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ABSTRACT

In modern structural engineering, the demand for innovative and efficient designs has increased significantly due to rapid urbanization and evolving architectural trends. To meet these challenges, engineers rely on advanced software tools like STAAD.Pro, which enable precise analysis and design of complex structures. This project focuses on the structural analysis and design of an irregular 'C'-shaped multi-storied college building (G+3) using STAAD.Pro. The irregularity in building shape plays a crucial role in determining its structural behavior under various loading conditions, including dead load, live load, wind load, and seismic forces. The primary objective of this study is to evaluate the performance of an irregularly shaped building and ensure its safety and stability through efficient design methodologies. The analysis considers M25 grade concrete for all structural elements, ensuring durability and strength. The behavior of the building is assessed by applying different loads as per IS codes, and the structural members, including beams and columns, are designed accordingly. The study also examines the impact of the building's irregular 'C' shape on load distribution, lateral stability, and structural efficiency. With STAAD.Pro's advanced features and integration capabilities with other software like AutoCAD, the design process becomes more efficient, reducing manual errors and saving significant time. The software enables quick iterations, making it easier to optimize structural components based on various constraints. The results of the analysis provide insights into the structural performance of irregular buildings, guiding engineers in making informed decisions to enhance safety, functionality, and cost-effectiveness. The project highlights the importance of software-based structural analysis in modern construction practices, especially for irregularly shaped buildings. By leveraging STAAD.Pro, engineers can achieve precision in design, ensuring compliance with safety standards while optimizing material usage. The findings of this study contribute to a better understanding of irregular building designs and their implications, ultimately aiding in the development of more resilient and efficient structures.

Key word: Structural Analysis, STAAD.Pro, Multi-storied Building, C-Shaped Building, Seismic Load Analysis.

1. INTRODUCTION

Our project involves analysis and design of C- Shaped multi-storeyed [G + 3] using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

The Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In every aspect of human civilization we needed structures to live in or to get what we need. But it is not only building structures but to build efficient structures so that it can fulfill the main purpose for what it was made for. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout, etc, of the buildings. Buildings can be classified as different types as residential and commercial. Residential buildings are those most commonly known as homes or houses for families to live. Residential buildings have various names depending upon their use. Commercial buildings are those known as offices etc., where the public will do their professional works. Irregular building has large portion of modern, urban infrastructure. Building structure has mass stiffness and strength irregularity known as irregular building. Irregular buildings are situated in high seismicity zone; the role of structural engineer is more challengeable. Irregular structures, like structures having an L, A and E shaped plan, that can be defined "irregular" according to both perceptive criteria and irregularity rules provided by guidelines, show that, if the diaphragms are rigid and the columns are distributed according to the shape, the irregularity is "apparent". Asymmetry may in fact exist in a nominally symmetric structure because of uncertainty in the evaluation of center of mass and stiffness, inaccuracy in the measurement of the dimensions of structural elements.

1. Auto cad: AutoCAD can be defined as the use of computer systems to assist in the creation, modification, optimization of a design In this, we can create both 2D and 3D drawings used in construction and manufacturing. It was developed by John Walker in the year 1982 with the help of AUTODESK and maintains it successfully.

2. STAAD.PRO: - It is structural analysis design program software. It includes a state of art user interface, visualization tools and international design codes. It is used for 3D model generation, analysis and multi - material design. The commercial version of STAAD PRO supports several steel, concrete and timber design codes. It is the one of the software application created to help structural engineer to automate their task and to remove the tedious and long procedures of the manual methods.

2. LITERATURE REVIEW

Many pieces of contemporary urban infrastructure may be found in non-conformist structures. Irregular buildings have mass stiffness and strength irregularities. Structural engineers have a greater task when dealing with structures that are located in a seismically active area. Perceptual criteria and irregularity standards specified by guidelines may describe "irregular" constructions like L, C, A, and Eshaped plans as "apparent" irregularities when the diaphragms are stiff and the columns are distributed according to the form. The error in measuring the size of structural parts and the ambiguity in determining the center of mass and stiffness may lead to the appearance of asymmetry in a supposedly symmetric construction.

One of the most common ways to describe AutoCAD is that it is the use of computers to aid in the development, revision, and optimization of a design. Drawings for building and manufacture may be created in this method. In 1982, John Walker created it with the aid of AUTODESK and has been keeping it running ever since.

In the second place, STAAD.PRO: It is a structural design software application. It has a cutting-edge user interface, sophisticated visualization features, and adheres to internationally recognized design standards. It is used to create 3D models, conduct analysis, and develop multi-material products. Several steel, concrete, and wood design regulations are supported by the commercial edition of STAAD PRO. Structural engineers may use this programme to automate their work and eliminate the laborious and time-consuming manual operations.

Aradhanna Chavan et.al, Analysis, Design and Estimation of G+4 Residential building. The study includes G+4 building with parking at ground floor and rest of floors occupied with 2BHK flats. The design and analysis is done by using STAAD PRO, estimation by MS-EXCEL.

Deshmukh D.R et.al, Analysis and Design of G+19Multistoried Building .The study includes designing of multistory building by well-known civil engineering software named as STAAD-PRO and it also includes wind and Seismic load. They also compare the results of earthquake load applied on structure by STAAD-Pro and manual calculations both by seismic coefficient method.

Preeti Singhe et.al, this work consist each regular and irregular geometric shapes. Every shape with G+ 10 storied models was created by exploitation STAAD-Pro code with earthquake and wind load conditions. In regular form building static analysis was dole out within the unstable zones II and particularly in irregular form building T form was choosened and also the dynamic analysis was in dire straits the unstable zones IV and V. Finally calculated base shear, volume of concrete, weight of steel and also the value comparison analysis area unit compared for all unstable zones.

