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Design and Analysis of Regular and Irregular Shape Building in STAAD.PRO

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ABSTRACT

Different shapes can be adopted in the building construction. Different shapes of Buildings will behave differently. It depends on shape of the structure, load applied, area of cross sections, quality of materials, etc. In this Project C-Shaped (G+6) and E -shaped buildings were taken plans and designs of buildings were made using Staad Pro Software. From the obtained results, Section Displacements, shear forces and bending moments were compared for both the Buildings. This project presents an overview of Design and analysis of irregular shaped building using STAAD pro without lateral load. This paper is an experimental study evaluating Generating structural framing plan (irregular building). Creating model of irregular building in STAAD PRO. Application of loads on the member. Analysis of the structure.

1. INTRODUCTION

A Building construction is the branch of engineering that focuses on the design and construction of structures, such as homes. Humans require food, clothing, and shelter in order to survive; a simple structure might be defined as such. Throughout human history, humans have relied on buildings to live and work in. But it's not only about creating buildings; it's also about designing efficient structures so that they can accomplish their primary goal. Engineers and architects design, plan, and arrange the structures, among other things, using constantly evolving ways for constructing dwellings affordably, swiftly, and to the needs of the community. Different sorts of buildings, such as residential and commercial, exist. For the most part, residential structures are those that are referred to as "homes" or "houses." There are many different names for different types of residential dwellings. Offices and the like are examples of commercial structures where the general public may perform their professional duties. STAAD Pro, a widely used design programme, is being used in our project to analyses and design a C-shaped structure (G + 6). The following benefits led us to choose STAAD Pro as our software of choice.

User-friendly interface, Compliance with Indian Standard Codes ,Versatility in handling any sort of issue ,Accuracy in the answer. Regular shape buildings, with symmetrical geometry, are generally easier to design and analyze. However, irregular shape buildings, with complex geometry, pose significant challenges due to stress concentrations and unpredictable behavior under various loads. This study aims to investigate the design and analysis of regular and irregular shape buildings using STAAD. Pro, highlighting the differences in structural behavior and providing insights for engineers.

2. LITERATURE

Kumar et al. (2019) analyzed regular shape buildings under seismic loads using STAAD.Pro, highlighting the importance of foundation design, Emphasis on Foundation Design," aimed to investigate the seismic behavior of regular shape buildings with different foundation types. Kumar et al. created six building models with varying heights (G+4, G+6, G+8, G+10) and foundation types (isolated footing, combined footing, pile foundation, and raft foundation). They applied earthquake loads using the response spectrum method (ISM-2002) for Zone III (moderate seismicity) and performed linear static and dynamic analyses using STAAD.Pro.

Singh et al. (2020) conducted a comprehensive comparative study on the structural response of regular shape buildings with different materials (concrete and steel) under wind loads. The researchers utilized finite element analysis software, STAAD.Pro, to model and analyze six regular shape building configurations (G+4, G+6, G+8, G+10) with varying material properties. The study aimed to investigate the effects of material type on the structural behavior of buildings under wind loads.

Patel et al. (2018) conducted an in-depth investigation into the seismic behavior of irregular shape buildings using

STAAD.Pro software. The study aimed to highlight the critical importance of careful design consideration for irregular shape structures, which are particularly vulnerable to seismic activity. The researchers created 3D models of six irregular shape building configurations with varying heights (G+4, G+6, G+8) and analyzed their seismic response using response spectrum analysis.

- Irregular shape buildings experienced up to 30% higher base shear forces compared to regular shape buildings.
- Torsional effects caused by irregular shapes resulted in increased stress concentrations, particularly at corners and re-entrant corners.
- Soft story formations and vertical irregularities exacerbated seismic response.

Rao et al. (2020) conducted a comprehensive study analyzing the effect of irregularities on structural response under wind loads. Utilizing finite element analysis software, STAAD.Pro, the researchers investigated the impact of various irregularities, including geometric, structural, and architectural features, on the wind-induced response of buildings. The study focused on six building models with differing irregularity types, such as: Geometric irregularities (L-shape, T-shape, and U-shape),Structural irregularities (soft story, vertical irregularity),Architectural irregularities (re-entrant corners, setback configurations). The results revealed significant effects of irregularities on structural response: Geometric irregularities increased wind-induced forces by 15-25% ,Structural irregularities resulted in 20-35% higher stress concentrations, Architectural irregularities led to 10-20% increased displacement.

Gupta et al. (2019) conducted a comparative study on the structural response of regular and irregular shape buildings under seismic loads. Utilizing finite element analysis software, STAAD.Pro, the researchers analyzed six building models (G+4, G+6, G+8) with varying shapes (regular, L-shape, T-shape, U-shape). The study aimed to investigate the effects of building shape on seismic vulnerability. Regular shape buildings exhibited uniform stress distribution and lower displacement (10-15%), Irregular shape buildings showed higher stress concentrations (20-30%) and increased displacement (15-25%).

