members of the frame.
- Horizontal shear taken by each interior column is double of that taken by external column.

5.6. Matrix Method:

This method is based on the elastic theory, where it can be assumed that most structures behave like complex elastic springs, the load-displacement relationship of which is linear. Obviously, the analysis of such complex springs is extremely difficult, but if the complex spring is subdivided into a number of simpler springs, which can readily be analysed, then by considering equilibrium and compatibility at the boundaries, or nodes, of these simpler elastic springs, the entire structure can be represented by a large number of simultaneous equations. Solution of the simultaneous equations results in the displacements at these nodes, whence the stresses in each individual spring element can be determined through Hookean elasticity.

6. METHODOLOGY

6.1. Plan:

The plan clearly shows that it is a combination of four apartments. It is a G+4 proposed building. The plan shows the details of dimensions of each and every room and the type of room and orientation of the different rooms like bed room, bathroom, kitchen, hall etc. All the four apartments have similar room arrangement. The plan gives details of arrangement of various furniture like sofa etc. The plan also gives the details of location of stair cases. We have 1 stair cases for each block. In the middle we have a small construction which consists of 1 lift and those who want to fly through lift can use this facility and we know for a building with more than G+4 floors should compulsory have lift and the charges for the facilities is collected by all the members. So, these represent the plan of our building.

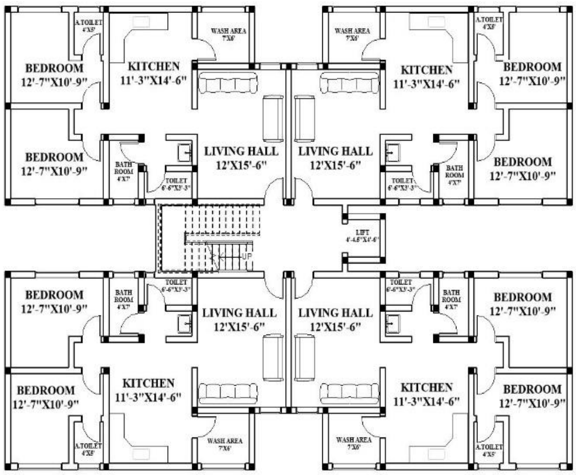


Fig.4: First Floor Residential Building Plan

The below figure represents the skeletal structure of our building in staad pro. Each support represents the location of different columns in the structure. This structure is used in generating the entire structure using a tool called transitional repeat and link steps. After using the tool, the structure that is created can be analysed in staad pro under various loading cases. All the loadings are acted on this skeletal structure to carry out the analysis of our building. This is not the actual structure but just represents the outline of the building in staad pro. A mesh is automatically created for the analysis of these building.

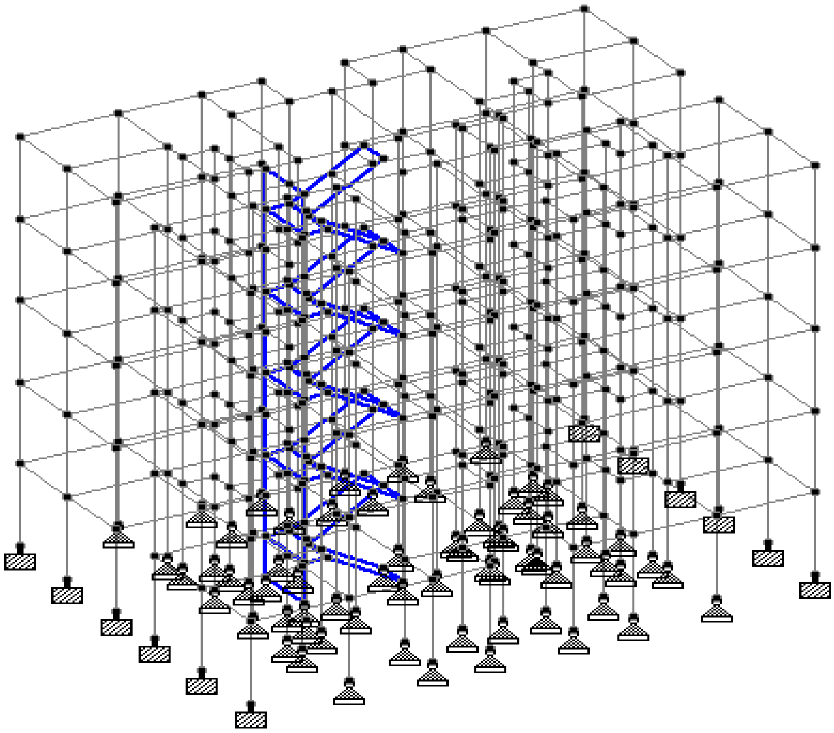


Fig.5: Skeletal Structure of G+4 Residential Building

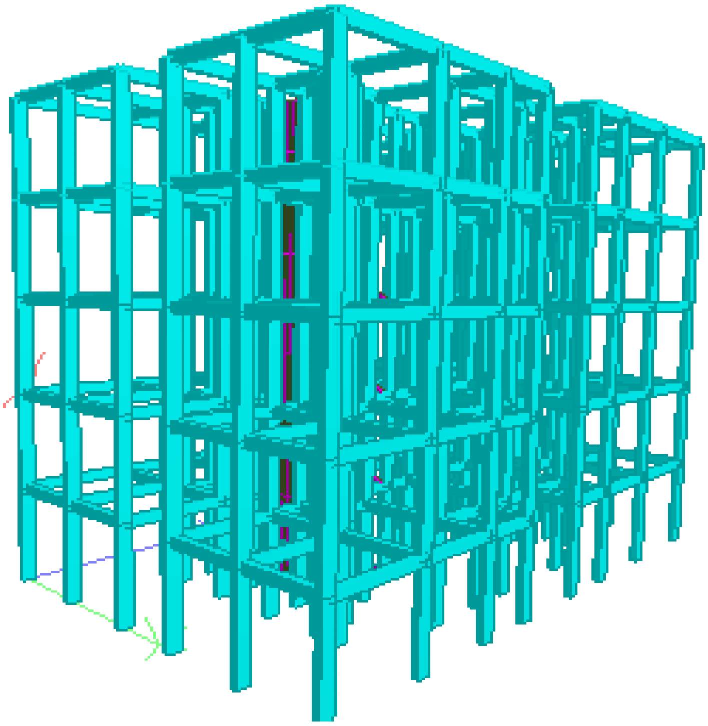


Fig.6: 3-D Rendered View of Structure

6.2. Loadings:

The concepts presented in this section provide an overview of building loads and their effect on the structural response. Building loads can be divided into types based on the orientation of the structural action or forces that they induce: vertical and horizontal (i.e., lateral) loads. Types of loads on a hypothetical building are as follows:

- Vertical Loads
- Dead (gravity)
- Live (gravity)
- Snow(gravity)
- Wind (uplift on roof)
- Seismic and wind (overturning)
- Seismic (vertical ground motion)

Loads are a primary consideration in any building design because they define the nature and magnitude of hazards. Loads are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life. The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions). Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration. Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically.
While the buildings considered in this guide are primarily single-family detached and attached dwellings, the principles and concepts related to building loads also apply to other similar types of construction, such as low-rise apartment buildings. In general, the design loads recommended in this guide are based on applicable provisions of the ASCE 7 standard-Minimum Design, loads for buildings and other structures (ASCE,1999). The ASCE 7 standard represents an acceptable practice for building loads in the United states and is recognized in virtually all U.S. building codes. For this reason, the reader is encouraged to become familiar with the provisions, commentary, and technical references contained in the ASCE 7 standard. In general, structural design of housing has not been treated as a unique engineering discipline or subjected to a special effort to develop better, more efficient design practices. Therefore, this part of the guide focuses on those aspects of ASCE 7 and other technical resources that are particularly relevant to the determination of design loads for residential structures.

6.2.1. Dead Loads:

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc. In staad pro, assignment of dead load is automatically done by giving the property of the member. In load case, we have option called self-weight which automatically calculates weights using the properties of material i.e., density and after assignment of dead load, the skeletal structure looks red in colour as shown in the figure. Dead load is calculated as per **IS 875 part 1.**

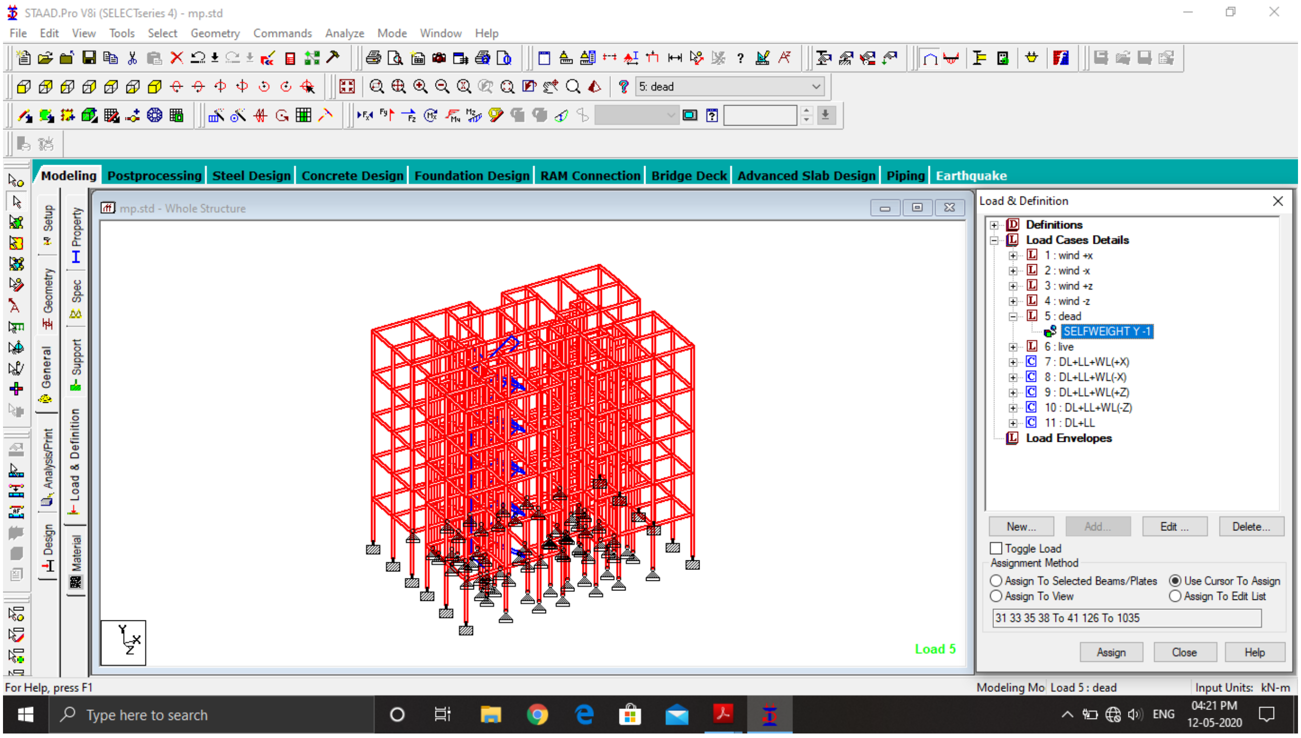


Fig.7: Dead Load Assigned to Structure

6.2.2. Live Loads:

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously n a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in endues conditions.

