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A Review paper of Comparative analysis of a T shaped structure considering viscous dampers with general framed structure under seismic load using analysis tool

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ABSTRACT

In this paper, the seismic performance of a 33-meter-tall, irregular T-shaped structure with viscosity dampers is examined and contrasted with a standard RCC model without dampers. The analysis is carried out in the setting of soil type III, which relates to soft soil conditions that are extremely vulnerable to seismic activity, and seismic zone V, which has a zone factor of 0.36. This study's main objectives are to assess how well viscosity dampers reduce seismic impacts on irregular structures and to examine important structural factors such base shear, story drift, overturning moment, and shear force.

KEYWORDS: Irregular building, viscosity dampers, seismic resistance, Structural analysis.

INTRODUCTION

Because of its unique cross-sectional shape, T-shaped buildings are becoming more and more common in contemporary design. Although they have significant practical and aesthetic benefits, their seismic susceptibility poses special difficulties. Torsional effects, which can greatly affect how T-shaped structures react to lateral loads like those brought on by earthquakes, are a common occurrence. Uneven stress distribution, localized damage, and equal collapse may result from these torsional effects. Many tactics have been investigated to lessen the seismic risk of T-shaped buildings. Using passive energy dissipation devices, like viscosity dampers, is one possible strategy. Viscosity dampers are mechanical devices that use viscous resistance to dissipate seismic energy. By absorbing and dispersing the energy that would otherwise be transferred to the structure, they lessen damage and the amplitude of vibrations.

TYPES OF IRREGULARITY

Plan irregularity

In architecture and building design, plan irregularity is a prevalent concept, especially for non-rectangular structures. It describes the difference between the idealized, regular shape assumed in design calculations and analyses and the actual shape of a building or its components. Plan irregularity can result from a number of things, including irregular building shapes, non-rectangular floor plans, and disturbances to the regular structural grid.

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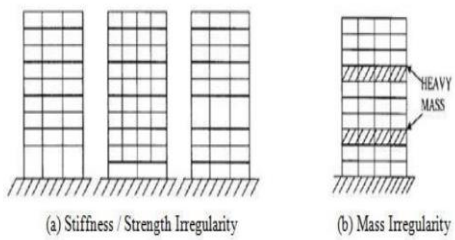

Fig. 1 Mass and stiffness irregularity

Torsional irregularity

Buildings with torsional irregularity experience irregular torsional (twisting) loads as a result of asymmetry or unpredictability in the floor plan or structural system. This may have a substantial impact on the building's overall performance, seismic resistance, and structural integrity.

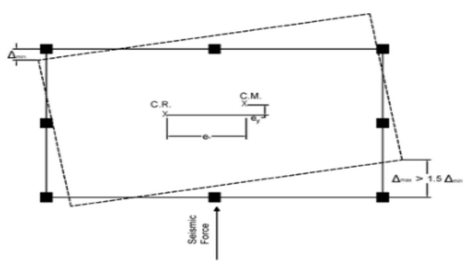

Fig. 2 Torsional irregularity

Re- entrant corner- Reentrant corner irregularity is characterized by projection dimensions in both perpendicular directions that are greater than 15% of the total plan dimensions of that building story in each direction.

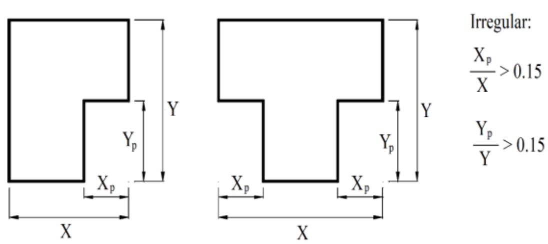

Fig. 3 Re- entrant corner

Seismic Vulnerability of T-Shaped Structures

Because of its characteristic cross-sectional shape, T-shaped structures are frequently seen in a variety of building types, such as commercial, industrial, and residential buildings. They have significant functional and architectural benefits, but their seismic susceptibility also poses special difficulties. Torsional effects introduced by the T-shape can have a major impact on a building's seismic reaction. The T-shape can cause the structure to twist or rotate when exposed to lateral loads, as those brought on by earthquakes, which could result in damage and an unequal distribution of stresses. In buildings with uneven floor plans or higher elevations, this torsional tendency can be very troublesome.

