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DESIGN AND ANALYSIS OF COMMERCIAL BUILDING UNDER WIND LOAD ANALYSIS USING STAAD.PRO C+G+5

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Abstract: In this Commercial building we are doing C+G+5 office building. It consists of 4 floors. A four stored office building having a regular layout and which can be divided in to a number of similar vertical plane frames has been considered in this project to illustrate the analysis and design of a rigid jointed plane. Structural planning, Estimation of load, Analysis of structure, Member design, Drawing, Preparation of schedules. Structural planning: Involves determination of Form of the structure, Material of the structure, Structural system, Layout of components, Method of analysis, Philosophy of structural design. In Estimation of loads we are taking dead loads, live loads & wind load according to code IS: 875. To Analysis the structure we are using STAAD for Member design: Slabs, Beams, Columns, Footings. Designing process is doing by the Limit state method & Analysis is by using STAAD. Condition of a structure just before failure is called Limit state method. The structure should have same load carrying capacity, serviceability throughout the life time.

INTRODUCTION

GENERAL

Engineering term applied to the profession in which a knowledge of the mathematical and natural sciences, gained by the experiment and practically is applied to the effective use of the materials, and forces of nature. The term engineer properly denotes a person who has received professional training in pure and applied sciences, but is often loosely used to desire the operator of an engineer, marine locomotive engineer or a stationary engineer. In modern terminology, these later occupations are known as crafts or trades, Civil Engineering is perhaps the broadest of engineering fields, for it deals with the creation, improvement, and protection of the communal environment, providing facilities for living. Industry and transportation, include large buildings, roads, bridges, canals rail road lines, airports, water supply systems, dams, irrigation, harbors, docks, aqueducts tunnels and other engineered constructions. The Civil Engineering must have a thorough knowledge of all types of surveying of the properties and mechanics of construction materials, mechanics of structures and soils and of hydraulics and fluid mechanics.

Before the middle of the 18th century, large-scale construction works usually placed in the hands of military engineers. Military engineering involved such work as preparation of topographical maps, their location, design and construction of road and bridges and the buildings of forts and docks. In 18th century, however, the term Civil Engineering came in to use to describe engineering work that was performed by civilians for non-military purpose.

Concrete, artificial engineering material made from a mixture of Portland cement, water, fine and coarse aggregates and a small amount of air. It is the most widely used construction material in the world. Concrete is the only major building material that can be delivered to the job site in a plastic state. This unique quality makes concrete desirable as a building material because it can be molded to virtually any form or a shape. Concrete provided wide latitude in surface textures and colors and can be used to construct a wide variety of structures such as highways and streets, bridges, dams, large buildings, airport runways, irrigation structure, break waters, piers and docks, side walks, soils and farm building homes and even barges and ship. Other desirable qualities of concrete as a building material are its strength, economy and durability. Depending on the mixture of materials used, concrete will support, in compression, 700 or more kg/sq cm, (10,000 or more 1b/sq cm). The tensile strength of concrete is much lower, but by using properly designed steel reinforcing. Structural members can be made that are as strong as in tension as in compression. The durability of concrete is evidenced by the fact that concrete columns built by the Egyptians more than 3600 years ago are still standing.

Concrete used in most construction works in reinforcement is with steel. When concrete structural members must resist extreme tensile stresses, steel supplied the necessary strength. Steel is embedded with twisted bars or in concrete in the form of a mesh or roughened. A bond forms between both compounds. This assembly of concrete and steel is called as REINFORCED CEMENT CONCRETE.

Reinforced concrete has a remarkable capacity to adapt to the assumptions of the designer. This has been pointed out to number of engineers. Lugi Nervy, the renowned Italians architect engineer has stated it eloquently as follows:

Mainly because of plastic flow, a concrete structure tries with admirable ductility to adapt itself to our calculations, which don't always represent the most logical and spontaneous answer to the request of the forces at play and even tries to correct our deficiencies and errors sections and regions too highly stressed yield and channel some of their loads to other sections or regions, which accept this additional task with commendable spirit of collaboration with the limits of their own strength.

NEED FOR THE STUDY

Multi Storied Buildings have become a part of the day-to-day development. So, the construction of the Multi Storied Buildings gained importance, their method of constructions also gained importance.

A multi-story building is a building that has multiple floors above ground in the building.

Multi-story buildings aim to increase the area of the building without increasing the area of the land the building is built on, hence saving land and, in most cases, money (depending on material used and land prices in the area).