In staad we assign live load in terms of U.D.L. We have to create a load case for live load and select all the beams to carry such load. After the assignment of the live load, the structure appears as shown below.

For our structure live load is taken as **25 N/mm** for design.

Live loads are calculated as per **IS 875 part 2.**

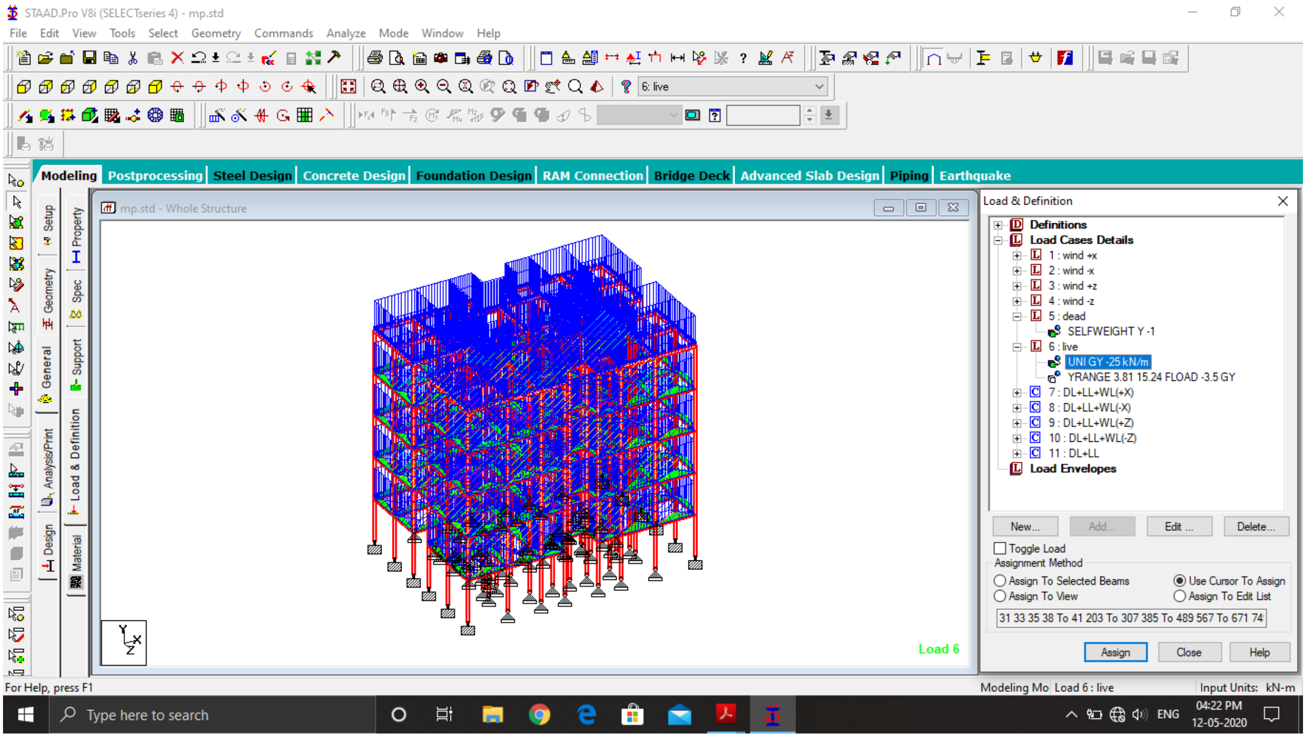


Fig.8: Live Load Assigned to Structure

6.2.3. Wind Loads:

In the list of loads we can see wind load is present both in vertical and horizontal loads. This is because wind load causes uplift of the roof by creating a negative(suction) pressure on the top of the roof. Wind produces non static loads on a structure at highly variable magnitudes. The variation in pressures at different locations on a building is complex to the point that pressures may become too analytically intensive for precise consideration in design. Assignment of wind speed is quite different compared to remaining loads. We have to define a load case prior to assignment. After designing wind load can be assigned in two ways:

1. collecting the standard values of load intensities for a particular height and assigning of the loads for respective height.
2. calculation of wind load as per **IS 875 part 3.**

We designed our structure using second method which involves the calculation of wind load using wind speed. In Raipur, we have a wind speed of 39 kmph for 10 m height and this value is used in calculation.

After the assignment of wind load the structure looks as shown in figure.

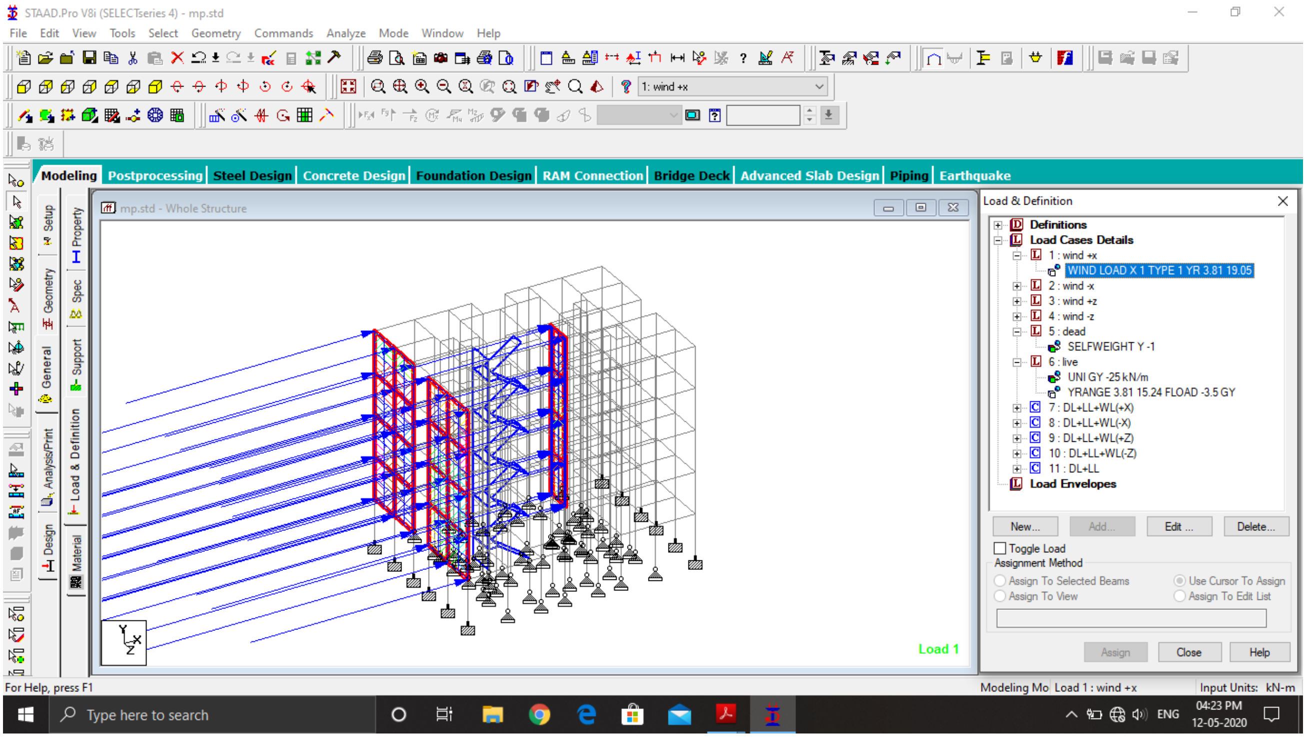


Fig.9: Wind Load Assigned to Structure in +X Direction

Design Wind speed: The basic wind speed (Vb) for any site shall be obtained the following effects to get design wind velocity at any height (Vz) for the chosen structure.

a) Risk level

b) Terrain roughness, height and size of the structure and

c) Local topography

It can be mathematically expressed as follows:

$Vz=Vb* K1* K2* K3$

Where, Vz = design wind speed at any height Z in m/s

K1= probability factor (risk coefficient)

K2=terrain height and structure size factor and

K3=topography factor

Height of Building(m)	K1	K2	K3
10	1	1	1
15	1	1.05	1
20	1	1.07	1
30	1	1.12	1

Table 1: Design Wind Speed Coefficients

City Names	Wind Zone	Wind Speed (Vb)
Ahmedabad	2	39
Amritsar	4	47
Bangalore	1	33
Baroda	3	44
Bhopal	2	39
Bombay	3	44

Calcutta	5	50
Cochin	2	39
Gaya	2	39
Gopalpur	2	39
Hakimpet	3	44
Hashimara	4	47
Hyderabad	3	44
Indore	2	39
Jagdalpur	2	39
Jaipur	4	47
Jamnagar	5	50
Lucknow	4	47
Madras	5	50
Nagpur	3	44
New Delhi	4	47
Port Blair	3	44
Pune	2	39
Raipur	2	39
Trivandrum	2	39
Vishakhapatnam	5	50

Table 2: Basic Wind Speed of Important Cities

6.2.4. Floor Load:

Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure.

The intensity of the floor load taken is: **3.5 N/mm2**

Negative sign indicates that floor load is acting downwards.

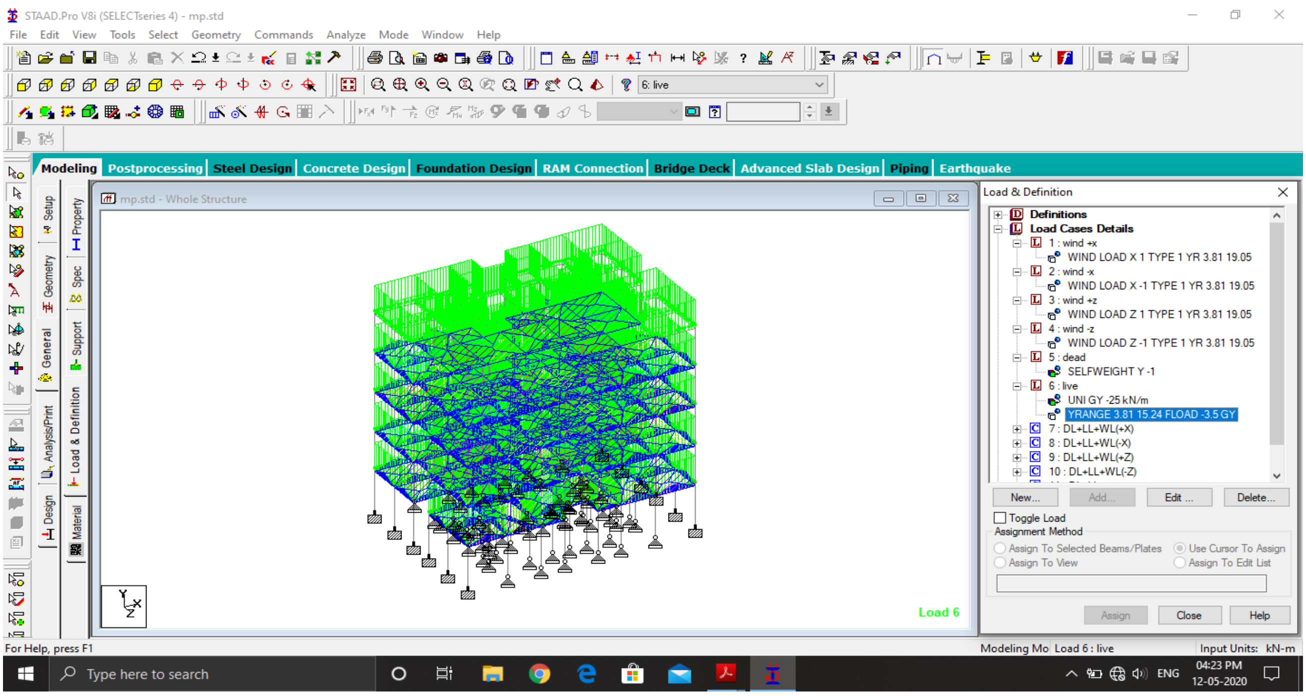


Fig.10: Floor Load Assigned to Structure

6.2.5. Load Combinations:

All the load cases are tested by taking load factors and analysing the building in different load combination as per **IS456** and results are taken and maximum load combination is selected for the design. When the building is designed for both wind and seismic loads, maximum of both is taken. Because wind and seismic do not come at same time as per code. Structure is analysed by taking all the above combinations. In the below figure, highlighted components represent load combination.

