RESEARCH ARTICLE OPEN ACCESS

A Comparative Analysis of Seismic Behaviours of Regular and Irregular Shaped Buildings with OMRF and SMRF Structural Systems

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Abstract

The investigation of a building's stiffness, strength, and stability is done through structural design. Building a structure that can withstand all applied loads without failing over the course of its intended life is the fundamental goal of structural analysis and design. There are several steps in the structural design process, including member design, detailing, load calculations, and many more. The traditional approach to structural analysis and design involves many laborious, time-consuming calculations and complications. These days, quick software is used to finish design and analysis tasks quickly. Residential building computer-aided design with STAAD PRO, which consists of:Making a plan for the structural framing, obtaining a model for structural analysis, the structure's design. Achieving a reasonable chance that the structures built will function well for the duration of their design life is the aim of design. They should be able to withstand all loads and deformations brought on by typical construction and use with an adequate level of safety, and they should be strong enough to withstand the effects of wind and seismic activity here we have analysed g+8 structure under base shear, nodal displacement and other aspects under SMRF and OMRF.

Key words: STAAD PRO, SHEAR, NODAL DISPLACEMENT, SESMIC RESISTANCE, SMRF AND OMRF

Introduction

An essential component of any building's design is its seismic resistance. During an earthquake, a structure that is not appropriately designed to withstand seismic forces may have disastrous results. A structural system must be able to withstand the lateral forces produced by an earthquake in order to keep the building from collapsing.

Structures' ability to withstand earthquakes is largely dependent on their structural systems. The building's intended use, the soil conditions, and the seismic zone where it is located are all taken into consideration during the structural system's design. Without significantly harming the building, the structural system should be able to transfer the lateral forces produced by an earthquake to the foundation with sufficient resistance.

The height, location, and intended use of the building are just a few of the variables that affect the structural system selection. Taller buildings, for instance, need a more robust structural system to withstand lateral forces because they are generally more susceptible to them. More robust structural systems are needed for buildings in high seismic zones than for those in low seismic zones.There exist diverse categories of structural systems, each possessing distinct attributes and benefits. The Ordinary Moment Resisting Frame (OMRF) and the Special Moment Resisting Frame (SMRF) are the two most widely utilised structural systems in seismic-resistant design.

One kind of structural frame called an OMRF is made to withstand the lateral forces produced by earthquakes. Usually, it is applied to structures with mild to moderate seismic activity. OMRFs rely on beam and column connections to withstand seismic forces and are typically designed using minimum ductility and strength criteria. OMRFs are commonly employed in structures with a low-to-moderate aspect ratio and a regular shape.

However, SMRF is a more sophisticated kind of structural frame that is made to withstand stronger earthquakes. It is usually applied to buildings in seismically active areas or areas where there is a high risk of earthquake damage.

Because SMRFs are made to be highly ductile and strong, they can flex without losing their structural integrity, minimising damage to the building. SMRFs are typically used in buildings with an irregular shape and a high aspect ratio. They work by using special connections between beams and columns to resist the seismic forces.

Many studies have been conducted on the behaviour of OMRF and SMRF systems during earthquakes. Scientists have examined the seismic performance of structures made of steel and reinforced concrete, as well as structures with a variety of shapes and materials. Additionally, they have looked into the impacts of various design parameters, including ductility requirements, height-to-width ratios, and beam-column moment ratios.

The capacity of OMRF and SMRF systems to tolerate varying degrees of seismic forces is one of their main distinctions. Compared to OMRFs, SMRFs are intended to offer a higher degree of safety and dependability during a seismic event. The cost of materials and construction, as well as the intricacy of the design and construction process, are all higher due to this increased safety.

A building's ability to withstand earthquakes is largely dependent on its structural system. During an earthquake, a building can be significantly protected by a well-designed structural system. The height, location, and intended use of the building are just a few of the variables that affect the structural system selection. To design a strong and resilient structural system for a building, one must have a thorough understanding of the seismic zone, soil conditions, and other environmental factors.

The project's goals

Numerous topics are covered in the study, including the choice of building model, material characteristics, loading and boundary conditions, and structural system analysis and design. The assessment of important factors like displacements, understory drifts, shear forces, bending moments, and axial forces are used to compare the structural behaviour.

The analysis of a G+8 building with both regular and irregular plan shapes will be the only subject of the study. According to the Indian seismic code, the two structural systems' ability to withstand seismic forces will be the basis for comparison.

This project's primary goals are to compare the seismic behaviour of buildings with regular and irregular shapes using OMRF and SMRF structural systems. The goal of the project is to find out how well these two structural systems withstand seismic forces and what influences their performance.