Aman et.al, Analysis and Design of multi-storey building at Gulbarga city, Karnataka, India. The study includes design of columns, beams, footings and slabs by well-known civil engineering software named as STAAD-PRO.

Annop .A et.al, Design a multistoried building of G+5 floors, at kalakode, Keral, India. The design is done by taking into account standards recommended by IS code, Kerala building and national building rules. And also includes requirements for seismic and wind load.

STAAD.pro was used to model and test the stability of a 20-story structure with horizontal irregularity. The L-shape, the H-shape, and the U-shape were all proposed for investigation. An earthquake load analysis is performed using IS 1893: 2002 and the IS 875 standards for dead loads, live loads, and wind loads. [Gaur et.al. (2014)] employed parameters including internal forces and roof displacement for the evaluation. No. 12 eccentrically braced frame (EBF) structures were constructed and examined for their fundamental periods. According to statistical comparisons, the Rayleigh data was better matched to the 3-variable power model than equations that were simply dependent on height [Young Kelly et al. (2016)].

RCC Seismic behavior of a ten-story building with and without shear walls was studied. According to Chandurkar et al. (2013), a massive shear wall was ineffective in buildings with ten or less stories, but it was successful in high-rise structures. According to Encina Javier et al.

(2013), they provided findings of a study of free plan structures using a simpler model based on sub structuring of the structural components, such as WCA, perimeter frame, and floor slabs (finite element model).

3. PROPOSED SYSTEM

The proposed system focuses on the structural analysis and design of a multi-storied irregular ‘C’-shaped college building (G+3) using STAAD.Pro. This system aims to enhance the efficiency, accuracy, and reliability of structural design by utilizing advanced computational tools instead of traditional manual calculations. The primary objective is to ensure that the building structure is safe, economical, and capable of withstanding various loads, including dead load, live load, wind load, and seismic forces. In this research, STAAD.Pro is employed to model the structural components of the building, including beams, columns, slabs, and foundations. The software allows for the application of different loading conditions as per IS: 456 (2000) and IS: 1893 (Seismic Code), ensuring that the structure meets the required safety standards. The program's built-in analysis capabilities enable the evaluation of shear forces, bending moments, and deflection in structural members, allowing for optimal reinforcement detailing. The design also considers shear reinforcement to enhance the building’s strength and durability. The system ensures that the amount of steel and concrete used in the structure is optimized, making the design cost-effective without compromising safety. Additionally, STAAD.Pro’s data-sharing capabilities with other software like AutoCAD streamline the design process, enabling seamless integration between architectural and structural drawings. This proposed system also considers irregularities in building shape and assesses their impact on stability, ensuring that the design is robust under real-world conditions.

4. RESULTS AND DISCUSSIONS

4.1 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.

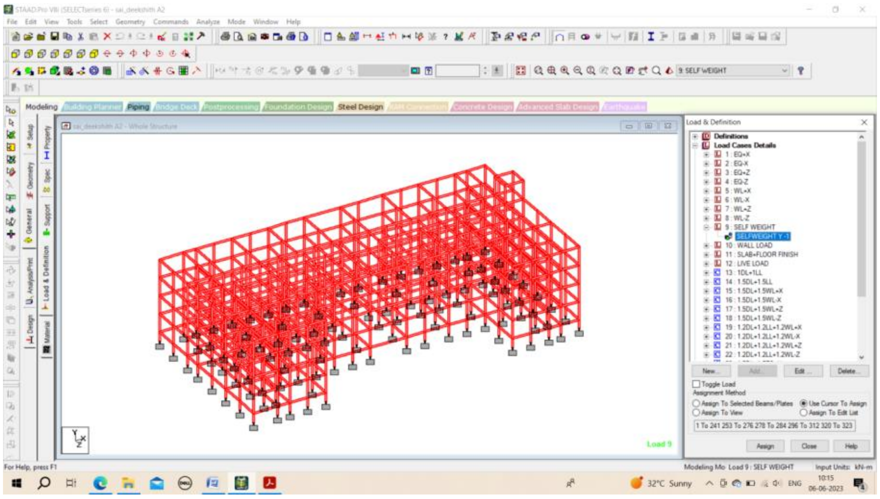

Fig: 4.1 Self weight

4.2 Dead load

Loading details:

Height of external or internal wall = 3 – 0.3 = 2.7m
Height of parapet wall = 1m
Thickness of slab = 125mm = 0.125m
Thickness of Floor finish = 50mm = 0.05m
Thickness of external wall (9inch) = 0.23 m
Thickness of internal wall (4 ½ inch) = 0.115m
Thickness of parapet wall (4 ½ inch) = 0.115m
Density of brick work = 20 KN/m^3
Density of plaster = 22 KN/m^3
Density of concrete = 25 KN/m^3

External wall load	(0.23 x 2.7 x 20) = 12.42KN/m
Internal wall load	(0.115 x 2.7 x 20) = 6.21 KN/m
Parapet wall load	(0.23 x 1 x 20) = 4.6 KN/m
Slab + Floor finish load	(0.125 x 25) + (1.2) = 4.32 KN/m^2
Stair case load	20 KN/m