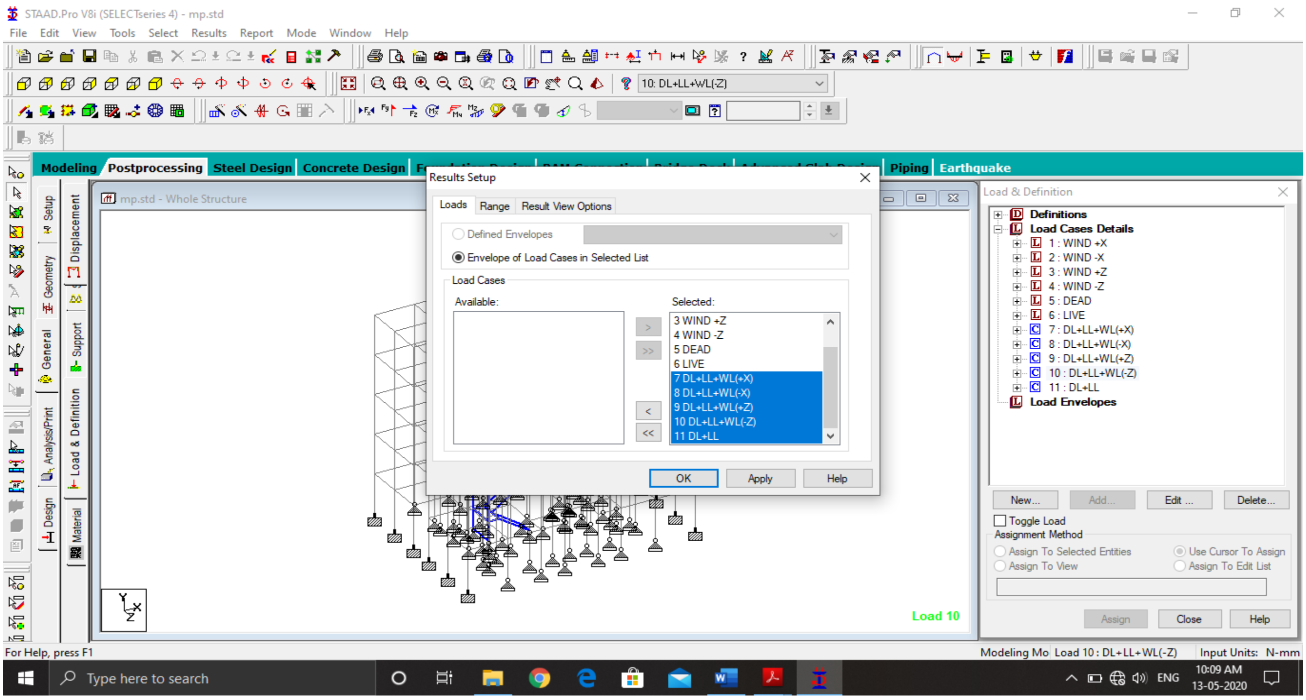


Fig.11: Load Combination Details

6.3. Beams:

Beams transfer load from slabs to columns. Beams are designed for bending. In general, we have two types of beam: single and double. Design beam command is assigned and analysis is carried out, now reinforcement details are taken. A reinforced concrete beam should be able to resist tensile, compressive and shear stress induced in it by loads on the beam. In singly reinforced simply supported beams, steel bars are placed near the bottom of the beam where they are more effective in resisting in the tensile bending stress. In doubly reinforced, it is reinforced under compression tension regions.

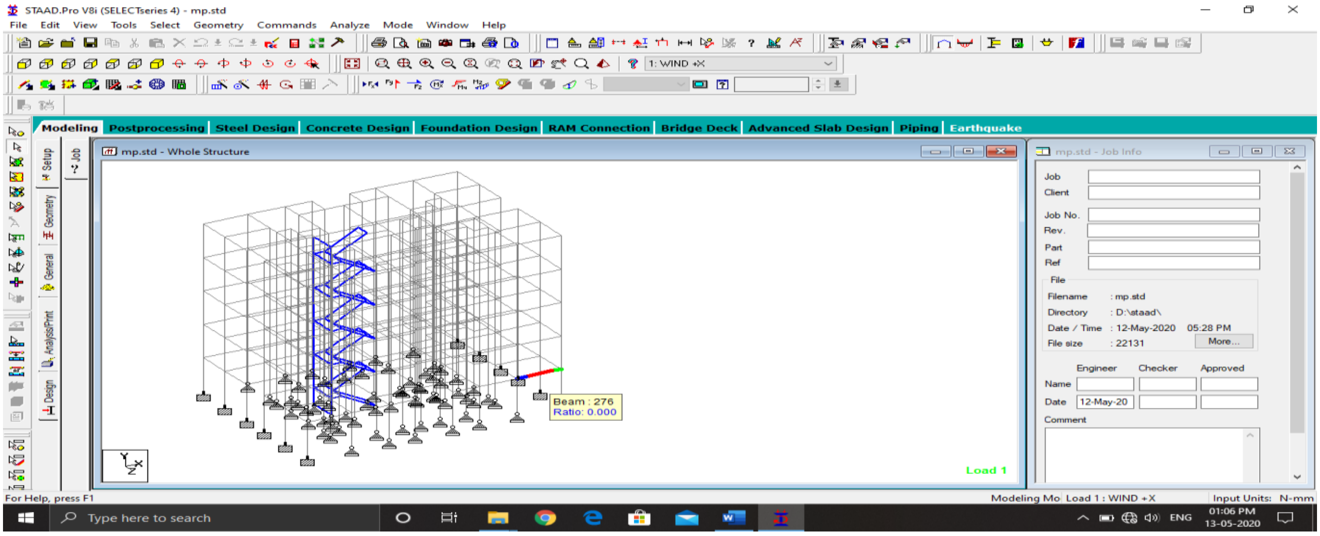


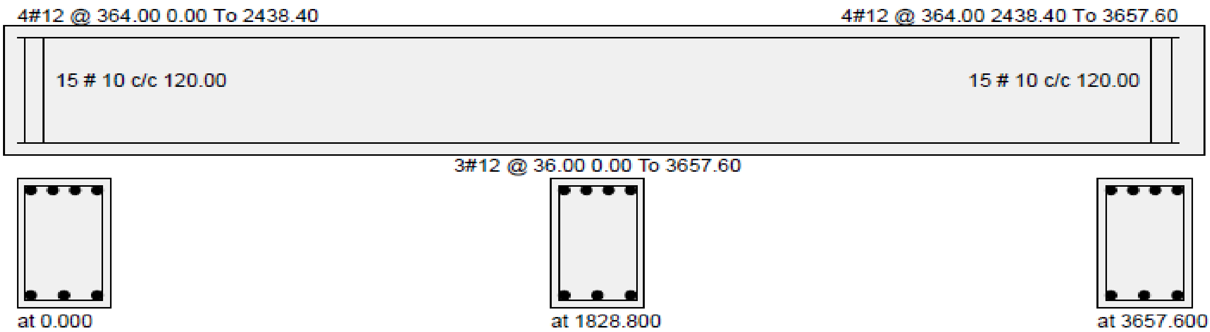
Fig.12: Location of Beam 276

Figure shows the bottom and top reinforcement details at three different sections.

STAAD.Pro Query Concrete Design

Beam no. 276

Design Code: IS-456



Design Load

Mz(Kn Met)	Dist.et	Load
31.490000	1.800000	11
-45.880001	0.000000	11
-48.950001	3.700000	11

Design Parameter

Fy(Mpa)	415.000000
Fc(Mpa)	25.000000
Depth(mm)	400.000006
Width(mm)	250.000000
Length(mm)	3657.600403

Fig.13: Design of Beam 276

STAAD.Pro Query   Deflection Result

Beam no. 276

Deflection in Global Y axis. Load case 7.

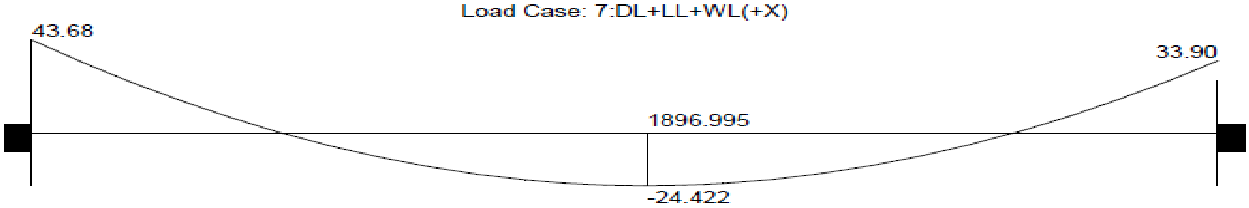
Dist.mm	X(mm)	Y(mm)	Z(mm)
0.000000	0.8790	-1.0445	0.1922
304.800028	0.8789	-1.1593	0.1978
609.600057	0.8788	-1.3521	0.2011
914.400085	0.8786	-1.5699	0.2024
1219.200114	0.8785	-1.7706	0.2024
1524.000142	0.8784	-1.9227	0.2013
1828.800171	0.8782	-2.0062	0.1998
2133.600199	0.8781	-2.0126	0.1981
2438.400228	0.8780	-1.9451	0.1969
2743.200256	0.8779	-1.8187	0.1964
3048.000285	0.8777	-1.6593	0.1973
3352.800313	0.8776	-1.5041	0.1999
3657.600342	0.8775	-1.4007	0.2046

Fig.14: Deflection of Beam 276

STAAD.Pro Query   Bending and Shear Results

Bending about Z for Beam 276

Load Case: 7:DL+LL+WL(+X)