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The Role of Damping Systems in Modern Structural Engineering

Damping systems are essential to contemporary structural engineering because they improve a building's ability to withstand earthquakes and dissipate energy. These devices are made to lessen the impact of dynamic loads, including those brought on by earthquakes, and to lessen the amplitude of vibrations. Damping systems can lower the chance of damage or collapse by dispersing energy and preventing excessive structural deformations. Systems.

Impact of Architectural Design on Seismic Performance

A building's seismic performance is largely determined by its architectural design. A structure's size, shape, and arrangement can all have a big impact on how it reacts to lateral loads like those brought on by earthquakes. Torsional effects, for instance, might be introduced by asymmetrical floor layouts or irregular geometries, increasing the likelihood of seismic damage and causing an unequal distribution of stress. Another important consideration is the distribution of mass inside a building.

LITERATURE REVIEW

Yingfei Guo et al (2024), The study investigated the potential for well-designed viscous dampers to reduce the damage that earthquakes could do to structures. A displacement-based structural seismic model was developed and conventional viscous dampers were investigated to identify potential improvements. An improved viscous damper was used and incorporated into a displacement seismic model using comparable damping expressions. Two earthquake scenarios—one common and one uncommon were selected for experimental investigation.
The study found that adding superior viscous dampers can significantly improve the seismic performance of building structures. Specifically, the enhanced viscous damper structure demonstrated reduced interstory displacement and shear forces, low structural deformation, and a 35.65% improvement in shock absorption rate.

Adnan Kiral et al (2024), A Reinforced Concrete (RC) bridge with linear and nonlinear viscous dampers at the pier tops and abutments was examined for seismic performance. Elastomer bearings (EBs) and viscous dampers (VDs) were installed on the abutments and pier tops of the Incesu Bridge in Turkey, which was chosen as the model.
When compared to a fixed connection, the results showed that the maximum bending moment in two piers was considerably decreased by adding EBs and VDs to the pier tops. However, the deck may sustain structural damage as a result of severe dampening forces. The study looked at various combinations of EBs and VDs and discovered that while it was possible to minimize bearing drifts and reduce pier shear pressures, large damping forces in the abutments increased deck shear forces. Lead Rubber Bearings (LRBs), which have a large capacity for horizontal motions and energy dissipation, were suggested as a solution to this problem. Overall, the findings indicate that a system with EBs and linear viscous dampers (LVDs) is better; nevertheless, excessive damping forces should be avoided to prevent damage to the deck.

Mohammad Reza Arefi et al (2023), Descriptive methods were used to examine how well viscous dampers mitigate seismic vibrations. The library technique and previous studies on viscous dampers and how they affect external excitation control were used in this investigation. Structures were modeled using ETABS software, and seismic analysis was done using nonlinear dynamic analysis. The results showed that by lowering displacement, velocity, base shear, and acceleration, viscous dampers greatly enhanced seismic characteristics. It has been discovered that viscous fluid dampers improve structural performance and strength during strong earthquakes, which makes them appropriate for recently built buildings. At a 90% confidence level, the study found that a passive viscous damper significantly reduced seismic response.

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Furthermore, at an 80% confidence level, it was demonstrated that the nonlinear behavior of components employing dampers significantly reduced structural energy hysteresis. According to the findings, an Elastomeric Base Isolator (EBF) with a short joint had a lateral resistance that was 4/5 to 9 times greater than that of a Metallic Rubber Frame (MRF). It was discovered that the behavior coefficient of a fifteen-story EBF ranged from 6/5 to 7/75, and that the bray's length had no effect on these frames' behavior coefficient.

