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SEISMIC ANALYSIS OF MULTISTOREY BUILDING (G+9) BY USING STAAD-PRO

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***Abstract** - The computation of the response of a structure subjected to earthquake stimulation is known as seismic analysis. An earthquake is a natural occurrence that has the potential to cause the most structural damage. As a result, a building should be safe for people by using adequate design and detailing of structural parts to ensure that they are ductilein the event of a breakdown, keeping the structure safe from the seismic force of multi-storey working. Seismic investigationand planning are required for earthquake protection constructions. The purpose of seismic resistance building is tobuild structures that perform better than their conventional counterparts during seismic activity. The seismic analysis anddesign of a G+9 RCC building are included in the project report. The applied dead and live loads, as well as the beam, column, slab, and footing designs, are obtained. Using the STAADPRO software, the entire structure was evaluated by this software. Nowadays, a variety of software is available, although STAAD-PRO is the most often used for earthquake analysis and design, as well as for reviewing and studying thebehaviour of multi-storey buildings using Equivalent Static Method. As a result, it can be inferred that the staad pro package is suited for multi-storey structure design.*

KEYWORDS: Seismic Analysis, STAAD-Pro, BaseShear, Equivalent, Static Force, Seismic Resistance, Load Assignment, Earthquake behavior.

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I INTRODUCTION

Because of population and land constraint, the construction of high-rise buildings is a need. If we employ the traditional way of manual building design, itwill take longer and there will be higher chances of human error. As a result, software is required to obtain amore precise result. STAAD Pro is a civil engineering structural programme that is widely used, which can solve problems such as wind analysis and seismic analysis using various load combinations to confirmvarious codes such as IS456:2000, IS1893:2002,IS875:1987, IS1893:2016, and so on.

The full form of STAAD is "STRUCTURAL AIDED ANALYSIS AND DESIGN". STAAD Pro is one of the best software used in the analysis of the structure and even design structure using an analyzed report. We choose STAAD Pro due of the following benefits:

- Ease of use,
- Compliance with Indian Standard Codes
- Versatility in solving any type of problem
- Increase efficiency and save time.
- The precision of the solution.

In order to analyze a structure, it is important toknow what kind of loads are being acted on the structure. Various kinds of loads that a structurefaces are as follows-

1) Dead load
2) Live load
3) Wind load
4) Seismic loads or earthquake loads

- Dead load refers to the self-weight of the structure including walls.
- Live load refers to temporary loads that act on structural elements.
- Wind load refers to the force exerted by wind pressure.
- Seismic loads refer to the lateral forces exerted by thewaves produced during an earthquake.

II LITERATURE REVIEW

Narendra Kumar Adapa (2017) [1] In this paper it isabout the study of static analysis of G+4 residential building which deals with lateral static forces at beamand column joints and their displacements.

Wind loads are not considered as within the height limitations of the locality. Seismic load factor Z is takenas 0.16 as the project area belongs to seismic zone III.

Dr. S . G Makarande , Vikas V Agrawal , Prof. G. D Dhawale , A.B Dhawane , Prof. M . R Nikhar (2019)[2] This project "analysis and design of a multistoried building using staad pro and manually calculation for two seismic zones". Is an attempt to analyze and design a building using staad-pro G+9 building is considered for the study. analyze and design is done as per IS456:2000 code. To study the difference for the same structure for two different seismic zones by comparing beam, column, footing, design, and seismic data by using staad pro software and manual calculations.

Ankit Bhaskar, Ajay Kumar, Mamta Gupta, Anurag Upadhyay, Surya Prakash Sharma

(2020)[3] In this investigation of seismic design & analysis of (G+6) residential building in zone 3& 4 using staad-pro and its cost estimation, they thought of doing a total plan of the principle auxiliary components of a multi–celebrated structure including sections, pillars, segments, and footing.They found that if a building is converting from zone 3 to zone 4, then if we take12.5% more steel, the building will also be maintained in zone 4.

Dr. Shaik Yajdhani, Anirudh Gottala, Kintali Sai Nanda Kishore (2015) [4] The static and dynamic methods are used to compare the multi-story framed structure of the (G+9) pattern. According to IS-1893- 2002Part-1, a static (Seismic Coefficient Method) and dynamic (Response Spectrum Method) linear seismic analysis is performed for the building using STAAD-Pro. In comparison to static loads, seismic excitation caused substantially higher nodal displacement and bending moments in beams and columns.

Anoop Singh , Vikas Srivastava , N . N. Harry (2016)[5] In this study, the seismic response of the structures is evaluated in terms of member forces, joint displacement, support reaction, and storey drift. Using the STAAD PRO design programme, the reaction of g+10 building structures is explored.