Dist.mm	Fy(N)	Mz(kNm)
0.000000	69538.2690	43.6835
304.800034	59337.3820	24.0329
609.600067	48746.3022	7.5510
914.400101	37765.0294	-5.6432
1219.200134	26393.5638	-15.4309
1524.000168	14631.9054	-21.6931
1828.800201	2675.1511	-24.3307
2133.600235	-9281.6032	-23.3238
2438.400269	-21043.2616	-18.6924
2743.200302	-32414.7272	-10.5355
3048.000336	-43396.0000	1.0280
3352.800369	-53987.0798	15.8790
3657.600403	-64187.9668	33.8988

Fig.15: Shear & Bending of Beam 276

DESIGN LOAD SUMMARY (KN MET)

SECTION (in mm)	FLEXURE (Maxm. Sagging/Hogging moments) P	MZ	MX	Load Case	SHEAR VY	MX	Load Case
0.0	0.00	8.00	-0.07	2	82.74	0.07	11
	0.00	-45.88	0.07	11			
304.8	0.00	6.83	-0.07	2	69.85	0.07	11
	0.00	-23.26	0.67	10			
609.6	0.00	5.66	-0.07	2	56.87	0.07	11
	0.00	-6.91	0.67	10			
914.4	0.00	14.95	-0.03	8	42.84	0.07	11
	0.00	-2.84	0.51	4			
1219.2	0.00	22.93	0.07	11	26.36	0.67	10
	0.00	-2.09	0.51	4			
1524.0	0.00	29.46	0.07	11	14.22	0.67	10
	0.00	-1.34	0.51	4			
1828.8	0.00	31.49	0.07	11	2.27	0.67	10
	0.00	-0.60	0.51	4			
2133.6	0.00	28.95	0.07	11	-17.23	-0.03	8
	0.00	-0.19	-0.07	2			
2438.4	0.00	21.91	0.07	11	-30.96	0.07	11
	0.00	-1.36	-0.07	2			
2743.2	0.00	10.30	0.67	10	-44.51	0.07	11
	0.00	-2.53	-0.07	2			
3048.0	0.00	2.38	0.51	4	-58.55	0.07	11
	0.00	-8.68	-0.03	8			
3352.8	0.00	3.13	0.51	4	-71.53	0.07	11
	0.00	-25.95	-0.03	8			
3657.6	0.00	3.88	0.51	4	-84.42	0.07	11
	0.00	-48.95	0.07	11			

Fig.16: Design Load Summary of Beam 276

SUMMARY OF REINF. AREA (Sq.mm)

SECTION (in mm)	TOP Reqd./Provided reinf.	BOTTOM Reqd./Provided reinf.	STIRRUPS (2 legged)
0.0	376.06/ 452.39(4-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
304.8	191.66/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
609.6	186.39/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
914.4	186.39/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
1219.2	186.39/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
1524.0	186.39/ 226.19(2-12í)	235.29/ 339.29(3-12í)	10í @ 120 mm
1828.8	186.39/ 226.19(2-12í)	252.20/ 339.29(3-12í)	10í @ 120 mm
2133.6	186.39/ 226.19(2-12í)	231.04/ 339.29(3-12í)	10í @ 120 mm
2438.4	186.39/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
2743.2	186.39/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
3048.0	186.39/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
3352.8	205.72/ 226.19(2-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm
3657.6	403.29/ 452.39(4-12í)	186.39/ 226.19(2-12í)	10í @ 120 mm

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 585.0 mm AWAY FROM START SUPPORT
VY = 57.92 MX = 0.07 LD= 11
Provide 2 Legged 10í @ 120 mm c/c

SHEAR DESIGN RESULTS AT 585.0 mm AWAY FROM END SUPPORT
VY = -59.68 MX = 0.07 LD= 11
Provide 2 Legged 10í @ 120 mm c/c

Fig.17: Reinforcement Details of Beam 276

6.4. Columns:

A column may be defined as an element used primary to support axial compressive loads and with a height of a least three times its lateral dimension. The strength of column depends upon the strength of materials, shape and size of cross section, length and degree of proportional and dedicational restrains at its ends. Depending upon the architectural requirements and loads to be supported, RCC columns may be cast in various shapes, that is, square, rectangle, and hexagonal, octagonal, circular. Columns of L shaped or T shaped are also sometimes used in multi-storeyed buildings.
In this structure, we adopted same cross section throughout the structure with a rectangular cross section. The column design is done by selecting the column and from geometry page, assign the dimensions of the column. Now analyse the column for loads to see the reactions and total loads on the column by giving appropriate parameters like

1. Minimum reinforcement, max, bar sizes, maximum and minimum spacing.
2. Select the appropriate design code and input design column command to all the columns.
3. Now run analysis and select any column to collect the reinforcement details.

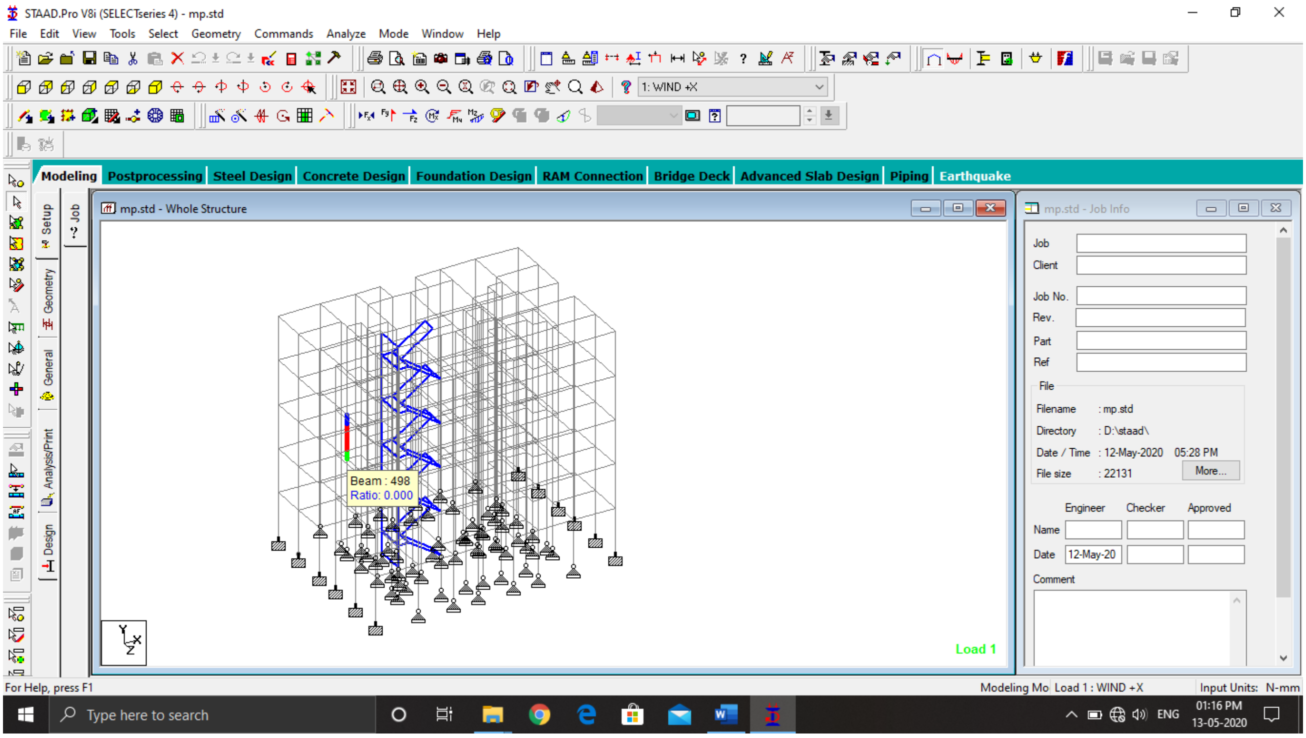


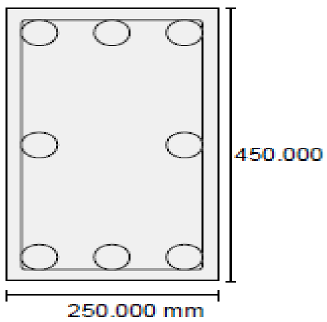
Fig.18: Location of Column 498

The following figure shows the reinforcement details of a column.

STAAD.Pro Query   Concrete Design

Beam no. 498

Design Code: IS-456



Design Load

Load	3
Location	End 1
Pu(Kns)	-4.580000
Mz(Kns-Mt)	0.830000
My(Kns-Mt)	2.900000

Design Results

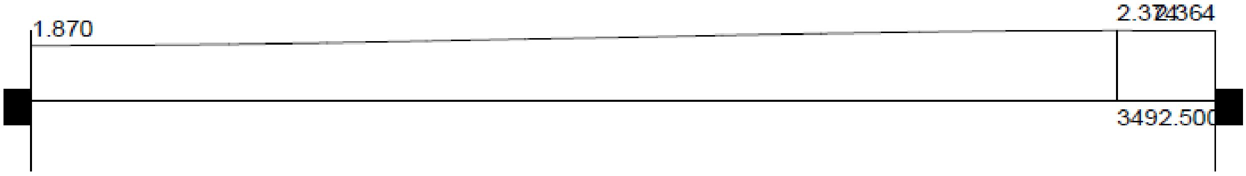
Fy(Mpa)	415
Fc(Mpa)	25
As Reqd(mm²)	900.000000
As (%)	0.804000
Bar Size	12
Bar No	8

Fig.19: Design of Column 498

STAAD.Pro Query   Deflection Result

Beam no. 498

Deflection in Global X axis. Load case 7.



