International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue14
November 2017

Design And Analysis Of Multistoried Residential Building Using Staad Pro

Voddineni Praveen[1] (PHD Scholar)
Jangam Mahesh Kumar[2](PHD Scholar)
Dr.Md.Subhan[3]
Professor & HOD (Civil engineering Department) AVN Institute of engineering and technology.

ABSTRACT: *The design process of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides the knowledge of practical aspects, such as recent design codes, bye laws, backed up by ample experience, intuition and judgment. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety. In the present study multistoried building at Madhapur, Hyderabad, India is designed (Slabs, Beams, Columns and Footings) using Auto CAD software. In order to design them, it is important to first obtain the plan of the particular building that is, positioning of the particular rooms (Drawing room, bed room, kitchen toilet etc.) such that they serve their respective purpose and also suiting to the requirement and comfort of the inhabitants. Thereby depending on the suitability; plan layout of beams and the position of columns are fixed. Thereafter, the loads are calculated namely the dead loads, which depend on the unit weight of the materials used (concrete, brick) and the live loads, which according to the code IS:456-2000 and HYSD BARS FE415 as per IS:1786-1985. Safe bearing capacity of soil is adopted as 350KN/M2 at a depth of 6ft and same soil should extent 1.5 times the width of footing below the base of footing. Footings are designed based on the safe bearing capacity of soil. For designing of columns and beams, it is necessary to know the moments they are subjected to. For this purpose, frame analysis is done by limit state method. Designing of slabs depends upon whether it is a one - way or a two way slab, the end conditions and the loading. From the slabs, the loads are transferred to the beam. Thereafter, the loads (mainly shear) from the beams are taken by the columns. Finally, the sections must be checked for all the four components with regard to strength and serviceability.*

Keywords: Beams, columns, footings, slabs, Structural Designing.

INTRODUCTION: Due to the concentration and increase of population into urban cities there is a need to accommodate the influx in the urban cities. However, due to rapid increase of land cost, and limited availability of land the trend is to build high rise building. The advantages of high rise buildings include but not limited to high ratio rentable floor space per unit area of land. These high rise buildings are sky scrapers are built not just for economy of space they are considered icons of a city's economic power and the city's identity.Our main aim to complete an Analysis and design of multi storey building by using STAAD.PRO against all possible loading conditions and to full fill the function for which they have built. Safety requirements must be met so that the structure is able to serve its purpose with the maintain cost. Detailed planning of the structure usually comes from several studies made by town planners, investors, users, architects and other engineers. On that, a structural engineer has the main influence on the overall structural design and an architect is involved in aesthetic details. For the design of the structure, the dead load, live loads, seismic and wind load are considered. The analysis and design for the structure done by using software package STAAD.PRO. In this project multistoried construction, we have adopted Finite Element Method of analysis and design the structure. The design is in confirmation with IS456-2000.the analysis of one frame is worked out manually and simultaneously it has been checked using STAAD.PRO Therefore an attempt has been made to present the multistoried building for purpose in the busy city of Hyderabad.

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p-ISSN: 2348-795X
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The complex consisting of five storey's The structure is design based on the theory of Finite Element Method which provides adequate strength, serviceability and durability besides economy.

Objectives of the project:

A structure can be defined as a body, which can resist the applied loads without appreciable deformations. Civil engineering structures are created to serve soma specific like, Human habitation, transportation, bridges, storage etc. in safe and economical way. A structure is assembling of individual elements like pinned elements (truss elements), beam elements, column, and shear wall slab able or arch. Structural engineering is concerned with the planning, designing and the construction of structures. Structural analysis involves the determination of the forces and displacements of the structures or components of a structure 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.

STUDY METHODOLOGY: The exponential growth of the Indian as well as the global Construction industry has directly impacted the demand for structural engineers. Hence, it has become important for civil design engineers to be well equipped with the structural software like STAAD Pro. Since most of the companies are using STAAD as a tool for designing massive structures, it is imperative that professionals should get trained in this field too to gain advantage in the highly competitive market. It's a known fact that computers reduce man hours required to complete a project, and knowledge of STAAD will ensure fast and efficient planning as well as accurate execution.STAAD Pro**.** Is Structural Analysis and Design computer Program, originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineer International was bought by Bentley Systems.STAAD Pro. Is a comprehensive structural engineering software that addresses all aspects of structural engineering, including model development, verification, analysis, design and review of results? It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric nonlinear analysis or a buckling analysis. It also includes various forms of advanced dynamic analysis and push over analysis for wind loads, and from modal extraction to time history and response spectrum analysis the concepts from the basis for understanding the design procedures and overall design approach addressed in the remaining chapter of the guide. With this conceptual background, it is hoped that the designer will gain a greater appreciation for creative and efficient designof home, particularly the many assumptions that must be made. The world is leading Structural Analysis and Design package for StructuralEngineers.