Rashmi Agashe, Marshal Baghele, Vaishanvi Deshmukh, Sharad Khomane, Gaurav Patle, KushalYadav (2020) [6]. This project is generally based on theoretical design and analysis of the structural framed building. Using the IS Code approach, analyse and designa G+4 storey residential building structure. Manual design was used to finish the analysis and verification of the entire structure, which was then verified using STADD Pro. They discovered that the structure of a G+4 storey residential building can withstand all loads occurring on it when developing it.

K Aparna Shrivastav (2016)[7] investigation was based on seismic analysis & design of the residential building(G+5). The method of analysis & design of residential building G+5 located in zone III. In this study of G+5 Building, seismic load dominates windload

under the seismic zone III. The wind pressures are highfor

high-rise buildings based on weather conditions such as coastal areas, hilly stations. For buildings, prominently seismic forces created the major cause of damage to a structure.

C . V. Siva Rama Prasad, Sumith . K, Shivani. R, Tejaswini. R (2019)[8] In this a general structure of 7 stories are considered for analysis and design considering seismic loads by Indian codal provisions IS-456:2000, SP-16, IS-1893:2002. The software's GUI

provides cool and easily understandable for a user towork.

Mr. Anurag Wahane, Mrs. Shubha Waghmarey, Mr. Ashish Chandra (2019)[9] Study of this paper based on seismic analysis on RCC Frames of different shapes by using staad pro software. This study was carried out through response spectrum analysis (RSA) for four different shaped RCC frame buildings by considering equal physical properties such as built-up area, beam size, column size, load calculations, seismic parameters & material specifications, etc. and making each frame economical. The displacement of the regular shape frame is very much less to the irregular U-Shape framed structure. As regular frames have more rigid members which result in minimum displacement as concluded from the analysis.

Sangeeta Uikey, Er. Rahul Satbhaiya (2020)[10] Investigation of this paper is based on Seismic Response Analysis of Tall Building Using STAAD Pro Software. This study carried out analyzed and designed a G+4, G+9, G+14, & G+19 story building and checked it for all possible load combinations (Dead, live, wind, and seismic loads). It is done to compare the performance of the structure in a different seismic zone and soil conditions.

Mr. A. P. Patil1, Mr. A. A. Chaudhari, Mr. P. A. Mudhole, Mr. V. V. Patole, Ms. A. D. Dange, Ms. S. K. Chendake (2017)[11] The principal objectives of this paper is a comparison between staad-pro software and manual calculations and design a multi-storied building (G+10) using STAAD Pro. The design involves load calculations and analyzing the whole structure by STAAD Pro. They found that the wind load combinationsare more than earthquake load combinations in Bending moment and shear force.

V S Satheesh, S. Varna Rao, Mohammed Salamath, S.Manikanta Reddy, M.Obendra, P.Nandini (2020)[12] The paper design consists of G+10 residential building. This project presents the seismic load and wind load estimation for residential buildings as per IS:18932002 and IS:875-2015 Part 3 recommendations. They found that the short-term deflection of all horizontal members is within 20mm. The structural components of the building are safe in shear and flexure.

Brajesh Kumar Tondon, Dr. S Needhidasan (2018)[13] This study discusses how a building responds when it is subjected to a seismic load, as seen by storey drift and foundation shear. STAAD Pro software was used to perform seismic analysis on the (G+8) building, which is located in zones 2 and 4. They discovered that inboth directions, the base shear, lateral force, storey shear, maximum storey displacement, and overturning moment are enhanced from seismic zone 2 and 4.

Amresh .A. Das, G. B. Bhaskar (2017)[14] This paper is about a standard G+7-story skyscraper. The static and dynamic analyses were carried out with the aid of STAAD - Pro software, using the design parameters specified in IS-1893-2002-Part-1 for Zone V, and the postprocessing results were summarised. In which it is concluded that the outcome of Static analysis is roughly uneconomical because the deflection values for Dynamicanalysis are higher.

Rajat Srivastava, Sitesh Kumar Singh (2018)[15] This paper is based on seismic analysis and design of G+9 RCC residential building in STAADPro for zone II Region. The building is more practically analyzed over

STAADPro software which is nowadays a helpful tool inthe analysis of frames for various loading conditions. In the paper, the design and detailing of all required elements of the building were calculated manually andvalues were kept in the required field in the software.