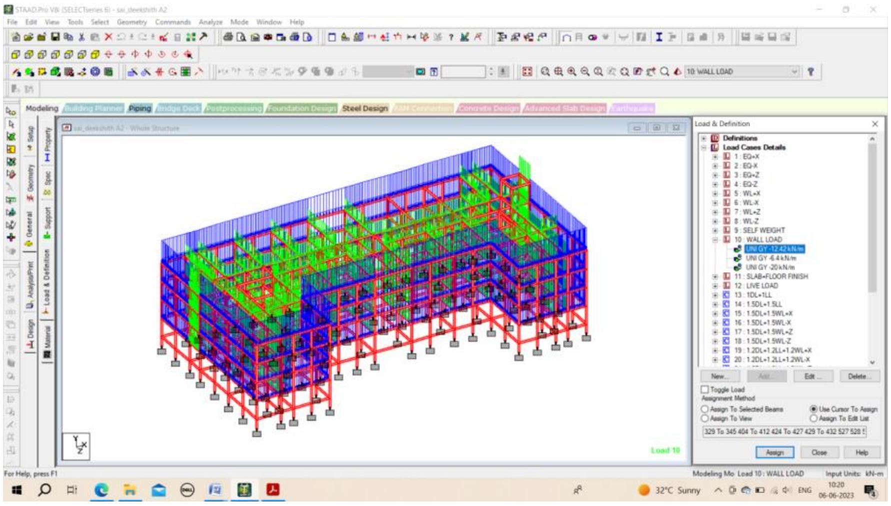

Fig 4.2: External Wall load

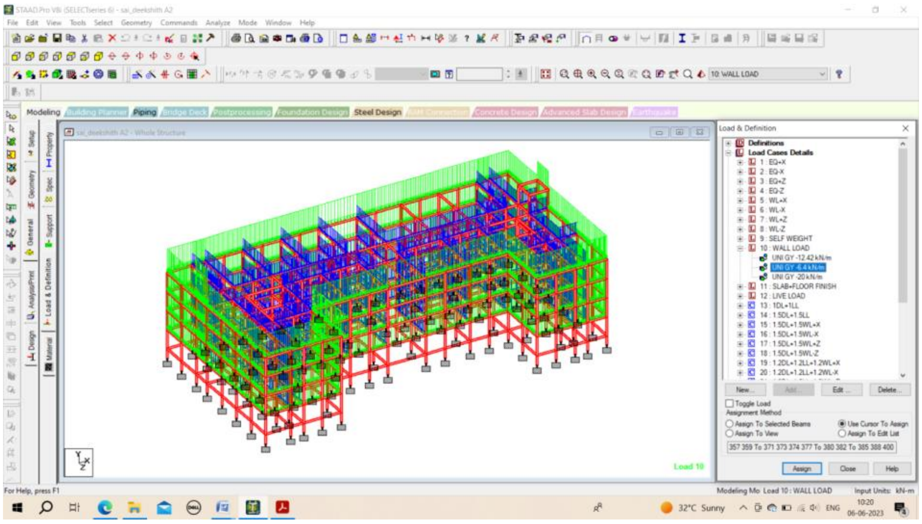

Fig 4.3: Internal Wall load

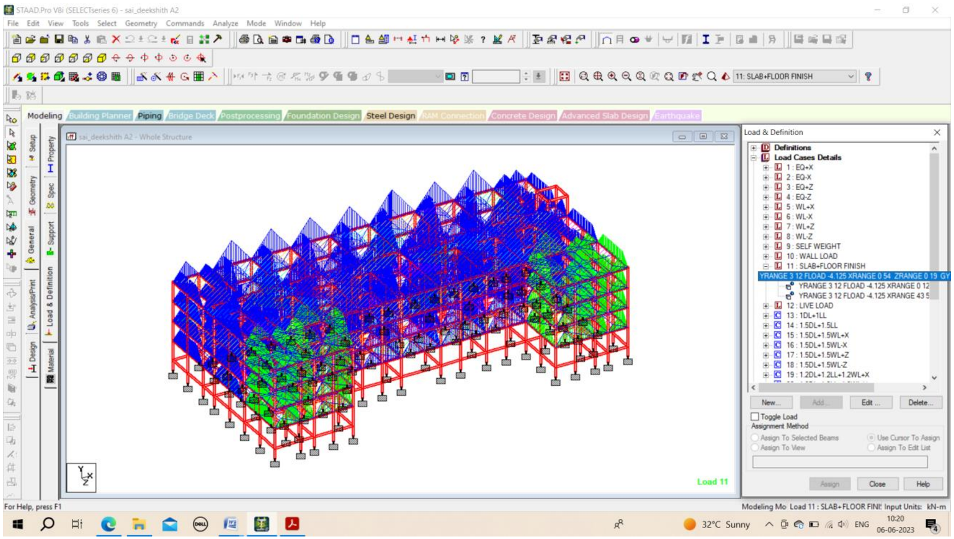

Fig 4.4: Slab + floor finish load

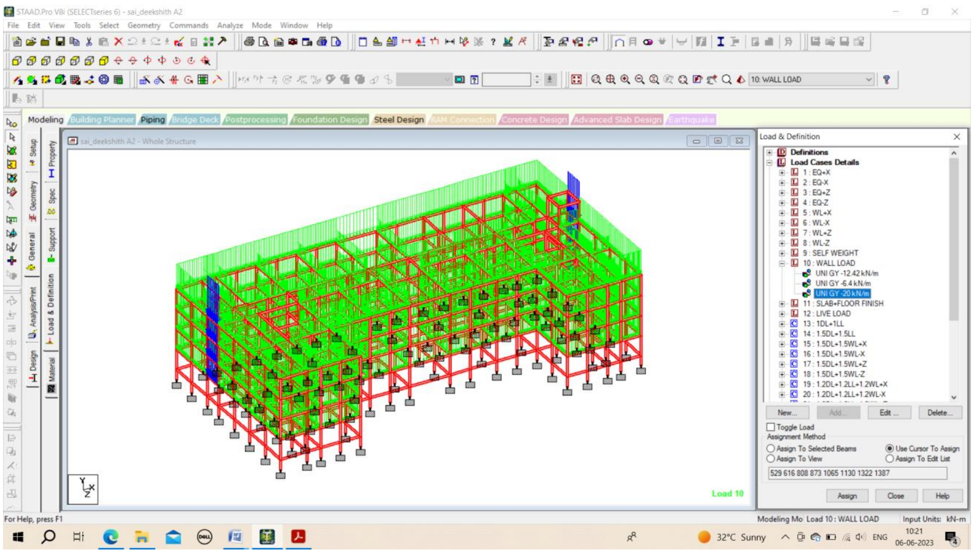

Fig 4.5: stair case load

4.3 LIVE LOAD

The live load considered in each floor & terrace was 2 KN/sq m. The live loads were generated in similar manners as done in the earlier case dead load in floor. This may be done from the member load button from the load case column.