METHODOLOGY

Step 1: Initialization of the model which is focused towards analyzing multi storey high rise structures considering seismic loads with same seismic zones and soil condition.
Step 2: In order to initiate the modelling of the case study, firstly their's need to initialize the structural model on the basis of defining display units on metric SI in region India as ETABS supports the building codes of different nations.

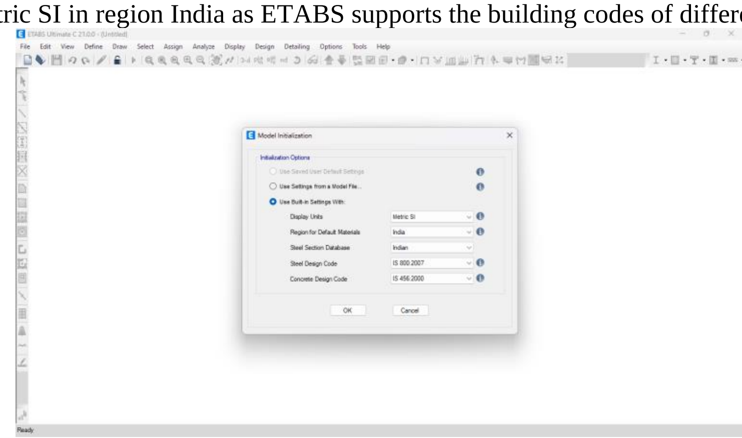

Fig 4 Model initialization

Step 3: ETABS provides the option of modelling the structure with an easy option of Quick Template where the grids can be defined in X, Y and Z direction. Here in this case, we are considering 33m long T-Shaped Building. G+10 storey structure is considered with typical storey height of 3 m and Bottom storey height of 3 m.

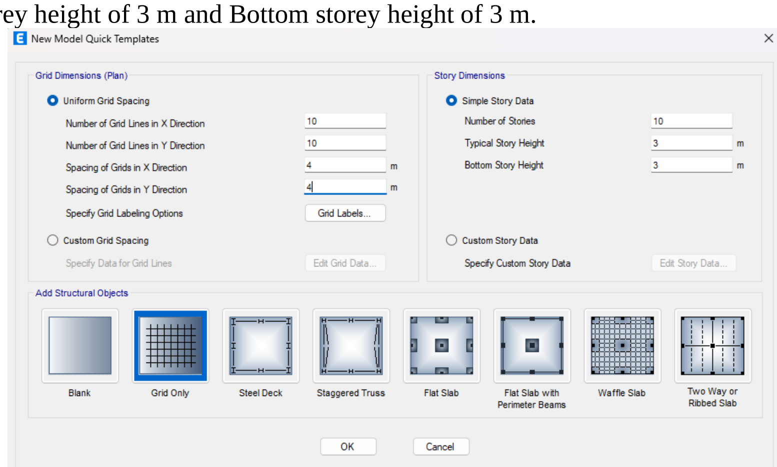

Fig 5 New Model Quick Template

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Step 4: Next step is to define the material properties of concrete and steel. Here in this case study, M30 concrete is considered and its predefined properties are available in the ETABS application.

Step 5: Defining section properties for Beam, Column. Beam size of 300x500mm, Column size of 200x400mm and Slab size of 150 mm is considered in the study.

Step 6: Assigning Fixed Support at bottom of the structure in X, Y and Z direction for all the considered cases.

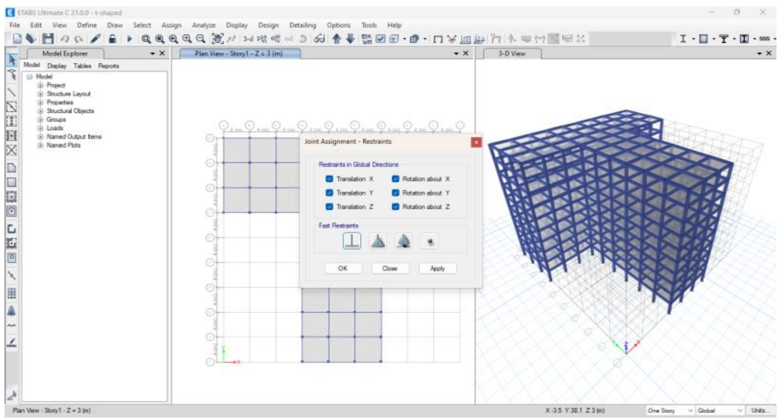

Fig 6 Assigning Fixed Support

Step 7: Defining Load cases for dead load, live load and seismic analysis for X and Y Direction.

