SEISMIC PERFORMANCE OF SOFT STOREY BUILDING WITH DAMPERS

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Abstract - *Open floors, also known as soft floors, are a typical feature of contemporary high-rise structures in urban India. These elements are not particularly appealing in structures constructed in seismically active regions; numerous instances of intense shaking during previous earthquakes have attested to this. Open (soft) first-floor high-rise structures are nevertheless frequently built in developing nations like India, despite the fact that they are vulnerable to collapse from earthquakes. There are fewer chances to build an earthquake resistant system when there is a soft floor, either for aesthetic or business reasons. Etabs software was used to develop and analyze the plan's symmetrical flexible story structure for the current study. The structure is analyzed using both static and dynamic analytic techniques. Attached dampers are used on the structure to reduce seismic energy and boost structural integrity. Using Etabs software, the composite damper structure was modeled and assessed using the same parameters. A comparison is made between the displacement, story drift, and main shear data.*

***Key Words*: Structures, Analysis, Seismic Response, Earthquake, Viscous Damper, Wind Analysis, Etabs, Staad Pro**

1.INTRODUCTION

In the metropolis, parking has become an essential aspect of the majority of high-rise structures. In order to make parking easier, the building's first level is often open and wall-free. High-rise structures known as "soft-rises" contain large apertures that allow for parking or commercial spaces. This means that there are no partition walls (RC or construction) between the first-floor columns. According to IS-1893: 2016 (Part I), a soft floor is defined as one that has less than 80% of the average lateral strength of the three above levels or less than 70% of the upper layer. Less than 60% of the upper layer or less than 70% of the average stiffness of the three layers above characterize a very soft layer's lateral stiffness. Tall buildings are primarily affected by three types of loads: snow loads, dynamic loads (such as earthquakes, wind, explosions, collisions, etc.), and gravity (both live and dead loads). The two dead loads that most significantly influence building design are earthquake and wind loads. Depending on the time, wind loads can be separated into static and dynamic loads. Seismic loads on structures are caused by both horizontal and vertical earthquake motion. In structural members, these horizontal forces result in axial forces, bending moments, torsional moments, and shear forces. Seismic analysis is used to make sure a structure responds appropriately to seismic loads.

1.1 Dampers

An apparatus that distributes the kinetic energy of seismic waves passing through a building or other structure is called a seismic damper. During earthquakes, seismic dampers lessen the vibrations in buildings. Dampers improve the structure's strength and lessen its tendency to distort. Adhesive, viscoelastic, friction, vibration, tuned mass, performance, and magnetic dampers are some of the seismic dampers utilized in tall buildings. Types of Dampers:

1) Viscous Dampers
2) Viscoelastic Dampers
3) Friction Dampers
4) Tuned Mass Dampers
5) Yielding Dampers
6) Magnetic Dampers

Figure 1: Seismic Dampers in Building

1.2 Objective

- The goal of this project is to investigate the seismic response of structures with dampers installed at various levels of soft layers since dampers are the most efficient structural system for building design.
- Examine the impact of dampers in order to enhance soft-story structures' seismic performance.

- Comparative analysis of different seismic parameters, including layer shear, undamped, damper, and base shear for solid layers.

1.3 Need for the Study

- Superiority of technology
- Infrastructure innovation
- Because of the quickening rate of population growth
- Growing need for parking and housing
- Financial progress
- Aesthetic preference in cities

2. LITERATURE REVIEW

[1] Akshay Shaji, Amrutha Binu, Dibi Divakaran, Swaraj V, "Seismic Analysis of Soft Storey Buildings", International Journal of Scientific & Engineering Research

This study compares the seismic behaviour of several soft-story frame building models reinforced with stiff columns, shear walls, and bracing to the soft-story frame model. Response spectrum analysis is carried out using ETABS, and variables such main shear, stiffness, interaxial drift, and layer drift are examined.