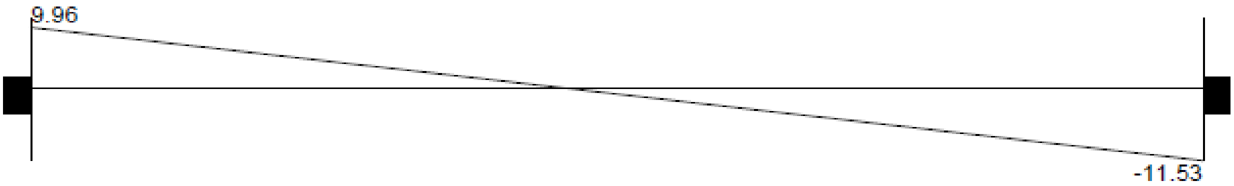
Dist.mm	X(mm)	Y(mm)	Z(mm)
0.000000	1.8697	-1.4332	-0.4376
317.500041	1.8813	-1.4744	-0.4743
635.000081	1.9129	-1.5155	-0.4909
952.500122	1.9601	-1.5567	-0.4916
1270.000163	2.0185	-1.5978	-0.4809
1587.500203	2.0837	-1.6390	-0.4630
1905.000244	2.1514	-1.6801	-0.4425
2222.500285	2.2172	-1.7213	-0.4236
2540.000326	2.2767	-1.7624	-0.4107
2857.500366	2.3255	-1.8036	-0.4082
3175.000407	2.3593	-1.8447	-0.4204
3492.500448	2.3736	-1.8859	-0.4518
3810.000488	2.3642	-1.9270	-0.5066

Fig.20: Deflection of Column 498

STAAD.Pro Query   Bending and Shear Results

Bending about Z for Beam 498

Load Case: 7:DL+LL+WL(+X)



Dist.mm	Fy(N)	Mz(kNm)
0.000000	5638.6914	9.9580
317.500035	5638.6914	8.1677
635.000070	5638.6914	6.3774
952.500105	5638.6914	4.5871
1270.000140	5638.6914	2.7968
1587.500175	5638.6914	1.0065
1905.000210	5638.6914	-0.7837
2222.500245	5638.6914	-2.5740
2540.000280	5638.6914	-4.3643
2857.500315	5638.6914	-6.1546
3175.000350	5638.6914	-7.9449
3492.500385	5638.6914	-9.7352
3810.000420	5638.6914	-11.5255

Fig.21: Shear & Bending of Column 498

```
          C O L U M N   N O.    498  D E S I G N   R E S U L T S

      M25                    Fe415 (Main)               Fe250 (Sec.)

LENGTH:  3810.0 mm   CROSS SECTION:  250.0 mm X  450.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    3 END JOINT:   215  TENSION COLUMN


DESIGN FORCES (KNS-MET)
-----------------------
DESIGN AXIAL FORCE (Pu)             :      -4.58

                                         About Z            About Y
INITIAL MOMENTS                     :       0.83               2.90
MOMENTS DUE TO MINIMUM ECC.         :       0.10               0.09

SLENDERNESS RATIOS                  :     -                  -
MOMENTS DUE TO SLENDERNESS EFFECT   :     -                  -
MOMENT REDUCTION FACTORS            :     -                  -
ADDITION MOMENTS (Maz and May)      :     -                  -

TOTAL DESIGN MOMENTS                :       0.83               2.90

REQD. STEEL AREA   :       900.00 Sq.mm.
REQD. CONCRETE AREA:   111600.00 Sq.mm.
MAIN REINFORCEMENT : Provide   8 - 12 dia. (0.80%,    904.78 Sq.mm.)
                     (Equally distributed)
TIE REINFORCEMENT  : Provide 10 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
----------------------------------------------------------
Puz :   1535.63   Muz1 :     60.14   Muy1 :     30.53

INTERACTION RATIO: 0.11 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
----------------------------------------------------------
WORST LOAD CASE:    11
END JOINT:   215 Puz :   1537.06   Muz :    105.41   Muy :     53.06   IR: 0.42
============================================================================
```

Fig.22: Design Results of Column 498

6.5. Slabs:

Slab is plate elements forming floor and roofs of buildings carrying distributed loads primarily by flexure. One-way slab is in which the length is more than twice the breadth. It can be simply supported beam or continuous beam. When slabs are supported to four sides, two ways spanning action occurs. Slabs are designed for deflection based on yield theory.
In order to design a slab, we have to create a plate by selecting a plate cursor. Now select the members to form slab and use form slab button. Now give the thickness of plate as 0.125 m. Now similar to the above designs give the parameters based on code and assign design slab command and select the plates and assign commands to it. After analysis is carried out, go to advanced slab design page and collect the reinforcement details of the slab. Slabs are also designed as per **IS456-2000.** The below figure shows the distribution of loads in slabs.

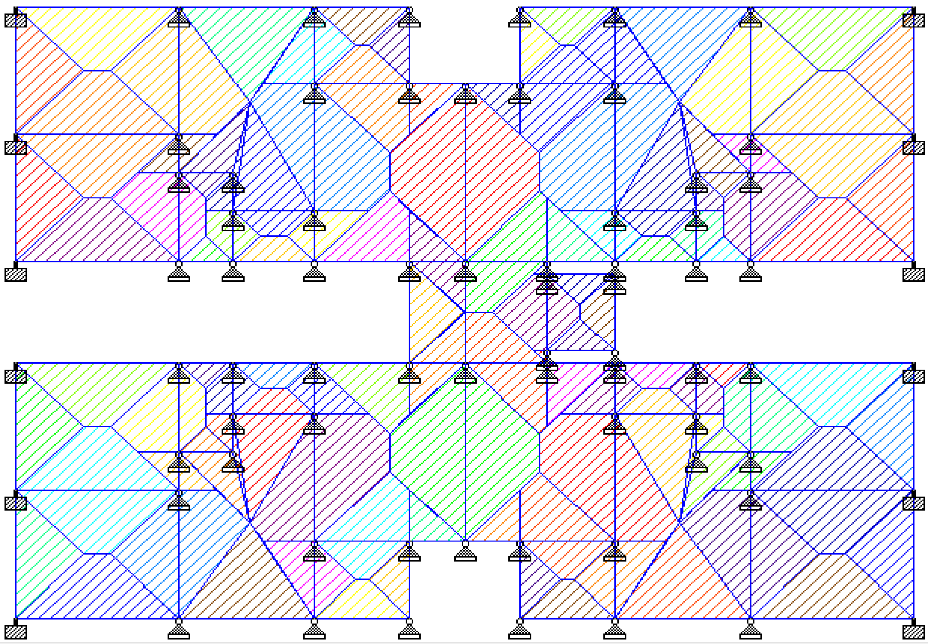


Fig.23: Distribution of Loads on Roof Slab

ELEMENT DESIGN SUMMARY

ELEMENT	LONG. REINF (SQ.MM/ME)	MOM-X /LOAD (KN-M/M)	TRANS. REINF (SQ.MM/ME)	MOM-Y /LOAD (KN-M/M)
1028 TOP :	120.	0.24 / 7	120.	0.13 / 11
BOTT:	120.	-0.10 / 2	120.	-0.01 / 2
1029 TOP :	120.	0.01 / 3	120.	0.07 / 11
BOTT:	120.	-0.03 / 10	120.	-0.02 / 5
1030 TOP :	120.	0.03 / 9	120.	0.07 / 3
BOTT:	120.	-0.02 / 4	120.	-0.12 / 10
1031 TOP :	120.	0.09 / 7	120.	0.34 / 11
BOTT:	120.	-0.03 / 2	120.	-0.03 / 3
1032 TOP :	120.	0.03 / 9	120.	0.07 / 3
BOTT:	120.	-0.02 / 4	120.	-0.12 / 10
1033 TOP :	120.	0.09 / 8	120.	0.35 / 11
BOTT:	120.	-0.03 / 1	120.	-0.03 / 3
1034 TOP :	120.	0.02 / 3	120.	0.07 / 11
BOTT:	120.	-0.03 / 10	120.	-0.02 / 5
1035 TOP :	120.	0.24 / 8	120.	0.13 / 11
BOTT:	120.	-0.10 / 1	120.	-0.01 / 1
1036 TOP :	120.	0.03 / 8	120.	0.01 / 2
BOTT:	120.	-0.01 / 1	120.	-0.04 / 7
1037 TOP :	120.	0.24 / 7	120.	0.13 / 11
BOTT:	120.	-0.10 / 2	120.	-0.01 / 2
1038 TOP :	120.	0.01 / 4	120.	0.07 / 11
BOTT:	120.	-0.03 / 9	120.	-0.02 / 5
1039 TOP :	120.	0.09 / 7	120.	0.34 / 11
BOTT:	120.	-0.03 / 2	120.	-0.03 / 4
1040 TOP :	120.	0.03 / 10	120.	0.07 / 4
BOTT:	120.	-0.02 / 3	120.	-0.12 / 9
1041 TOP :	120.	0.09 / 8	120.	0.35 / 11
BOTT:	120.	-0.03 / 1	120.	-0.03 / 4

Fig.24: A Part of Reinforcement Details of Slab

6.6. Footings:

Foundations are structural elements that transfer loads from building or individual column to Earth. These loads are to be properly transmitted. Foundations must be designed to prevent excessive settlement, rotation and to provide adequate safety to isolated footings for multi-storey buildings. These may be square, rectangle or circular in plan. The choice of type of foundation to be used in a given situation depends on a number of factors:

- Bearing capacity of soil
- Type of structure
- Type of loads
- Permissible differential settlements
- Economy

After the analysis of structure, at first, we have to import the reactions of the columns from staad.pro using import button. After we import the loads the placement of columns is indicated in the figure.

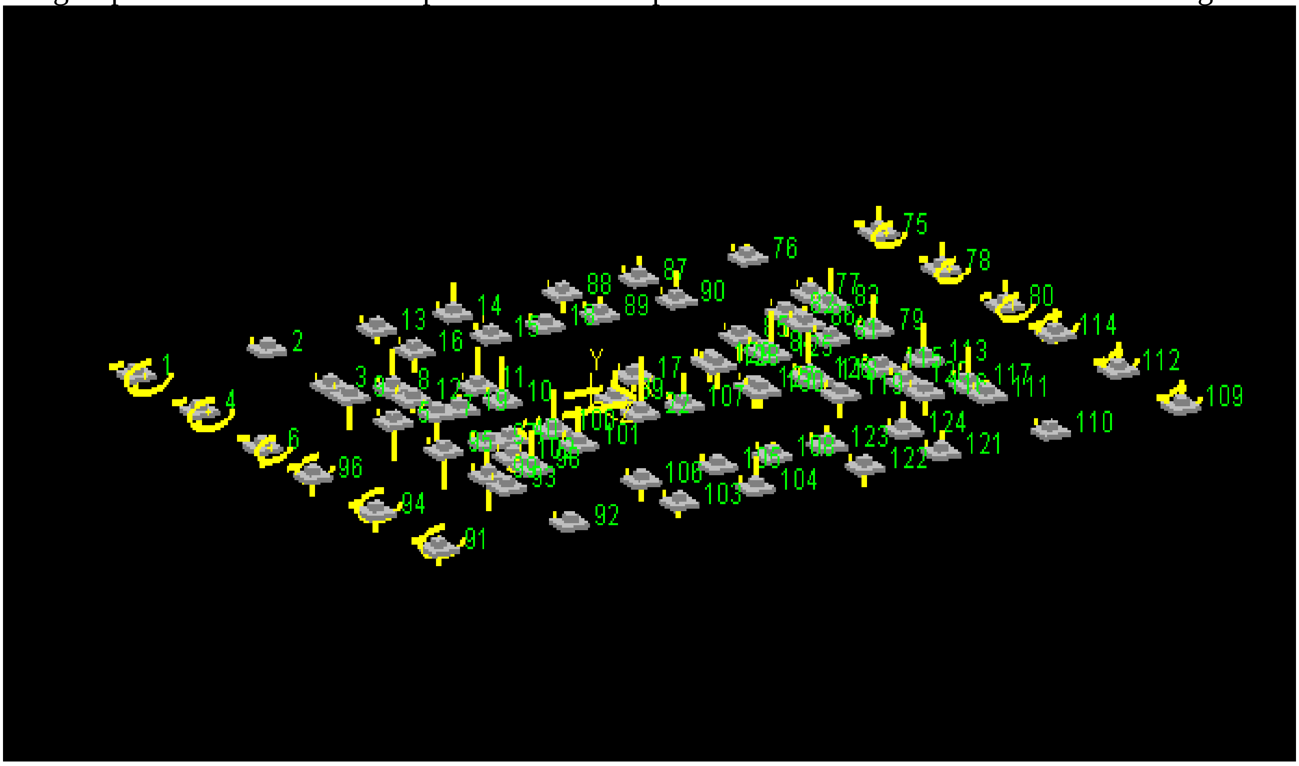


Fig.25: Location of Columns

After importing the reactions in the staad foundation, the following input data is required regarding materials, Soil type, Type of foundation, safety factors.

