Comparative Study of SMRF Structure in the Different Conditions of Soil: A Review

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Abstract - *Seismic force-resisting devices are often used in the building process of structures that are designed to withstand the effects of earthquakes. The reinforced concrete special moment frame is one example of this kind of technology. Beams, columns, and beam-column connections make up the components of moment frames. These components are proportioned and specified such that they can endure flexural, axial, and shearing movements. These processes take happen whenever a building wobbles through several displacement cycles as a result of strong ground shaking caused by an earthquake. The frame that was produced as a consequence of these particular proportioning and finishing criteria can resist the extreme shaking that is caused by an earthquake without experiencing a significant loss of stiffness or strength. Because of these extra criteria, which serve to strengthen the seismic resistance of the moment-resisting frames, we call them "Special Moment Resisting Frames." [On the other hand, Intermediate and Ordinary Moment Resisting Frames have details that aren't as meticulously detailed as Special Moment Resisting Frames do. Special Moment Resisting Frames are more specific in their attention to detail. In this review study, we assessed the Special Moment Resisting Frame as well as the Ordinary Moment Resisting Frame of the RC construction under different situations. These conditions included the important factor as well as the seismic zone, amongst other things.*

Key Words: SMRF, Hard Soil, Medium Soil, Soft Soil, Seismic Condition, Importance Factor.

1. INTRODUCTION

In the process of analyzing and designing structures, it is standard practice to assume that the foundation of the structure is immovable. However, in practice, the supporting soil affects the structural reaction. This occurs because the supporting soil has the inherent tendency to deform, which permits movement to some degree. This may lead to structural issues in buildings. The lessons learned from previous earthquakes, which highlighted the fact that the influence of the soil was ignored, demonstrated the necessity of taking into account the interaction between the soil and the structure in seismic analysis. This requirement was shown by the fact that previous earthquakes highlighted the fact that the influence of the soil was ignored. The reaction of the soil affects the motion of the structure, and the action of the structure affects the reaction of the soil. This process is referred to as the "interaction of soil and structure." Both of these mutually beneficial partnerships are examples of what are known as feedback loops (SSI). The designer can conduct an accurate analysis of the genuine displacements that the soil-structure system experiences in response to seismic motion if interaction effects between the soil and the structure are used. The seismic response of structures as a consequence of the effect of soil flexibility is reliant not only on the property of the soil but also on the property of the structure. This is because soil flexibility may cause buildings to move as a result of earthquakes.

When it comes to the construction of buildings to withstand earthquakes, the consequences of soil flexibility are often overlooked in almost all situations. In their research, Mylonakis et al. [1] and Roy and Dutta [2, 3] revealed the potential severity of the repercussions that may result from disregarding the effects of the SSI. These repercussions may come about as a result of ignoring the effects of the SSI. Tabatabaiefar et al. [4] showed a similar study on the implication of neglecting the SSI in ensuring structural safety by conventional elastic and inelastic design procedures of moment-resisting building frames. This study focused on the implication of neglecting the SSI in ensuring structural safety. The significance of ignoring the SSI in the design of moment-resistant building frames was the primary focus of this research. Both Bielak [5] and Stewart et al. [6, 7] provided evidence of the effect of soil flexibility creating a lengthening of the lateral natural period in structures as a result of a decrease in lateral stiffness. This effect was seen and recorded. The decrease in lateral stiffness was the primary contributor to this outcome. They discovered that extending the duration of the lateral natural period altered the seismic responses of the buildings, which made it a crucial issue from the perspective of design issues.

To demonstrate the significance of lengthening the natural period in the seismic behavior of structures, Bhattacharya and Dutta [8] researched lowrise buildings with a fundamental lateral period in the short period region of the design response spectrum. These buildings had a fundamental lateral period in the short period region of the design response spectrum. How they presented their results was in the form of a design response spectrum. The research was carried out by Saad and colleagues [9] to study the impact that soil-structure interaction has on the base shear, inter-storey shears, and moments of reinforced concrete buildings that contain subterranean storeys. Tabatabaiefar and Massumi [10] used a three-dimensional finite element model to simulate the effects of soil-structure interaction on reinforced concrete moment-resisting frames. This demonstrates the significance of taking into account SSI in the seismic design of RC-MRF buildings that are higher than three and seven storeys and are located on soft soils. Specifically, the significance of this is demonstrated by the fact that Tabatabaiefar and Massumi [10] used a three-dimensional Raychowdhury [11] and demonstrated the benefits of accounting for nonlinear soil–structure interaction analyses in comparison to traditional fixed-base and elastic-base models by demonstrating a considerable decrease in the amount of force and displacement that is required. This reduction in force and displacement was one of how Raychowdhury [11] demonstrated the advantages of accounting for nonlinear soil–structure interaction analyses.