Working procedure in staad.pro:

Input Generation:

The GUI (or user) communicates with the STAAD analysis engine through the STD input file. That input file is a text file consisting of a series of commands which are executed sequentially. The commands contain either instructions or data pertaining to analysis and/or design. The STAAD input file can be created through a text editor or the GUI Modeling facility. In general, any text editor may be utilized to edit/create the STD input file. The GUI Modeling facility creates the input file through an interactive menu-driven graphics oriented procedure.

Types of Structures:A STRUCTURE can be defined as an assemblage of elements. STAAD is capable of analyzing and designing structures consisting of frame, plate/shell and solid elements. Almost any type of structure can be analyzed by STAAD.

- A SPACE structure, which is a three dimensional framed structure with loads applied in any plane, is the most general.
- A PLANE structure is bound by a global X-Y coordinate system with loads in the same plane.
- A TRUSS structure consists of truss members which can have only axial member forces and no bending in the members. 11
- A FLOOR structure is a two or three dimensional structure having no horizontal (global X or Z) movement of the structure [FX, FZ &MY are restrained at every joint].

e-ISSN: 2348-6848
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The floor framing (in global X-Z plane) of a building is an ideal example of a FLOOR structure. Columns can also be modeled with the floor in a FLOOR structure as long as the structure has no horizontal loading. If there is any horizontal load, it must be analyzed as a SPACE structure.

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 12 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.

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.

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.

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.

Member load: 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 trapezoidal). 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.

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.

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; moment y, and moment z.

Seismic Load Generator: The STAAD seismic load generator follows the procedure of equivalent lateral load analysis. It is assumed that the lateral loads will be exerted in X and Z directions and Y will be the direction of the gravity loads. Thus, for a building model, Y axis will be perpendicular to the floors and point upward (all Y joint coordinates positive). For load generation per the codes, the user is required to provide seismic zone coefficients, importance factors, and soil characteristic parameters. Instead of using the approximate code based formulas to estimate the building period in a certain direction, the program calculates the period using Raleigh quotient technique. This period is then utilized to calculate seismic coefficient C. After the base shear is calculated from the appropriate equation, it is distributed among the various levels and roof per the specifications. The distributed base shears are subsequently applied as lateral loads on the structure. These loads may then be utilized as normal load cases for analysis and design.

Wind Load Generator: The STAAD Wind Load generator is capable of calculating wind loads on joints of a structure from user specified wind intensities and exposure factors. Different wind intensities may be specified for different height zones of the structure. Openings in the structure may be modeled using exposure factors.

An exposure factor is associated with each joint of the structure and is defined as the fraction of the influence area on which the wind load acts. Built-in algorithms automatically calculate the exposed area based on the areas bounded by members (plates and solids are not considered), then calculates the wind loads from the intensity and exposure input and distributes the loads as lateral joint loads.So forSeismic analysisthereare18 loadcombinations and for Wind load analysisthere are11 loadcombinations.“ Earth quake resistant design of structures “describing in a building which resist lateral loads originating from wind or earthquakes are known as shear walls”. He considered flexural strength in the wall to be dominant force based on which design of structure to be carried out in tall shear walls. He described in detail about various types of shear walls with their load bearing capacities as per code requirements.

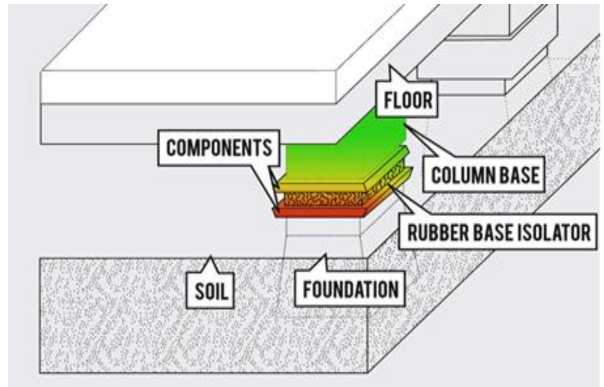

Diagram showing different components of the structure

Types of loads : Loads are primary consideration in any buildings design because they define the nature and magnitude of hazards or external forces that a building must resist to provide 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 (shape and size) and location (climate and site conditions). Ultimately, the type and magnitude of the design loads affect critical decisions such has the material selection, 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 building consider in this guide are primary 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’s buildings. In general, the design loads recommended in this guide are based on:

- Dead load.
- Live load.
- Imposed loads.

