International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 12 | Dec - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

# Analysis and Design of Multistory Building by Using Stadd-Pro

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**ABSTRACT**—In the last few decades tall or multistory buildings has gain very much importance, because in metro cities there is a rapid increase in population with limited land. Most of the people require good accommodations, aesthetic, comfort and safety. That's the reason for increase in construction of multistory buildings. Earthquake will cause more severe effect on tall buildings compare to small buildings. Due to earthquake asymmetrical buildings will damage more than symmetrical buildings. A review of the analysis and design of a multistory building with STAAD Pro is carried out. Planning is done by using AutoCAD and load calculations were done manually and then the structure was analyzed using STAAD Pro. The dead load, imposed load and wind load with load combination are calculated and applied to the structure. Overall, the concepts and procedures of designing the essential components of a multistory building are described. STAAD Pro software also gives a detailed value of shear force, bending moment and torsion of each element of the structure which is within IS code limits.

## 1. Introduction

Now a days tall or multistory buildings has gain very much importance, because in metro cities there is a rapid increase in population with limited land. All people require good accommodations, aesthetic, comfort and safety. That's the reason for increase in construction of multistory buildings. Structural design of multistory buildings is basically worried with safety during ground motion, serviceability what's more, potential for monetary misfortune. Design of structures using Limit State method Design the members are designed for the limiting bending moment and serviceability limits, hence the structures are left with minimum reserve energy. Earthquake will cause more severe effect on tall buildings compare to small buildings. Due to earthquake asymmetrical buildings will damage more than symmetrical buildings. In case of high rise structures horizontal loads produce develop high lateral displacements which is not desirable for the occupants and the structure itself. The enormous increase in population and scarcity of land makes the people to move from rural areas to urban paces and construction of multi-storied buildings in small areas is being common now-a-days. Functional designing of the building has become very important and the requirements vary from one building to another.

### 1.1 Objectives

- Generating structural framing plan.
- Creating model in STAAD PRO.
- Analysis of the structure.
- Design the structure.

### 1.2 About Staad-Pro

Our project involves analysis and design of multistoried [G+5] using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following.

### 1.3 Advantages

- Easy To Use Interface,
- Conformation With The Indian Standard Codes,
- Versatile Nature Of Solving Any Type Of Problem,
- Accuracy of the Solution.

STAAD Pro features a state-of-the-art user interface, visualization tools, and powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD Pro is the professional's choice for steel, concrete, timber, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more. The STAAD Pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the STAAD engine. After analysis and design is completed, the GUI can also be used to view the results graphically. The STAAD analysis and design engine: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminum design. Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it. To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behavior.

### 1.1 Loads Considered

#### 1.1.1 Dead Load

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. The unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 $kN/m^2$and25$kN/m^2$respectively.

#### 1.3.1 Imposed Load

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

1.3.2 **Wind Load**

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earths rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizon- tal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term wind denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above ground.

1.3.3 **Seismic Load**

Seismic Load can be calculated taking the view of acceleration response of the ground to the super structure. According to the severity of earthquake intensity they are divided into 4 zones.