It is essential to carry out the method of estimating the natural period of vibration of the structure to ensure that structures built of reinforced concrete are conceptualized and evaluated in the most effective manner possible. This unique natural period may supply knowledge that will aid enhance understanding of the global pressures that are put on buildings when they are exposed to seismic activity. It has been shown by Goel and Chopra [12] that the times that are provided by seismic code equations are, on average, shorter than the periods that are observed. As a consequence of this, they came up with a more sophisticated formula that makes use of regression analysis to provide a stronger relationship with frame buildings. After determining the yield stiffness using several methods, Crowley and Pinho [13] utilized those methods to create analytical yield period-height equations for bare frames. These equations were then used to calculate the yield stiffness. In their evaluation of the existing reinforced concrete structures, Crowley and Pinho [14] were sure to take into consideration the existence of infill panels. They found that the uncracked yield period that was predicted using eigenvalue analysis for existing reinforced concrete structures of different heights was longer than the simplified period height equation. This was the case even when the height of the buildings varied.

1.1. SMRF and OMRF

IS 1893 (Part 1), 2002 outlines the criteria that must be followed when designing buildings to withstand earthquakes. The first section provides information on the general provisions and structures. Ordinary Moment Resisting Frames (OMRF) and Special Moment Resisting Frames (SMRF) are the two categories that RC frame structures fall under when categorized by the Bureau of Indian Standards (BIS). These two kinds have response reduction factors of 3 and 5, respectively. If the building is to maintain its elasticity while reacting to the shaking caused by the Design Basis Earthquake (DBE), then it has to be scaled down to acquire the lateral force response that was designed for it. The reduction factor, denoted by the letter R, is the factor that determines how the actual base shears are formed.

Ductility: The degree of entire structural behavior was used to calculate the needed ductility, whereas the available ductility was derived via the study of the local behavior of individual nodes (joint panels, connections, or member ends). In most cases, the process of verifying the ductility of columns is difficult to do. To accomplish a global mechanism using SMRF structures, the column sections are made larger. This additional strength of the column will result in a reduction in the possible ductility of the columns. It's possible that the building won't have enough ductility to prevent a collapse when it happens. It was discovered that the parameters related to seismic activities, such as velocity and cyclic loads, decrease the available ductility of the material. The ability of columns to undergo deformation may be described in a few different ways, the most common of which are curvature ductility, displacement ductility, and drift.

Earthquake Design Philosophy: In the case of an earthquake, the magnitude of ground shaking that occurs at any given site is dependent on the magnitude of the quake itself, which may be classified as mild, moderate, or significant. Constructing a building that is strong enough to withstand even the most severe shaking caused by an earthquake is the goal of structural designers and engineers. It is very uncommon to observe, and it may only take place once per 500 or 1000 years on average. Therefore, the issue that emerges is whether or not we need to construct the structures to be earthquake-proof or earthquake-resistant. Because of this, the standard procedure is to strengthen buildings so that they can withstand earthquakes. In the case of an earthquake, these buildings could sustain some damage but would not be brought down completely. Therefore, the protection of persons and goods is of the utmost significance; this may be accomplished with a lower financial outlay when compared to the construction of earthquake-resistant buildings.

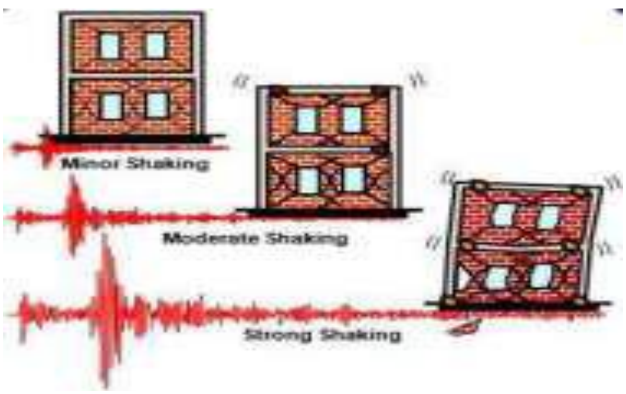

Figure- 1: Effect on buildings due to ground shaking

2. LITERATURE REVIEW

In this review paper, we have studied the special moment resisting frame of the RC structure at different parameters such as the different important factors, seismic zone, etc. The summary of each research paper is given below:

Mukesh, Paliwal: OMRF braced, which is also known as ordinary moment resisting frame bracing at the lintel level, and SMRF, which is also known as special moment resisting frame, were analyzed in this study with all seismic zones while taking into consideration a variety of regular and irregular constructions. Both of these types of bracing were used at the lintel level. With the use of analytical data, one may arrive at several significant conclusions, some of which are listed below: It was found that buildings with an irregular plaza had the highest amount of bending moment, whilst structures with a standard bare frame had the lowest amount of bending moment. The seismic activity in a region is increasing in intensity, which in turn causes an increase in the rate at which the bending moment is rising. The ordinary moment-resistant braced type frame is less effective than the special moment-resisting frame (SMRF), which is more effective because it minimizes moments, which implies that it reduces the area of steel. The SMRF is also more effective than the ordinary moment-resistant braced type frame. It became abundantly clear to me as I was analyzing the nature of the graph that was found to be the same in all seismic zones that a bare frame is the best option, stepped is the second best option, and plaza construction is essential. This realization came about as I was determining the nature of the graph that was found to be the same in all seismic zones. When compared to OMRF structures, SMRF ones provide greater degrees of information in their respective diagrams.

Prakash, Sanjay: The following is the inference that may be made in light of the results of our investigation: According to the findings of RSA, the tale shear power was regarded to be at its peak position for the first story, and then it steadily reduced until it reached its lowest point in the popular narrative. This was the case for all three stories. According to the findings of RSA, mass sporadic structure outlines seem to be capable of comprehending bigger base shear than corresponding standard structure outlines can. This is the case. The aftereffects of RSM showed that the control structure had more base shear, but the unexpected firmness structure had less base shear. Additionally, the unexpected firmness structure had bigger entomb story floats. The most significant relocations obtained from the time history examination of mathematics sporadic working at particular hubs were seen as more significant than that if there should happen to be an occurrence of ordinary structure for upper stories, but gradually, as we move to lower stories, relocations in both structures would in general combine. This is because upper levels in a geometrically uncertain design have a lower rigidity (as a result of the L shape) than lower stories do. The reason for this is as follows: When the difficulty is lowered, a greater number of tales are removed from the top spot in the rankings.

Anupam et.al: Following an investigation of the structure and a comparison of the findings with those acquired from earlier investigations, the following conclusions were arrived at: When the structure in question is an OMRF, the axial load that is placed on column C1, also known as the column that is situated at the corner, is significantly reduced when compared with the axial load that is placed on an SMRF. In both architectures, the axial load is distributed in the same manner across column C2 in both sets of components. The OMRF system's maximum shear force on the floor beam is about 20–25 percent lower than the SMRF system's maximum shear force on the floor beam. The SMRF system has between 15 and 20 percent less torsion in its structure when compared to the OMRF system. In an SMRF system, the bending moment that is carried by each floor is 25–30% lower when compared to an OMRF system. OMRF systems are more common. When compared to the drift that is caused by the OMRF system, the drift that is caused by the SMRF system is approximately forty percent less significant. The lateral force that is distributed on each floor does so in a linear fashion, and the SMRF system displays a lower level of attraction of lateral force. This is because the lateral force is distributed linearly. When compared to the OMRF system, the base shear of the SMRF system is 40 percent less than that of the OMRF system.

Sarafraz et al: Combined footing shows 23% fewer occurrences of uneven pressures as compared to Pad form footing, which results in rectangle footing. This difference is because of rectangle footing. In the chapter that came before this one, it was made clear that Pad form footing distributes the highest amount of axial force compared to other scenarios, while Combined footing displays the least amount of this force. Combined footing also shows the least amount of this force. When compared to the other types of footing, it is clear to observe that combined footing gives the greatest support response possible; this is visible. A combined footing is considered to be the finest and most suitable alternative for this distribution of weight since the reaction of the support reveals the degree to which it distributes weight to the soil. The value of deflection is demonstrated to be at its largest when it happens in a pad, but it is shown to be at its lowest when it occurs in a circumstance with an oval shape. Therefore, one can state that the amount of deflection that will occur as a consequence of this condition will be little, and the oval shape will be the one that comes in as the runner-up in terms of its prominence. The footing deflection in an oval shape is rather minor, coming in at around 13% total. It has been determined that combined footing results in the most cost-effective type of footing for the same conditions, whereas circular footing is more expensive and, in comparison, more challenging to construct. This discovery was made as quantity estimation is carried out and rate analysis is performed following S.O.R.