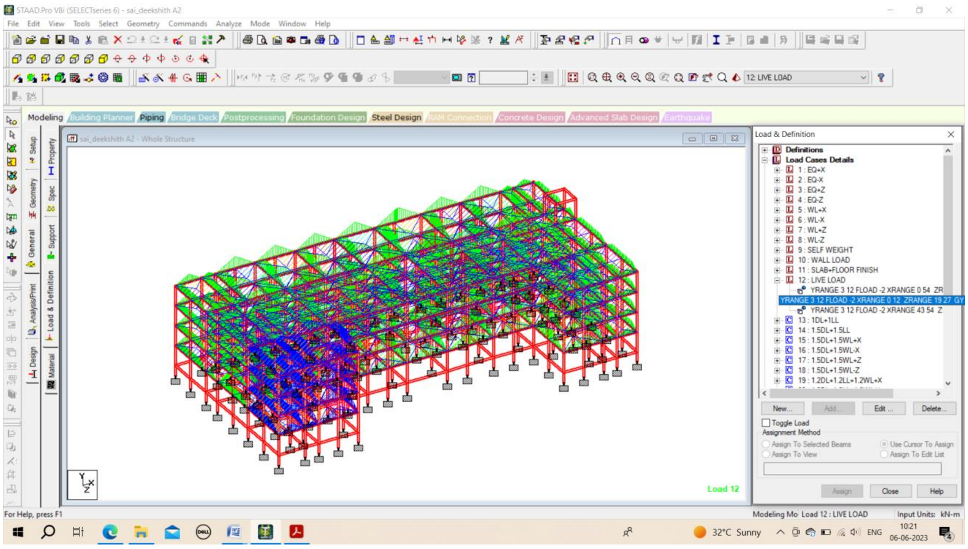

Fig 4.6: The structure under live load

4.4 Wind load

Wind is the relative motion of air to the surface of the earth. Wind speed in atmospheric boundary layer increases with height form zero at ground level to maximum at gradient height, the slight change in wind direction, within this height is neglected. Typically, buildings are designed to resist a strong wind with a very long return period, such as 50 years or more. The design wind speed is determined from historical records using Extreme value theory to predict future extreme wind speeds.

Wind Properties

i) V_b = Basic wind speed in m/s = 44 m/s [clause 5.2 - from IS:875(PART 3) -1987] - for Hyderabad region

ii) k_1= Probability factor (risk coefficient) =1 [Table 1 - from IS:875(PART 3) -1987]

iii) k_2= Terrain, height and structure size factor = 0.94 (Table 2, category 3, class B)

iv) k_3 = Topography factor Basic wind speed =1 (as per IS:875(PART 3) -1987)

v) k_4 = important factor = 1 (general constructions as per IS:875(PART 3) -1987)

vi) For 66 meters;
Vz = Vb * k1 * k2* k3 = 44 * 1 * 0.94 * 1 * 1 = 41.36
Calculation of Pz:
$Pz= 0.6 \times Vz^2 = 0.6 \times (41.36)^2 = 1026.39\ N/m^2 = 1.026\ kN/m^2$