Buildings serve several needs of society – primarily as shelter from weather and as general living space, to provide privacy, to store belongings and to comfortably live and work. A building as a shelter represents a physical division of the human habitat (a place of comfort and safety) and the outside (a place that at times may be harsh and harmful).

OBJECTIVE OF THE STUDY

This project describes a method of analysis and design of a multi storied residential quarters. The scope behind presenting this project is to learn the concept of construction, and to design an elegant, safe and durable structure with economy. The most prominent convenient method of designing and analyzing Multi Storied Building is STAAD.pro.

STAAD.Pro is one of the first software applications in the world made for the purpose of helping the structural engineers to automate their work, to eliminate the tedious and lengthy procedures of the manual methods. STAAD.Pro is a general-purpose structural analysis and design program with applications primarily in the building industry - commercial buildings, bridges and highway structures, industrial structures, chemical plant structures, dams, retaining walls, turbine foundations, culverts and other embedded structures, etc.

The interfaces with AutoCAD to provide design drawings are some of the highlighting features of this project. The Main advantage of displaying the drawing in auto cad is the user has more flexibility to modify the detailing drawing Auto CAD as per his decision. The total design and analysis is done by STAAD-Pro 2006 version.

LITERATURE REVIEW

2.0 GENERAL

Designing of structures is an art and science of designing a safe, durable and elegant structure with economy. This is not only requiring imaginations but also a good knowledge of science of designing besides practical aspects, like the relevant codes and local municipal byelaw experience and judgment.

The architect whereas the requirement of safety, serviceability, durability and economy are taken care of by the structural engineer looks after the design structure of the structure and the aesthetics.

The structural planning of structure involves the determination of the form of the structure, the materials to be used, and the structural system, the layout of its components.

The Principal elements of the **R.C.C**. building frame are:

1. Slabs to cover large areas
2. Beams to support slabs and walls
3. Columns to support beams, and
4. Footings to distribute concentrated column loads over a large area of the supporting soil.

The Structural planning of the building frame involves the determination of the following:

1. Column position
2. Beam location
3. Slab spacing
4. Planning of stairs
5. Type of footing

2.1 STRUCTURAL DESIGNING

Structural Design for framed R.C.C structure can be done by three methods.

a) Working stress method
b) Ultimate strength method
c) Limit state method

2.1.1 Working Stress Method of Design

It is the earliest modified method of R.C.C. structures. In this method structural element is so designed that the stress resulting from the action of service load as computed in linear elastic theory using modular ratio concept does not exceed a pre-designed allowable stress which is kept as some fraction of ultimate stress, to avail a margin of safety. Since this method does not utilize full strength of the material it results in heavy section, the economy aspect cannot be fully utilized in the method.

2.1.2 Ultimate Strength Method of Design

This method is primarily based on strength concept, in this method the structural element is proportioned to with stand the ultimate load which is obtained by exchanging the service load of some factor referred to as load factor for giving margin of safety. Since this method is based on actual stress strain behavior of the material, of the member as well as structure that too right up to failure, the value calculated by this method agree well the experiment results.

2.1.3 Ultimate State Method Design

During the past several years, extensive research works have been carried out on the different aspects of research in the actual behavior of the member and structure have lead to the development of design and approach of *LIMIT STATE METHOD OF DESIGN*.

METHODOLOGY

3.0 METHOD OF ANALYSIS

- One of the most famous analysis methods to analyze continuous beams is "Moment Distribution Method", which is based on the concept of transferring the loads on the beams to the supports at their ends.
- Each support will take portion of the load according to its *K*; *K* is the stiffness factor, which equals *EI/L*. As you can see *E*, and *L* is constant per span, the only variable here is *I*; moment of inertia. *I* depends on the cross section of the member. So, if you want to use this analysis method, you have to assume a cross section for the spans of the continuous beam.
- If you want to use this method to analyze a simple frame, it will work, but it will not be simple, and if you want to make the frame a little bit more complicated (simple 3D frame) this method falls short to accomplish the same mission.
- Hence, a new more sophisticated **method** emerged, which depends fully on matrices, this method called "Stiffness Matrix Method", the main formula of this method is:

  $[P] = [K]x[\Delta]$
- The 3 matrices are as follows:
  - [P], is the force matrix, which includes the forces acting on the whole structure, and the reactions at the supports. This matrix is partially known, as the acting forces on the structures are already known from the different codes, like Dead Load, Live Load Wind Load, etc., but the reactions are unknown.
  - [K], is the stiffness factor matrix. *K=EI/L*, and all of these data either known or assumed. So this matrix is fully known.
  - [Δ], is the displacement matrix. The displacements of supports are either all zeros (fixed support) or partially zeros (other supports), but the displacements of other nodes are unknown. So this matrix is partially known.