D.R. Deshmukh, A.K. Yadav1 , S. N Supekar1 , A. B. Thakur, H. P Sonawane 1 , I. M. Jain2 (2016)[16] Themain goal of this project is to use STAAD Pro software to study and design a multi-story building G+19 (3- dimensional frame). The design entails using STAAD Pro to analyse the entire structure. Limit State Design, asdefined by the Indian Standard Code of Practice, is employed in the STAAD-Pro analysis. They conclude that STAAD-PRO is a very powerful tool that can save much time and is very accurate in designs.

III OBJECTIVES

- The main goal is to estimate and assess the building's seismic response, then evaluate and design itusing STAAD-Pro software..

- G+9 building modelling and application of various loads on STAAD Pro, load calculations owing to various loading combinations, analysis, and structure design on STAAD-Pro.

- Comparison of results of earthquake load appliedon the structure by STAAD-Pro and manual calculations both by an equivalent static method.

- Studying the responses, shear forces, bending moment, seismic forces, and node displacement, and restrict them by applying appropriate properties and materials, then assigning again.

IV METHODOLOGY

A. Code-based procedure for seismic analysis main features of the seismic method of analysis based on Indian standard 1893(Part 1):2002 are described as follows:

— Equivalent static lateral force method

— Response spectrum method

— Square roots of the sum of squares (SRSS method)

— Complete Quadratic combination method (CQC)

— Elastic time history methods.

B. Method used for seismic design & analysis ofmultistory building (G+9) in this paper is:

• Equivalent Static Analysis:

The equivalent lateral force for an earthquake is a unique concept used in earthquake engineering. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings. It starts with a calculation of the base shear load and its distribution on each level using the code's calculations. Equivalent static analysis can thus work well for low to medium-rise buildings without large coupled lateral-torsional effects; but, buildings with significant coupled lateral-torsional effects are significantly less suited for the method, and more complex approaches must be utilised in these cases.

For both Staad & manual calculations we have used the "Equivalent Static Method".

C. ***Design Data of RCC Frame Structure***: → A 10- Storey OMRF building has plan dimensions as shownbelow :

• *Specifications:*

1.	Size of beam	600 x 300 mm
2.	Size of column	300 x 600 mm
3.	Size of building	24 x 24 m
4.	No. of storey	10
5.	Height of storey	3m
6.	D.L of slab including finishes	4 KN/m^2
7.	Weight of partition on floor	2 KN/m^2
8.	Live load on each floor	3 KN/m^2
9.	Live load on the roof	1.5 KN/m^2
10.	Soil below foundation	Hard Soil
11.	Building located	Delhi
12.	Type of building	OMRF

D. ***Steps For Manual Calculations***:

Step-1: The total design lateral force or design seismicbase shear (V b) along any principal direction shall be determined by the following expression:

→ V b = (Ah) x (W) eq.(1) where,

Vb = Design Base Shear

Ah = Design Horizontal AccelerationCoefficient.W = Seismic Weight Of Building.

To find 'Vb' we need to find first 'Ah' & 'W'.

Step-2: Ah=?

Where,

$$A_h = \frac{\left(\frac{Z}{2}\right)\left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)}$$

Z = Seismic Zone Factor

Sa/g = Design Acceleration CoefficientFor Different Soil Types

R = Response Reduction FactorI =

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Importance Factor

- ***By using IScode1893(Part 1): 2016 → we get***

  - *Design Parameters*:

→ (Clause 6.4.2)(Table 3), For Delhi (Zone IV), Zone Factor Z = 0.24

→ (Clause 7.2.3)(Table 8), Importance Factor I = 1.0

→ (Clause 7.2.6)(Table 9), Response Reduction Factor R = 3.0

→ (Clause 6.4.2),

a) For use in equivalent static method [*see* Fig. 2(a)]:

$$\frac{S_a}{g} = \begin{cases} \text{For rocky or hard soil sites} & \begin{cases} 2.5 & 0 < T < 0.40\ \text{s} \\ \dfrac{1}{T} & 0.40\ \text{s} < T < 4.00\ \text{s} \\ 0.25 & T > 4.00\ \text{s} \end{cases} \\ \text{For medium stiff soil sites} & \begin{cases} 2.5 & 0 < T < 0.55\ \text{s} \\ \dfrac{1.36}{T} & 0.55\ \text{s} < T < 4.00\ \text{s} \\ 0.34 & T > 4.00\ \text{s} \end{cases} \\ \text{For soft soil sites} & \begin{cases} 2.5 & 0 < T < 0.67\ \text{s} \\ \dfrac{1.67}{T} & 0.67\ \text{s} < T < 4.00\ \text{s} \\ 0.42 & T > 4.00\ \text{s} \end{cases} \end{cases}$$

upto and including = 3 KN/m^2

- Design Acceleration Coefficient For Different Soil Types Sa/g = 1.04

- **using all design parameters we get 'Ah' as** –

Ah = 0.0416 → eq.(a)

Step-3: W =?