- Type of foundation: ISOLATED.
- Unit weight of concrete: 25 kN/m^3
- Minimum bar spacing: 50 mm
- Maximum bar spacing: 500 mm
- Strength of concrete: 25 N/mm^2
- Yield strength of steel: 415 N/mm^2
- Minimum bar size: 6 mm
- Maximum bar size: 40 mm
- Bottom clear cover: 50 mm
- Unit weight of soil: 22 kN/m^3
- Soil bearing capacity: 300 kN/m^3

- Minimum length: 1000 mm
- Minimum width: 1000 mm
- Minimum thickness: 500 mm
- Maximum length: 12000 mm
- Maximum width: 12000 mm
- Maximum thickness: 1500 mm
- Plan dimension: 50 mm
- Aspect ratio: 1
- Safety against friction, overturning, sliding: 0.5,1.5,1.5

After this input of various properties of the structure and click on design. After the analysis, detailed calculation of each and every footing is given with plan and elevation of footing including the manual calculation.

The following tables shows the dimensions and reinforcement details of all the footings.

Footing No.	Group ID	Foundation Geometry		
-	-	Length	Width	Thickness
1	1	1.800 m	1.800 m	0.803 m
2	2	2.000 m	2.000 m	0.953 m
3	3	1.750 m	1.750 m	0.803 m
4	4	2.100 m	2.100 m	1.003 m
5	5	1.550 m	1.550 m	0.702 m
6	6	1.750 m	1.750 m	0.803 m
7	7	2.050 m	2.050 m	0.702 m
8	8	1.350 m	1.350 m	0.501 m
9	9	1.550 m	1.550 m	0.702 m
10	10	1.500 m	1.500 m	0.702 m
11	11	1.650 m	1.650 m	0.752 m
12	12	1.400 m	1.400 m	0.652 m
13	13	1.700 m	1.700 m	0.803 m
14	14	1.450 m	1.450 m	0.652 m
15	15	1.700 m	1.700 m	0.803 m
16	16	1.800 m	1.800 m	0.853 m
17	17	1.950 m	1.950 m	0.903 m
18	18	1.700 m	1.700 m	0.803 m
19	19	5.700 m	5.700 m	1.303 m
22	20	2.750 m	2.750 m	0.903 m
39	21	2.400 m	2.400 m	0.501 m
40	22	5.600 m	5.600 m	1.253 m
75	23	1.900 m	1.900 m	0.853 m
76	24	2.000 m	2.000 m	0.953 m
77	25	1.750 m	1.750 m	0.803 m
78	26	2.050 m	2.050 m	1.003 m
79	27	1.600 m	1.600 m	0.752 m
80	28	1.750 m	1.750 m	0.803 m
81	29	1.450 m	1.450 m	0.652 m

82	30	1.750 m	1.750 m	0.652 m
83	31	1.550 m	1.550 m	0.702 m
84	32	1.400 m	1.400 m	0.652 m
85	33	1.650 m	1.650 m	0.752 m
86	34	1.450 m	1.450 m	0.652 m
87	35	1.700 m	1.700 m	0.803 m
88	36	1.650 m	1.650 m	0.652 m
89	37	1.700 m	1.700 m	0.803 m
90	38	1.800 m	1.800 m	0.853 m
91	39	1.800 m	1.800 m	0.803 m
92	40	2.000 m	2.000 m	0.953 m
93	41	1.750 m	1.750 m	0.803 m
94	42	2.050 m	2.050 m	1.003 m
95	43	1.550 m	1.550 m	0.702 m
96	44	1.750 m	1.750 m	0.803 m
97	45	2.050 m	2.050 m	0.702 m
98	46	1.350 m	1.350 m	0.501 m
99	47	1.550 m	1.550 m	0.702 m
100	48	1.450 m	1.450 m	0.602 m
101	49	1.600 m	1.600 m	0.752 m
102	50	1.400 m	1.400 m	0.602 m
103	51	1.700 m	1.700 m	0.803 m
104	52	1.450 m	1.450 m	0.652 m
105	53	1.700 m	1.700 m	0.803 m
106	54	1.800 m	1.800 m	0.853 m
107	55	1.650 m	1.650 m	0.753 m
108	56	1.700 m	1.700 m	0.803 m
109	57	1.900 m	1.900 m	0.853 m
110	58	2.000 m	2.000 m	0.953 m
111	59	1.750 m	1.750 m	0.803 m
112	60	2.050 m	2.050 m	1.003 m
113	61	1.600 m	1.600 m	0.752 m
114	62	1.750 m	1.750 m	0.803 m
115	63	1.450 m	1.450 m	0.652 m
116	64	1.800 m	1.800 m	0.702 m
117	65	1.550 m	1.550 m	0.702 m
118	66	1.400 m	1.400 m	0.652 m
119	67	1.600 m	1.600 m	0.752 m
120	68	1.450 m	1.450 m	0.652 m
121	69	1.700 m	1.700 m	0.803 m
122	70	1.650 m	1.650 m	0.652 m
123	71	1.700 m	1.700 m	0.803 m
124	72	1.800 m	1.800 m	0.853 m
125	73	1.300 m	1.300 m	0.501 m

126	74	1.300 m	1.300 m	0.501 m
127	75	1.400 m	1.400 m	0.652 m
128	76	1.400 m	1.400 m	0.652 m
129	77	1.450 m	1.450 m	0.652 m
130	78	1.400 m	1.400 m	0.652 m

Table 3: Geometry of Footings

Footing No.	Footing Reinforcement				Pedestal Reinforcement	
-	Bottom Reinforcement (M_z)	Bottom Reinforcement (M_x)	Top Reinforcement (M_z)	Top Reinforcement (M_x)	Main Steel	Trans Steel
1	Ø12 @ 60 mm c/c	Ø16 @ 80 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
2	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
3	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
4	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 70 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
5	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 80 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
6	Ø12 @ 65 mm c/c	Ø16 @ 90 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
7	Ø10 @ 65 mm c/c	Ø10 @ 50 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
8	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	N/A	N/A
9	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 80 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
10	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
11	Ø10 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
12	Ø10 @ 65 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
13	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
14	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
15	Ø12 @ 70 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
16	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
17	Ø12 @ 55 mm c/c	Ø16 @ 75 mm c/c	Ø10 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A

18	Ø12 @ 65 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
19	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c	Ø12 @ 70 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
22	Ø12 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 55 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
39	Ø8 @ 80 mm c/c	Ø8 @ 80 mm c/c	Ø8 @ 80 mm c/c	Ø8 @ 80 mm c/c	N/A	N/A
40	Ø12 @ 65 mm c/c	Ø12 @ 60 mm c/c	Ø12 @ 70 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
75	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
76	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
77	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
78	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 70 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
79	Ø10 @ 50 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
80	Ø12 @ 65 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
81	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
82	Ø10 @ 55 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
83	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
84	Ø10 @ 65 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
85	Ø10 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
86	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
87	Ø12 @ 70 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
88	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
89	Ø12 @ 70 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
90	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
91	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
92	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
93	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A

94	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 70 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
95	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 80 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
96	Ø12 @ 65 mm c/c	Ø16 @ 90 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
97	Ø10 @ 70 mm c/c	Ø10 @ 55 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
98	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	N/A	N/A
99	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 80 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
100	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
101	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 70 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
102	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
103	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
104	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
105	Ø12 @ 70 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
106	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
107	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 70 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
108	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
109	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
110	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 65 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
111	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 55 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
112	Ø12 @ 50 mm c/c	Ø16 @ 75 mm c/c	Ø12 @ 70 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
113	Ø10 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
114	Ø12 @ 65 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
115	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
116	Ø10 @ 65 mm c/c	Ø12 @ 70 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
117	Ø10 @ 50 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A

118	Ø10 @ 65 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
119	Ø10 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
120	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
121	Ø12 @ 65 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
122	Ø10 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
123	Ø12 @ 70 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
124	Ø12 @ 60 mm c/c	Ø16 @ 85 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
125	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	N/A	N/A
126	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø8 @ 75 mm c/c	N/A	N/A
127	Ø10 @ 65 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
128	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
129	Ø10 @ 60 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A
130	Ø10 @ 65 mm c/c	Ø12 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 70 mm c/c	N/A	N/A