Dead Loads: This is the permanent of the stationary load like self weight of the structural elements. This include the following

a) Self-weight

b) Weight of the finished structure part.

c) Weight of partition walls etc.

Dead loads are based upon the unit weights of

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue14
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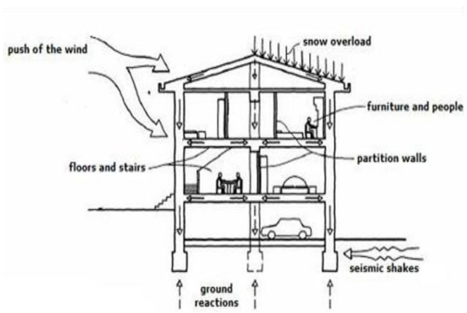
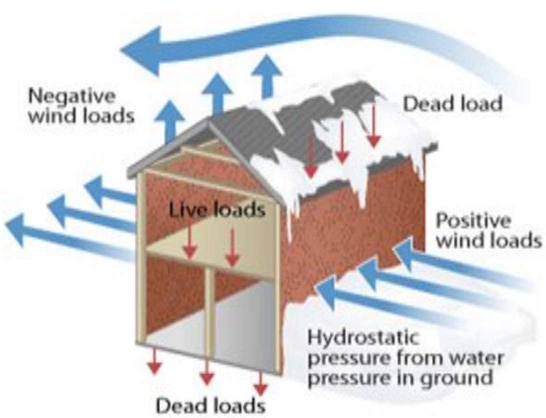
elements, which are established taking in account materials specified for construction, given IS 1911-1967 Dead loads consists of the permanent construction material loads compressing the roof, floor, wall, and foundation system, including claddings finishes and fixed equipment. Dead load is the total load of all of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc.,



Representation of the dead loads on the structure

Live loads: These loads are not permanent or moving loads. The following loads includes in this type of loading: imposed loads(fixed) weight of the fixed seating in auditoriums, fixed machinery, partition walls these loads through fixed in positions cannot be relieved upon to act permanently throughout the life of the structure. Imposed loads (not fixed) these loads change either in magnitude or position very often such as the traffic loads, weight of the furniture etc.



Representation of the live load

Live loads are produced by the use occupancy of the building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and constriction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform are loads, concentrated loads, and uniform line loads.

Imposed loads: Loads produced by intended use occupancy of a building including the weight movable portions distributed concentrated loads and loads that vibration and impact called imposed loads estimated by IS 456-2000.

Wind Loads: The effects of wind on structures are still not perfectly understood and our knowledge in this area is constantly improving with the periodic revisions of the applicable wind code provisions. High winds can cause four types of structural damages which are stated as

- Collapse
- Partial collapse
- Over damage

Height (h)	Design wind speed(Vz)	Design wind pressure(Pz)
Up to 10 m	36.379m/s	0.793KN/sq m
15m	38.85m/s	0.905KN/sq m
20m	40.51m/s	0.984KN/sq m
30m	42.58m/s	1.087KN/sa m

Design wind pressure at various heights

Often partial damage occurs most frequently. Wind forces are applied perpendicular to all roofs and walls and both internal and external wind pressures are considered. Wind is not constant with height or with time, is not uniform over the side of the structure and does not always cause positive pressure. Both the wind pressure and the wind suction must be taken into account during the structural analysis.The deviating effect, called Carioles force (isobars), is small and is usually disregarded except in the atmosphere and ocean. Certain periodic gusts within the spectrum of gustiness in wind may find resonance with natural vibration frequency would be much less than the static design load for the structure, dangerous oscillations may be set up. Pressure coefficients used in the practice have usually been obtained experimentally by testing models of different types of structures in wind tunnels. When wind interacts with a structure, both positive and negative pressures occur simultaneously.

Earth Quake Load: Seismic motions consist of horizontal and vertical ground motions, with the vertical motion usually having a much smaller magnitude. The factor of safety provided against gravity loads usually can accommodate additional forces due to vertical acceleration due to earthquakes. So, the horizontal motion of the ground causes the most significant effect on the structure by shaking the foundation back and forth.

However in practice all structures are flexible to some degree but a very flexible structure will be subjected to a much longer force under repetitive ground motion. This shows the magnitude of the lateral force on a structure is not only dependent on the acceleration of the ground but it will also depend on the type of structure (F=Ma). The earthquake load is estimated by response spectrum method in the project and is as specified by the provisions in IS 1893. In the earthquake resistant design focus is on the ductility and energy absorption by the material used (steel) for construction. It was shown repeatedly that no static analysis can assure a good dissipation of energy and favorable distribution of damage in irregular structures and in general the more slender a structure, the worse the overturning effect of an earthquake

DATA CALUCULATION AND ANALYSIS: However, the computer programs can be easily misused without proper precautions in analysis and design procedures. If the design of any structure is based on the results obtained from erroneous computer analysis, it can lead to structural failures, costly disputes and poor performing structures. Performing the following procedures can eliminate many of the errors.