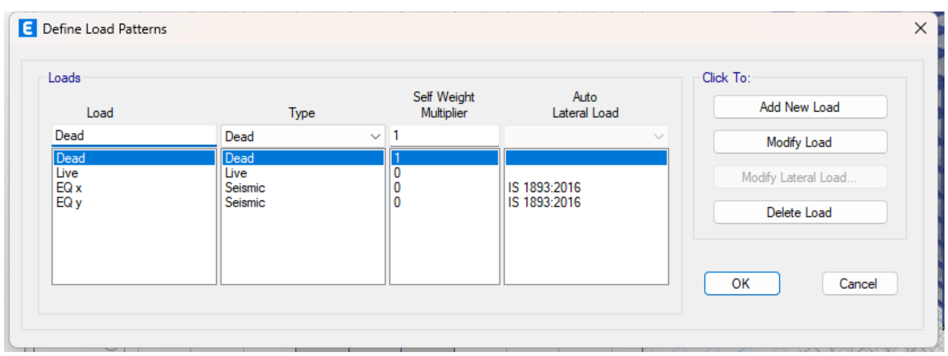

Fig 7 Defining load cases

Step 8 Defining Seismic Loading as per IS 1893: 2016 Part I.

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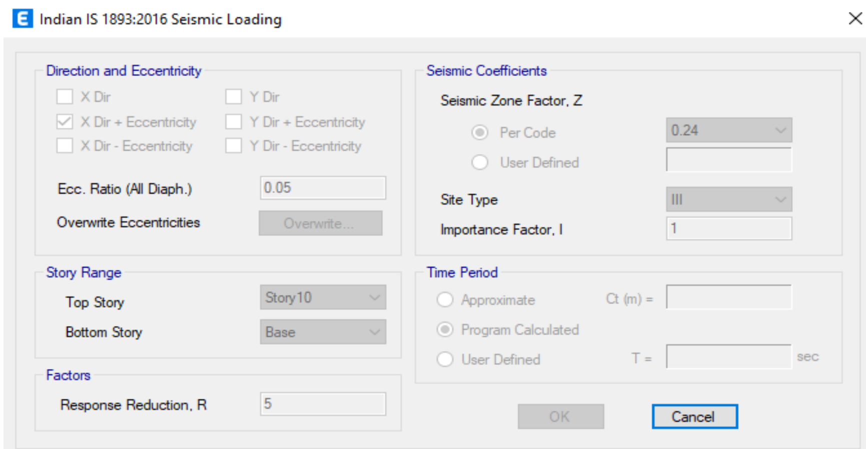