→ Floor area = 24 x 24 = 576 m^2
→ Dead load = 4 KN/m^2
→ Weight of partitions = 2 KN/m^2 → For liveload

Percentage of live load to be considered = 25%= 1080 KN

→ weight of the column at each floor

= 0.3 x 0.6 x 2.4 x 25 x 25

= 270 KN

→ weight of the column at the roof

= ½ x 270

= 135

→ Total plan area of the building

= 24 x 24 m^2

→ Equivalent load at roof level

= 4 x 576 + 1080 + 135

= 3519 KN

→ Equivalent load at each floor

= 6.75 x 576 +1080 + 270

= 5238 KN

→So,

∑Wi = 3519 + 5238 x 9

= 50661 KN

→ Therefore ,

W = 50661 KN → eq.(b)

→

→Total seismic weight on the floors, W = ∑Wi

Where,

∑Wi = sum of loads from all the floors, which includes dead loads and theappropriate percentage of live loads.

W = total seismic weight on the floors.

Step-4: Put equation (a) & (b) inWe will get 'Vb' as-

Vb = 2107.5 KN

Step-5: eq.(1)

- For calculating, ∑Wi =?

→ effective weight at each floor except the roof

= 4.0 + 2.0 + 0.25 x 3

= 6.75 KN/m^2

→ effective weight at roof = 4.0 KN/m^2

→ weight of the beams at each floor and the roof

= 0.3 x 0.6 x 240 x 25

- **Lateral Force at different levels (Qi):Qi = Ki x Vb**

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$$Q_i = \left(\frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2} \right) V_B$$

where

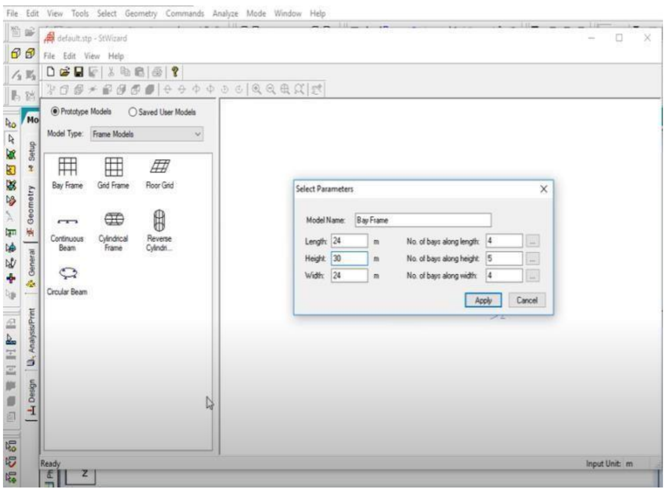
Q_i = design lateral force at floor i;
W_i = seismic weight of floor i;
h_i = height of floor i measured from base; and
n = number of storeys in building, that is, number of levels at which masses are located.

→ ***Calculation of design lateral forces at each floorlevel as shown –***

SL	Wi (KN)	hi (m)	Wihi² (KNm²)	Ki = Wihi²/∑Wi hi²	Lateral Force (KN) Qi = Ki x Vb	Lateral Force (KN)
					X-direction	**Z**
10	**3519**	**30.0**	**3167100**	**0.1907**	**402.0**	**402.0**
9	**5238**	**27.0**	**3818502**	**0.2299**	**484.6**	**484.6**
8	**5238**	**24.0**	**3017088**	**0.1817**	**382.9**	**382.9**
7	**5238**	**21.0**	**2309958**	**0.1391**	**293.3**	**293.3**
6	**5238**	**18.0**	**1697112**	**0.1022**	**215.5**	**215.5**
5	**5238**	**15.0**	**1178550**	**0.0709**	**149.5**	**149.5**
4	**5238**	**12.0**	**754272**	**0.0454**	**95.7**	**95.7**
3	**5238**	**9.0**	**424278**	**0.0255**	**54.0**	**54.0**
2	**5238**	**6.0**	**188568**	**0.0114**	**24.0**	**24.0**
1	**5238**	**3.0**	**47142**	**0.0028**	**6.0**	**6.0**
			Total - 16602570		**Vb - 2107.5**	**Vb - 2107.5**

