EFFECT OF THE LATERAL FORCE ON THE SPECIAL MOMENT RESISTING FRAME STRUCTURE IN THE VARIOUS TYPES OF SOIL TYPE ACCORDING TO IS 1893 PART-1:2016

Rishikesh Tiwari[1], Mr. Ushendra Kumar[2]

[1]Master of Technology, Civil Engineering, Lucknow Institute of Technology, Lucknow, India
[2]Head of Department, Department of Civil Engineering, Lucknow Institute of Technology, Lucknow, India

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Abstract - Throughout our research paper, we have delved into the intricacies of the Special Moment Resisting Frame of the RC Structure in varying soil conditions - namely soft soil (type-1), medium soil (type-2), and hard soil (type-3). In order to accurately assess each type of soil, we utilized RC structures with the same cross-section of beam, column, and slab made from different grades of concrete, including M25 and M30 Concrete. These structures were then placed in various types of soil in order to analyze their stability using the Time History Method through the ETABS Software. To ensure accuracy and consistency throughout our research, several Indian Standard Codes were implemented such as IS 875 Part (IS Code for Dead Load), IS 875 part-2 (IS Code for Imposed load), and IS 1893 part-1: 2016 (IS code used for Seismic Analysis). By studying three different models under various parameters - including Base Shear, period, storey overturning moment, and maximum storey displacement - we are able to gain valuable insight into the stability and resilience of the RC Structure in different types of soil.

***Key Words*:** ETABS, RC Frame, SMRF, Soft, Medium, and Hard Soil, Lateral Force.

1.HISTORY

The Reinforced Concrete (RC) frame structure emerged as a pivotal advancement in construction history, catalyzing a shift in architectural possibilities and engineering practices. Originating in the late 19th and early 20th centuries, its development intersected with the burgeoning exploration of concrete's potential as a structural material. François Coignet and Joseph Monier stand out as early pioneers, experimenting with combinations of concrete and reinforcing materials like steel. However, it was the refinement of structural systems, particularly the RC frame structure, that truly revolutionized construction methods. This innovative approach, characterized by a framework of reinforced concrete columns and beams, offered unparalleled advantages over traditional building systems. The iconic Ingalls Building in Cincinnati, completed in 1903, exemplified the transformative power of this new construction technique. Its ten stories stood as a testament to the strength, durability, and design flexibility of reinforced concrete. Throughout the 20th century, the popularity of RC frame structures soared, driven by their adaptability to various architectural styles and the ever-growing demand for urban infrastructure. Today, these structures continue to shape skylines worldwide, embodying a legacy of innovation and resilience. However, as the industry confronts sustainability challenges and seismic risks, ongoing research and innovation are essential to ensure the continued evolution of reinforced concrete construction.

Figure-01: First RC Frame Structure (Skyscraper)

2. REINFORCED CONCRETE STRUCTURE

A reinforced concrete frame structure is a versatile and robust system widely employed in construction, featuring a framework comprised of reinforced concrete columns and beams. Columns, serving as vertical load-bearing elements, transmit the structure's weight to the foundation, while beams, arranged horizontally between columns, distribute loads from floors and roofs. Reinforcement, typically steel bars embedded within the concrete, enhances its tensile strength, crucial for withstanding bending and tension forces. This combination of concrete and steel forms the primary structural elements, offering substantial compressive strength and resistance to deformation. Connections at column-beam intersections create a cohesive and rigid framework, crucial for maintaining structural integrity. These connections can be established through welding, bolting, or specialized connectors, ensuring stability and load distribution throughout the structure. Reinforced concrete frame structures are prized for their durability, adaptability, and capacity to withstand diverse environmental conditions, making them a popular choice for a wide array of construction projects, from residential buildings to towering skyscrapers.