Table 4: Reinforcement Details of Footings

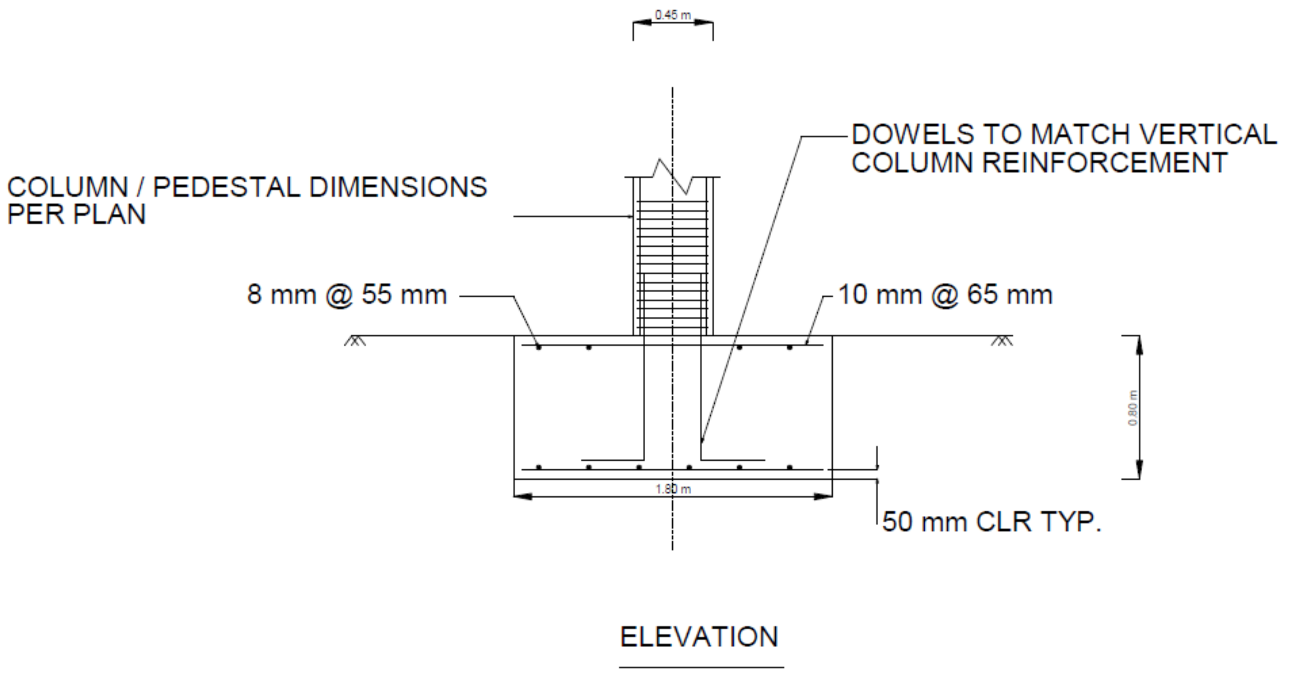


Fig.26: Elevation Details of Footing No. 1

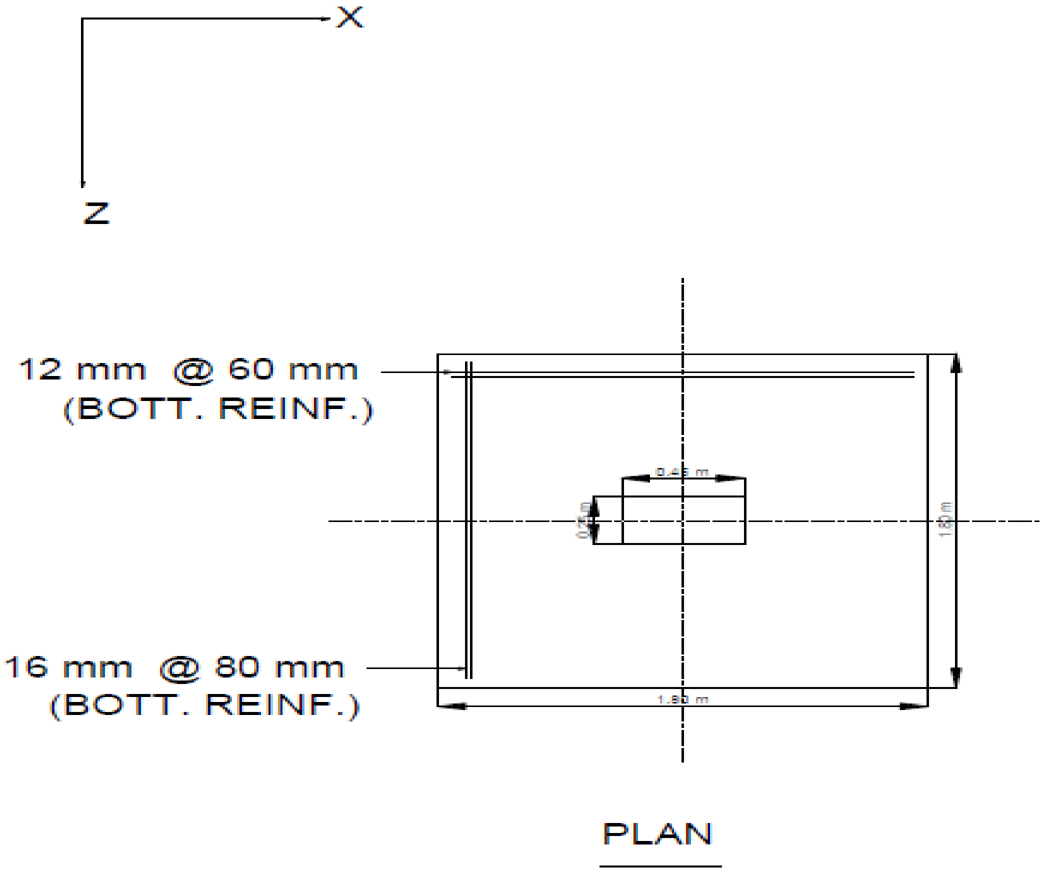


Fig.27: Plan of Footing No. 1

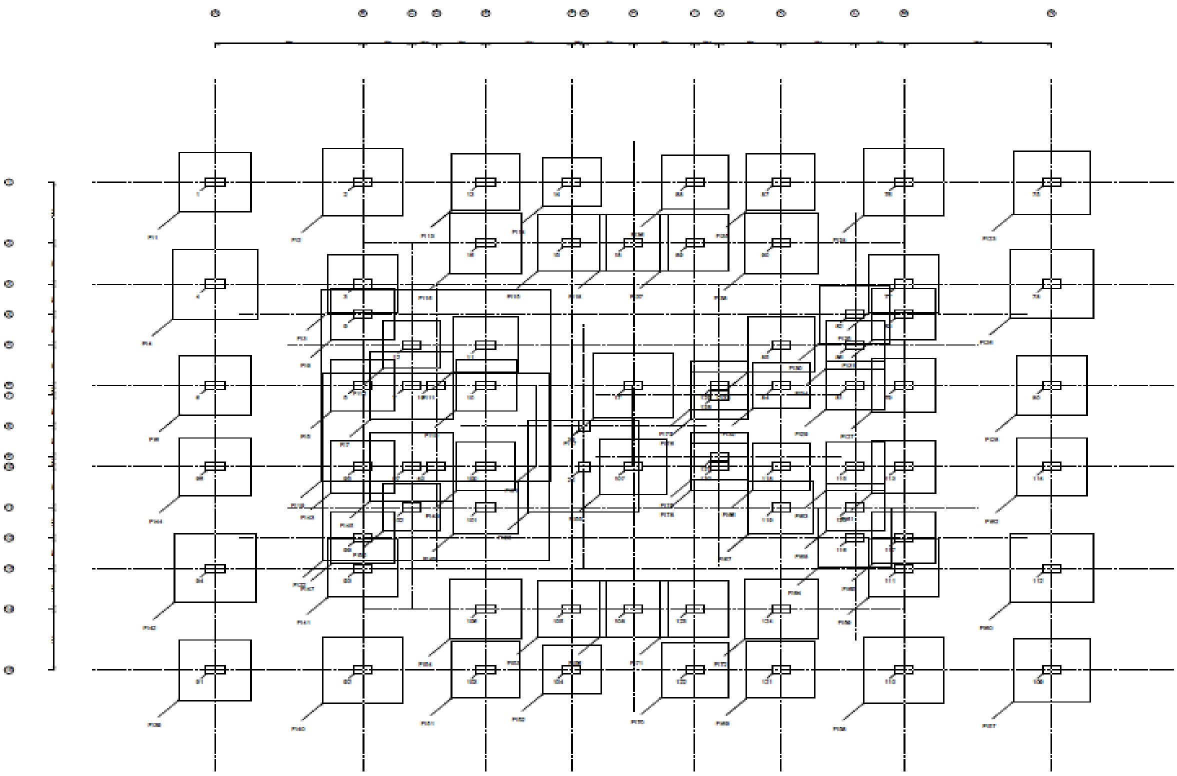


Fig.28: Center Line Plan of Footings

The figure shows layout of foundations for each and every column. Here we can observe that some of the footings coincide as they are very near, in such situations, Combined Footing (strap or cantilever) is laid.

6.7. Staircase:

Staircases are used in almost buildings. A staircase consists of a number of steps arranged in a series with landing at appropriate locations for the purpose of giving excess to different floors of a building. The width of a staircase may depend on the purpose for which it is provided and may generally vary between 1 m for residential buildings to 2 m for public buildings. A flight is the length of the staircase situated between two landings. The number of steps in a flight may vary between 3 to 12. The rise of a step and the thread should be so proportioned that it gives comfortable access.
In residential buildings, the rise may vary between 150 mm to 180 mm and thread between 200 mm to 250 mm.

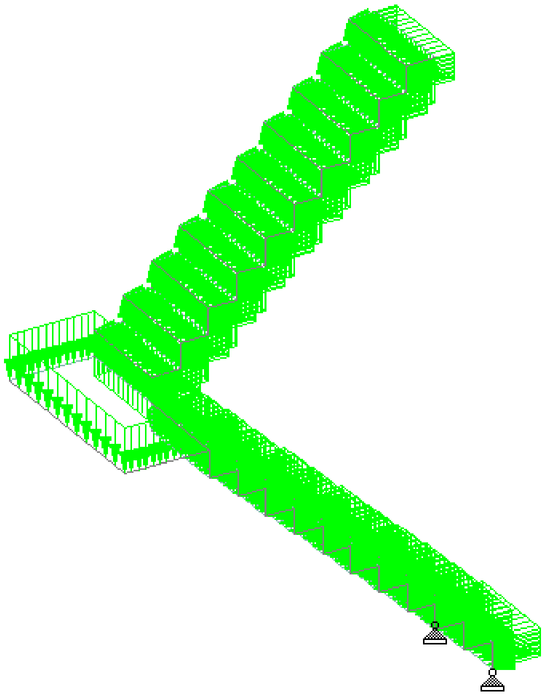


Fig.29: Load Assigned to Stairs

B E A M N O.   1 D E S I G N R E S U L T S

M25 Fe415 (Main) Fe250 (Sec.)

LENGTH: 304.8 mm SIZE: 250.0 mm X 450.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	76.2 mm	152.4 mm	228.6 mm	304.8 mm
TOP REINF.	230.42 (Sq. mm)	232.41 (Sq. mm)	243.01 (Sq. mm)	253.65 (Sq. mm)	264.32 (Sq. mm)
BOTTOM REINF.	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	76.2 mm	152.4 mm	228.6 mm	304.8 mm
TOP REINF.	3-10í 1 layer(s)	3-10í 1 layer(s)	4-10í 1 layer(s)	4-10í 1 layer(s)	4-10í 1 layer(s)
BOTTOM REINF.	2-10í 1 layer(s)	2-10í 1 layer(s)	2-10í 1 layer(s)	2-10í 1 layer(s)	2-10í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 140 mm c/c	2 legged 8í @ 140 mm c/c	2 legged 8í @ 140 mm c/c	2 legged 8í @ 140 mm c/c	2 legged 8í @ 140 mm c/c