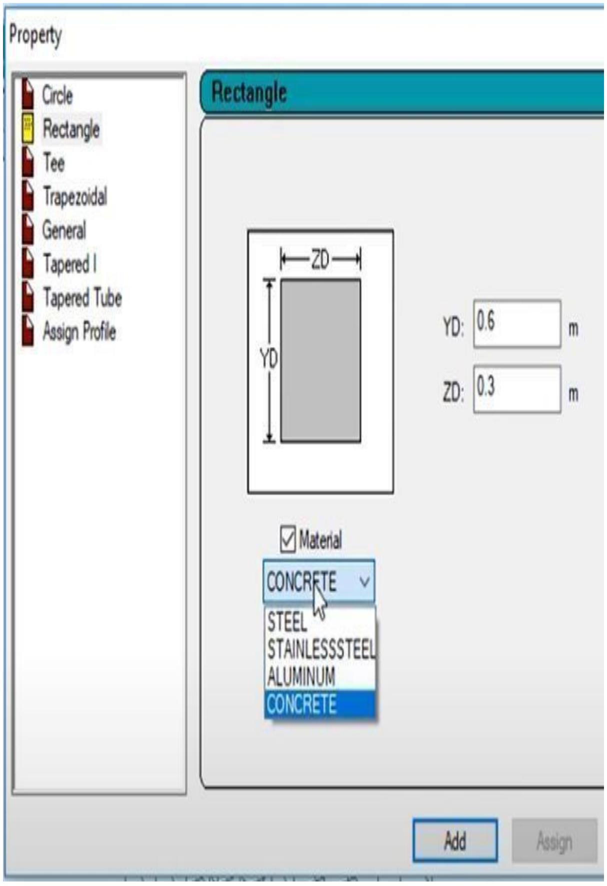
D. Steps For Staad Calculations:

Step-1: ***Modeling:*** Concerning the consideration of the type of structure modeling has been done using Geometryand Structural Wizard tool.



Step-2: ***Generation of Nodal Point:*** On that model, their corresponding nodal point has been generated according to the planning for the location of the column in the building..

Step-3: ***Property Definition:*** On STAAD-Pro, use the General-Property command to define the property according to the size requirements for the individual structure. As a result, after assigning selected beams and columns, beams and columns have been generated.



Step-4: ***Create and Assign Support & Member Property:***After selecting columns with the Node Curser and assigning cross-sections based on load calculations and property definition, column definition at supports has been presented as fixed underneath each column.

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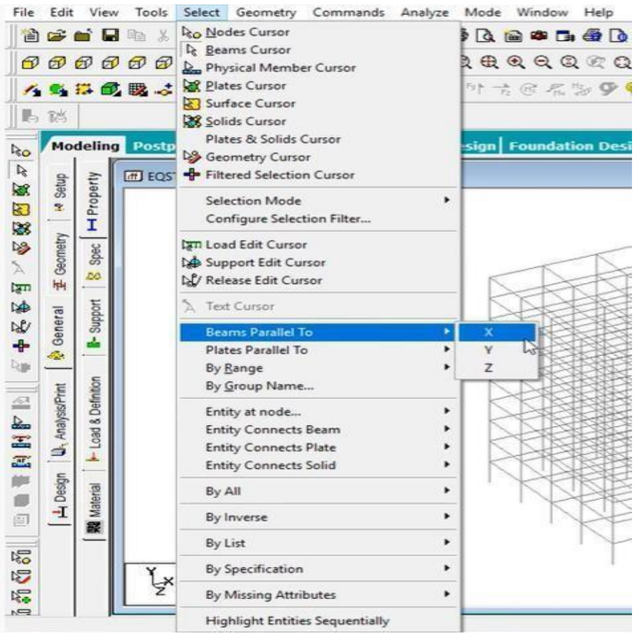
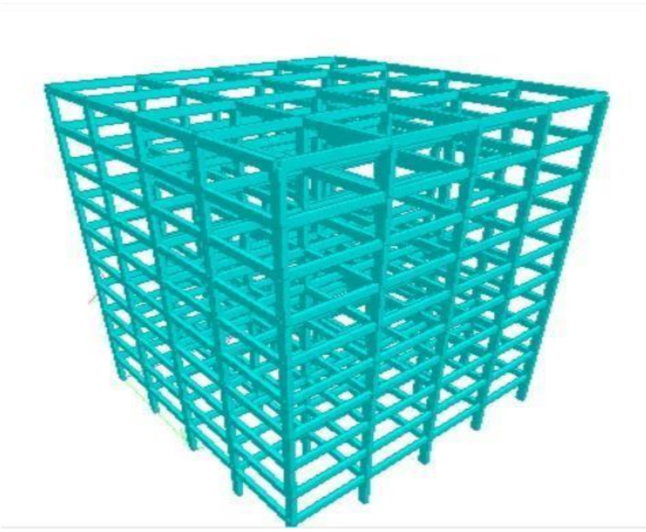
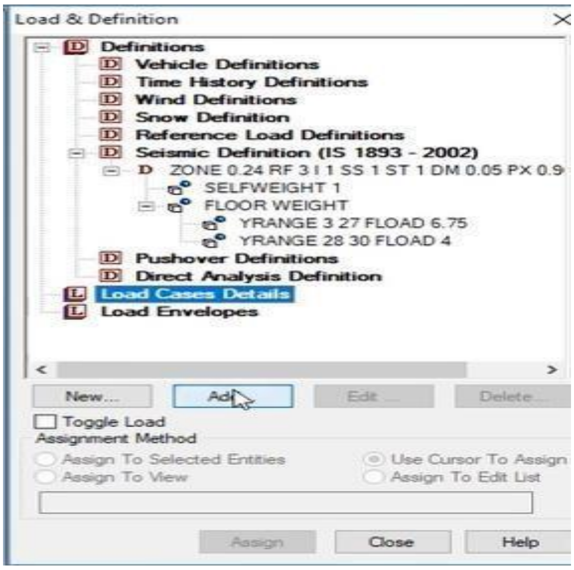