- With these three matrices presented as discussed above, the method will solve the system with ordinary matrix methods to get the unknowns. If we solved for the unknowns, the reactions will be known, hence shear and moment diagrams can be generated, and the displacement of the different nodes will be known, so the displacement and deflection shapes can be generated.
- This method was very hard to be calculated by hand as it needs more time than other methods, so, it was put on the shelves, up until the emergence of computers. The different programming languages revive the possibility to utilize this method, as the program will do all the tedious and lengthy procedures to solve for this system of matrices, therefore, structural software adopted it as the method of analysis. STAAD was one of the first to do that.

3.1 THREE STEPS TO REACH TO OUR GOAL

- Preparing input file.
- Sending the input file to the analysis/design engine.
- Reading the results and verifying them.

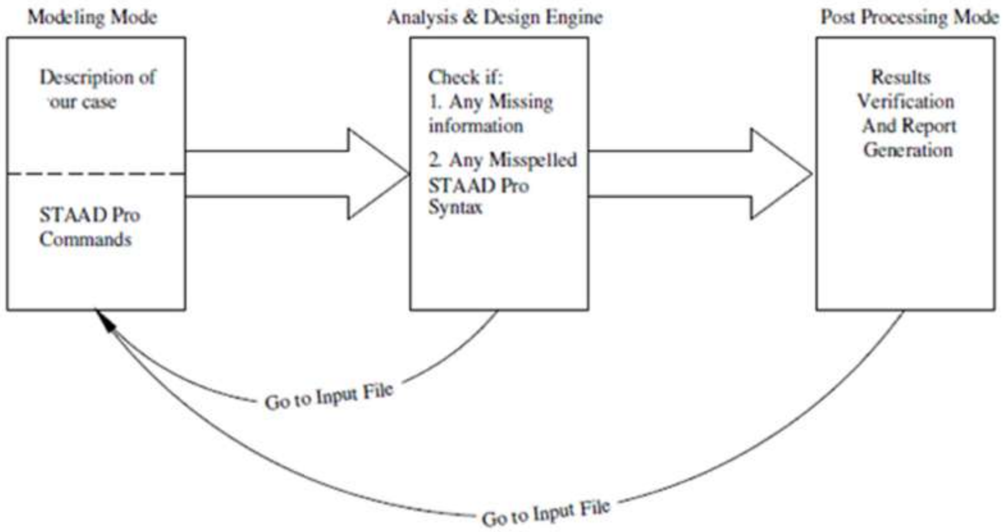


Fig - 3.1

3.1.1 Input File

Creating input file takes place in the Modeling Mode. It is our first step in working in STAAD Pro. Input file is the place where we describe our case; what do we have? And what do we want? We can cut the input file into two parts:

- In the first part we will describe our structure. This includes the geometry, the cross sections, the material and geometric constants, the support conditions, and finally the loading system.
- The second part may contain the analysis command, and printing commands.

3.1.2 Sending Input File To The Analysis And Design Engine

Just like any programming language compiler, STAAD Pro analysis and design engine, will start reading the input file from left to right, and from top to bottom. The engine will mainly check for two things:

- Making sure that the user used the syntax of STAAD Pro commands, or else the engine will produce an error message.
- Making sure that all the data needed to form a stable structure exists in the input file, or else, the engine will produce an error message.

If these two things are correct, STAAD will take the values mentioned in the input file (without verification) and produce the output files.

As a rule of thumb, generating the output files doesn't mean that results are correct! The concept of GIGO (Garbage In Garbage Out) applies. Based on this concept, don't take the results generated by STAAD Pro as final, but verify each piece of the output data, to make sure that our input data was correct.

3.1.3 Reading Results, And Verifying Them

Reading output takes place in **Post Processing** Mode. It includes:

- Seeing the results as tables and/or as graphical output.
- Changing the scale of each graphical output to visualize the correct shapes, and showing values, or hiding them.

After reading and verifying our results we may decide to go back to our Modeling Mode to alter your input file, for either to correct the input file, or to change some values to examine different results.

The input file always has extension of **STD**.

