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An Experimental Approach on Design Analysis of G+ 3 Multistory Building using Staad-Pro and Autocad

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ABSTRACT

Structural planning and analysis is an art and science of designing with economy, elegance and sturdiness. Structural designing requires an in-depth structural analysis on which the planning is predicted, to compete within the ever competitive market, The use of software can save many-man hours and efforts in structural analysis and an effort was made in the present study to achieve this objective. Study deals with the planning and analysis of G+3 multi-storey building using AutoCAD and Staad-Pro software. The building consists of a parking space on the ground floor and the other three units i.e. one unit of 2BHK and two units of 1BHK on the first second and third floor. The drafting and detailing work was completed using AutoCAD software and thereafter the entire design work was completed using "Staad-Pro v8i ss6. Manual analysis of seismic load is compared preferably with the results of software and thus it's concluded that Staad-Pro is suitable tool that may save considerable time and gives sufficiently accurate results.

INTRODUCTION

Structural analysis is the process of determining the effects of loads on physical structures and its constituent parts. All structures that must endure loads, such as buildings, bridges, aircraft, and ships, are subject to this type of examination. To compute a structure's deformations, internal forces, stresses, support responses, accelerations, and stability, structural analysis uses applied mechanics, materials science, and applied mathematics. The analysis' findings are used to validate a structure's suitability for usage. Structural analysis is thus an important aspect of structural engineering design. In order to do a thorough analysis, a structural engineer needs gather information such as structural loads, geometrical parameters, support conditions, and material properties from many sources. As a result of such an examination, support reactions, stresses, and displacements are often identified. It is then possible to compare this information to failure criteria. Structural engineers study, design, plan, and research structural components and structural systems to accomplish design goals and assure the safety and comfort of occupants, the beauty of structural engineer is that he makes life better for humanity; it is the business of saving lives.

LITERATURE REVIEW

The study makes use of two software programs. AutoCAD is used to draft the plan and design, and then the plan is transferred into Staad-Pro for analysis. The building is then analyzed for various loads such as live load, dead load, seismic load, and wind load using Staad-pro. The accuracy and difference between the values produced from Staad-Pro and manual computation are determined by comparing their base shear results generated from Staad-Pro with manual calculations.One of the project's goals is to describe the design and analysis of a G+3 multistory structure, with an emphasis on the seismic analysis. The findings achieved by hand are compared to the ones obtained by Staad-pro.

Patil et al. (2017) has presented the design and analysis of G+10 multistory residential building. To build an economical design, the bending moment, shear force, deflection, and reinforcement were all analyzed. In terms of bending and shear force, he concluded that wind load combinations are greater than earthquake load combinations. It is also necessary to change the reinforcement details in structural members for practical reasons.

Das et al. (2017) presents the paper of typical G+7-story skyscraper. The static and dynamic analyses were performed using STAAD - Pro software, and the post processing results were summarized, utilizing the design parameters stated in IS-1893-2002-Part-1 for Zone V. Because the deflection values for Dynamic analysis are higher, it is inferred that the result of Static analysis is roughly uneconomical.

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Rani, et al. (2018): They used STAAD Pro to design and assess the G + 4 Building. It was a three-dimensional framed design that included load calculations and STAAD Pro analysis of the entire structure. Limit State Design was utilized in the STAAD-Pro analysis, which followed the Indian Standard Code of Practice. The outcomes were extremely accurate.

Tandon et al. (2018) the research looks at how a building responds to a seismic load as measured by storey drift and foundation shear. The (G+8) building, which is located in zones 2 and 4, was seismically analyzed using STAAD Pro software. They discovered that seismic zone 2 and 4 increase base shear, lateral force, storey shear, maximum storey displacement, and overturning moment in both directions.

Malarande et al. (2019) presents the analysis and design of a multistory building using Staad Pro and manual calculation for two seismic zones. The study considers an attempt to assess and design a building utilizing Staad-pro G+9 building. The analysis and design are carried out in accordance with the IS456:2000 regulation. The result of design of beam, column, seismic weight obtained from software is compared to manual results.