Figure-02: RC Frame Structure

2.1. Purpose of RC Frame Structure

The reinforced concrete (RC) frame structure serves a multifaceted purpose, pivotal in modern construction endeavors. Primarily, it functions as a stalwart support system, tasked with bearing the substantial weight of buildings and infrastructure, efficiently channeling these loads downwards to the foundation. A core objective lies in its ability to evenly distribute various burdens encountered in structures, encompassing live, dead, and environmental loads, including those from seismic and wind forces. Yet, beyond mere utility, RC frame structures offer architects a canvas of design flexibility, accommodating diverse forms and layouts to realize architectural visions. Their durability stands as a testament to longevity, resisting corrosion, fire, and weathering, ensuring sustained structural integrity with minimal maintenance requirements. Paramount is the assurance of safety and stability, underpinned by meticulous design, construction, and material choices, safeguarding occupants against potential hazards. Additionally, these structures present an economically viable solution, balancing cost-effectiveness with performance metrics. Moreover, their adaptability extends beyond initial construction, facilitating retrofitting and modifications to meet evolving needs and standards, enhancing the sustainability and resilience of existing infrastructure. In essence, the RC frame structure embodies a harmonious amalgamation of strength, functionality, and versatility, underscoring its indispensable role in the built environment.

3. SPECIAL MOMENT RESISTING FRAME (SMRF) STRUCTURES

Special Moment Resisting Frame (SMRF) structures are sophisticated engineering solutions designed to withstand the formidable lateral forces encountered during seismic events, particularly in earthquake-prone regions. These structures are meticulously crafted to provide a robust defense against such forces, ensuring both the safety of occupants and the structural integrity of the building. Integral to their design is the concept of moment resistance, wherein the framework is engineered to effectively redistribute and absorb seismic energy, allowing controlled yielding and deformation while maintaining overall stability. Ductility is a hallmark feature, enabling the structure to undergo significant deformation without compromising its integrity, thereby dissipating seismic energy harmlessly. SMRFs are characterized by redundant load paths and robust connections, enhancing resilience and mitigating the risk of catastrophic failure. Compliance with stringent building codes specific to seismic regions is paramount, guiding the design and construction processes to meet rigorous safety standards. Engineers leverage advanced analytical tools and expertise in structural dynamics to optimize the performance of SMRF structures, ensuring their ability to withstand the unpredictable forces of seismic activity. In essence, SMRF structures represent a pinnacle of engineering innovation, embodying resilience, safety, and reliability in the face of seismic challenges.

4. IMPORTANCE OF LATERAL FORCE IN SMRF STRUCTURES

Lateral force plays a pivotal role in Special Moment Resisting Frame (SMRF) structures, particularly in seismic regions where the threat of earthquakes looms large. These forces, predominantly seismic in nature, pose a significant challenge to the stability and integrity of buildings. In SMRF structures, the management of lateral forces is of utmost importance, driving the design and engineering decisions to ensure the structure's resilience against seismic events. Moment resisting frames, a key feature of SMRFs, are specifically designed to counteract these lateral forces by redistributing bending moments and shearing forces throughout the structure. This capability allows SMRFs to effectively withstand the dynamic loading induced by earthquakes while maintaining structural stability. Ductility is another critical aspect, enabling the structure to undergo controlled deformation without catastrophic failure, thereby dissipating seismic energy and reducing the risk of damage. Compliance with stringent building codes tailored to seismic regions further underscores the importance of addressing lateral forces in SMRF structures, ensuring the safety and well-being of occupants. Ultimately, the meticulous consideration of lateral forces in the design and construction of SMRF structures is paramount, as it ensures their ability to withstand seismic events and provide a secure built environment for all.

5.ORDANARY MOMENT RESISTING FRAME (OMRF) STRUCTURES

Ordinary Moment Resisting Frame (OMRF) structures represent a practical yet robust solution in building construction, particularly in regions with lower seismic risk. These structures utilize moment resisting frames to provide stability, albeit with a design that is simpler and more cost-effective compared to their Special Moment Resisting Frame (SMRF) counterparts. OMRFs are tailored for areas where seismic forces are less intense, offering a moderate level of seismic resistance that meets the requirements of building codes without the need for extensive seismic provisions. While they may not withstand extreme seismic events like SMRF structures, OMRFs still ensure structural integrity and safety for occupants in regions with stable seismic conditions. Their simplified design and construction make them suitable for various applications, providing an economical and practical choice for building projects in regions with low to moderate seismic activity. Despite their reduced seismic resistance, OMRF structures must adhere to relevant building codes to guarantee compliance and ensure the safety of the built environment. In essence, OMRF structures strike a balance between structural stability, cost-effectiveness, and seismic resilience, offering a viable solution for construction projects in regions with milder seismic challenges.