1.3.3.1 Zone I and II are combined as zone II.
1.3.3.2 Zone III.
1.3.3.3 Zone IV.
1.3.3.4 Zone V

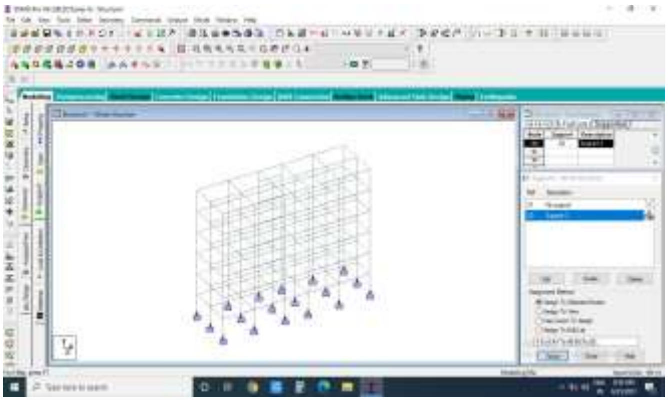


Fig.1 Generation of the structure

1.1 **Material constants**

The material constants are: modulus of elasticity (E); weight density (DEN); Poisson's ratio (POISS); co-efficient of thermal expansion (ALPHA), Composite Damping Ratio, and beta angle (BETA) or coordinates for any reference (REF) point. E value for members must be provided or the analysis will not be performed. Weight density (DEN) is used only when self- weight of the structure is to be taken into account. Poisson's ratio (POISS) is used to calculate the shear modulus (commonly known as G) by the formula, G = 0.5 x E/ (1 + POISS) If Poisson's ratio is not provided, STAAD will assume a value for this quantity based on the value of E. Coefficient of thermal expansion (ALPHA) is used to calculate the expansion of the members if temperature loads are applied. The temperature unit for temperature load and ALPHA has to be the same.

1.1.1 **Supports**

Supports are specified as PINNED, FIXED, or FIXED with different releases (known as FIXED BUT). A pinned support has restraints against all translational movement and none against rotational movement. In other words, a pinned support will have reactions for all forces but will resist no moments. A fixed support has restraints against all directions of movement. Translational and rotational springs can also be specified. The springs are represented in terms of their spring constants. A translational spring constant is defined as the force to displace a support joint one length unit in the specified global direction. Similarly, a rotational spring constant is defined as the force to rotate the support joint one degree around the specified global direction.

1.1.2 **Loads**

Loads in a structure can be specified as joint load, member load, temperature load and fixed- end member load. STAAD can also generate the self-weight of the structure and use it as uniformly distributed member loads in analysis. Any fraction of this self-weight can also be applied in any desired direction.

1.1.3 **Joint loads**

Joint loads, both forces and moments, may be applied to any free joint of a structure. These loads act in the global coordinate system of the structure. Positive forces act in the positive coordinate directions. Any number of loads may be applied on a single joint, in which case the loads will be additive on that joint.

1.1.4 **Member loads**

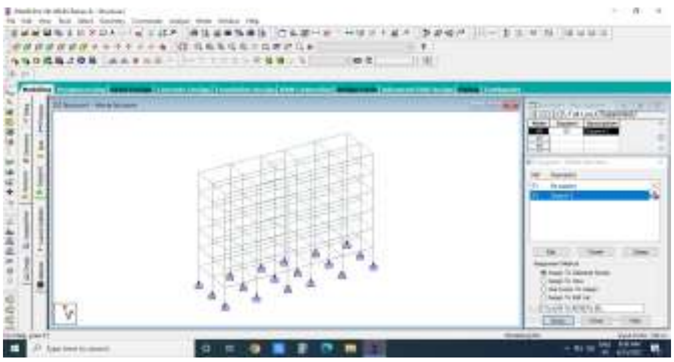
Three types of member loads may be applied directly to a member of a structure. These loads are uniformly distributed loads, concentrated loads, and linearly varying loads (including trape- zoidal). Uniform loads act on the full or partial length of a member. Concentrated loads act at any intermediate, specified point. Linearly varying loads act over the full length of a member. Trapezoidal linearly varying loads act over the full or partial length of a member. Trapezoidal loads are converted into a uniform load and several concentrated loads. Any number of loads may be specified to act upon a member in any independent loading condition. Member loads can be specified in the member coordinate system or the global coordinate system. Uniformly distributed member loads provided in the global coordinate system may be specified to act along the full or projected member length.

**1.1.5 Area/floor load**

Many times a floor (bound by X-Z plane) is subjected to a uniformly distributed load. It could require a lot of work to calculate the member load for individual members in that floor. However, with the AREA or FLOOR LOAD command, the user can specify the area loads (unit load per unit square area) for members. The program will calculate the tributary area for these members and provide the proper member loads. The Area Load is used for one way distributions and the Floor Load is used for two way distributions.