Dinesh et al. (2019) evaluated and developed a multistory (G+10) building using the Staad- pro software. Limit State Design, as defined by the Indian Standard Code of Practice, is employed in the STAAD-Pro analysis. Gravity Load, which includes both dead and live loads, and Lateral Load, which solely includes Wind Loads, are the loads that are taken into

account while designing a residential building. A residential structure has a total height of 30 meters and a total area of 9,048 square meters.

Satheesh et al. (2020) used Staad Pro to analyze a G+10 residential structure. They deal with estimating seismic and wind loads for residential buildings in accordance with IS:1893-2002 and IS:875-2015 part 3. They used Kani's method to manually analyze the structure and compared the results to Staad-Pro. They came to the conclusion that the findings of the staad- pro and kanis methods are nearly identical.

Tejaswini et al. (2021) the project report includes a seismic study and design for a G+9 RCC building. The beam, column, slab, and footing designs, as well as the applied dead and live loads, are derived. This software examined the entire structure using the STAADPRO software. The base shear values obtained from Staad-pro and manual calculations are compared.

METHODOLOGY AND FORMULATION OF PROBLEM

Plan is drafted in Auto cad. The plan and design are drafted in AutoCAD and further the plan is imported in Staad-Pro for analysis. Different loads such as live load, dead load, seismic load and wind load are then analyzed in Staad-pro.The building consists of a parking space on the ground floor and the other three units i.e. one unit of 2BHK and two units of 1BHK on the first second and third floor. Figure below shows the Auto cad plan below.

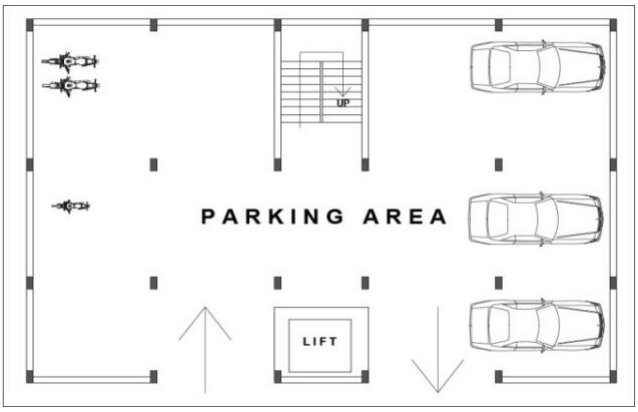

Figure 1 : Floor Plan

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The plan is then stored in.dxf format after being drafted in Auto Cad. DXF is an AutoCAD drawing file content interchange format (DWG). A DXF ASCII file is an ASCII text file; a binary version of DXF has also been created. This .dxf format file is now ready to export in Staad-Pro software. The Auto Cad 2D plan has now been loaded into the Staad-pro program. The plan has now been converted to G+ 3 models. After that, all node points are created as beams in the x and z dimensions, and columns in the y direction. Figure shows the Staad- Pro 2 D model and the render view.

Table 1: Staad- Pro 2 D model Parameter

S.no	Parameters	Description
1.	Utility of Building	Residential Building
2.	Dimension	18 x 12 meter
3.	No. of Stories	G+3
4.	Height of Building	12 meter
5.	Size of Column	200 mm x 400 mm
6.	Floor to Floor Height	3 meter
7.	External wall thickness	230 mm
8.	Internal wall thickness	115 mm
9.	Slab Thickness	150 mm

Assigning Loads to Model

The assessment of the effects of loads on physical structures and their components is known as structural analysis. All structures that must bear loads, such as buildings, bridges, aero planes, and ships, are subject to this sort of study. Structural analysis uses applied mechanics, materials science, and applied mathematics to compute the deformations, internal forces, stresses, support responses, accelerations, and stability of a structure. The findings of the study are used to validate the suitability of a building for usage, frequently precluding physical testing. Structural analysis is therefore an important element of structural engineering design. Vertical, horizontal, and longitudinal loads are the most common forms of loads acting on building structures and other structures. Vertical loads are divided into three categories: dead loads, live loads, and impact loads. Wind loads and earthquakes are examples of horizontal loads.