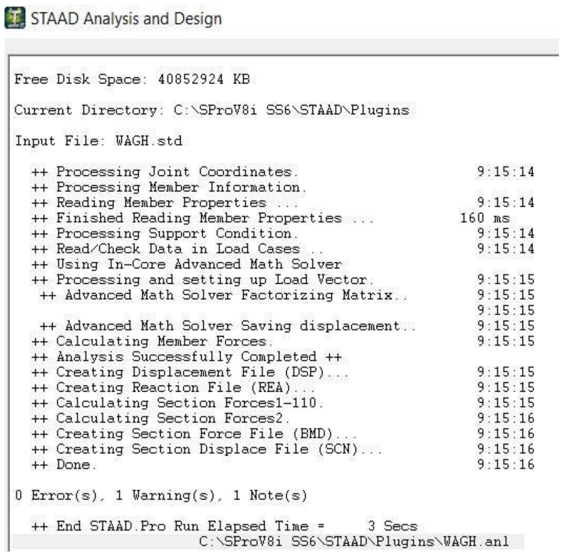
Step-5: ***3-DRendering***: After assigning the member property to the structure the 3-D view of the structure canbe shown using the #- D Rendering command.



Step-6: ***Load Assigning***: Dead load, Live Load, Roofload, Earthquake loads.



Step-7: ***Output Generation***: Following a structural analysis with STADD-Pro. The structure is then studied and a full examination of forces and bending moments iscarried out using the Post-processing mode to recognise their shear forces and bending moment diagrams to determine if they are safe or not. It's also error-checked.



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V RESULT

A. Result Obtain On Staad Pro:

```
************************************************************
*                                                          *
* TIME PERIOD FOR X 1893 LOADING =     0.96000 SEC         *
* SA/G PER 1893=     1.042, LOAD FACTOR= 1.000             *
* VB PER 1893=    0.0417 X    50655.41=    2110.64 KN      *
*                                                          *
************************************************************


************************************************************
*                                                          *
* TIME PERIOD FOR Z 1893 LOADING =     0.96000 SEC         *
* SA/G PER 1893=     1.042, LOAD FACTOR= 1.000             *
* VB PER 1893=    0.0417 X    50655.41=    2110.64 KN      *
*                                                          *
************************************************************
```

Here, is the result which we got by staad pro calculation:

Vb = 2110.64 KN

B. Check The Result We Obtain:

We can check our result by comparing staad readings with manual readings by any one factor like we can compare it by design base shear, time period, imposed load, etc. To checkour readings in this paper we are comparing it with design base shear (Vb).

Vb = 2107.5 KN (Manual)

Vb = 2110.64 KN (Staad)

Here, we can see that our staad result is as same as amanual result.