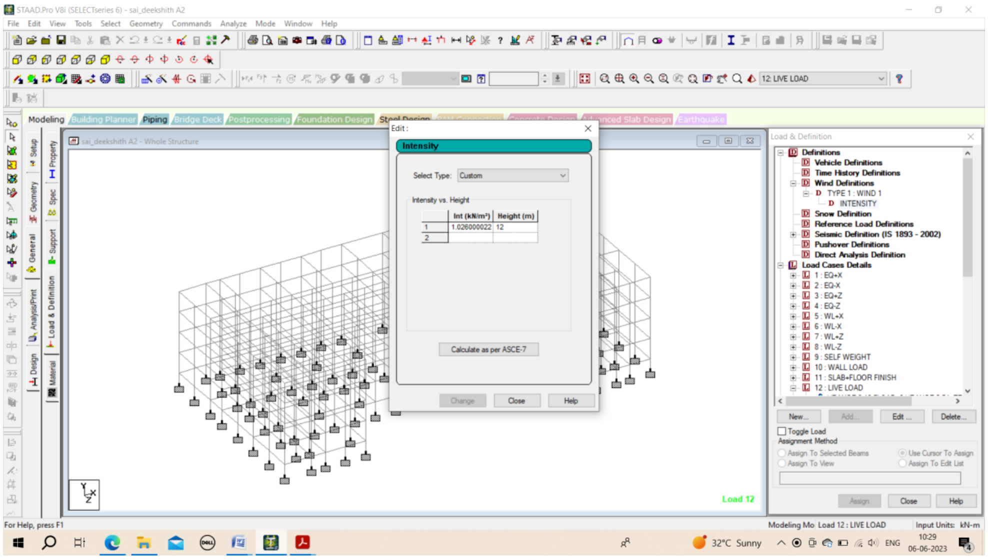

Fig 4.7 Defining wind

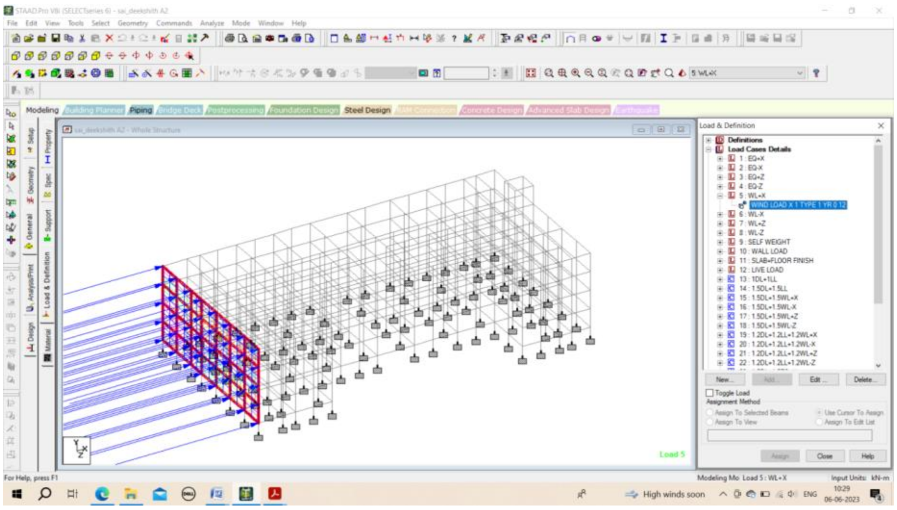

Fig 4.8: WL+X

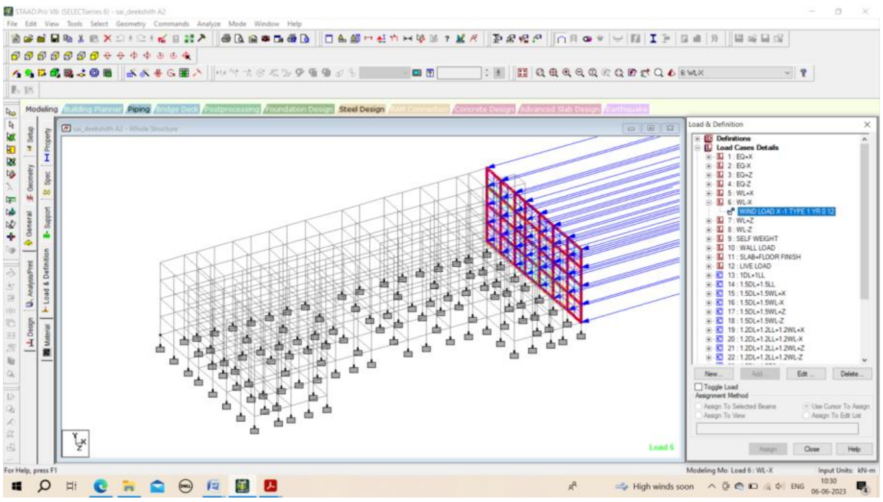

Fig 4.9: WL-X

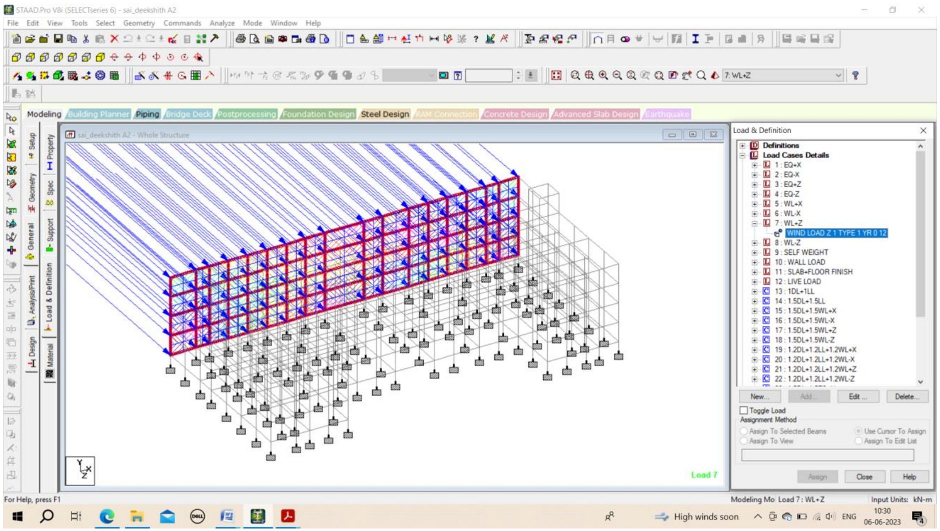

Fig 4.10: WL+Z

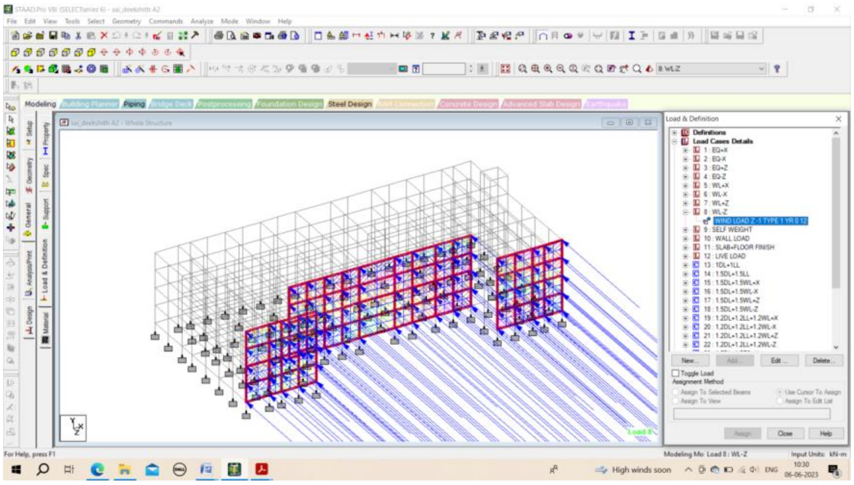

Fig 4.11: WL-Z

4.4 Seismic loads

Seismic loading is one of the basic concepts of earthquake engineering which means application of an earthquake-generated agitation to a structure. It happens at contact surfaces of a structure either with the ground, or with adjacent structures, or with gravity waves from tsunami.