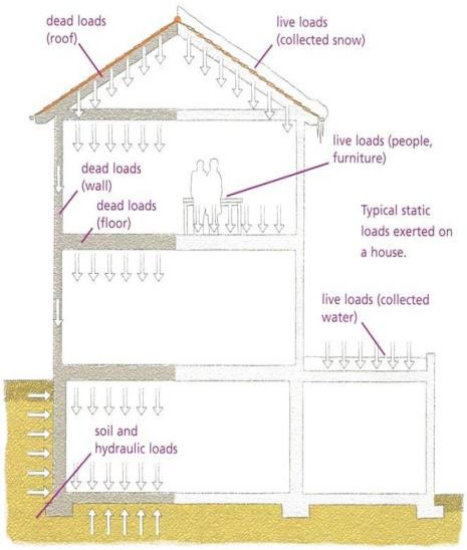

Figure 2 : Loads on a building

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Table 1 :Seismic Parameters of Zone V.

S.no	Parameters	Value
1	Zone	0.24
2	city	Delhi
3	Response reduction factor	5
4	Type of soil	Medium
5	Importance Factor	General Building

The Staad-pro software is used to create the design and analysis after entering the information for each zone. The building's seismic weight is determined to be 9073.97 KN, with a time period of 0.48356 seconds. Staad-pro, on the other hand, provides a different of base shear values as well as steel quantity in different seismic zones.

Design and Analysis

Beam

A beam is a lateral element that resists loads applied laterally to its axis. Beams can be characterized by their shapes, materials, etc. They are also known, tension members. A beam is a horizontal element that spans an opening and supports a weight, which may be a brick or stone wall above the entrance, in which case the beam is referred to as a lintel. The beam is termed a floor joist or a roof joist depending on whether the weight is a floor or a roof in a structure. Stringers are the lighter longitudinal elements of a bridge deck, whereas floor beams are the heavier transverse members. In this study, the beam dimensions are 0.2 × 0.4 meters, or 200 x 400 mm. The following are the different types of beams based on their supports:

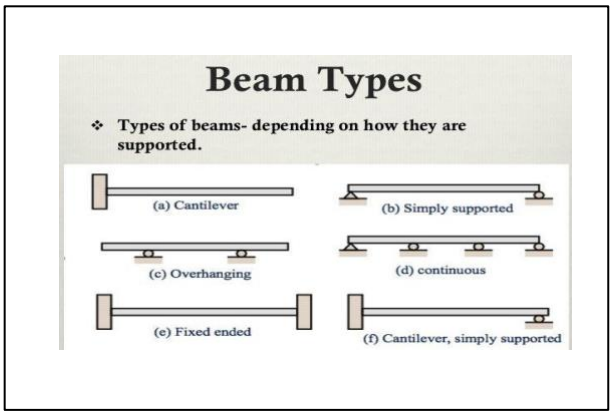
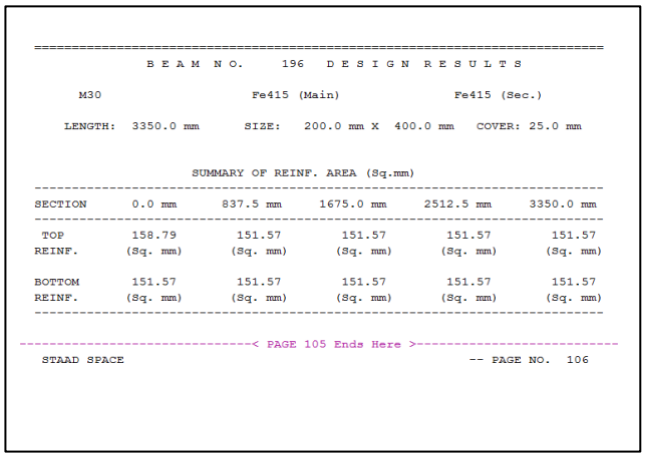


Figure 3 : Reinforcement and Design details of random beam



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==========================================================================
              B E A M   N O.    196   D E S I G N   R E S U L T S

     M30                    Fe415 (Main)              Fe415 (Sec.)