3.2 FLOW CHART

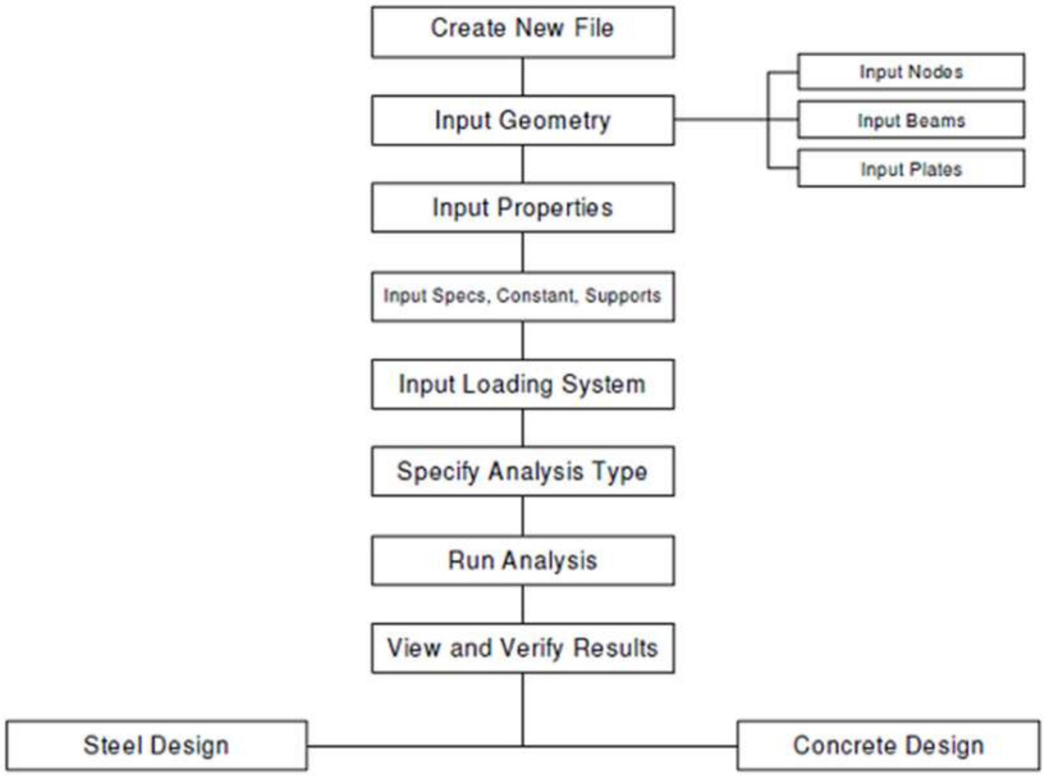


Fig - 3.2

APPLICATION OF METHODOLOGY

4.0 GENERAL

STAAD stands for **ST**ructural **A**nalysis **A**nd **D**esign. It is one of the first software applications in the world made for the purpose of helping the structural engineers to automate their work, to eliminate the tedious and lengthy procedures of the manual methods. STAAD.Pro 2006 is a suite of proprietary computer programs of Research Engineers, a Bentley Solutions Center. STAAD.Pro is a general purpose structural analysis and design program with applications primarily in the building industry - commercial buildings, bridges and highway structures, industrial structures, chemical plant structures, dams, retaining walls, turbine foundations, culverts and other embedded structures, etc.

STAAD.Pro is a general purpose program for performing the analysis and design of a wide variety of types of structures. The basic three activities which are to be carried out to achieve that goal are –

a) Model generation

b) Calculations to obtain the analytical results

c) Result verification

These are all facilitated by tools contained in the program's graphical environment.

We have chosen a multi stored building of bay frame. We generated a model, performed analysis, and designed concrete beams and columns. It contains extensive details on the various facilities available for visualization and verification of results.

The modeling and analysis of a slab is also demonstrated. Slabs and other surface entities like walls are modeled using plate elements. Large surface entities may have to be defined using several elements and this sometimes requires a tool called mesh generator.