When sheared walls are used in construction, the structure's strength is improved and displacement is decreased in comparison to reinforced concrete structures. When compared to other models, the shear wall model's main shear was found to be the least.

[2] Pravesh Gairola, Mrs. Sangeeta Dhyani, "Seismic Analysis of Open Soft Storey Building for Different Models", International Journal of Engineering Research & Technology

This paper presents the results of an investigation of the seismic behavior under earthquake loads of various models of soft floor buildings, including bare frame, infill frame, span frame, and shear wall frame. In contrast to the soft layer offered, it improves the structure's durable mobility when given a different model.

In every instance, the top layer had the lowest single-layer shear strength, whereas the first layer had the strongest. The bare frame model is shown to have a higher solid drift. The comparison shows that the shear wall model has the highest rigidity. These findings demonstrate that the shear wall system is the best model out of all of them and offers better retention and performance against seismic variations.

[3] Eben C. Thomas, "Seismic Response of Soft Storey Buildings with Viscoelastic Dampers", International Journal of Engineering Research & Technology

The current study looked into how soft-story structures with VED performed seismically. ETABS software is used to do dynamic analysis while taking various time history analyses into account. Roof acceleration, interstory drift, and upper story displacement were examined in relation to the software's output for models with and without dampers.

Building earthquake resistance can be significantly reduced with viscoelastic dampers. Compared to conventional dampers, VEDs require no maintenance and are simple to install. VEDs' primary benefit is that they can absorb even minute tremors, whereas friction dampers, which also act as dampers, can only absorb seismic energy up to a predetermined threshold.

[4] S. uttamraj, K. Mythili, "Analysis of Soft Storey for Multi Storied Building in Zone-4", International Journal of Research and Innovation (IJRI)

The behavior of soft floor buildings at various floor levels under the action of seismic stress and wind load is analyzed and studied in this thesis analysis of soft floor for high-rise buildings in zone 4. The finite element approach is employed. Etabs software was used for all analyses. For every model, base shear, layer displacement, and layer drift are computed and compared.

The study's findings demonstrate that the soft floor will significantly impact the building's structural behavior and capacity to support lateral loads. Structural abnormalities affect changes and relative tale drifts.

[5] S. Zubair Ahmed, K.V. Ramana, Ramancharla Pradeep Kumar, "SEISMIC RESPONSE OF RC FRAME STRUCTURE WITH SOFT STOREY", International Journal of Research in Engineering and Technology

Three scenarios were analyzed and a model of this building, R.C.C. I) Bare model (model without walls). II) A bottom-layered open model. III) Ground level structural steel model. In ETABS, the building model is dynamically analyzed. Store drifts, lateral displacements, lateral force, layer stiffness, base shear, time period, and torque are all taken into consideration while evaluating a building's performance.

It was discovered that the exposed sub-floor's steel bracing system greatly increases the building's structural strength and lessens the displacement of its maximum story span. It was discovered that the sub-floor steel structure had a minimal X-type torsional effect.

[6] Uma Devi R, Kavitha S, Sahana S Sastry, "Seismic Performance of A RC Frame with Soft Storey Criteria", International Journal of Research in Engineering & Technology

An attempt was made to look at the seismic behavior of multi-story buildings with soft soil floors in the current study. Soft-ply frames were shown to be less resilient than infill frames when subjected to seismic loads.

Because the first floor of an open first floor frame is larger than the top floor, which could lead to the collapse of the structure, filled frames should be used instead of open first floor frames in seismic areas.

3. METHODOLOGY

Three different models were considered for the analysis and they are:

- Model 1: Building without soft storey(Conventional building).
- Model 2: Building with ground storey as soft storey.
- Model 3: Building with ground storey as soft storey with dampers.