   LENGTH:  3350.0 mm      SIZE:   200.0 mm X  400.0 mm   COVER: 25.0 mm

                        SUMMARY OF REINF. AREA (Sq.mm)
--------------------------------------------------------------------------
SECTION      0.0 mm      837.5 mm     1675.0 mm     2512.5 mm     3350.0 mm
--------------------------------------------------------------------------
 TOP         158.79       151.57        151.57        151.57        151.57
REINF.      (Sq. mm)     (Sq. mm)      (Sq. mm)      (Sq. mm)      (Sq. mm)

BOTTOM       151.57       151.57        151.57        151.57        151.57
REINF.      (Sq. mm)     (Sq. mm)      (Sq. mm)      (Sq. mm)      (Sq. mm)
--------------------------------------------------------------------------

-----------------------------< PAGE 105 Ends Here >---------------------------
 STAAD SPACE                                              -- PAGE NO.  106
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Figure 4 : Design Results of Beam no. 196

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Column

A column is an axial and mainly vertical member that transmits the load through compression. The weight of the above structure is transmitted to the lower one and then finally to the foundation. Hence a column is also said to be a compression member. Structural columns are often constructed from high-strength materials such as stone, brick, and concrete. The type of column used in construction is rectangular column, circular column, axially loaded column, reinforced concrete column, steel column etc. Types of column are shown below in figure 4.24. In this study, the beam dimensions are 0.2 × 0.4 meters, or 200 x 400 mm.

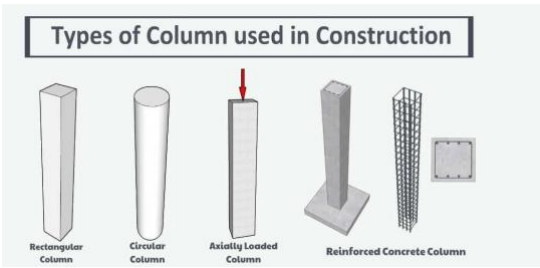

Figure 5: Types of column

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        C O L U M N   N O.   205  D E S I G N   R E S U L T S

     M30                    Fe415 (Main)              Fe415 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  200.0 mm X  400.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    1 END JOINT:   129  TENSION COLUMN


REQD. STEEL AREA   :      640.00 Sq.mm.
REQD. CONCRETE AREA:    79360.00 Sq.mm.
MAIN REINFORCEMENT : Provide   8 - 12 dia. (1.13%,    904.78 Sq.mm.)
                     (Equally distributed)
TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
-----------------------------------------------------------
Puz :   1270.56   Muz1 :     37.92   Muy1 :     17.41