Fig.30: Reinforcement Details of Stairs

7. RESULTS

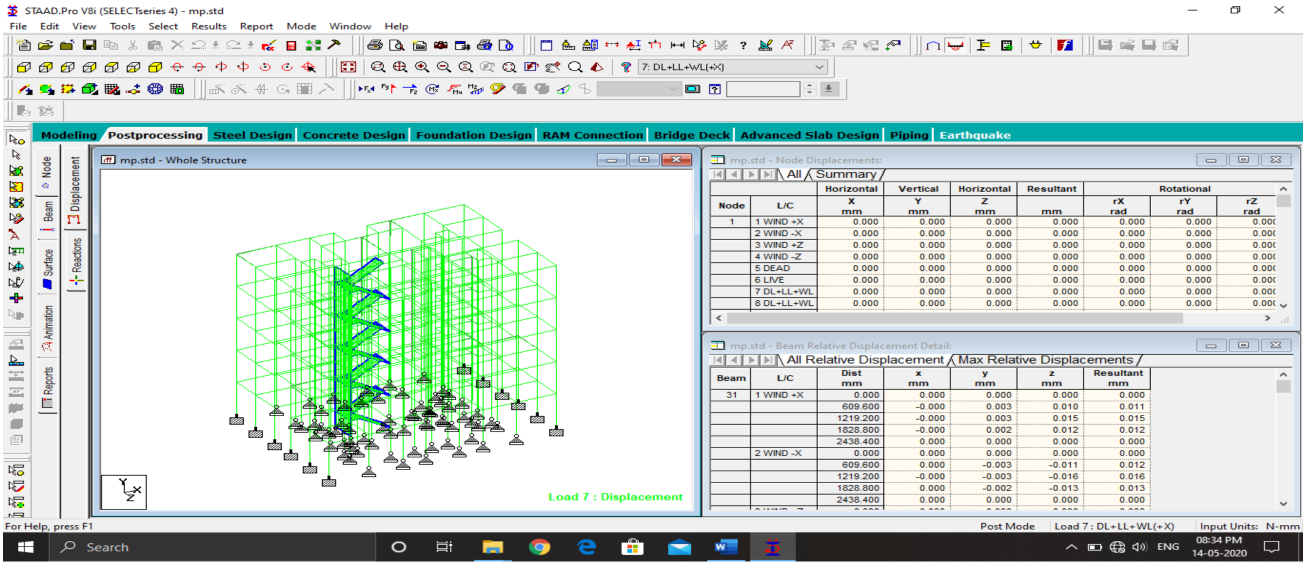


Fig.31: Displacement of Structure

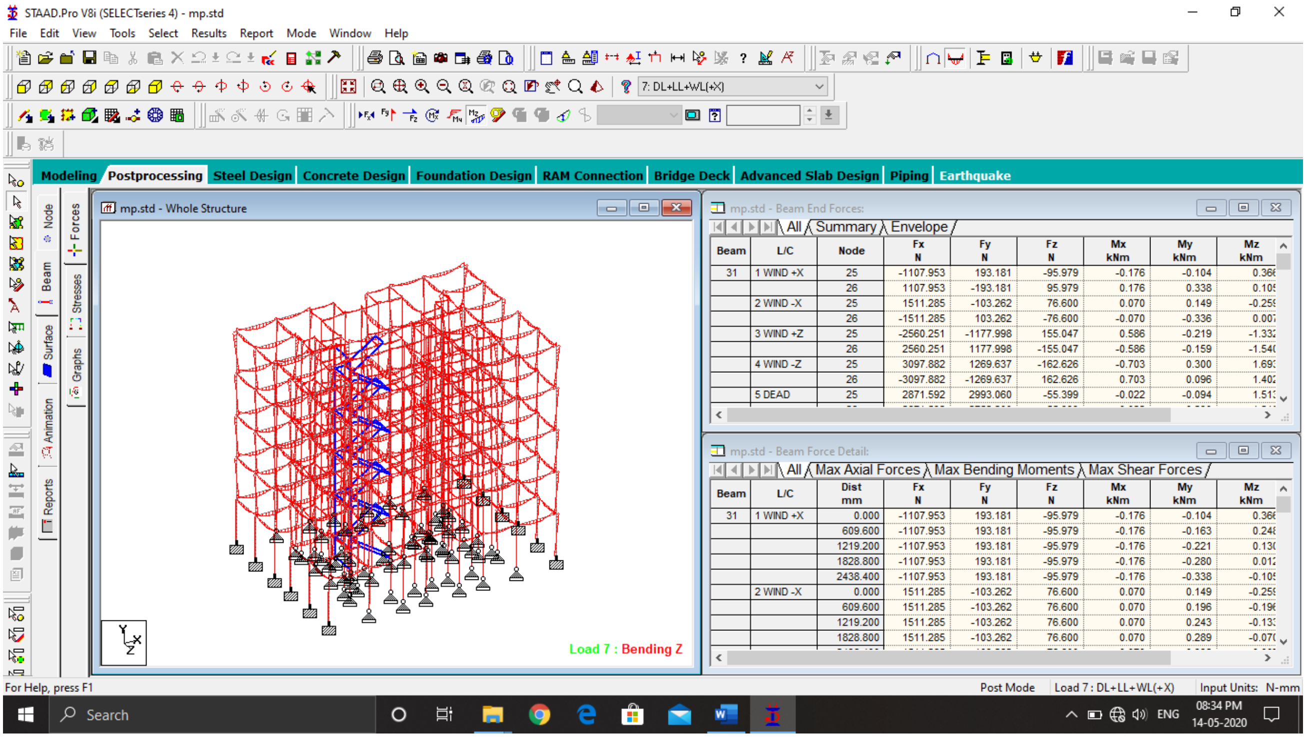
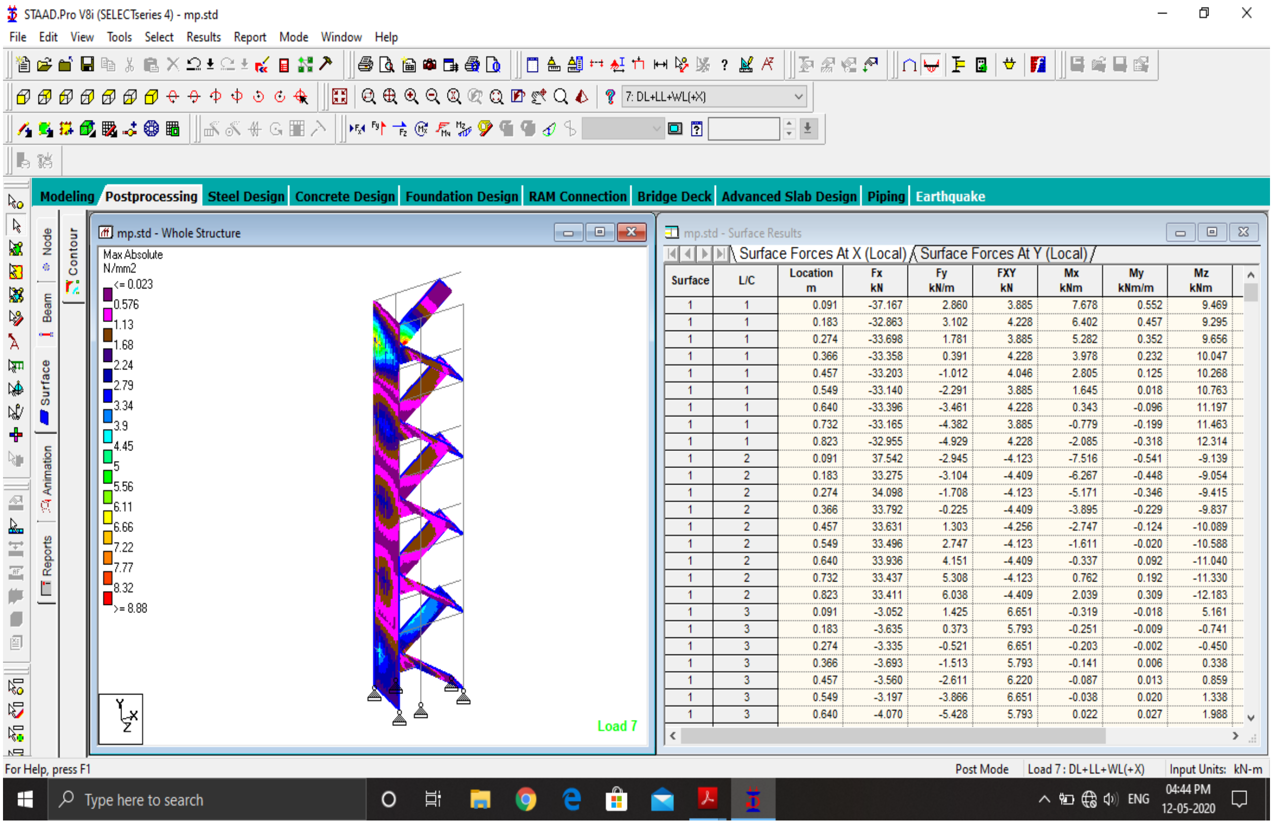


Fig.32: Bending of Structure in Z Axis



Surface	L/C	Location m	Fx kN	Fy kN/m	FXY kN	Mx kNm	My kNm/m	Mz kNm
1	1	0.091	-37.167	2.860	3.885	7.678	0.552	9.469
1	1	0.183	-32.863	3.102	4.228	6.402	0.457	9.295
1	1	0.274	-33.698	1.781	3.885	5.282	0.352	9.656
1	1	0.366	-33.358	0.391	4.228	3.978	0.232	10.047
1	1	0.457	-33.203	-1.012	4.046	2.805	0.125	10.268
1	1	0.549	-33.140	-2.291	3.885	1.645	0.018	10.763
1	1	0.640	-33.396	-3.461	4.228	0.343	-0.096	11.197
1	1	0.732	-33.165	-4.382	3.885	-0.779	-0.199	11.463
1	1	0.823	-32.955	-4.929	4.228	-2.085	-0.318	12.314
1	2	0.091	37.542	-2.945	-4.123	-7.516	-0.541	-9.139
1	2	0.183	33.275	-3.104	-4.409	-6.267	-0.448	-9.054
1	2	0.274	34.098	-1.708	-4.123	-5.171	-0.346	-9.415
1	2	0.366	33.792	-0.225	-4.409	-3.895	-0.229	-9.837
1	2	0.457	33.631	1.303	-4.256	-2.747	-0.124	-10.089
1	2	0.549	33.496	2.747	-4.123	-1.611	-0.020	-10.588
1	2	0.640	33.936	4.151	-4.409	-0.337	0.092	-11.040
1	2	0.732	33.437	5.308	-4.123	0.762	0.192	-11.330
1	2	0.823	33.411	6.038	-4.409	2.039	0.309	-12.183
1	3	0.091	-3.052	1.425	6.651	-0.319	-0.018	5.161
1	3	0.183	-3.635	0.373	5.793	-0.251	-0.009	-0.741
1	3	0.274	-3.335	-0.521	6.651	-0.203	-0.002	-0.450
1	3	0.366	-3.693	-1.513	5.793	-0.141	0.006	0.338
1	3	0.457	-3.560	-2.611	6.220	-0.087	0.013	0.859
1	3	0.549	-3.197	-3.866	6.651	-0.038	0.020	1.338
1	3	0.640	-4.070	-5.428	5.793	0.022	0.027	1.988

Fig.33: Maximum Absolute Loads on Stairs

From staad.pro, we have got the following results of concrete and steel bars:

Total Volume of Concrete = 277.5 cubic meter

BAR DIA (in mm)	WEIGHT (in Newton)
10	110383
12	140463
16	6604

Total Weight= 257450 Newton

8. CONCLUSION

From the above results, the following points were concluded:

- Design and Analysis of G+4 Multi-Storey Residential Building was done. It has parking in the basement and the rest of the floors are occupied with apartments.
- The design and analysis were done according to standard specifications for using Staad.pro for static and dynamic loads. Staad.pro reduces lot of time.
- Details of each and every member can be obtained using Staad.pro. All the list of failed beams can be obtained and also better section is given by the software.
- Accuracy is improved by using Staad.pro and Revit.
- Advantage of using Revit is it makes Elevation automatically when drawing 2-Dimensional plan. It saves a lot of time for Architects.
- Deflection and Shear results were obtained for each and every Beam, Column and Slab. And the results were safe.
- The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.
- All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS 456 have been taken care of in the column design of Staad.pro
- This study concludes that application software in the field is quite good and comprehensive for further study of structural parameter.

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    3. IS 875-Part 2 (Live load)
    4. IS 875-Part 3 (Wind load)
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