4.1 METHODS OF CREATING THE MODEL

There are two methods of creating the structure data:

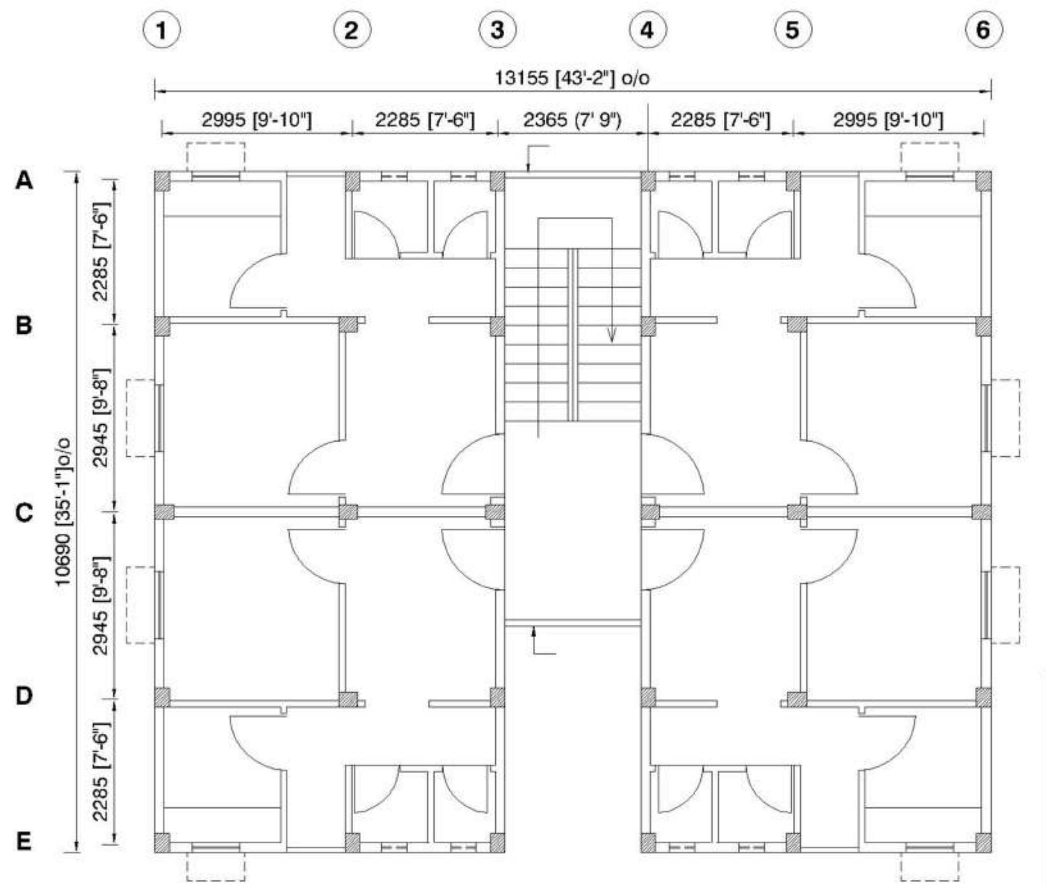
- Command File Method
- Graphical Model Generation Mode

Command File is a text file which contains the data for the structure being modeled. This file consists of simple English language like commands. This command file may be created directly using the editor built into the program, or for that matter, any editor which saves data in text form, such as Notepad or WordPad available in Microsoft Windows. This command file is also automatically created behind the scenes when the structure is generated using the Graphical User Interface.

Graphical model generation mode and the command file are seamlessly integrated. So, at any time, we may temporarily exit the graphical model generation mode and access the command file. We will find that it reflects all data entered through the graphical model generation mode. Further, when we make changes to the command file and save it, the GUI immediately reflects the changes made to the structure through the command file.

4.2 DESCRIPTION OF THE MODEL

The structure for this project is a bay frame, multistoried (G+3) reinforced concrete bay frame is analyzed and designed and the plan of the structure is shown in the **fig- 4.1.**