6.IS 1893 PART-1:2016 AND ITS SIGNIFICANCE IN SEISMIC DESIGN

IS 1893 Part-1:2016 stands as a cornerstone in seismic design within India, providing comprehensive guidelines and criteria for ensuring the earthquake resistance of structures. This standard, titled "Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings," issued by the Bureau of Indian Standards (BIS), offers a meticulous framework encompassing seismic hazard assessment, structural analysis, design criteria, detailing requirements, and construction practices. Notably, it categorizes regions across the country into seismic zones, enabling engineers to tailor seismic design and detailing accordingly to mitigate risks effectively. Through its provisions, IS 1893 Part-1:2016 facilitates precise structural analysis techniques, such as response spectrum analysis and dynamic analysis, aiding in accurately evaluating seismic forces and structural responses. Furthermore, it underscores the significance of detailing requirements for enhancing ductility, strength, and energy dissipation capacity, crucial factors in minimizing structural damage during earthquakes. As a mandatory compliance standard for new constructions and significant renovations, IS 1893 Part-1:2016 underscores the importance of quality control measures and construction practices to ensure the effective implementation of seismic design provisions, thus fortifying structures against seismic hazards and safeguarding lives and property across India.

7.TYPE OF SOIL ACCORDING TO IS 1893 Part1:2016

According to IS 1893 Part-1:2016, the Indian Standard for seismic design of structures, soils are categorized into different types based on their seismic characteristics. These soil types are classified as per their seismic response and amplification effects during earthquakes. The classification is as follows:

7.1.Type I (Hard Soil)

This category includes hard rock and soils with a shear wave velocity greater than 760 m/s. Such soils typically exhibit minimal amplification of seismic waves and are considered to have low vulnerability to seismic shaking.

7.2.Type II (Medium Soil)

Type II soils have shear wave velocities ranging from 360 m/s to 760 m/s. They include stiff to medium stiff soils, such as gravelly soils and stiff clays. These soils may experience moderate amplification of seismic waves and are considered to have moderate vulnerability to seismic shaking.

7.3.Type III (Soft Soil)

Soft soils, including loose to medium dense sands, silty soils, and soft clays, fall under Type III classification. These soils have shear wave velocities between 180 m/s and 360 m/s. They are susceptible to significant amplification of seismic waves and are considered to have high vulnerability to seismic shaking.

8.METHODOLOGY

The methodology section of our research delves into an in-depth analysis of the Special Moment Resisting Frame. We have carefully examined and studied various aspects, including the Indian Standard Code utilized, the geometry of the building, as well as seismic parameters. By conducting a comprehensive study of these elements, we aim to gain a deeper understanding of this important framework and its significance in construction practices. Through our meticulous analysis and research, we hope to provide valuable insights and contribute to the advancement of knowledge in this field.

8.1.Indian Standard Code

The focus of our research paper was to investigate the various Indian Standard Codes that are applicable to the design and construction of structures. Specifically, we delved into the US Code 875 part-1, which pertains to the dead load of a structure, as well as the IS Code 875 part-2, which deals with imposed loads on structures. Additionally, we explored the IS code 1893 part-1:2016 in relation to seismic loads on reinforced concrete (RC) structures. Our aim was to gain a comprehensive understanding of these codes and their significance in ensuring safe and efficient structural design and construction practices in India. By examining and analyzing these codes, we hope to contribute towards improving the quality and safety standards of structures across India..

8.2.Seismic Parameter

In the section of the seismic parameter section, we have studied the all seismic parameter included in this RC Structure, these details are given below in the form of the table:

Table 1: Seismic Parameter

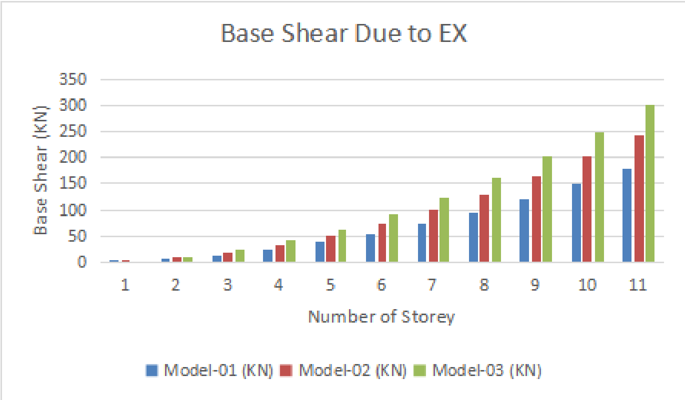
Serial Number	Seismic Parameter	Values
1	Seismic Zone	Third (Z= 0.16)
2	Importance Factor (I)	1.5
3	Response Spectrum Factor (R)	5
4	Type of Soil	Type-I, Type-ii, and Type-iii

9. RESULT AND ANALYSIS

We'll analyze the results of three ETABS models in various soil conditions. We'll use seismic data such as base shear and storey drift to study factors like natural period and maximum displacesment.