For zone II – factor: 0.1 (As per IS 1893)

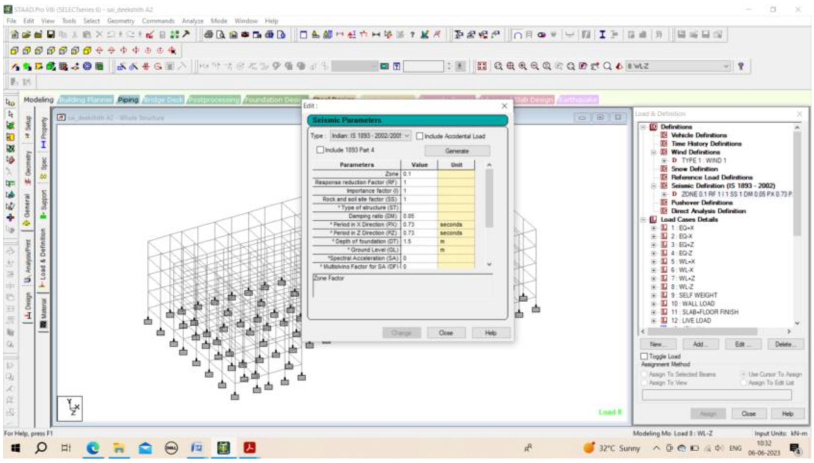

Fig 4.12: Defining seismic

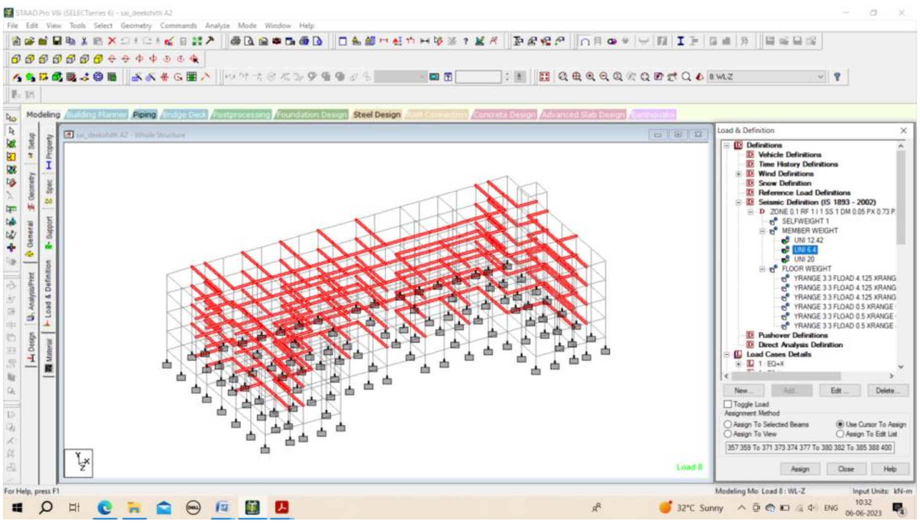

Fig 4.13: Adding weights in seismic definition

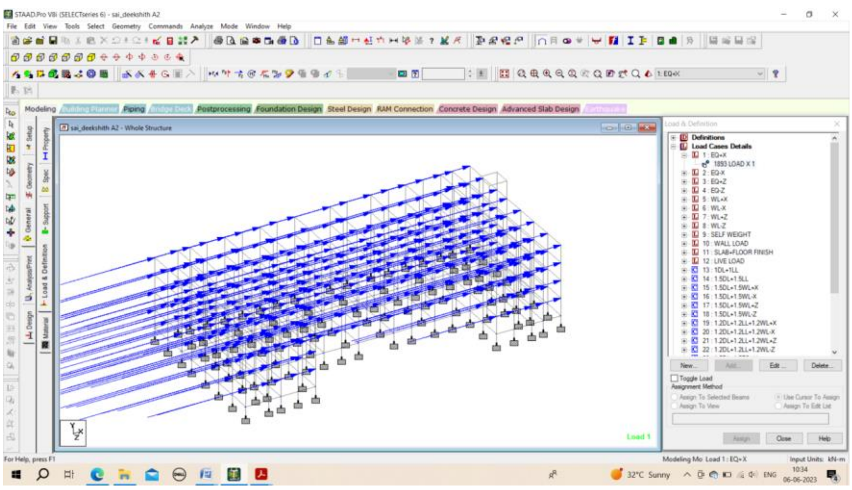