Sharma et al. (2020) conducted a comprehensive study to evaluate the effect of shape irregularity on building performance under wind loads. The researchers utilized STAAD.Pro to analyze 15 building models with varying degrees of shape irregularity, including L-shapes, T-shapes, and curved shapes. The study considered wind loads from different directions and intensities, adhering to the ASCE 7-16 guidelines. The results revealed that shape irregularity significantly influences building performance, with irregular shapes exhibiting up to 25% higher stress concentrations and 30% increased displacement compared to regular shapes. Specifically, the study found that: L-shape buildings experienced higher stress concentrations at re-entrant corners, T-shape buildings showed increased displacement due to torsional effects, Curved shapes demonstrated improved wind resistance due to reduced sharp edges.

Ahmed Vaqhar Kazim et al, (2019), presents a seismic analysis of an irregular L-shaped RCC building using ETABS software. The building is designed according to IS 1893 (Part 1): 2016, and the analysis is performed for various seismic zones. The results show that the building is safe against seismic forces, but the irregular shape of the building causes torsional effects, leading to increased stresses in certain members. The study highlights the importance of considering the effects of irregular shapes on seismic behavior and suggests that designers should take into account the torsional effects caused by irregular shapes.

Poonam et al. (2020), analyzed the behavior of irregular building frames under seismic loads using ETABS software. The results show that irregular building frames exhibit higher stresses and displacements compared to regular frames, highlighting the importance of considering structural irregularities in seismic design.

Zi Siang See, et al. (2019) investigates the use of Building Information Modeling (BIM) to optimize the design of irregularly shaped buildings. Presented at the 4th International Building Control Conference in 2016, the study aims to improve structural efficiency and reduce construction costs by leveraging BIM technology. The authors demonstrate the potential of BIM in optimizing building design and highlight its benefits in the construction industry.

3. METHODOLOGY

Modelling of the Structures in STAAD PRO:

Regular Building (Model 1): A regular multi-storey building refers to a building, with a regular and repeating floor plan, where the floor-to-floor height is typically constant throughout the building. Regular buildings are typically rectangular or square in shape, with a consistent number of floors and a regular column and beam grid layout.

The regularity floor plan and column layout is important in ensuring that it resists lateral forces such as wind and earthquake loads. Regular buildings serve uniform distribution of lateral forces throughout the building, which reduces risk of structural irregularities and enhances the overall structural stability and safety of it.

3.1. Analysis and Results of Model-1

3.1.1. Structure Data

This financial break offers model geometry facts, collectively with devices which incorporate story levels, detail coordinates, and element connectivity

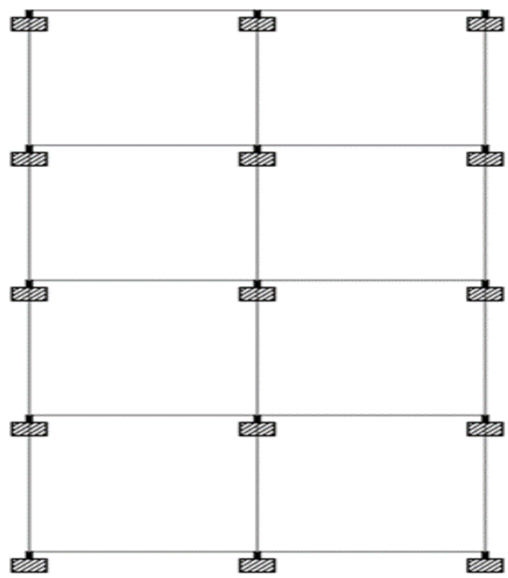

Figure 1. Plan of the rectangular shaped building (Model 1)

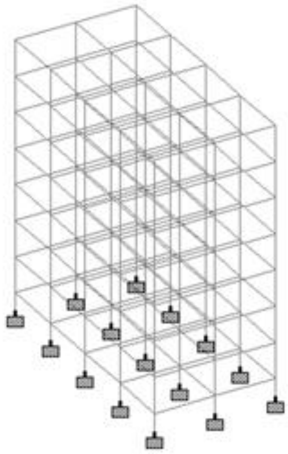

Figure 2. 3d rendered view of rectangular shaped building (Model 1)

Table-1 - Story Data:

Name	Height Mm	Elevation mm	Master Story	Similar To
Story 6	3000	18000	No	
Story 5	3000	15000	No	Story6
Story 4	3000	12000	No	Story6
Story 3	3000	9000	No	Story6
Story 2	3000	6000	No	Story6
Story1	3000	3000	No	Story6
Base	0	0	No	None