INTERACTION RATIO: 0.22 (as per Cl. 39.6, IS456:2000)
```

Figure 6: Design Results of Column no.205

Take off Details

For each member, Staad-pro software estimates how much material is needed to support it. The whole concrete volume and the total reinforcing details make up the takeoff details. It takes 83.6 cubic metres of concrete and 73489N of steel to build this structure. The steel reinforcement consist of bar size of 8, 10, 12 and 16 mm. Figure 5.24 shows the size and weight of the bar.

Running Analysis*:*

The analysis window is run and the analysis results are obtained with zero error, no warning and two notes after assigning properties to the members, applying loads and completing the design. The running analysis window is shown in figure .

Designs in Staad-pro:

Reinforcement details of sample beams and columns are describes in table 6.5 and table 6.6 respectively

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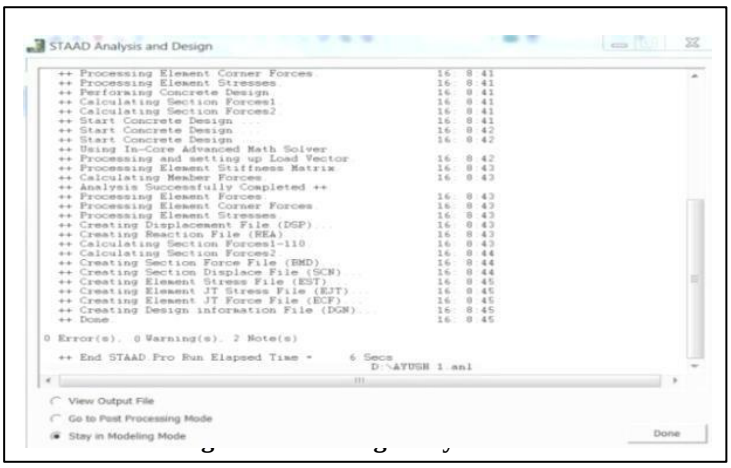

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Table 2:Reinforcement Details of Random Beams.

Beam No.	Size in Meter	Main Reinforcement	Shear Reinforcement
107(3Floor)	0.2 X 0.4	Top- 3-12mm dia Bottom- 2 12mm dia	2 legged 8mm dia @ 125mm c/c
13 (2Floor)	0.2 X 0.4	Top- 2- 10mm dia Bottom 2 - 12mm Dia	2 legged 8mm dia @ 125m c/c
96 (1Floor)	0.2 x 0.4	Top- 4- 10mm dia Bottom 2 - 10mm Dia	2 legged 8mm dia @ 125mm c/c

Comparison of manual & Staad-Pro Results:

The manual calculation and the analysis of seismic parameters i.e. seismic weight, base shear are as discussed in table. The seismic parameters are calculated with manual calculation and the same is then calculated with Staad-pro software. The results obtained in Staad-pro are slightly more as compared with manual calculation. The average increment of nearly 1.4% is identified in the results of Staad-pro.

Table 3: Manual & Staad-Pro Results

Parameters	Manual	Staad-Pro	%Increment
Seismic Weight	13410.444 KN	13436.8 6 KN	0.196 %
Base Shear	335.261 KN	336.92KN	0.49 %

Table 4 : Comparison of Base Shear at Different Height

Floor Height (meter)	Base shear (Manual)	Base shear (StaadPro)	% Increment
12	150.86	154.48	2.39 %
9	268.2	273.21	1.86 %
6	320.83	325.86	1.56 %
3	335.26	336.92	0.49 %

Comparison of Seismic parameters in different zones of India:

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The Staad-pro software is used to create the design and analysis after entering the information for each zone. The building's seismic weight is determined to be 9073.97 KN, with a time period of 0.48356 seconds. Staad-pro, on the other hand, provides a different of base shear values as well as steel quantity in different seismic zones.

Base Shear

The greatest predicted lateral stress on the base of the structure owing to seismic activity is called base shear. It is computed using the seismic zone, soil material, and lateral force formulae from the building code. The base shear values of all four zones are highlighted below in table 5.9.

Table 5 : Base shear values of all four zones

S.no	Zones	Base shear values (KN)
1.	II	226.85
2.	III	362.96
3.	IV	544.43
4.	V	816.66

Table 6 : Quantity of steel of all four zones.