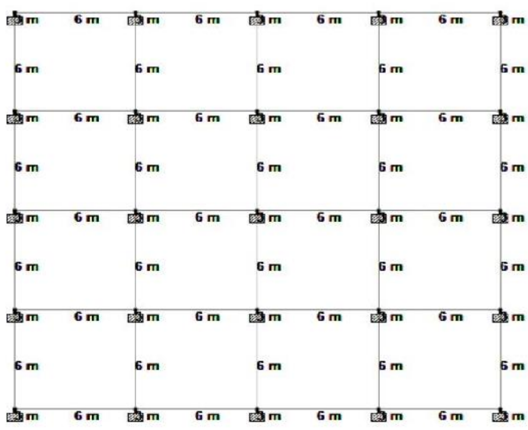
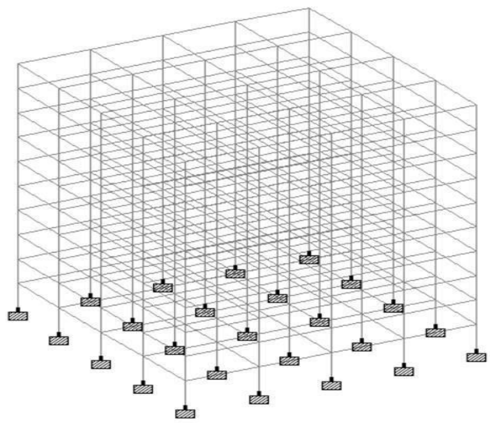