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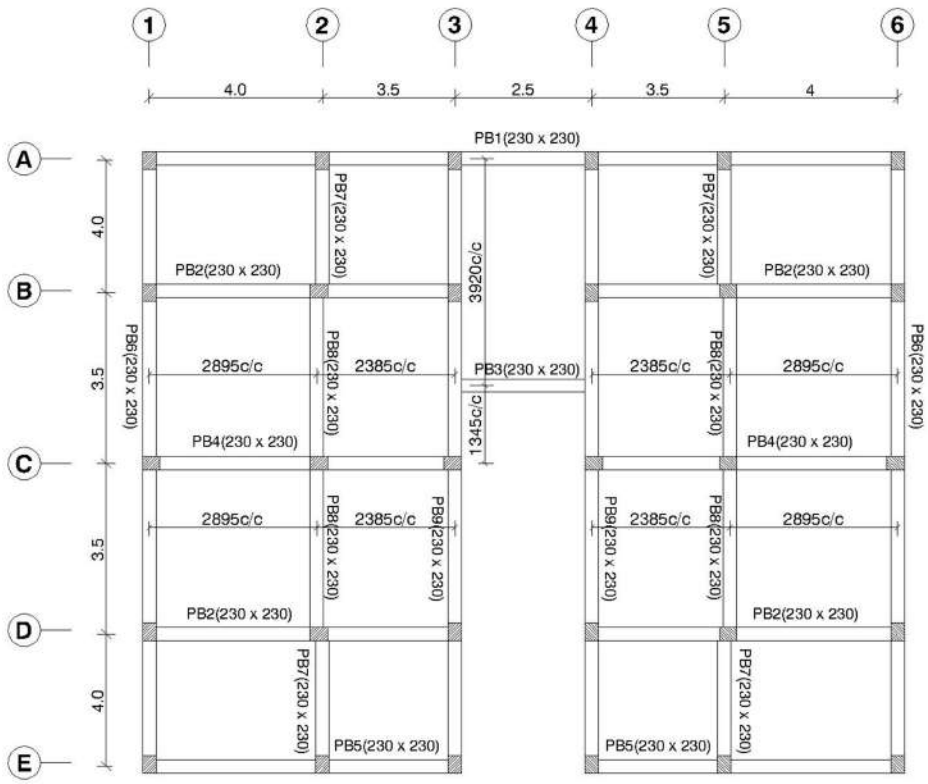
ARCHITECTURAL PLAN



PLINTH BEAM CENTRE LINE

Table – 4.1 Basic Data Of The Structure

Attribute Data	Data
Member properties	Plinth Beams : 230 X 230 mm Roof beams : 230X330 mm & 230X400 mm Midlanding Beams: 230 X 450 mm
Member Orientation	Rotated by 90 degrees with respect to default condition as per the plan
Material Constants	Modulus of Elasticity :2.236e+007 Poisson's Ratio :0.17 Density of concrete :25 kN/m^3 Density of masonry wall (Hallow bricks) : 14.4 kN/m^3
Member Offsets	Member Offsets is done according to Column center line marking plan
Supports	Base of all columns : Fixed
Loads	Load case 1 to 4 : SEISMIC LOADS Load case 5 & 6 : DEAD LOADS Load case 7 :LIVE LOADS Load case 8 to 33 : Load Combination
Concrete & steel Design	Parameters: Ultimate Strength of Steel : 415 N/sq.mm Concrete Strength : 20 N/sq.mm

Attribute Data	Data

Load calculations

1. 9" or 230mm WALL LOAD :

unit weight of brick = 19.0 kN/m3
floor height = 3.0 m
Beam depth = 0.450 m
9" Or (230MM) Brick wall = (3.0-0.450) x 0.230 x 19
= 11.14 kN/m
say 11.15 kN/m

2. Railing Load :

Railing load or Parapet wall looad = 1.0 X .115 X19
= 2.18
say 2.2 kN/m

FLOOR LOADS

1. 180mm thick slab load :

Unit weight of concrete = 25 kN/m3
Slab Self weight = 0.180 x 25 = 4.5 kN/m2
Floor finishes = 1.0 kN/m2
Partion load on slab panel = 1.0 kN/m2

Total Load = 6.5 kN/m2

2. 150mm thick slab load : (water tank)

Unit weight of concrete = 25 kN/m3
Slab Self weight = 0.150 x 25 = 3.75 kN/m2
Floor finishes = 1.5 kN/m2

Total Load = 5.25 kN/m2

- *Water Load on oht Bottom slab (1.0 mt. Height water level)*
  = 1.0 X10 = 10 kN/m2