S.no	Seismic Zones	Quantity of steel (Newton)
1	II	51383
2	III	54104
3	IV	65835
4	V	75484

Reinforced steel Quantity:

Building an earthquake-resistant structure begins with the right materials with the right properties, and reinforced steel is by far the most widely used material for earthquake- resistant construction.. The three most significant earthquake resistant qualities of reinforced concrete buildings are stiffness, strength, and ductility. Such structures will not be harmed by mild tremors and will be safe from significant damage or collapse in the occurrence of a major earthquake. The amount of steel used in construction varies by seismic zone; table 8 indicates the amount of steel used in construction.The base shear values are determined in each of India's four seismic zones. Different values of base shear and steel amount are generated from the same building model. The values of base shear mainly influenced on the factors such as type of zone, type on soil, type of building, and building importance factor. The graphical representation of base shear and steel quantity values are revealed in figure 5.1 and 5.2 respectively

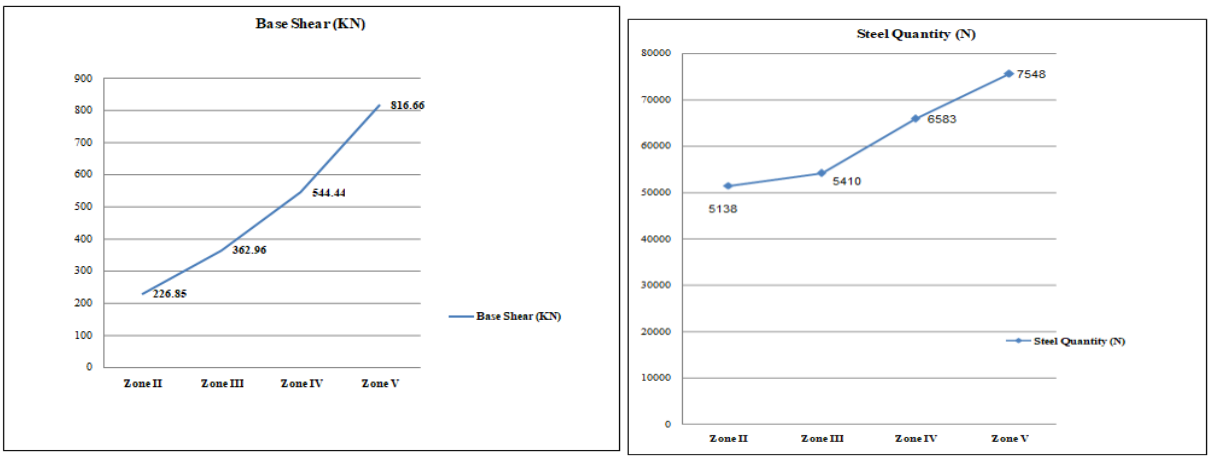

Figure 5.1: Base shear and Steel Quantity results of all four zones of India

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CONCLUSIONS

The study conclude that, analyzing multi-storey buildings with Staad pro reduces manual computations and consequently provides correct results in less time.The comparison between base shear results of manual to software calculation gives maximum increment of 2.39 % at top most height of building i.e. at 12 meter, with minimum increment of 0.4 % at the height of 3 meter.The average increment is nearly 18%. As a result, when compared to manual results, Staad pro results are almost as accurate. In addition Staad pro provides reinforcement details of all its members, as well as take off quantities of concrete and steel.When analyzing the seismic parameters in various parts of India, the base shear levels vary considerably. Zone II has a value of 226.85 KN, zone III has a value of 362.96 KN, zone IV has a value of 544.44 KN, and zone V has a value of 816.66 KN.In addition, different steel quantities are acquired in different zones, comprising 51383 N in zone II, 54104 N in zone III, 65835 N in zone IV, and 75484 N in zone V.As a result we conclude that same building with same dead load, live load, and same seismic weight gives different base shear and steel values to resist it in different seismic zones.

FUTURE SCOPE

STAAD-Pro is becoming increasingly important in the study of engineering and scientific challenges. These capabilities will allow for the construction of more effective and professional engineering software, allowing us to use software instead of manual methods.Software allows us to analyze a building by shaking in earthquakes, blows wind on it, and informs us where section of the structure will collapse and tells us which part of structure is going to fail and allows us to fix it even before it is built. It should be affordable to encourage their widespread use among civil engineers.

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