For this study, a 7-storey building model with a 5 meters length for each bay, regular in plan was chosen. The buildings were assumed to be fixed at the base. The buildings were modeled using software ETABS. Models were studied by comparing storey displacement, storey drift and base shear in X and Y direction for all structural models. The dimensions and loads were selected according to IS 456: 2000 and IS 875: 1987 codes.

Building parameters are as follows:

- G+7 Building
- Symmetrical
- Floor to floor height: 3m
- Soft storey height: 4m
- Medium strength soil
- M20 and Fe500
- Column size: 300 mm X 600mm
- Beam size: 300mm X 600mm
- Seismic Zone IV
- Dead load: 25 KN/m^2
- Live load: 2.5 KN/m^2
- Floor finish: 1 KN/m^2

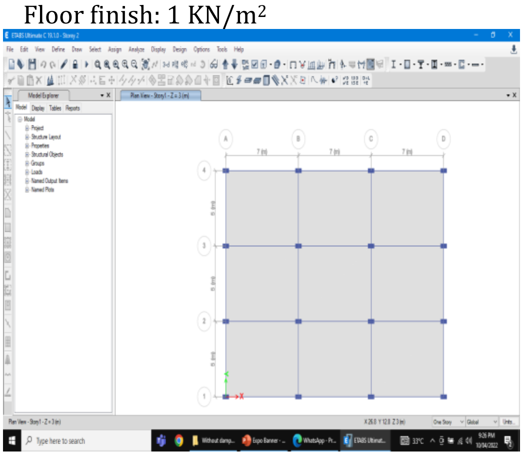

Figure 2: Plan view of model

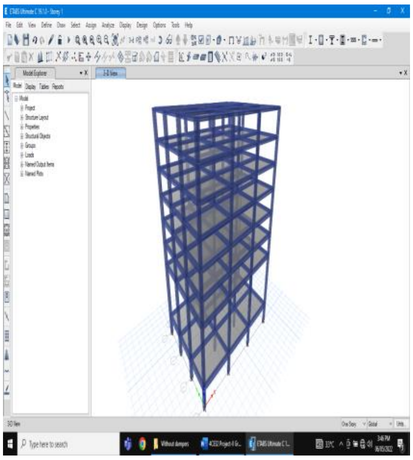

Figure 3: 3D view of Building with first floor as soft storey

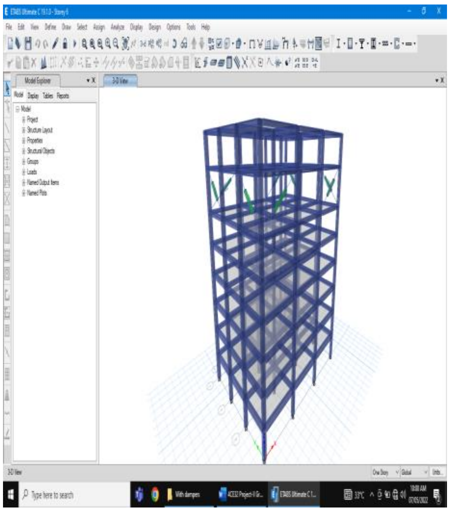

Figure 4: 3D view of Building with sixth floor as soft storey

3.1 Seismic Analysis of model

As per IS 1893: 2016 (part 1), for the purpose of determining seismic forces, India is classified into four seismic zones. The design horizontal seismic coefficient As, for a structure shall be determined by the following expression:

$$Ah – Z\ I\ Sa/2\ Rg$$

(Provided that for any structure with T ≤ 0.1 s, the value of Ah will not be taken less than Z/2 whatever be the value of I/R) Where,

Z Zone factor, is for the Maximum Considered Earth quake (MCE) and service life of structure in a zone. The factor 2 in the denominator of Z is used so as to reduce the Maximum Considered Earthquake (MCE) zone factor to the factor for Design Basis Earthquake (DBE).

I- Importance factor, depending upon the functional use of the structures, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance.