9.1.Base Shear

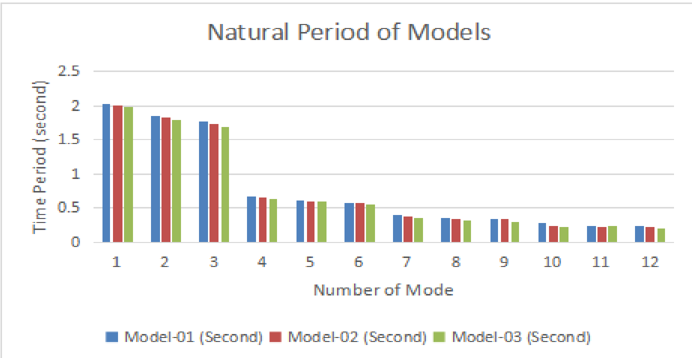
"Base shear" is the term used to describe the greatest lateral force that a structure will experience due to ground motion during an earthquake. This force is generated when seismic activity causes the ground to move, and it acts in the opposite direction of the motion. The building must be designed and constructed to withstand this base shear value, rather than intermediate values. If the lateral force exceeds the base shear, the structure may collapse.



Graph-01: Base Shear of all models due to EX.

9.2.Natural Period

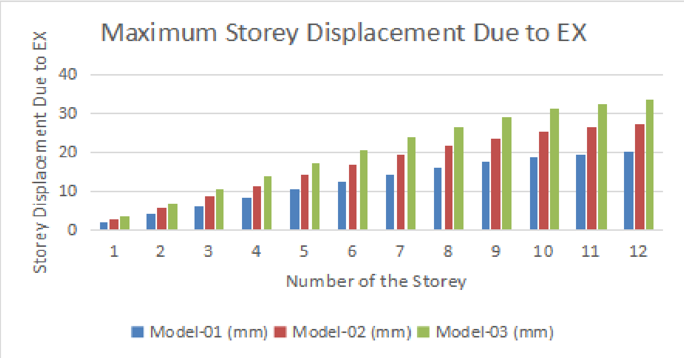
When it comes to buildings, one of the key characteristics that is always present is their fundamental natural period, denoted as T. This property can be affected by any alterations or modifications made to the structure of the building, resulting in a different value for T. It's worth noting that the range of typical structures varies greatly, from single-story buildings to towering skyscrapers reaching twenty stories high. The fundamental natural periods T for these various types of buildings can typically be found within a range of 0.05 to 2.00 seconds. To help visualize this information, a graph has been created below which displays the natural period values for all models in question.



Graph-02: Natural Period of all these models

9.3.Maximum Storey Displacement

The term "storey displacement" pertains to the movement of a storey laterally outwards from its base. This movement can be prevented by implementing a lateral force-resisting system in the building. In situations where wind loads are present, an acceptable limit for lateral displacement is H/500, although some may opt for H/400 instead. A graph depicting the maximum storey displacement resulting from load case EX (seismic force in the X-direction) for all three models is provided below.



Graph-03: Maximum Storey Displacement of these models.

10. CONCLUSION

Upon conducting an analysis of three different models based on seismic parameters, including the Base shear of the structure, maximum storey displacement, maximum storey drift, and natural period, we have come to a conclusion. Specifically, when examining the graph of the base shear of the Special Moment Resisting Frame of the RC Structure, it was found that model-03 had the highest maximum base shear. Notably, this model exists in hard type soil. Conversely, model-01 had the lowest value for base shear and is situated in soft soil. When considering the natural period graph for all three models, it was determined that model-03 had the highest maximum natural period due to its location in hard type soil. In contrast, model-02 had the lowest value for natural time as a result of its presence in soft type soil. Finally, upon reviewing the graph for maximum storey displacement and storey drift, it became apparent that model-03 exhibited the highest values for both metrics compared to model-01 and model-02.

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