Dongare, Kulkarni: To determine the response reduction factor for each of the 10 distinct types of RC structures, a non-linear static analysis is used. The Response Reduction Factors that were gained are studied further and compared with many different structural aspects of the buildings. After performing the necessary analyses and making appropriate interpretations of the obtained data, the following are some of the conclusions that may be derived from the study: Structures that do not have floating columns have a base shear value that is greater than the base shear value of structures that do have floating columns. Bringing the floating column up to the top floor of the building causes an increase in the base shear of the structure as a whole. However, this impact is contingent on the kinds of soil conditions that are present, and a building that has a floating column at the ground level can only be constructed in circumstances with a maximum of medium soil rather than conditions with hard soil conditions. When compared to the displacement of the structure that does not have the floating column, the displacement of the structure that does have the floating column is just slightly higher. Both OMRF and SMRF have a value that is lower when conditions of hard soil are present compared to when conditions of medium soil are present. This is indeed the situation. The value of the response reduction factor, designated by the letter R, is lower for a structure that has a floating column than it is for a structure that does not have such a column. This difference may be seen by comparing the two structures' response reduction factor values. When compared to the R-values of the floating column on the upper levels, which are much greater, the value on the ground level is significantly lower. Both OMRF and SMRF have an R-value that is greater for the condition of hard soil in comparison to the R-value that is found for the condition of medium soil.

Abhishek et.al: The following are some conclusions that can be derived from all of the analysis that was done above when the soil conditions are altered but all of the seismic parameters stay the same. This analysis was done before the soil conditions were modified. It has been discovered that the base shear value of the soft soil is found to be much greater when compared to both the soft soil and the hard soil. The tale drift value in soft soil is observed to be much greater when compared to both soft soil and hard soil. Therefore, the value of storey displacement is at its largest for model M1 with soft soil, and it is at its lowest for model M2 with hard soil. This is because the value of storey displacement grows as the stiffness property of the soil stratum falls. This is because the value of storey displacement rises as the stiffness property of the soil stratum diminishes. The reason for this is because of the relationship between the two. This is because the value of storey displacement grows as the stiffness of the storeys diminishes, which is the reason why this is the case.

S. M. Dhawade: Isolation of the base is an extremely promising new approach that has the potential to protect a variety of structures from the consequences of seismic excitation. These structures include buildings, bridges, airport terminals, nuclear power plants, and other kinds of infrastructure. The base-isolated model has a much less level of variation in the maximum displacement of its tales when compared to the fixed base model. It has been observed that the variation in the maximum displacement of stories will become a great deal more important as the number of stories included inside the structure rises. The fact that base isolation results in the superstructure having a stiff movement is one of the most important aspects of this feature. This in turn demonstrates that the relative story displacement and story drift of structural elements will decrease, which in turn will result in a reduction in the internal forces exerted by beams and columns. In turn, this will demonstrate that the relative story displacement and story drift of structural elements will decrease. The lateral weights that are being applied to the tales are being decreased, which has the effect of slowing down the accelerations that are being provided to the tales. Because of this, the total quantity of forces that are created by inertia will, in the end, be reduced. When a building is base-isolated, the lowering of the story overturning moment and the story shear both have the effect of making the superstructure that is placed above the isolation plane more rigid and stiff. The information that was supplied earlier allows one to conclude that the effectiveness of the performance of isolated buildings in areas that are prone to earthquakes may be supported by this evidence.

Abhyuday, Gupta: The seismic risk must be properly analyzed and taken into account before the construction of major and tall structures. This is something that should not even need explanation. Based on the aforementioned analytical investigation that was carried out on three separate structures, one may derive the following inferences: BSF undoubtedly provides the designers with an increased level of safety, but it also ends up being rather expensive for them to implement. According to the International Standard 1893 (IS:1893), the storey drift is permitted in all of the systems so long as it does not exceed the permitted parameters (Part 1). However, when compared to the results achieved by OMRCF, the ones obtained by SMRCF were much better. When compared to OMRCF, the quantity of steel that is produced by SMRCF is 18.5% more than what is produced by OMRCF. This is because SMRCF has a larger production capacity. On the other hand, because this has directly resulted in it, the overall quantity of storey drift in SMRCF has decreased by 66.12%. The BSF offers the best degree of protection against lateral loading that can be found elsewhere. As a direct result of this factor, the service life of this specific frame design will be far longer than any other.