R- Response reduction factor, depending on the perceived seismic damage performance of the structure, characterized by ductile or brittle deformations. However, the ratio (I/R) shall not be greater than 1.0.
Sa/g- Average response acceleration coefficient. The value depends upon the soil type and the selected soil type is type II medium soil.
Seismic parameters are considered as per IS 1893(Part1):2016

- Soil type= II
- Seismic zones = V
- Seismic Zone Factor = 0.36
- Importance factor = 1
- Response reduction factor: 5

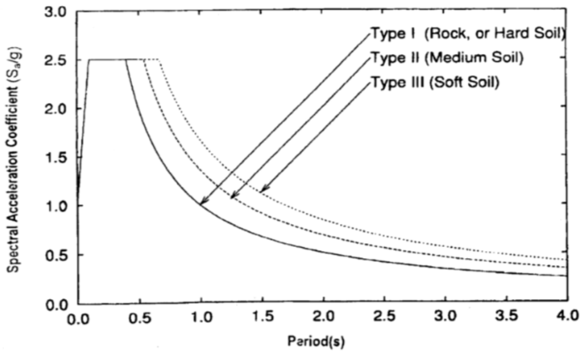

Figure 5: Design Response Spectra with 5% damping

3.2 Response Spectrum Analysis

The peak response of a simple harmonic oscillator to a transient event is displayed in a response spectrum, which is a function of frequency or period. The oscillator's damping and natural frequency determine the response spectrum. As a result, rather than directly representing the excitation's frequency content (as in a Fourier transform), it instead represents the signal's impact on a hypothetical system with one degree of freedom (SDOF).

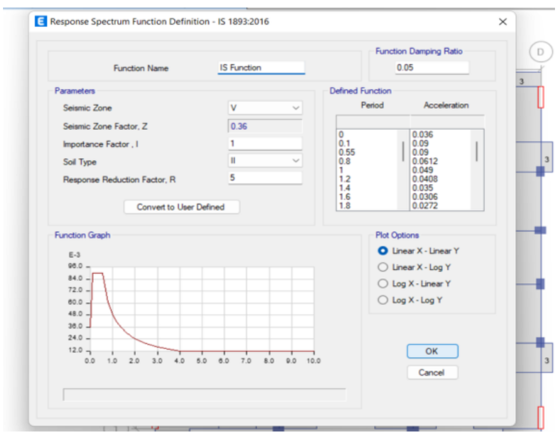

Figure 6: Response Spectrum Analysis

3.3 Viscous Damper in Etabs

FVD 250 is linear with fixed end properties used for project. The Mass is 44kg and Weight is 250kN. Based on previous studies adding dampers to the exterior corner gives much more effective results, hence dampers are added at a corner. Fluid viscous dampers with different forces can be used for different types of buildings, since structure modelled is of high height; smaller devices were used to start analysis.
The damping force of viscous damper is given by,
F=CVα
where, F – The damping force
C - The damping coefficient
V - Velocity of Piston
α – Velocity Exponent
This tabular data can be fed in program as shown below.
ETABS MENU=> Define=> Link Properties=> Add new Link=> Link Property Data.