Fig 4.14: EQ+X

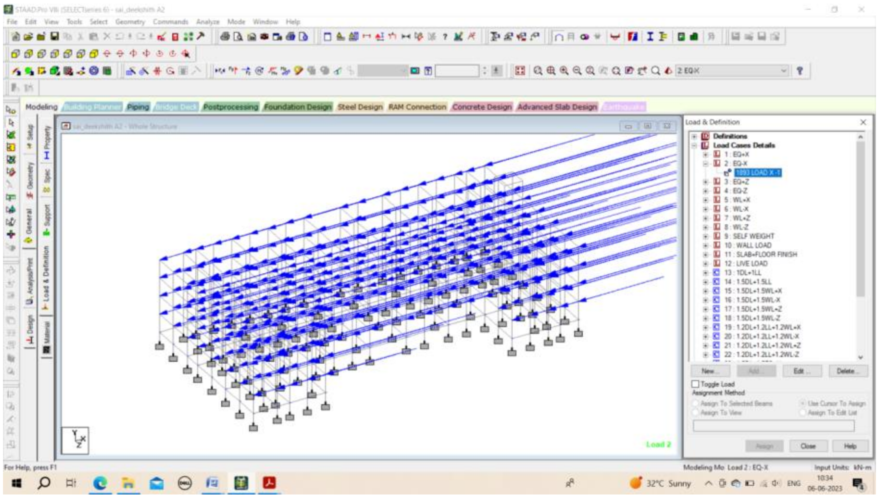

Fig 4.15: EQ-X

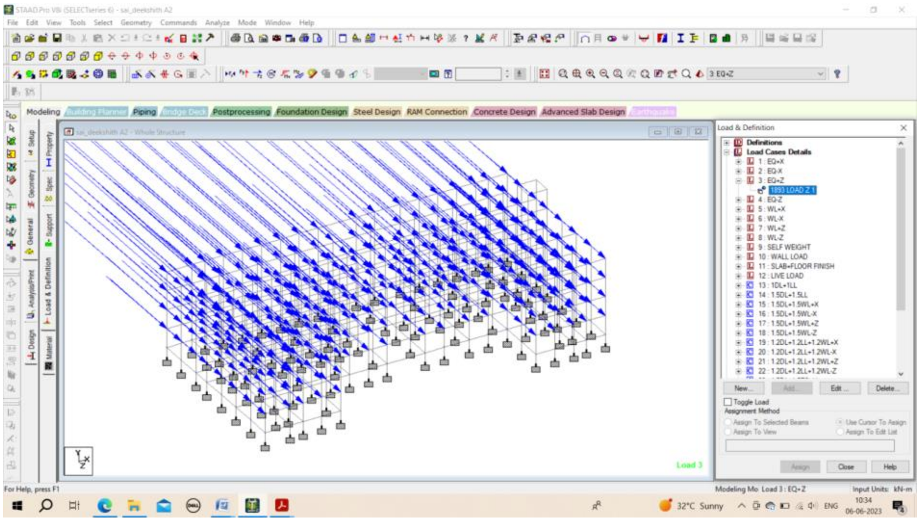

Fig 4.16: EQ+Z

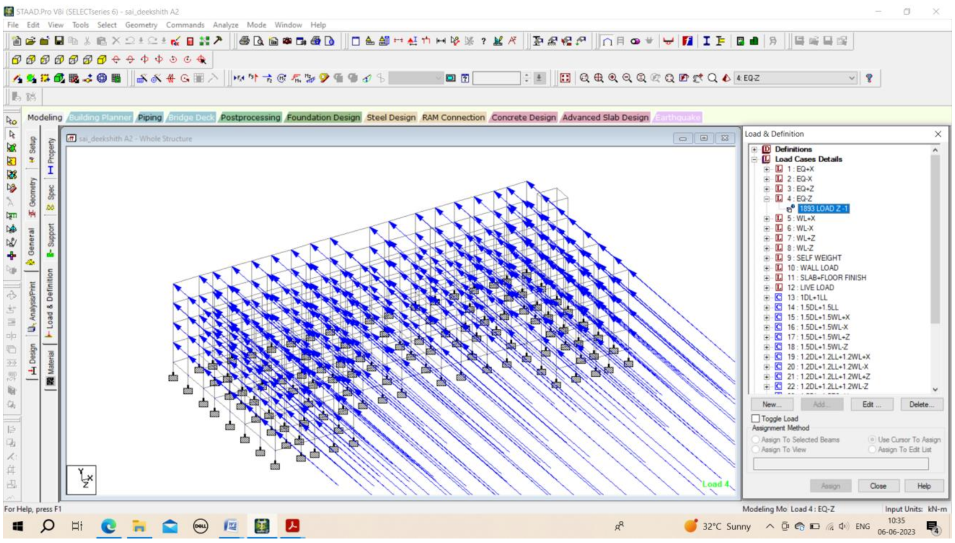

Fig 4.17: EQ-Z

4.5 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.

