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Analytical Study of Soft Storey effect on Building with both Irregular Plan and Vertical Setback

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ABSTRACT: Soft first storey is a typical feature in the modern multi-storey constructions in urban India. Though multistoreyed buildings with soft storey floor are inherently vulnerable to collapse due to earthquake, their construction is still widespread in the developing nation like India. Setback structures are highly vulnerable during earthquakes due to its vertical geometrical and mass irregularity, but the vulnerability becomes higher if the structures also have stiffness irregularity in elevation. With the availability of fast computers and also Software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects. In this paper, seismic analysis of RCC buildings with vertical irregularity at different floor level is carried out. Further, a study is performed on a building with open ground storey and vertical Setback to highlight the importance of their presence in the seismic analysis using program in ETABs. For any meaningful research, there is ample scope to work on various Combinations for new analytical conditions. Storey drift was found to increase at levels where soft storey height was provided and inferred that Storey drift increases at this level. For Plan shape in model, C, T and H shaped were considered and C, T and H shaped plan was found to be effective respectively. For better Structural Performance combinations of Shear wall and Plan shape is the most effective solution to counter Base shear increase that occurs due to Vertical Setback and soft storey.

KEYWORDS: Soft storey, Torsion, Shear wall, Setback, Response Spectrum Method, Base Shear, Lateral storey drift, Re entrant Corner.

I. INTRODUCTION

Soft storey building plays an important role in development of multistoried buildings in India. Functional and Social requirements to provide car parking space at ground level and for offices open stories at different level of structure far out-weighs the caution and warning against such buildings from engineering Fraternity. With the availability of fast computers systems and software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects. The present work has been made to study the seismic behaviour of soft storey building with different arrangement in soft storey building when subjected to static and dynamic earthquake loading.

II. LITERATURE REVIEW

A Literature review has been carried out on various studies of buildings with Soft Storey and seismic design parameters. A review of the work is presented below.

Pavithra R and Dr T.M.Prakash (2018) have studied soft storey effects at different Locations in vertical dimension of the Structure at multiple levels. In this paper, Author has studied optimum location of soft storey over the height of the building and optimum location of multi soft storey over the height of the building. Structural member with elastic deformation during Ground motion depend on capacity of member considered. Floors with soft storey deflection seen to be increased. Open first storey deflection found to be maximum in all the cases considered for analysis. The author concludes that RC frame buildings with open first storeys are known to perform poorly during in strong earthquake



Rahul Ghosh and Rama Debbarma (2017) carried out analysis of Setback Buildings with Open storey. Setback Structures are highly vulnerable during earthquake due to vertical irregularity and mass irregularity. It is aimed to mitigate this soft storey effect and the extreme responses, three individual mitigation techniques have been adopted and the best solution among these three techniques is presented. These structures were observed for differential movement of either sides of the structure, as the taller side moves more than the shorter side along the direction of force. It is aimed to achieve ultimate performance with a poor Configuration. Combination of stiffness, geometric and elevation irregularity makes the structure highly vulnerable to Seismic forces. Differential movement of either sides of the Structure is observed. Infill wall consideration, 2.5 times Column design forces and RC filled steel tubes have been suggested to increase storey stiffness for the results analysed and studied.

Nakul Singh et al.(2017) has given a review of retrofitting methods for structurally deficient buildings. Buildings with soft storeys need special arrangement to avoid stresses in concrete Columns. These retrofit methods planned to avoid Local such as shear and reinforcement detailing and Global deficiencies such as Plan and Vertical irregularities. Column jacketing, Steel jacketing and FRP sheet wrapping are suggested methods to strengthen soft storey heights. Soft stories are subjected to larger lateral loads during earthquakes and under lateral loading. This lateral force cannot be well distributed along the height of structure. This situation causes the lateral forces to concentrate on the storey having large displacement. Its aim is to evolve strategies to assess the seismic susceptibility of reinforced concrete (RC) G+4 storeyed, dormitory buildings, located in Jaipur and to suggest retrofit measures for the structurally deficient buildings.