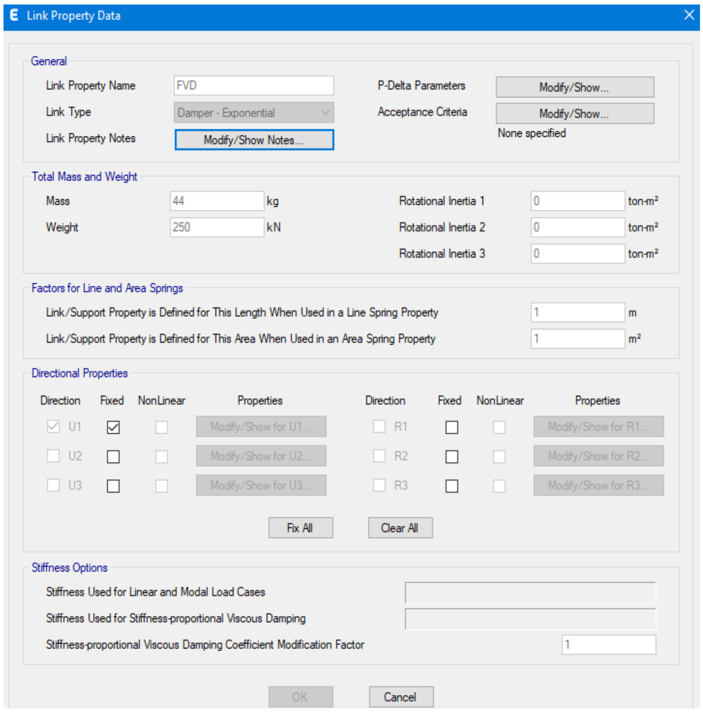

Figure 7: Link Properties in Etabs

4. ANALYSIS RESULTS

Case 1: Comparison between Conventional & Soft storey
Case 2: Comparison between Soft Storey & Soft storey with dampers
Analysis results and conclusion are Discussed based on following parameters:

- Storey Displacement
- Storey drift
- Storey stiffness
- Base shear

4.1 Storey Displacement

Displacement determines the structure's failure pattern; it is the parameter with the greatest significance. The displacement of the model with and without a viscous damper is observed in the current study. By adding a damper to the structure, we find that the displacement of the structure is decreased.

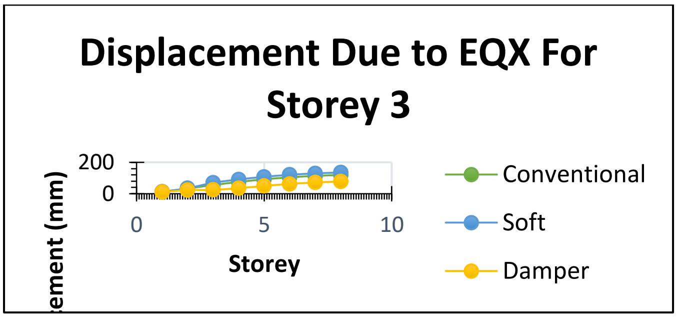

Figure 8: Storey displacement due to EQx for Storey 3

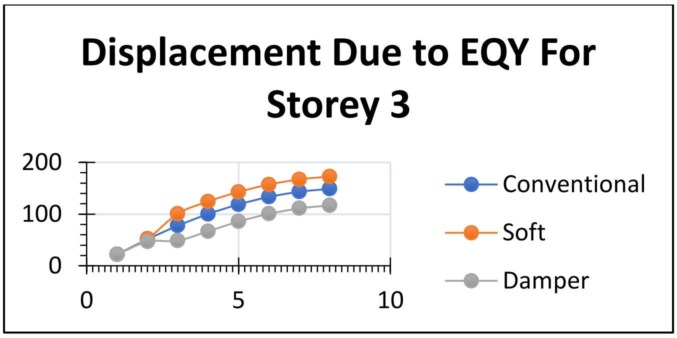

Figure 9: Storey displacement due to EQy for Storey 3

4.2 Storey Drift

The drift is a prevalent feature in multi-story buildings as the number of stories grows in the structure. Story drift is the difference between the lateral displacements of two floors that are next to each other in a structure. The response spectrum method, or dynamic analysis, is used to model and analyze the structure. The structure's story drift values are reported for both wind and seismic loads.