Fig. Staad Plan



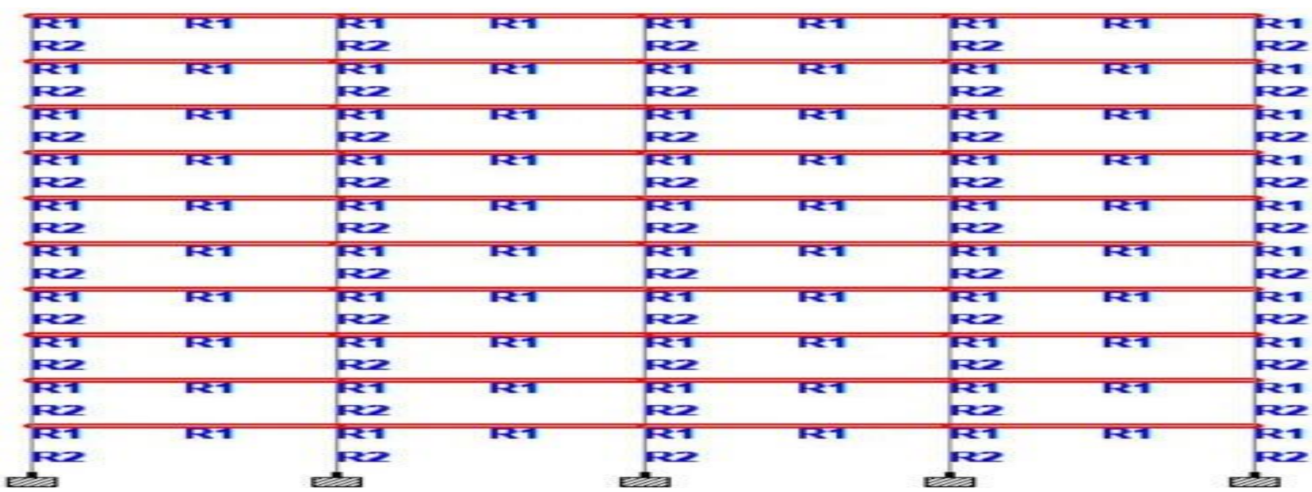


Fig. Assigning Beams

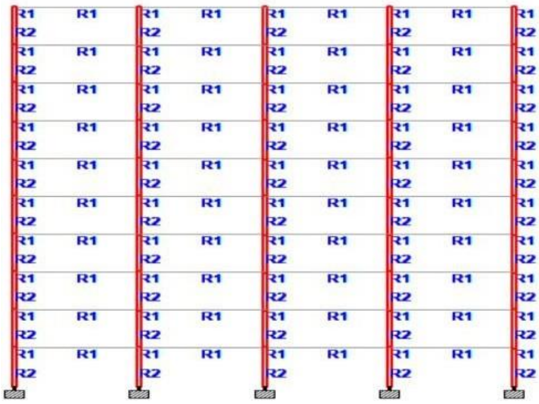


Fig. Assigning Columns

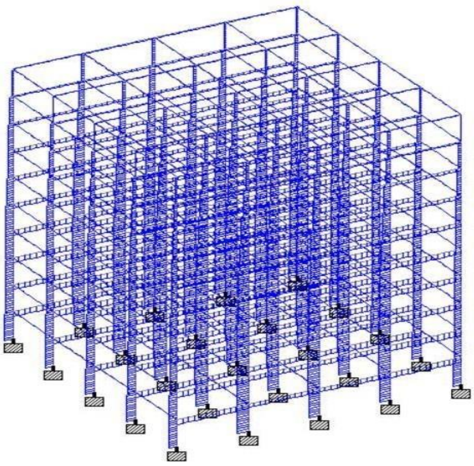


Fig. Shear Force Y

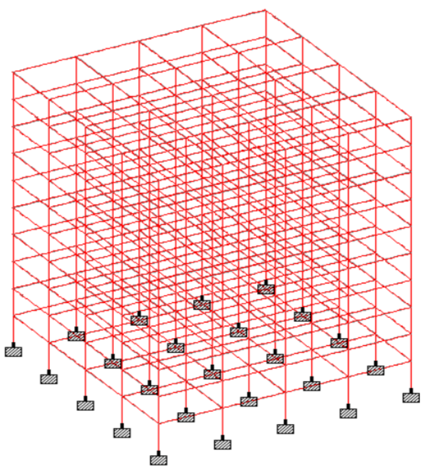


Fig. Shear Force Z

VI CONCLUSION

- Design Base Shear (Manually)
  = 2107.5 KN
- Design Base Shear (STAAD Pro)
  = 2110.64 KN
- The G+9 residential building has been analyzed and designed using STADD. Pro.
- Seismic forces have been addressed, and the construction has been constructed to withstand earthquakes.
- Finally, STADD Pro is a versatile software that can calculate the reinforcement needed for any concrete section depending on its loading as well as nodal deflections against lateral forces.

REFERENCES

[1] Narendra Kumar Adapa (2017) "Static Analysis andDesign of Multi- Storied (G+4) Residential Building Using Staad-Pro."

[2] Dr. S. G Makarande , Vikas V Agrawal , Prof. G. D Dhawale , A.B Dhawane , Prof. M . R Nikhar(2019)"Analysis and Design of Multi Storeyed Building Using Staad Pro and Manually for Two Seismic Zones."

[3] Ankit Bhaskar, Ajay Kumar, Mamta Gupta, Anurag Upadhyay, Surya Prakash Sharma.

(2020) ''Seismic Design & Analysis Of (G+6) Residential building In Zone 3& 4 Using Staad-Pro AndIts Cost Estimation."

[4] Anirudh Gottala, Kintali Sai Nanda Kishore, Dr. Shaik Yajdhani (2015) "Comparative Study of Static andDynamic Seismic Analysis of a Multistoried Building."

[5] Anoop Singh , Vikas Srivastava, N.N.Harry (2016) "Seismic Analysis and Design ofBuilding Structures in STAAD Pro."

[6] Rashmi Agashe, Marshal Baghele, Vaishanvi Deshmukh, Sharad Khomane, Gaurav Patle, Kushal Yadav (2020) "To StudyAnalysis and Design of Multi-Storey building using STAAD-pro. and Comparing with Manual Calculations."

[7] K Aparna Shrivastav (2016) "SeismicAnalysis & Design of Residential Building(G+5)".

[8]C . V. Siva Rama Prasad, Smith . K, Shivani. R, Tejaswini. R (2019) "Earthquake and Wind Analysis of Multi storey building using Staad.Pro."

[9] Mr. Anurag Wahane, Mrs. Shubha Waghmarey, Mr. Ashish Chandra (2019) "Seismic Analysis on RCC Frames of Different Shapes by Using STAAD. Pro Software."

[10] Sangeeta Uikey, Er. Rahul Satbhaiya

(2020) "Seismic Response Analysis of Tall Building Using STAAD Pro Software."

[11] Mr. A. P. Patil1, Mr. A. A. Choudhari,

Mr. P. A. Mudhole, Mr. V. V. Patole, Ms. A. D.Dange, Ms. S. K. Chendake (2017)

"Design & Analysis of Multi Storeyed Building (G+10)By Using Stadd Pro V8i."

[12]V S Satheesh, S. Varna Rao, Mohammed Salamath, S.Manikanta Reddy, M.Obendra, P.Nandini (2020)"Analysis of G+10 Residential Building By STAAD Pro."

[13] Brajesh Kumar Tondon, Dr. S.

Needhidasan (2018) "Seismic Analysis Of Multistoried Building In Different Zones."

[14] Amresh .A. Das, G. B. Bhaskar (2017) "Static and Dynamic Analysis of Multistorey Building."

[15] Rajat Srivastava, Sitesh Kumar Singh (2018) "Seismic Analysis and Design of G+9 RCC ResidentialBuilding in STAAD.PRO for

Zone II Region."

[16]D.R. Deshmukh, A.K. Yadav1, S. N Supekar1, A. B. Thakur, H. P Sonawane, I.

M. Jain2 (2016) "Analysis and Design of G+19 Storied Building Using Staad-Pro."

[17] Miss. Tejashri S. Gulve "Feasibility ofImplementing Water Tank As Passive Tuned Mass Damper."

[18] IS-1893(part1):2016 Criteria forEarthquake Resistant Design of Structures, Part 1: General Provisions and Buildings.