Fig 8 Seismic Loading

Step 9: Application of damper

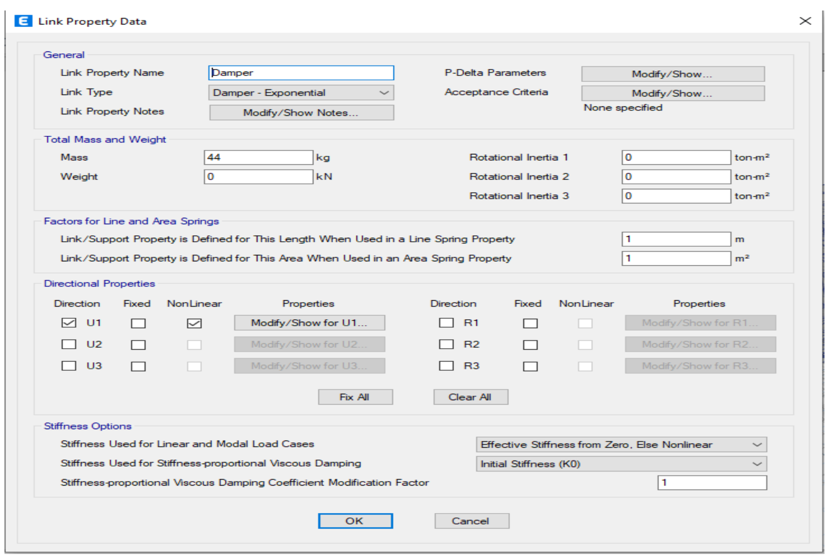

Fig 9 Damper assignment

Step 10: Conducting the model check for both the cases in ETABS.

Step 11: Analyzing the structure for dead load, stress analysis and displacement.

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PROBLEM IDENTIFICATION

Geometrical data

Table 4.1 Geometrical Specifications of the Structure

Geometrical Specification	
Particulars of Item	Properties
Number of Storey	G+9
Typical Storey height	3m
Bottom Storey Height	3m
Floor Diaphragm	Rigid
Shape of the Building	T-Shaped
Beam Size	400x400mm
Beam Shape	Rectangular
Column Size	400x500mm
Column Shape	Rectangular
Slab Depth	150mm
Slab Type	Thin Shell
Grade of Concrete	M25
Coefficient of Thermal Expansion, A	0.000013 1/C
Material Name	Fe500
Coefficient of Thermal Expansion, A	0.0000117 1/C

Load Calculation

Dead Load

The dead load is considered as per IS 875-1987 (Part I-Dead loads),
Unit weight of Reinforced Concrete = 25 kN/m3
Self-weight = 1kN
Floor load=4.75

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Imposed load (LL)

Imposed load is also known as Live load. The imposed load is considered as per IS 875-1987 (Part II-Imposed loads),
Live load on slab = 3 kN/m2

Earthquake load (EL)

The earthquake load is considered as per the IS 1893-2002 (Part I). The factors considered are
Zone factor = 0.36 (Zone V)
Importance factor = 1
Response reduction factor = 1
Soil condition = soft soil
Damping = 5 %

Load Combinations

The structural systems were subjected to 6 types of load combinations as per provisions of IS 1893-2002 (Part I),

1. 1.5 DL
2. 1.5 (DL+LL)
3. 1.2 (DL + LL + EQX)
4. 1.2 (DL + LL - EQX)
5. 1.2 (DL + LL + EQY)
6. 1.2 (DL + LL - EQY)
7. 1.5 (DL + EQX)
8. 1.5 (DL - EQX)
9. 1.5 (DL + EQY)
10. 1.5 (DL - EQY)
11. (0.9DL + 1.5EQX)
12. (0.9DL - 1.5EQX)
13. (0.9DL + 1.5EQY)
14. (0.9DL - 1.5EQY)