Following are the project's particular objectives:

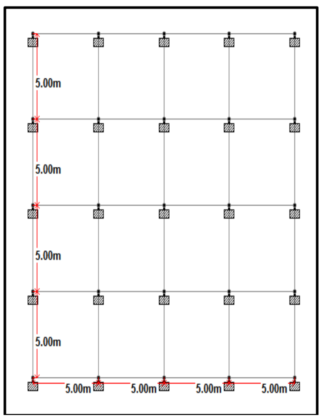
To use STAAD-Pro software to develop 3D structural models of regular and irregularly shaped buildings with OMRF and SMRF systems.
To assess the buildings' seismic behaviour through static analysis.
To evaluate the buildings' seismic performance according to different metrics, including base shear, maximum displacement, bending moment, shear force, and structural response.
To determine the building's shape, size, and irregularities; the kind and placement of the structural system; and other factors that impact the buildings' seismic performance.

Evaluation of performance: Following analysis, the building models' behaviour and structural response to seismic loads are used to assess their performance. When evaluating performance, the different attributes that were discussed in the preceding sections are taken into account.
Lastly, a comparison using OMRF and SMRF systems is made between buildings with regular and irregular shapes. The performance evaluation results are compared in order to determine each system's effectiveness and suitability for various building shapes.

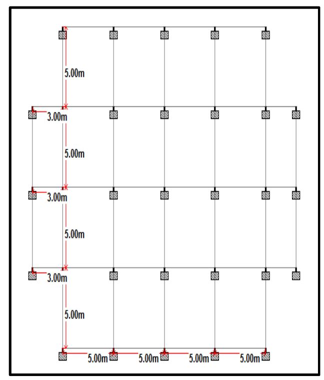
To offer suggestions for the choice of suitable structural systems by considering the buildings' seismic performance.
The project's overarching goal is to advance our knowledge and comprehension of seismically resistant building design and support the construction of stronger, safer structures in areas vulnerable to earthquakes.

Methodology

The building chosen for assessment is an eight-story structure with a ground floor, three stories of height, and a five-meter-wide bay. The building's seismic design took into account two distinct zones, zones 4 and 5, and included provisions for both ordinary moment resisting frames (OMRF) and special moment resisting frames (SMRF). Three response reduction factors for OMRF and five for SMRF were taken into account in the analysis. It was believed that the structure's support conditions would never change. A naming convention has been implemented in order to make the results easier to interpret. For example, SMRF4 refers to a structure that is designed with a special moment resisting frame for seismic zone 4.



Plan view of the Regular building



Plan view of the Irregular building

geometrical and material properties used

S.No	Design parameters	Values
1	Concrete	M 25
2	Steel	Fe 415
3	Characteristic strength of concrete Fck	25 MPa
4	Characteristic strength of steel Fy	415 MPa
5	Modulus of elasticity of steel	2e5 MPa
6	Damping ratio	5.00%
7	Slab thickness	150 mm
8	Wall thickness	230 mm
9	Story height	3 m

Loads considered for analysis

Imposed load: Live loads, commonly referred to asprobabilistic loads, are all the forces that can change during an object's typical operating cycle, excluding loads from the environment or construction. Live loads on the roof and floor are generated by labourers, tools, and materials during maintenance, as well as by movable items like planters and people throughout the structure's lifespan. The building has assumed the imposed load in accordance with IS:875(PART-2)

Dead load: Permanent or static loads are another name for dead loads. Building materials are not considered dead loads until they are permanently erected. The weights of plain concrete units (24 KN/m2) and reinforced concrete (25 KN/m2) that are made with crushed natural stone aggregate or sand and gravel can be determined, respectively. IS:875(PART-1) provides design dead load details.

Earthquake load: Determined in compliance with IS: 1893-2016, earthquake loads are horizontal loads brought on by an earthquake. Seismic forces are not critical for monolithic reinforcement concrete structures in seismic zones II and III that are not taller than five stories and have an importance factor below one.

S.No	Design Parameters	Values
1	Self-weight	As per dimensions
2	Member weight	13.8 KN/m
3	Weight of slab	3.75 KN/m^2
4	Floor finish	4 KN/m^2
5	Live Load on floor	4 KN/m^2
6	Live Load on roof	4 KN/m^2
7	Parapet wall load	2 KN/m^2

Summary

According to all above mentioned load conditions we have then tested our G+8regular and irregular structure using software STAAD-Pro under SMRF and OMRF. Tested under parameters as like base shear, nodal displacement, bending moment and shear force under different zones.

After comparing all of the data for both regular and irregular buildings, we were able to draw the conclusion that, regardless of the kind of building and seismic zone, the base shear values for SMRF are consistently lower than those for OMRF. For instance, in seismic zone 4, regular and irregular buildings using SMRF have base shear values that are 60% and 40% lower, respectively, than those using OMRF. This implies that SMRFs provide superior seismic performance compared to OMRFs.

Because irregularly shaped buildings have higher nodal displacement values than regularly shaped buildings, it is necessary to design irregular structures with greater care and attention to ensure their safety because they are more susceptible to seismic forces.

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