1.1.6 **Fixed end member load**

**Load Effects On A Member May Also Be Specified In Terms Of Its Fixed End Loads. These Loads Are Given In Terms Of The Member Coordinate System And The Directions Are Opposite To The Actual Load On The Member. Each End Of A Member Can Have Six Forces: Axial; Shear Y; Shear Z; Torsion;**



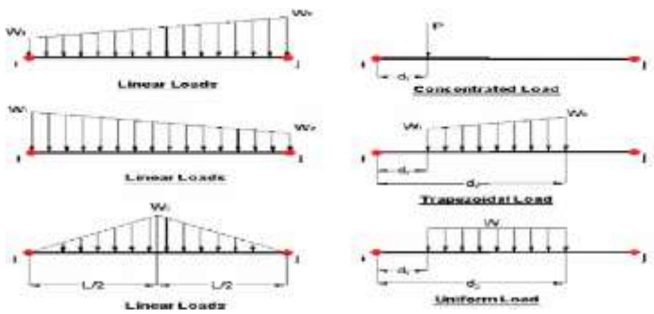



Fig.2 Member load configuration moment y, and moment z.

### 1.2 Analysis of G+5 Rcc Framed Building Using Staad-Pro

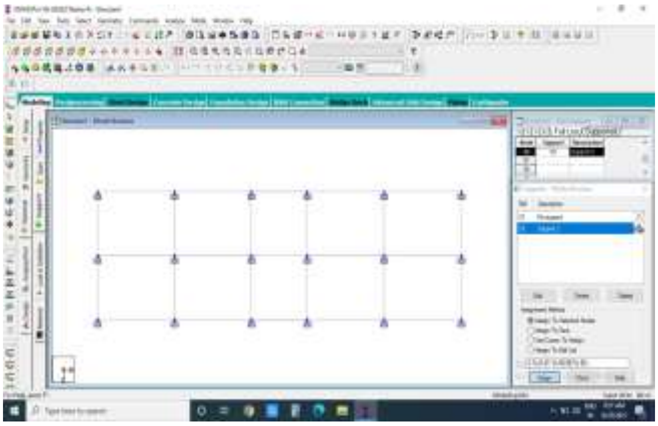


Fig.3 Plan of the G+5 story

### 1.3 Physical parameters of building

Length = 4 bays @ 5.5m + 1 bay @ 4m =26m Width = 2 bays @ 4 m =8.0m

Height = 3m + 5 storeys @ 3.5m = 20.5m Live load on the floors is 2kN/m2

Live load on the roof is 1.5kN/m2

### 1.4 Grade of concrete and steel used

Used M25 concrete and Fe 415 steel

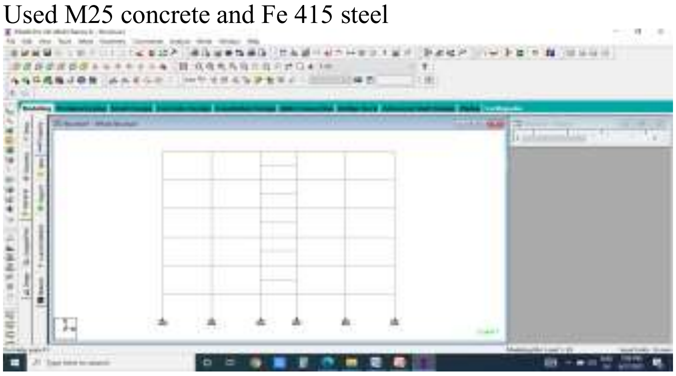


Fig.4 Elevation of the G+5 story building

### 1.1 Generation of member property

Generation of member property can be done in STAAD. Pro by using the window as shown above. The member section is selected and the dimensions have been specified. The beams are having a dimension of 0.3*0.5 m and the columns are having a dimension of 0.4*0.6 m.

### 1.1 Supports

The base supports of the structure were assigned as fixed. The supports were generated using the STAAD. Pro support generator.

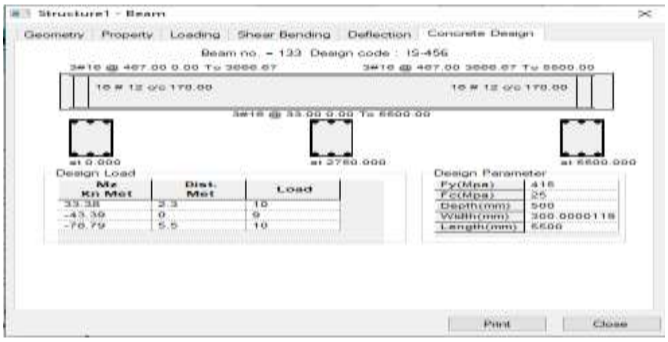



Fig. 5 Fixing supports of the structures

### 1.2 Materials of the structure

The materials for the structure were specified as concrete with their various constants as per standard IS code of practice.