Sagar P. Jain, and Dr. M. N. Bajad (2017) carried out model analysis for buildings with set back with different heights considering different Seismic Zones. It highlights the effect of vertical irregularity on-base shear carrying capacity of a structure, time period, story displacement and drift under the severe zone of India. Subsequent floors in building step back towards the hill slope, resulting in unequal column height at a particular story causing stiffness irregularity in both directions. Model with Shear wall provision shows less storey displacement. Taller side behaves more flexible than shorter Face. . Drift in building frames may be results of flexural and shear mode contributions, due to the column axial deformations. In the medium to high rise structures, the higher axial forces and deformations in the columns, and the accumulation of their effects over a greater height cause the flexural component of displacement to become dominant. the main objective of this paper is focused on the behavior of RC frame building on plain and sloping terrain under response spectra analysis.

III. METHODOLOGY

In this study, a comparative seismic analysis is done for multi-storeyed building of 20 storeys models with irregular plan and vertical setback. The result of this analysis will include base shear, lateral drift and displacement and finalise structural system depending on their analytical results. 1. In present research we have used two model of Multi-Storeyed Building having irregular plan, soft storey with and without vertical setback .2. Model the structure in E-TABS 3. Seismic analysis is done as per IS1893-2016. 4. Running the model in E-TABS. 5. Obtaining seismic parameters like base shear, lateral drift and displacement. 5. Observation and comparison of result. 6. Conclusion

IV. STRUCTURAL MODELLING

Modeling of frame structure-

Modeling of structure is done in standard software ETAB which is based on finite element method. the space frame of multi-storey building is prepared considering special moment resisting frame. Column base are assigned as fixed support, column and beam are model as line element, slab and shear wall are area section but are assigned as membrane.

1. G+25 storeyed building with Column and Beam Framing System have been modeled .
2. G+25 storeyed building with Column ,Shear wall and Beam Framing System have been modeled .
3. G+25 storeyed building having C shaped Plan with Column ,Shear wall and Beam Framing System have been modeled .
4. G+25 storeyed building having T shaped Plan with Column ,Shear wall and Beam Framing System have been modeled.
5. G+25 storeyed building having H shaped Plan with Column ,Shear wall and Beam Framing System have been modeled .

V. PRELIMINARY DATA

Following are the data assumed for carrying out this study,
Five Models with 25 Storey..Floor Height: 3.0 m and Ground Floor Height: 5 m
Concrete Grade: M45.Seismic Zone: IV as per IS 1893:2016(Part1)
Response Reduction Factor: 4
Importance Factor: 1.2