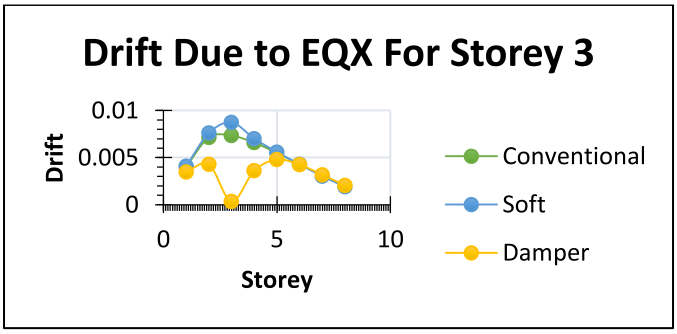

Figure 10: Storey drift due to EQx for Storey 3

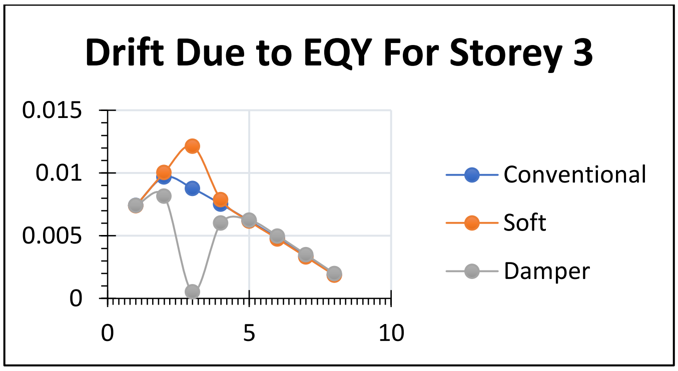

Figure 11: Storey drift due to EQy for Storey 3

4.3 Base Shear

Base shear is the maximum expected lateral forces on the structure's base that are expected as a result of seismic activity. Its mathematical value is determined by multiplying the net vertical forces at the base by a factor known as the horizontal seismic coefficient, whose value is dependent on various factors such as the seismic zone.

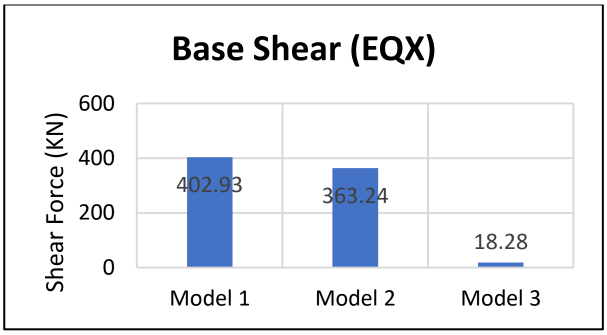

Figure 12: Base Shear in X direction

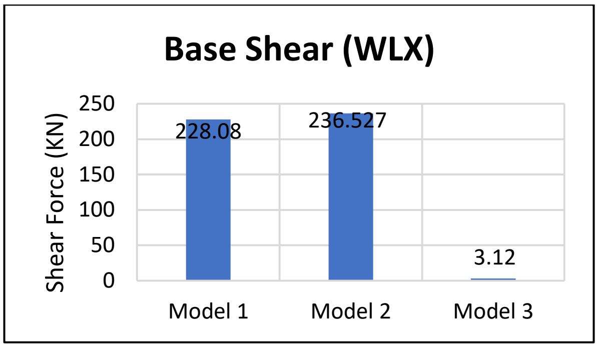

Figure 13: Base Shear in Y direction

5. CONCLUSIONS

Effects on models have been shown in the form of graph in successive part of results by comparing various parameters such as displacements, storey drifts and base shear. Hence from the obtained results the following conclusions are made,

1) Storey drift and storey displacement of soft storey building increase by 7.8% and 10.3% respectively, when compared to conventional building.
2) By using viscous damper in the structure, the story drift and storey displacement at soft storey is reduced by 53.7% and 47.89% respectively when compared without dampers model.
3) The displacement value at mid-story in a soft storey with Dampers model is the smallest (47.53%).
4) Storey drift is slightly increasing at a top floor because soft storey effect at top level is negligible.
5) From the comparative study it is clear that building with dampers at corner has better performance when seismic forces are considered.

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