The zone is becoming smaller, which indicates that the possibility of earthquakes will also grow up as a result of this change. In a scenario such as this one, a BSF or SMRF that has shear walls installed is the most suitable option. Because of the use of lateral bracing, the amount of strain that is placed on the columns of a structure that is constructed using BSF is maintained to an absolute minimum. When calculating the degree to which expenses differ from one another, the Response Reduction Factor is an essential component. Both the OMRCF and the SMRCF are the ones that have the most potential to develop storey drifts. When it comes to BSF, it has the lowest value. To further enhance the building's overall performance, construction strategies that are resistant to earthquakes, such as shear walls and base isolation, may be used in the building's design and construction.

J. Bhattacharjee: According to the findings of the aforementioned investigation, the structure is in a better state of safety when it is constructed with a Special RC Moment Resisting Frame Structure rather than an Ordinary RC Moment Resisting Frame Structure. However, in comparison to an ordinary RC moment resisting frame structure, the Special RC Moment Resisting Frame Structure calls for a greater amount of reinforcement to be installed. The more interesting fact is that the high rise building displacement value is within the permissible limit in special RC moment resisting frame structure as well as in ordinary RC moment resisting frame structure; the percentage of steel used in special moment resisting frame is high at joints due to the presence of more tie members near the joints as compared to ordinary moment resisting frame structure; and the fact that the high rise building displacement value is within the permissible limit in ordinary RC moment resisting frame structure. The results of this research make it abundantly evident that an SMRF structure with dimensions that are less than those of an OMRF structure may withstand a greater amount of lateral force. If we create the SMRF structure in zone II, rather than the OMRF structure in zone III, the SMRF structure will exhibit a less amount of displacement. A similar situation may be seen between the SMRF of zone III and the OMRF of zone IV, as well as between the SMRF of zone IV and the OMRF of zone V.

Ambika: In the case of an MRF structure, an increase in the amount of base shear and storey drift occurs as a result of an increase in the number of bays for the same storey and the same seismic zone, an increase in height for the same storey and the same seismic zone, and a change in the seismic zone from II to V for the same storey and the same bay. In seismic zones, II and III, the use of SMRF is preferable to that of OMRF from a financial perspective. Storey Drift and Base Shear are greater for MRF structures without Shear Walls than for MRF structures with Shear Walls (Dual system) for the same storey, same bays, and same seismic zone, in bare frame and frame with infill walls. This is the case regardless of whether the frame is bare or has infill walls. This is true for both bare frame construction and frame construction which includes infill walls. The MRF structure that incorporates a shear wall and is referred to as the Dual system is more cost-effective than the MRF structure that does not have a shear wall in seismic zones IV and V.

Bhavesh, Budhlani: The pushover analysis demonstrates that the curve achieved a displacement that is bigger than the displacement for the OMRF structure in both the X and Y directions. This is the case regardless of which direction is being considered. The SMRF structure may be understood in this manner. The beam-column connection in the SMRF architecture is particularly strong as a consequence of this factor. The pushover analysis indicates that the curve has obtained a displacement that is less than the intended displacement of 840mm in both the X and Y directions, resulting in a collapsed scenario. This is because the curve has acquired a displacement that is less than the planned displacement of 840mm. Therefore, renovations are required for both of the structures. In addition, the response spectrum investigation reveals that the shear at performance for both OMRF and SMRF structures is lower than the shear at the base; hence, retrofitting is required.

3. CONCLUSION

After studying the above literature review related to the special moment resisting frame of the RC Structure in different conditions, the following conclusion is that, In the traditional fixed base technique, the base shear grows as the soil's flexibility rises, but in reality, it falls due to the influence of soil and structure interaction. Compared to the traditional fixed base technique, the values of the spectrum acceleration coefficients and the base shear derived with real soil-structure interaction impact are much lower. Structures with shear walls have a greater spectral acceleration coefficient than bare-frame buildings. For structures having a shear wall at their center, it is the greatest.

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