Ductility Based Design of Reinforced Concrete Frame

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***Abstract*- The study presented here is a behavioral comparative study of OMRF(Ordinary Moment Resisting Frame) & SMRF (Special Moment Resisting Frame) on the basis of ductility. A 2x2 bay in plan and G+4 frame is modeled in SeismoStruct load of slab and walls are calculated and assigned to structure. Pushover analysis (Force Based & Displacement Based) is carried out for both OMRF & SMRF model. Obtained results are discussed here. Base shear is more for OMRF than SMRF.**

Keywords— SMRF, OMRF, Ductility, Pushover, Displacement Based Design,.

I. INTRODUCTION

Due to scarcity of land the horizontal development is get restricted and vertical development of buildings is increased. After the *Bhuj* earthquake in 2001 in Gujarat it has been made compulsory that each and every structure which may serve any function should be analysed and designed to resist earthquake forces. While designing, we have to consider strength, serviceability with economy required. Catastrophic failure of structures are observed in many earthquakes. It is a duty of an engineer to analyse and design a structure which saves human life as well as damages of structures. That is building should survive during earthquake. Hence our project aims ductility based design of RC frame. The safety and performance of reinforced concrete (RC) structures under seismic loads are critical concerns in civil engineering. Earthquakes impose dynamic and unpredictable forces on buildings, often exceeding the elastic limits of materials. To mitigate the risk of structural failure, the concept of ductility has emerged as a cornerstone in seismic design. Ductility is the ability of a structure to undergo significant deformations without loss of load-carrying capacity, enabling it to dissipate energy and avoid catastrophic collapse. Ductility-based design ensures that RC frames are capable of withstanding seismic forces by prioritizing controlled deformation and energy dissipation over rigid strength. This approach involves meticulous detailing of reinforcement, optimal material selection, and adherence to capacity design principles. By allowing specific components to yield while maintaining overall stability, ductility-based design provides a predictable and safer response to extreme events. The increasing complexity of urban infrastructure and the variability of seismic hazards necessitate continual advancements in ductility-based design methodologies. Research in this field spans experimental investigations, analytical modelling, and the development of robust design codes. Innovations such as high-performance materials and hybrid structural systems further enhance the potential for achieving superior ductility. This paper explores the principles, challenges, and advancements in ductility-based design of RC frames. By synthesizing existing knowledge and identifying gaps, it aims to contribute to the development of resilient structural systems capable of withstanding future seismic demands.

II. LITERATURE REVIEW

Paulay and Priestley (1992): Paulay and Priestley's foundational work on seismic design of RC structures emphasized the importance of ductility as a primary design consideration. They introduced the concept of capacity design, where plastic hinge regions are detailed to ensure controlled energy dissipation. Their studies formed the basis for modern seismic codes and standards.

Park and Ang (1985): This study proposed performance-based criteria for seismic design, explicitly incorporating ductility demands. Their framework balanced strength and ductility considerations, enabling the systematic design of RC frames capable of sustaining seismic loads without sudden failure.

Mander et al. (1988): Mander and colleagues conducted extensive research on confined concrete. They demonstrated how transverse reinforcement improves post-peak behaviour and enhances the deformation capacity of concrete, providing critical insights for ductile detailing in RC frames.

Xiao et al. (2006): Xiao's research explored the use of high-performance materials, such as high-strength concrete and fiber-reinforced polymers (FRP), to enhance the ductility of RC frames. Their findings highlighted the potential for advanced materials to improve both the strength and deformation capacity of structural elements.

Elnashai and Di Sarno (2008): The authors investigated alternative reinforcement layouts, including diagonal reinforcement and hybrid systems, to improve the performance of plastic hinge zones. Their work demonstrated how innovative detailing strategies could achieve superior ductility under cyclic loading.

Vecchio and Collins (1986): Vecchio and Collins developed analytical models for the nonlinear behaviour of cracked concrete. Their contributions provided a deeper understanding of the mechanisms governing ductility and informed the development of finite element tools for structural analysis.

Sezen et al. (2004): Sezen and colleagues conducted experimental shake table tests on full-scale RC frames. Their findings validated the effectiveness of ductility-focused detailing practices and provided empirical data to support design guidelines.

Post-Earthquake Assessments (e.g., 1999 Kocaeli Earthquake): Post-earthquake studies revealed the critical role of ductility in preventing structural collapse. Observations from damaged and undamaged structures underscored the importance of proper detailing and adherence to ductility principles in seismic design.

III. METHODOLOGY

A mathematical model is considered with view to understand the behavior of OMRF & SMRF. The plan, elevation, isometric view of the frame (2x2) bay and G+4 is shown in Fig.1 to 3 respectively.

The loads coming on the structure are same for both structures.

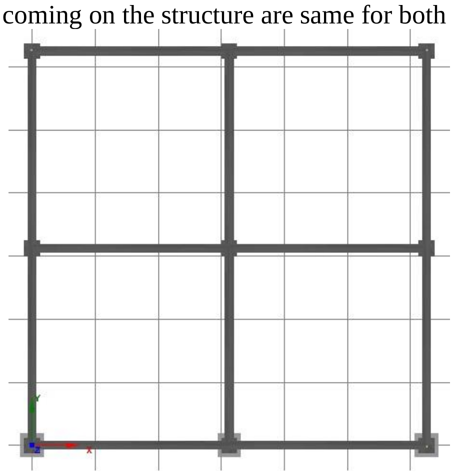

Fig. 1 Plan view of Structure

In plan, the length and width of each bay is 5m and storey height is 4m. It is a infill frame with wall thickness 150mm. Analysis is first done in ETABS for both the structures. Design of OMRF and SMRF is done as per IS 456:2000 & IS 13920:1993 respectively. Target displacement of structure is calculated using FEMA356 and again it is checked with the allowable storey drift provision given in IS1893-1:2002.