Table-1.1 – Base Reactions

			Horizontal	Vertical	Horizontal	Resultant	Rotational
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad
Max X	149	9 COMBIN	7.481	-1.425	0	7.616	0
Min X	143	5 COMBIN	-0.026	-1.558	0.052	1.559	0
Max Y	147	1 EQ X	4.987	0.064	0	4.987	0
Min Y	145	5 COMBIN	0	-2.378	0.023	2.378	0
Max Z	151	8 COMBIN	0	-0.927	6.98	7.042	0
Min Z	155	5 COMBIN	-0.026	-1.558	-0.052	1.559	0
Max rX	66	8 COMBIN	0	-0.615	2.273	2.355	0
Min rX	154	5 COMBIN	0	-2.083	-0.046	2.083	0
Max rY	141	9 COMBIN	6.479	-1.064	0.029	6.565	0
Min rY	153	9 COMBIN	6.479	-1.064	-0.029	6.565	0
Max rZ	146	5 COMBIN	-0.025	-2.117	0.027	2.117	0
Min rZ	72	9 COMBIN	2.337	-0.716	0	2.444	0

Table 1.2 – End Forces

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	16	5 COMBIN	13	1224.719	0	-1.478	0	1.028	0
Min Fx	23	1 EQ X	21	-33.596	6.434	0	0	0	18.931
Max Fy	290	5 COMBIN	126	1.81	56.219	0.017	0.191	-0.04	50.731
Min Fy	291	5 COMBIN	128	1.81	-56.219	-0.017	-0.191	-0.04	50.731
Max Fz	5	5 COMBIN	1	816.452	-19.709	19.891	-0.003	-7.533	-6.609
Min Fz	41	8 COMBIN	41	659.077	-14.566	-22.511	0.109	23.467	-4.867
Max Mx	297	8 COMBIN	139	4.159	43.072	0.515	0.411	-1.49	35.116
Min Mx	298	8 COMBIN	138	4.159	43.178	-0.515	-0.411	1.084	35.383
Max My	89	8 COMBIN	46	570.127	-11.501	-18.761	0.135	32.657	-17.134
Min My	200	7 COMBIN	108	315.161	-13.299	-17.423	0.21	-27.099	20
Max Mz	180	6 COMBIN	83	-0.181	-50.489	-0.202	-0.101	-0.566	54.67
Min Mz	264	9 COMBIN	128	110.339	16.669	12.039	-0.311	18.837	-29.886

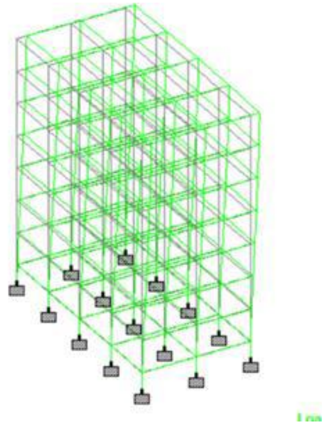

Figure 3. Relative displacement

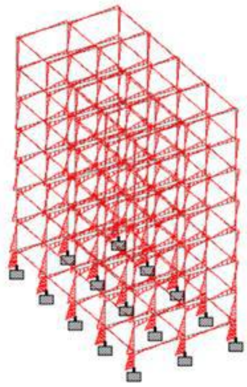

Figure 4. BMD

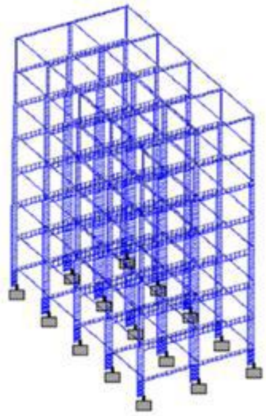

Figure 5. SFD

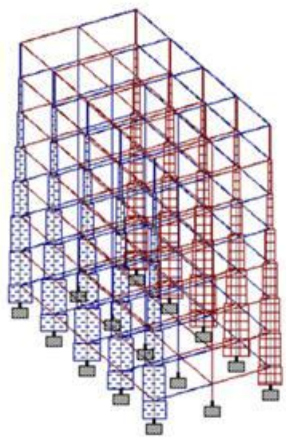

Figure 6. AXIAL

STADD PROGRAM FOR IRREGULAR BUILDING:

This STAAD.Pro model analyzes a 3D concrete structure with 155 nodes, 300 members, and various loads. The structure has a concrete strength of 27579 kN/m². Loads include dead, live, and seismic loads, with 13 load combinations. Member properties, material properties, support conditions, and load applications are defined. The model includes fixed supports at nodes 1, 2, 4, 5, 11-15, and 21-25. Analysis includes self-weight, floor weight, seismic loads in X and Z directions, and live loads. Load combinations follow ACI guidelines.

4. CONCLUSION

The design and analysis of regular and irregular shape buildings using STAAD.Pro have significant implications for structural engineering. The study's findings underscore the importance of considering shape irregularity in building design to ensure structural integrity and mitigate potential damage under seismic and wind loads. Future research should focus on addressing research gaps and exploring innovative design strategies, leveraging advancements in computational tools and sustainable materials. By integrating these insights, engineers and architects can create safer, more resilient, and efficient building designs, ultimately enhancing the built environment.

This comprehensive study on the design and analysis of regular and irregular shape buildings using STAAD.Pro has provided valuable insights into the structural behavior of complex structures. The findings underscore the critical importance of considering shape irregularity in building design to ensure structural integrity, mitigate potential damage, and enhance overall resilience.

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