B. Imposed loads:- Asper IS875 part-II

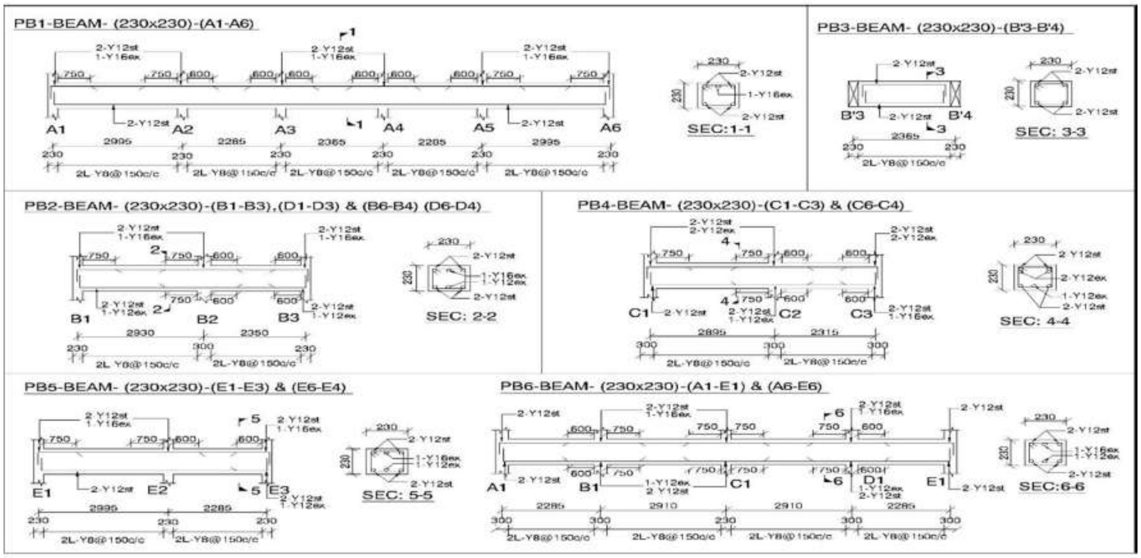
i. All rooms and kitchens – 2.0 kN/m^2
ii. Toilets and bath rooms – 2.0 kN/m^2
iii. Corridors, passages, staircases
Including fire escapes and store rooms – 3.0kN/m^2
iv. Balconies – 3.0kN/m^2
v. Commercials , Retail Merchantiles
Cafeterias and restaurants & Public lounges – 4.0kN/m^2

Distribution of slab load into equivalent uniform load per unit length of the beam (per meter)
(As per SP-24, clause 23.5) of the following equations:

On the short span $= \dfrac{Wl_x}{3}$

On the long span = $\frac{Wl_x}{6}\left[3-\left(\frac{l_x}{l_y}\right)^2\right]$

RCC DETAIL DRAWINGS



BEAM RCC DETAIL

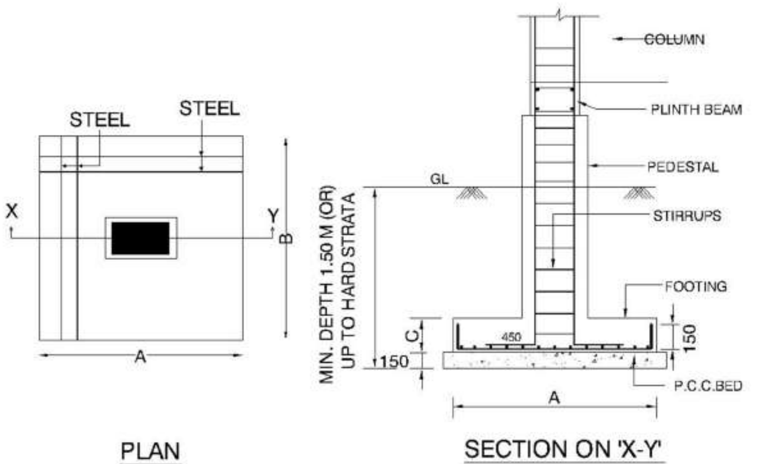
SCHEDULE OF COLUMNS

Column ID	NOS	Size	GROUND FLOOR	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR
C1	4	230 X 300	6 - Y12 Y8-190 c/c (1 Tie + 1Link)	6 - Y12 Y8-190 c/c (1 Tie + 1Link)	6-Y12 Y8-190 c/c (1 Tie + 1Link)	6-Y12 Y8-190 c/c (1 Tie + 1Link)
C2	4	230 X 300	8 - Y12 Y8-190 c/c (1 Tie + 1Link)	8 - Y12 Y8-190 c/c (1 Tie + 1Link)	6-Y12 Y8-190 c/c (1 Tie + 1Link)	6-Y12 Y8-190 c/c (1 Tie + 1Link)
C3	8	230 X 300	6-Y16 Y8-190 c/c (1 Tie + 1Link)	4-Y16 ●+ 2-Y12 Y8-190 c/c (1 Tie + 1Link)	4-Y16 Y8-230 c/c (1 Tie)	6-Y12 Y8-190 c/c (1 Tie + 1Link)
C4	12	230 X 300	4-Y16 ●+ 4-Y12 Y8-190 c/c (1 Tie + 1Link)	4-Y16 ●+ 4-Y12 Y8-190 c/c (1 Tie + 1Link)	4-Y16 Y8-230 c/c (1 Tie)	4-Y16 Y8-230 c/c (1 Tie)
C5	2	230 X 300	4-Y16 ●+ 2-Y12 Y8-190 c/c (1 Tie + 1Link)	4-Y12 + 2-Y16 ● Y8-190 c/c (1 Tie + 1Link)	6-Y12 Y8-190 c/c (1 Tie + 1Link)	6-Y12 Y8-190 c/c (1 Tie + 1Link)

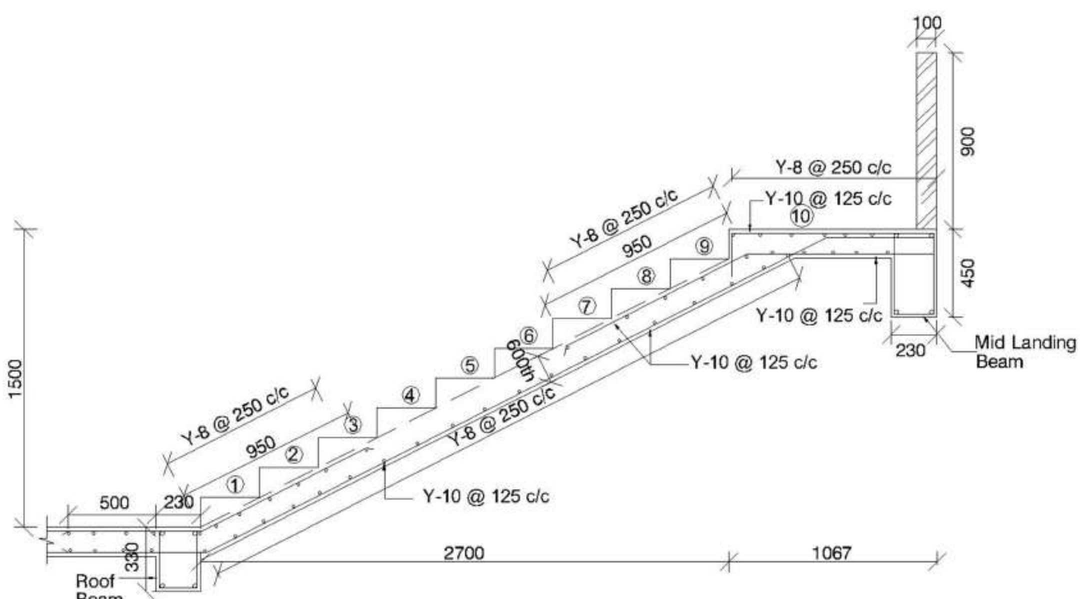
SCHEDULE FOR COLUMNS

SCHEDULE OF FOUNDATIONS

Type	S.B.C=250 kN/sq.m A X B X C (metres)	PEDESTAL
F1	1.10 X 1.10 X 0.275 7 nos- Y10 ON BOTH WAYS	0.30 x 0.38
F2	1.20 X 1.20 X 0.30 8 nos- Y10 ON BOTH WAYS	0.30 x 0.38
F3	1.35 X 1.35 X 0.35 10 nos- Y10 ON BOTH WAYS	0.30 x 0.38



STAIRCASE



SECTION 'XX'

SUMMARY AND CONCLUSION

SUMMARY

The present project work s done in the following stages:

- Creating a structural model.
- Generating the structural geometry, specifying member properties, material constants, load, analysis and design specifications, etc.
- Visualization and verification of the model geometry.
- Running the STAAD analysis engine to perform analysis and design.
- Verification of results - graphically and numerically.
- Report generation and printing.
- Structural designing by using STAAD results.
- Detailing drawings in Auto CAD.

CONCLUSION

STAAD is software which can be extensively used in the field of construction. In this project we have made an effort to enhance the applications of STAAD in the analysis and design of multi storied buildings. We have made efforts to show the various applications of STAAD at different stages of designing, updating the values of design etc.

In this project we have focused to display the extensive applications of STAAD in the analysis and design of multi storied buildings.

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