Displacement based pushover analysis is carried out on both the structures with a target displacement of 0.08m.

Force based pushover analysis is also carried out on both the structures.

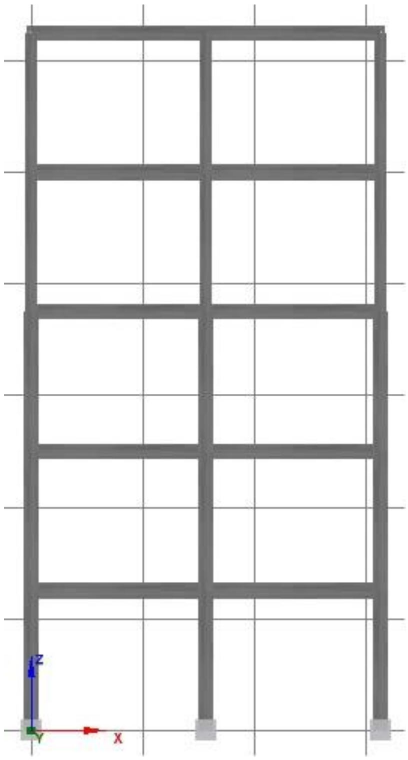

Fig. 2 Elevation View of Structure

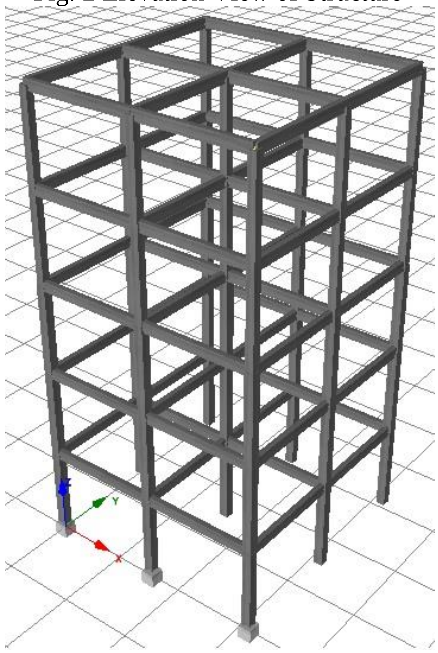

Fig. 3 Isometric view of Structure

IV. RESULT AND DISCUSSION

It is observed that base shear is less for SMRF structure than the OMRF structure.

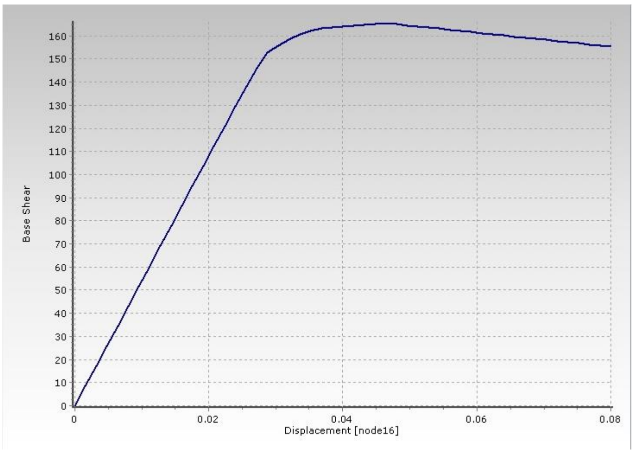

Fig. 5 Force-Displacement Curve for OMRF Frame

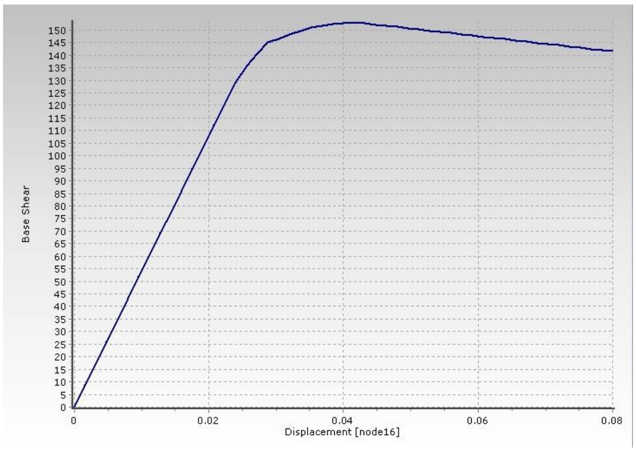

Fig. 5 Force-Displacement Curve for SMRF Frame

As it can be seen from the Force-Displacement curve for OMRF and SMRF, the yield displacements are occurred at 0.029 and 0.027 respectively for OMRF & SMRF for a target displacement of 0.08. The ductility ratio is more for SMRF structure than OMRF structure.

V. Conclusion

- Design base shear is more for SMRF structure than OMRF structure.
- As base shear is less for SMRF, the energy absorption is more. Its allows structure to undergo large inelastic deformation without significant loss of strength.
- SMRF is more ductile than OMRF.
- Ductility provides us sufficient warning in terms of large deformation before collapse of structure.
- Ductility can be achieved by providing requirements given in IS13920.
- Also its is observed that lateral drift and bending moments of beams are more for OMRF structure than SMRF.

VI. References

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