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A Performance Seismic Study of Different Structural Systems in Mass Irregular Building Using Time History Analysis

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ABSTRACT
This project is concerned with the performance of 40 storey vertically irregular buildings under lateral load with different structural systems such as rigid frame, core and outrigger structural systems at seismic zone V on soft soil. In present work mass irregularity is considered,mass irregularity is the presence of heavy mass on Certain floors of a building. In this case, additional mass is imposed to 5^{th}, 15^{th} and 25^{th} Storey. Analysis has been carried out by using ETAB's software as per IS 1893 (part 1) :2016. Different parameters like top Storey displacement, time period and Base shear are considered to check the efficiency of the different structural systems such as core and outrigger system under varying height at seismic zones V.

Keywords: Mass irregularity, rigid frame, core, outrigger structural system, time history analysis (THA).

I. INTRODUCTION

Earthquakes are the most unforeseeable and devastating of all-natural calamities, which makes it challenging to protect our lives and engineering properties, against it. More often structural damages occur when the dynamic load that is earthquake and wind load act simultaneously on the building. Now a days, to a great extent, all structures are constructed with architectural significance; thus,it is necessary to introduce irregularities in real structures for aesthetic, functional and economic constraints.

In comparison to irregular structure, buildings with regular geometry and evenly distributed mass and stiffness in plan as well as in elevation sustain substantially less damage. As a result,extensive study is needed to achieve excellent performance even with a subpar design. The vertical irregularities are one of the main reasons of failure of building structures during seismic action. So, effect of the vertical irregularity should be evaluated.

LATERAL LOAD RESISTING SYSTEM

A lateral load resisting system is offered to withstand wind load and earthquake loads. Due to the passage of time and needs of the structure, these systems have evolved. It has been found that design of multi storey building is influenced by lateral loads, so every structural engineer should make sure to install an effectivesystem for resisting lateral loads. Lateral load resisting systems such as shear wall, bundle tube, frame tube, diagrid, outrigger etc, which are used according to the load acting on it and type and height of the building. These systems decrease lateral force generated by wind and earthquake loads and also increase the stiffness of the structure.

NON-LINEAR DYNAMIC THA

"It is an analysis of the dynamic response of the structure at each instant of time, when its base is subjected to a specific ground motion data".In a dynamic time-history method, the calculated deformations and internal forces are considered reasonable approximation of the actual structural response during an earthquake, because the mathematical model and the methodology itself can realistically stimulate the dominant features of inelastic seismic response of the real structures. For these reasons the time history analysis can be applied virtually to any kind of structure and foundation ground. In the present work El-Centro earthquake (19-05-1940) data is considered for time history analysis.

OBJECTIVES OF THE STUDY

1. Creating 3D model of a 40-storey irregular building.
2. To evaluate these models using time history method in ETABS and to perform seismic

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analysis as per IS1893 (part 1) : 2016 on rigid frame, core and outrigger structural systems.
3. The effectiveness and performance of the structural systems at various heights in seismic zone V on soft soil must be studied.
4. To investigate different parameters like top storey displacement, time period and base shear for rigid frame, core and outrigger systems.
5. In order to withstand lateral loads, the optimal structural system with critical sectional and material properties should be suggested at the desired height.
6. To study the efficiency of different structural systems.

METHODOLOGY OF THE STUDY

1 Thepresentworkisdonekeepinginviewtogettheto pstoreydisplacement,time period and baseshearinthe planforrigid frame, core and outrigger structuralsystems.
2 Assumehighersectionalandmaterialpropertyfort hebeamsandcolumnsandalsoforslabif needed.
3 Assignloadasperrelevant ISCodes.
4 Design- make sure all sections are passed and that the column's rebar percentage is below the permissible limit, whichisspecifiedasper IS456:2000.
5 Fortheselectedsectionalandmaterialpropertyther igidframe, core and outrigger structuralsystem are modelled and analysed and the top storey displacement is checked.
6 The permissible top storey displacement is H/500, where H is the building's overall height. If the rigid frame system exceeds this limit, then the necessary of new structural systems are adopted.
7 Efficiency of outrigger structural system depends on its position, so that the optimum location of outrigger system is determined if rigid frame and core system do not perform effectively.

MODEL DESCRIPTION

Propertiesofbuildingadoptedatpresentwork	
Numberofstories	40
Plan dimension	42m×42m
Storeyheight	3m
Centre to centre spacing of columns	6m
Gradeofrebar	Fe500
Gradeofconcrete	M30, M40
Columnsize(mm)	800×1000
Beamsize(mm)	500x×600
Slabthickness	150mm
Thickness of core	250mm
Outrigger beam size(mm)	400×750, 400×1000
Outrigger type	Diagonal bracing type
Floorwallload	10kN/m
Floorfinish	1.5 kN/m2
Liveloadatfloor	2 kN/m2
Parapetload	4 kN/m
Roofliveload	1.5 kN/m2
Seismic zone	V
Soiltype	Soft soil
Importancefactor	1.2
Response reduction factor	5 (SMRF)
Methodofanalysis	Time history analysis as per IS 1893-2016

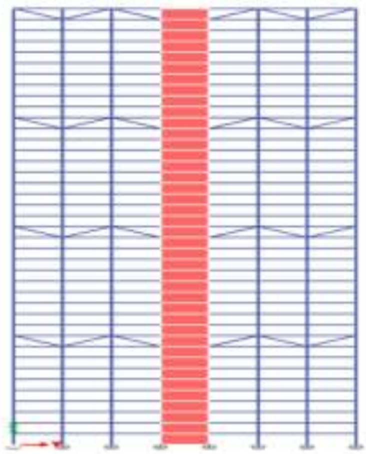

Fig. 1: Sectional view for 40 Storey with core wall and outrigger at 0.5H+0.25H+0.75H+H.