### 1.3 Loading

The loadings were calculated partially manually and rest was generated using STAAD. Pro load generator. The loading cases were categorized as

- Self-weight
- Dead load from slab
- Live load
- Wind load
- Seismic load
- Load combinations

### 1.4 Self-weight:

The self-weight of the structure can be generated by STAAD. Pro itself with the self-weight Command in the load case column.

### 1.5 Dead load:

Dead load from slab can also be generated by STAAD. Pro by specifying the floor thickness and the load on the floor per Sq. m2Calculation of the load per sq m was done considering the weight of beam, weight of column, weight of RCC slab, weight of terracing, external walls.

### 1.6 Live load:

The live load considered in each floor was 2.0 KN/sq m and for the terrace level it was considered to be 1.5 KN/sq m. The live loads were generated in a similar manner as done in the earlier case for dead load in each floor. This may be done from the member load button from the load case column.

### 1.7 Wind load:

The wind load values were generated by the software itself in accordance with IS 875.Under the define load command section, in the wind load category; the definition of wind load was supplied. The wind intensities at various heights were calculated manually and feed to the software. Based on those values it generates the wind load at different floors.

| Height [h] | Design Wind speed[V] | Design wind pressure[P] |
|---|---|---|
| Up to 10 m | 36.379 m/s | 0.793 KN/sq m |
| 15 m | 38.85 m/s | 0.905 KN/sq m |
| 20 m | 40.51 m/s | 0.984 KN/sq m |
| 30 m | 42.58 m/s | 1.087 KN/sq m |

Table 3.1: Design wind pressure at various heights

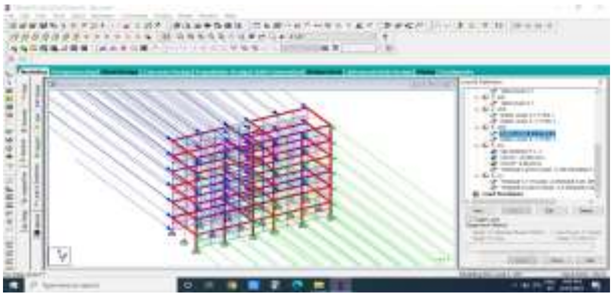


Fig. 6 Wind load effect on structure

**1.8 Seismic load**

The seismic load values were calculated as per IS 1893-2002. STAAD.Pro has a seismic load generator in accordance with the IS code mentioned.

DEFINE 1893 LOAD ZONE f1 1893-spec
SELFWEIGHT JOINT WEIGHT
Joint-list WEIGHT w 1893-Spec= RF f2, I f3, SS f4, (ST f5), DM f6, (PX f7), (PZ f8), (DT f9) Where,

- Zone f1 = Seismic zone coefficient.
- RF f2 = Response reduction factor.
- I f3 = Importance factor depending upon the functional use. of the structures, character- ized by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance
- SS f4 = Rock or soil sites factor (=1 for hard soil, 2 for medium soil, 3 for soft soil). Depending on type of soil, average response acceleration coefficient Sa/g is calculated Corresponding to 5
- ST f5 = Optional value for type of structure (=1 for RC frame building, 2 for steel frame building, 3 for all other buildings).
- DM f6 = Damping ratio to obtain multiplying factor for calculating Sa/g for different damping. If no damping is specified 5% damping (default value 0.05) will be considered corresponding to which multiplying factor is 1.0.
- PX f7 = Optional period of structure (in sec) in X direction. If this is defined this value will be used to calculate Sa/g for generation of seismic load along X direction.
- PZ f8 = Optional period of structure (in sec) in direction. If this is defined this value will be used to calculate Sa/g for generation of seismic load along Z direction.
- DT f9 = Depth of foundation below ground level. It should be defined in current unit. If the depth of foundation is 30 m or below, the value of Ah is taken as half the value obtained. If the foundation is placed between then ground level and 30 m depth, this value is linearly interpolated between Ah and 0.5Ah.