VI MODELS

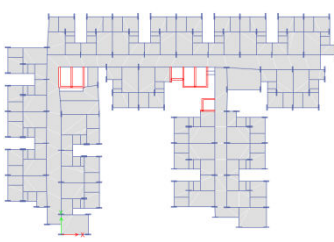


Fig 1: Model M1 Plan

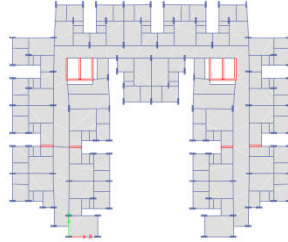


Fig 2: Model M2 Plan

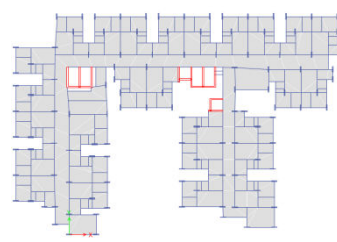


Fig 3: Model M3 Plan

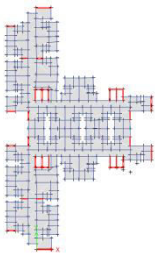


Fig 4: Model M4 Plan

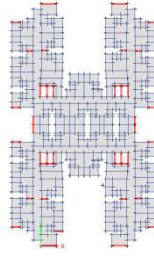


Fig 5: Model M5 Plan

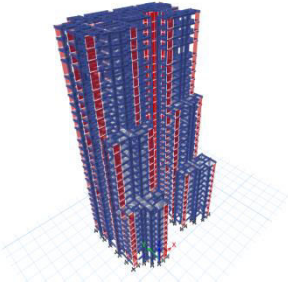


Fig 6: Model M1 3D View

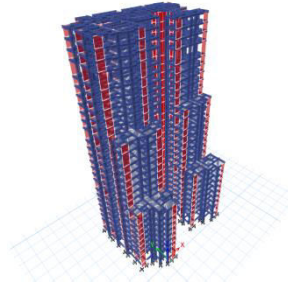


Fig 7: Model M2 3D View

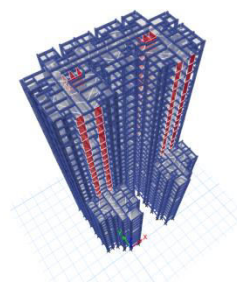


Fig 8: Model M3 3D View

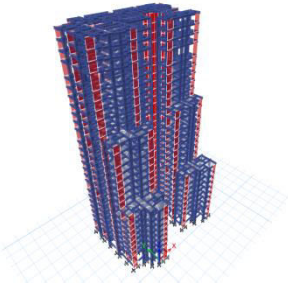


Fig 9: Model M4 3D View

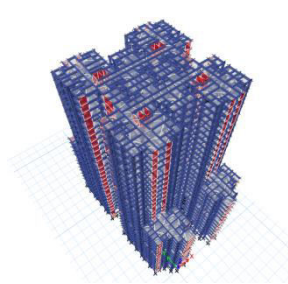


Fig 10: Model M5 3D View



VII. RESULTS AND DISCUSSION

Following observations were made after the analysis of the models and results obtained thereafter.

It was observed that Vertical setback, Plan Shape and soft storey has considerable effect on performance of the structure. It was observed that stiffness of the building is effected by the storey at which vertical setback and Soft storey is provided along the height of Building. Base shear reduction upto 35% is obtained by providing Shear walls compared to Columns in a Plan Layout. It was seen that for increase in Floor heights, Location of Soft storey and Setback causes G+15 Building to have 10 to 25 % higher base shear than G+25 building which means higher stiffness for less Floors. For Plan shape in model, C, T and H shaped were considered and C, T and H shaped plan was found to be effective respectively.

VIII. CONCLUSIONS

As by reviewing literature it can be concluded that Seismic effect of soft storey on Multi storeyed building has a major effect on behaviour. In this paper, an attempt has been made to highlight the importance of irregular layout, soft storey and setback in elevation which are architectural and space constraints that need to be addressed by design engineers. In such a situation, an investigation has been made to study the seismic behaviour of such building and develop guideline to minimise risk in such type of building. It can be concluded that analysis of multi-storeyed building has given an understanding of seismic behaviour which will be helpful to further research work.

Following conclusions are made from the study and results studied for all Models.

1. Provision of Shear wall at effective Locations can help increase Building stiffness and reduce Base Shear for a Structure. Shear wall Placement is important in irregular Plan layouts.
2. It can be inferred that Base Shear Reduction is significantly affected by level at which soft storey height and Vertical Setback occurs in a Structure. Base Shear increases by 10% to 25% for such cases depending on storey levels.
3. Comparing the results of C, T and H shaped Layout, Plan Layout in H shape is most effective to resist Lateral forces with more Base shear with similar Floor levels.
4. Structure with Soft storey and Setback must be provided with Shear walls at available locations to reduce Base Shear by significant amount as observed from the results in Model with no Vertical Irregularity.
5. Finally, for better Structural Performance combinations of Shear wall and Plan shape is the most effective solution to counter Base shear increase that occurs due to Vertical Setback and soft storey.

IX. FUTURE SCOPE

For any meaningful research, there is ample scope to work on various Combinations for new analytical conditions. The Research area has innumerable options to look into various avenues that can still be studied in details.

- Seismic Zones conditions can be taken for further studies.
- Different Soil conditions can be considered for further study.
- Multi storey Building with more storey can be considered.
- Floor Loads can be changed for further working on plans.
- Long shear walls with openings can be considered for study.
- Various Soft storey levels and Setback levels can be further studied.
- Various Load combinations can be used.

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