II. RESULTS AND DISCUSSION

All models are designed for load combinations as per IS 1893 (part 1): 2016.The results are presented for each of the building model considered for different structural systems like rigid frame system, core system and outrigger and belt truss under seismic zone V under soft soil. The

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results of top storey displacement, time period and base shear are discussed.

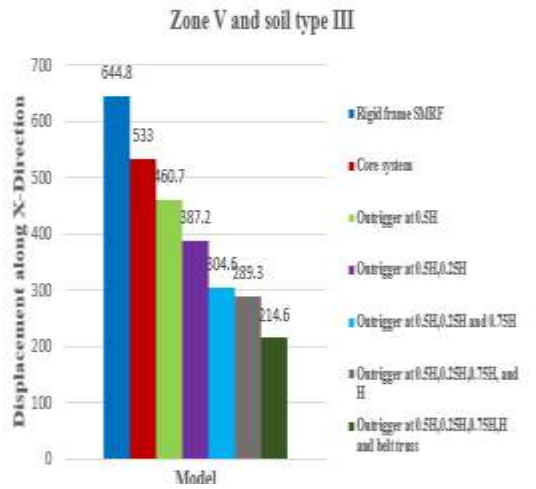

Fig.2: Displacement along X direction.

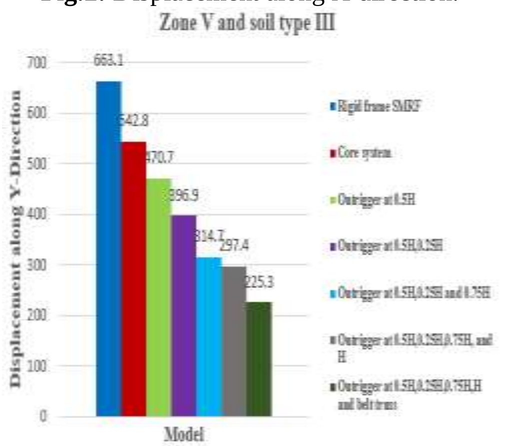

Fig.3: Displacement along Y direction**.**

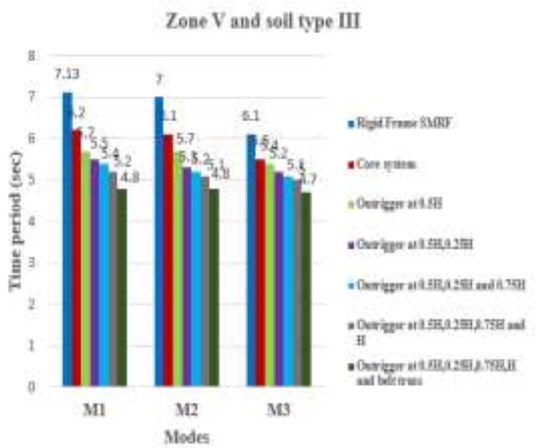

Fig 4: Time period for Modes M1, M2, M3.

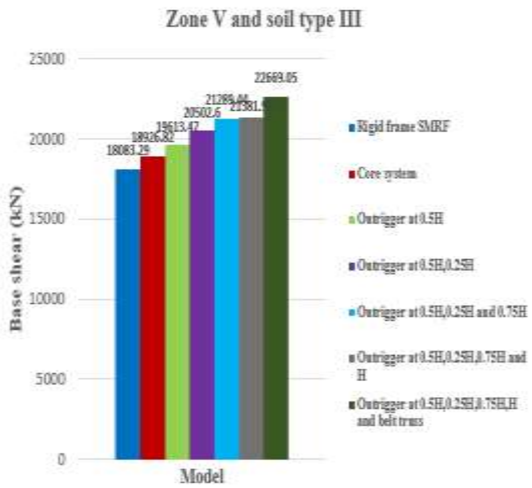

Fig 5: Base shear.

From the above figures it can be inferred that, at seismic Zone V, top storey displacement exceeds permissible limit for all structural systems, so by keeping the outrigger at 0.5H as constant, four numbers of outriggers at 0.5H+0.25H+0.75H+1H with belt truss is adopted. Hence, displacement along X and Y direction is reduced by 59.7% and 58.5% respectively. Time period is reduced by 22.58%, 21.31% and 14.54% in mode M1, M2, and M3.Base shear is increased by 19.7% when outrigger at 0.5H+0.25H+0.75H+H with belt truss is adopted.

III. CONCLUSION

1 As the mass of the building increases, overall stiffnessdecreases results in maximum displacement.
2 The introduction of different structural systems increases the overall stiffness of the building;hence displacement and time period decreases and base shear increases.
3 It is confirmed that optimum location of outrigger is at 0.5 times the height of the building when single outrigger is used.
4 The building’s efficiency is increased by the outrigger system.

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