- Model the structure as closely to the real structure as possible.
- Recognize the important structural reactions
- Check the input and understand the material behavior and boundary conditions
- Perform simple equilibrium and compatibility checks using hand calculations.

A series of hand design calculations were performed on a typical slab panel, a randomly selected set of three beams and columns, one critical footing supporting the highest column load in the structure, and a typical combined footing. The purpose of the hand design calculation was to verify manually.

RESULTS AND DISSCUSSION: It is well known fact that any software for structural analysis and Design do not know whether the program is having any bugs or its correctness while using. Since any program developed may contain some error or bugs it is necessary for the us to check the model and analysis and design results at some point to check the results manually so as to make sure that

1. The input data while modeling the structures is correct
2. The assumed and the input loads on the structure are in par with the actual condition of the structure.
3. The support condition considered are as per site condition.
4. A countercheck to verify that ΣH=0; ΣV=0 and ΣM=0.

Also it should know the universal well spread phrase of the word "GOINGOOUT". An attempt has been made to list the number of manual checks that can be carried out while using STAADPRO and as an aid the following check list are prepared. The list of checks may be applicable not only to STAADPRO but also to any software used for structural analysis and design.

Discussion: In the manual calculations of provision of the steel, concrete will be approximate so the dead load on structure will be more an it may effects can be seen in future To avoid such deformations the software is used and we can directly assign the load as a input so that it can show the results accurately. By assigning the loads in staad pro the amount of requirement of the steel and concrete for the structure is given as output.

CONCLUSIONS AND RECOMMENDATIONS:

The above checks can help to a greater extend and it makes sure that the user has modeled the structure with no mistake and further that there is

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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no error in the input. After running the analysis also a simple check on the result can be made using the available formulae for fixed and simple beams. By the above technique a software user make sure that his model; the analysis result will yield an error prone design.Once analysis id carried out with error free results then design can be made either manually or using the same software or excel standalone programs. The above methods gives a clear picture how a software user to check his inputs and get the maximum use out of any software. Always better to know two or more than single software so that a counter check can be made especially for a large and mega projects to avoid suspicious results and to continue the design with peace of mind.

- Beams are designed for flexure, shear and torsion. If required the effect of the axial force may be taken into consideration. For all these forces, all active beam loadings are prescanned to identify the critical load cases at different sections of the beams. For design to be performed as per IS: 13920 the width of the member shall not be less than 200mm. Also the member shall preferably have a width-to depth ratio of more than 0.3.
- Flexure Design is same as that for IS 456. However while designing following criteria are satisfied as per IS-13920: The minimum grade of concrete shall preferably be M20Steel reinforcements of grade Fe415 or less only shall be used.
- The minimum tension steel ratio on any face, at any section, is given by: Pmin = $0.24\sqrt{fck}/fy$The maximum steel ratio on any face, at any section, is given by $\rho max = 0.025$
- The positive steel ratio at a joint face must be at least equal to half the negative steel at that face. The steel provided at each of the top and bottom face, at any section, shall at least be equal to one-fourth of the maximum negative moment steel provided at the face of either joint
- The shear force to be resisted by vertical hoops. Elastic sagging and hogging moments of resistance of the beam section at ends are considered while calculating shear force. Plastic sagging and hogging moments of resistance can also be considered for shear design if PLASTIC parameter is mentioned in the input file. Shear reinforcement is calculated to resist both shear forces and tensional moments.
- Columns are designed for axial forces and biaxial moments per IS 456:2000. Columns are also designed for shear forces. 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.
- The minimum grade of concrete shall preferably be M20Steel reinforcements of grade Fe415 or less only shall be used. The minimum dimension of column member shall not be less than 200 mm. For columns having unsupported length exceeding 4m, the shortest dimension of column shall not be less than 300 mm.
- The ratio of the shortest cross-sectional dimension to the perpendicular dimension shall preferably be not less than 0.The spacing of hoops shall not exceed half the least lateral dimension of the column, except where special confining reinforcement is provided.
- Special confining reinforcement shall be provided over a length lo from each joint face, towards mid span, and on either side of any section, where flexural yielding may occur. The length lo shall not be less than a) larger lateral dimension of the member at the section where yielding occurs, b) 1/6 of clear span of the member, and c) 450 mm.

The spacing of hoops used as special confining reinforcement shall not exceed ¼ of minimum member dimension but need not be less than 75 mm nor more than 100 mm.

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