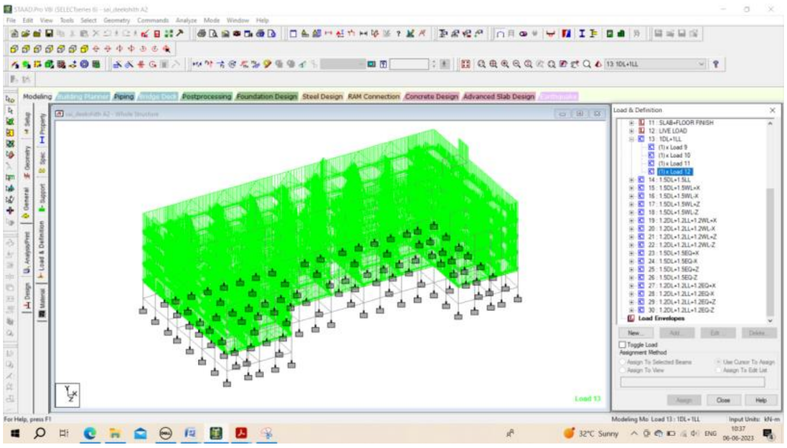

Fig 4.18 Load combinations assign

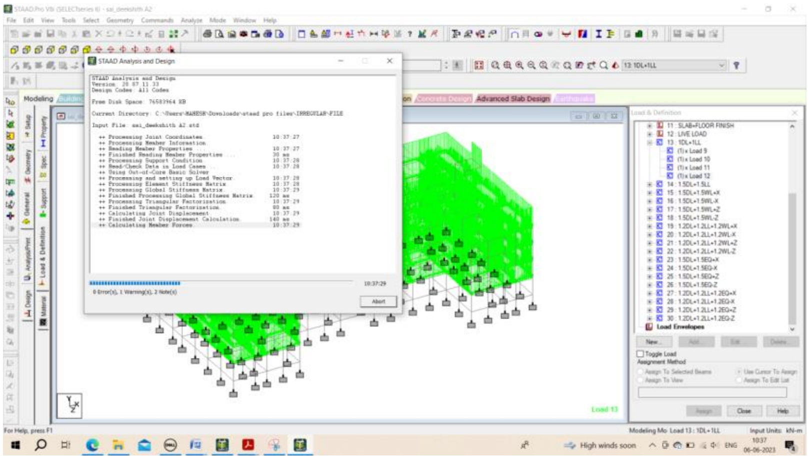

Fig 4.19: post processing

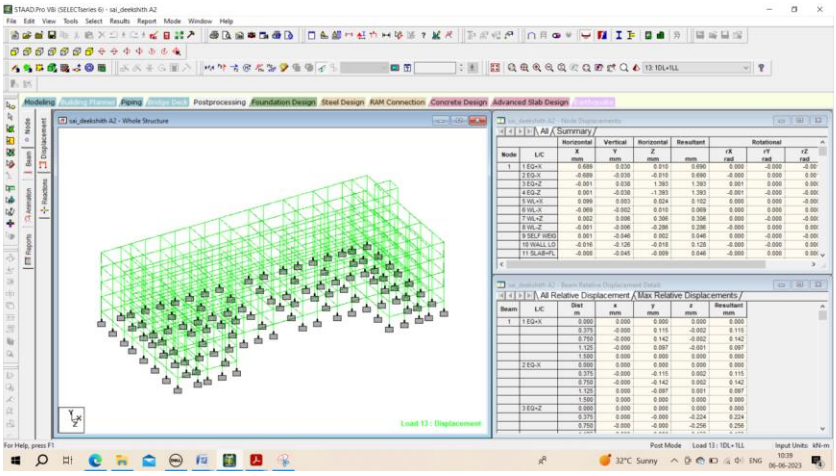

Fig 4.20: Displacements

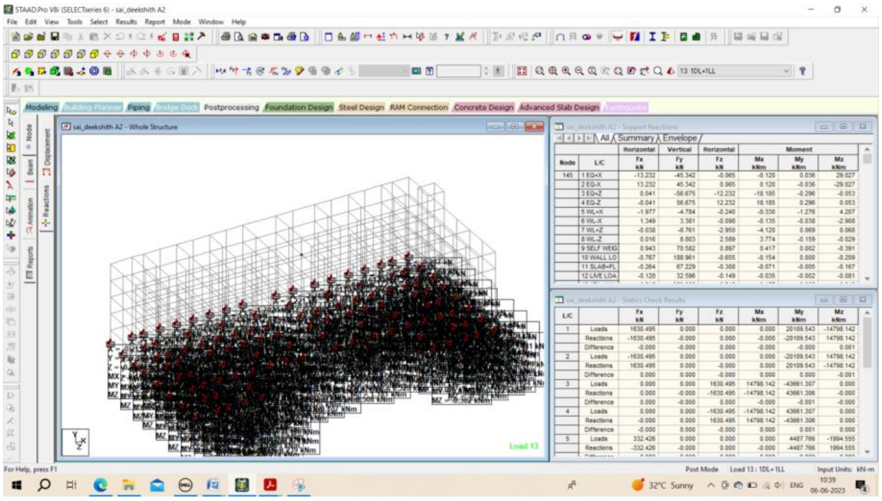

Fig 4.20 Base reactions

4.6 RESULTS

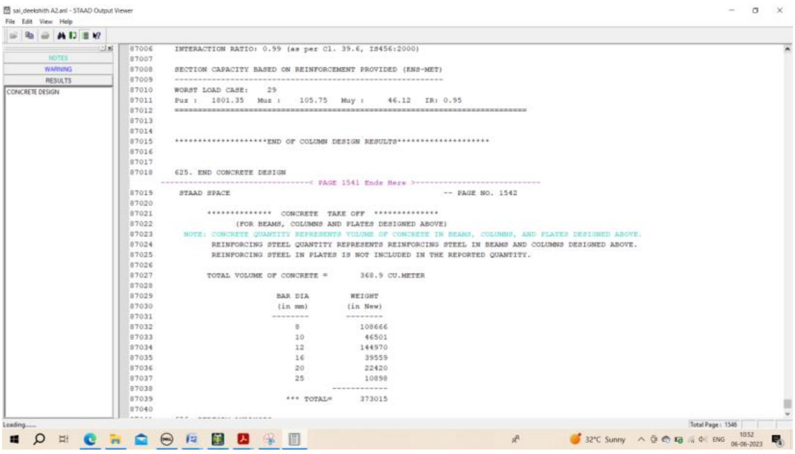

Fig 4.21 Stadd output quanties

5. CONCLUSION

The project primarily focuses on the analysis and design of a multi-storied residential building using STAAD.Pro, incorporating all necessary structural details. STAAD.Pro is a powerful structural analysis and design software that helps engineers efficiently analyze various structural components and ensure the building's stability. By utilizing this software, the project aims to achieve an optimized and safe design for a multi-storied structure. One of the key features of STAAD.Pro is its capability to calculate the reinforcement required for any concrete section. The program follows the design standards set by IS: 456 (2000), ensuring compliance with Indian structural design codes. The structural elements, such as beams and columns, are carefully analyzed for shear, bending, and deflection to ensure their performance under applied loads. The results indicate that the building's structural components are safe in shear and bending, providing the necessary strength and stability. The present study primarily considers only dead loads and live loads in the analysis. However, future work can extend this study by incorporating wind and seismic load analysis to assess the building's performance under dynamic forces. Furthermore, this analysis has been conducted on a 2D frame structure, but it can be expanded to 3D structures for a more comprehensive understanding of real-world building behavior. By implementing these enhancements, future studies can achieve a more detailed and accurate representation of structural performance, leading to improved safety and efficiency in building designs.

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