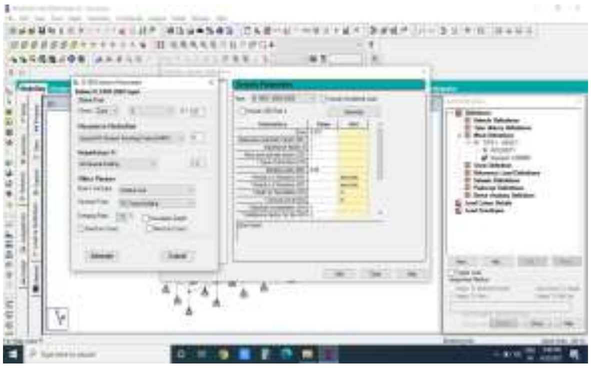


Fig. 7 Seismic load definition

**1.9 Load combination**

The structure has been analyzed for load combinations considering all the previous loads in proper ratio. In the first case a combination of self-weight, dead load, live load and wind load was taken in to consideration. In the second combination case instead of wind load seismic load was taken into consideration.

## 2. Design of G+5 RCC Building

### 2.1.1 Beam Design

The beam is designed in Staad pro software by using IS code 475 there are two types of reinforced concrete beams

1. Single reinforced beams 2. Double reinforced beams.

Single reinforced beams: In singly reinforced simply supported beams steel bars are placed near the bottom of the beam where they are effective in resisting in the tensile bending stress.

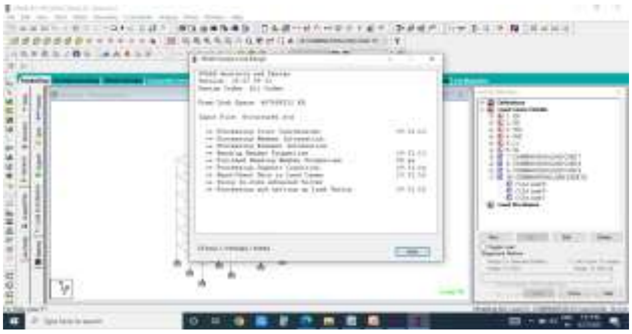


Fig .8 Beam Design

Double reinforced beams: It is reinforced under compression tension regions. The necessities of steel of compression region arise due to two reasons. When depth of beam is restricted. The strength availability singly reinforced beam is in adequate.

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### 2.1.2 Column Design

A column may be defined as an element used primarily 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

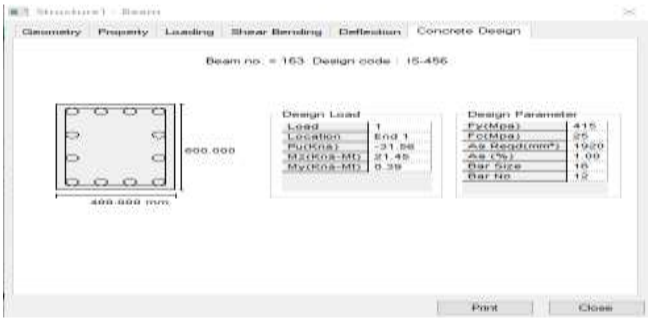


Fig. 9 Column Design

### 2.1.3 Manual Analysis (Kanis Method)

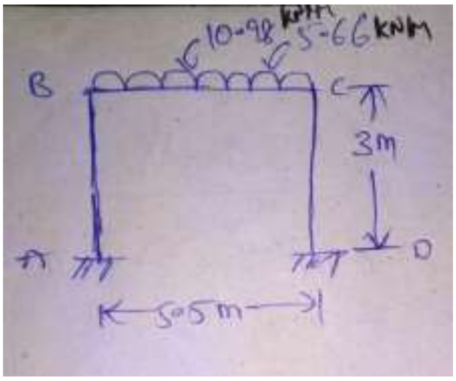


Fig. 9 Fixed End Moments

## 3. Conclusions

1. By Using STADD Pro., analysis and design of multistory building is easier and quick process than manual process.
2. Proposed size of the beam and column can be safely used in the structure.
3. The structure is safe in shear bending and deflection.

## 4. References

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