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RESULTS & DISCUSSION

Maximum story displacement Y-direction

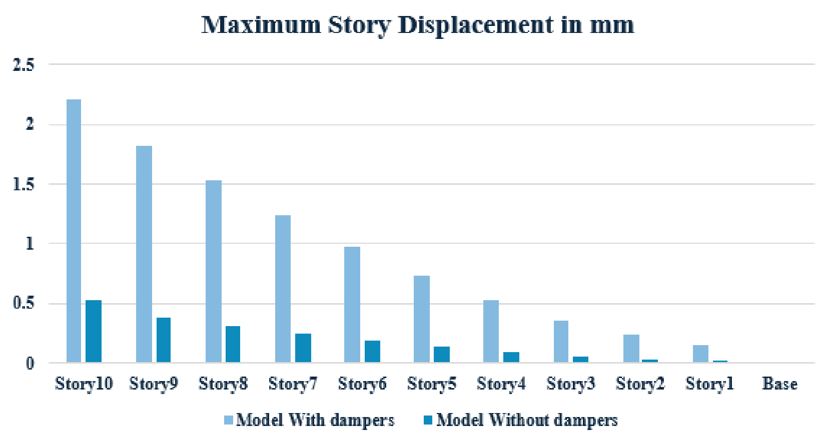

Fig 10 Maximum story displacement in mm

Story drift Y-direction

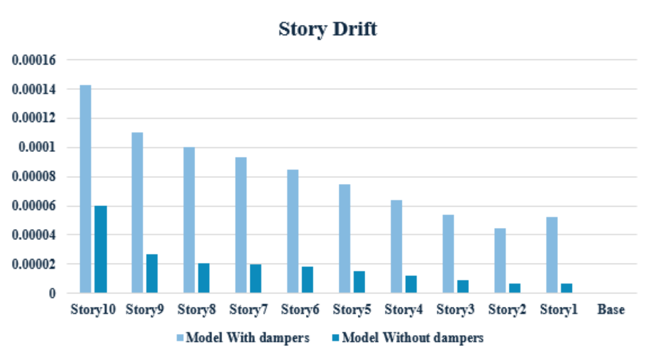

Fig 11 Story Drift

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Story shear in X-direction

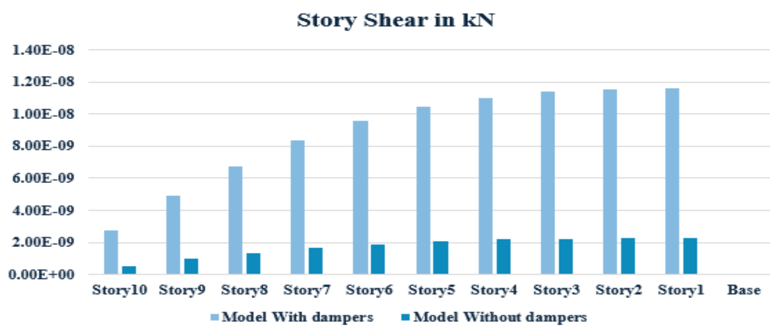

Fig 12 Story Shear in kN

Overturning moment X-direction

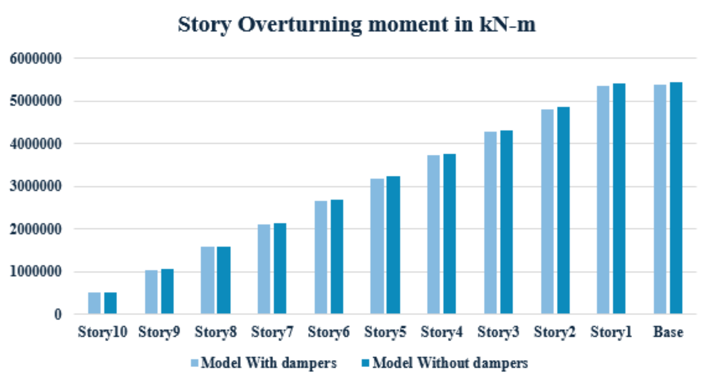

Fig 13 Overturning Moment in kN-m

CONCLUSION

- The highest story shear of Model I is 2.21 kN, which is much larger than the maximum story shear of Model II, which is 0.532 kN. This suggests that when compared to Model II, Model I undergoes significantly higher lateral forces. In comparison to Model II, Model I has a staggering 315.41% higher maximum story shear.
- The highest tale drift for Model II is.000143, much lower than the maximum story drift for Model I, which is much higher at 6.00E-05. Based on this, it can be concluded that Model I moves around a lot more laterally than Model II.The maximum story drift for Model I is 138.33% greater than that of Model II.

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- The highest story shear for Model I is 2.72E-09 kN, which is much larger than the maximum story shear for Model II, which is 5.40E-10 kN. This suggests that the lateral forces experienced by Model I are significantly higher than those of Model II. The maximum story shear of Model I is a staggering 403.70% greater than that of Model II.
- The highest narrative shear for Model I is 2118179 kN, which is much larger than the maximum story shear for Model II, which is 2140862 kN. This suggests that the lateral forces experienced by Model I are significantly higher than those of Model II. In comparison to Model II, Model I displays a maximum narrative overturning moment that is 1.06% higher.

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