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Determination of Actual Damping of RC Structure & its Effect on Design using ETABS

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ABSTRACT: This research project delves into the seismic behavior of an RC (Reinforced Concrete) structure, specifically focusing on the profound influence of damping and the potential ramifications of modifying damping parameters within the widely used ETABS software.

The significance of this project is underscored by the pivotal role damping plays in seismic design and structural integrity. By unravelling the actual damping characteristics of the RC structure and experimenting with different damping values in ETABS, this research promises to advance the field's understanding of how such modifications impact seismic design outcomes. This knowledge is particularly pertinent for architects, engineers, and stakeholders involved in designing structures located in seismicallyactive regions.

KEYWORDS: damping, Etabs, damping, Actual damping ratio, Reinforced concrete, Structural load,s

I.INTRODUCTION

The field of structural engineering is a realm of precision, where every beam, column, and foundation is meticulously designed and analysed to ensure the safety and stability of buildings and infrastructure. At the heart of this meticulous process lies the concept of damping—a critical factor that influences the dynamic behavior of structures subjected to external forces.

Damping is a fundamental concept in structural engineering, embodying the principle of energy dissipation within a structure when it experiences dynamic loads or vibrations. It acts as the counterforce that combats the natural tendency of structures to oscillate when subjected to external forces. By absorbing and dissipating energy, damping ensures that structures remain stable and safe.

Actual damping refers to the real-world damping characteristics exhibited by a structure under dynamic loads. Unlike idealized or assumed damping values during the design phase, actual damping considers the combined effects of material properties, structural configurations, and environmental conditions. Understanding actual damping is essential for accurately assessing a structure's dynamic response.

II.MOTHODOLOGY

This chapter outlines the comprehensive methodology employed to determine actual damping in the RC structure and its subsequent impact on structural behaviour. It also explores various methods to calculate actual damping and the crucial role of ETABS in this process.

A) Log Decrement Method

One of the widely accepted methods for calculating actual damping is the Log Decrement Method. This method involves analysing the structure's response to dynamic loads and measuring the decay in oscillations over successive cycles. The formula for calculating actual damping using this method is:

Actual Damping Ratio $\xi = (1 / \sqrt{(1 + (2\pi / n)^2)}) * (\log(A1 / A2) / n)$ Where:

ξ: Actual damping ratio.

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n: Number of cycles between two successive maxima of displacement. A1n: Maximum displacement amplitude at cycle 'n.'
A2: Maximum displacement amplitude at the subsequent cycle 'n+1.'

B) Half-Pour Bandwidth Method: The Half-Pour Bandwidth Method assesses the bandwidth of the structure's response spectrum at half of its peak value. It employs the following formula:

Actual Damping Ratio (ξ)= Δf/ f_n Where:
ξ: Actual damping ratio.
Δf: Bandwidth at half of the peak response spectrum. f_n: Natural frequency of the structure.

C) Calculating Natural Frequency
Natural frequency (f_n) is a fundamental parameter in structural dynamics. It represents the frequency at which a structure will naturally vibrate when excited by a dynamic force. Response data, specifically story acceleration data, is analyzed to calculate this vital parameter. The procedure involves identifying the peak acceleration in the response spectrum, as this corresponds to the natural frequency.

D) Peak Acceleration
Peak acceleration is another essential parameter derived from response data. It represents the maximum acceleration experienced by the structure during dynamic loading. This value is crucial for various design considerations, including assessing the seismic response of the structure.

The formula for calculating peak acceleration is:
Peak Acceleration=max (Story Acceleration Data)

III.ROLE OF ETABS

ETABS, as a state-of-the-art structural analysis software, plays a major role in determining actual damping. Its capabilities enable engineers and researchers to model, analyze, and extract essential data from complex structural systems. ETABS' accuracy and versatility are crucial in obtaining reliable results for the calculation of actual damping ratios.

a) Data Extraction Procedure
The extraction of response data and story acceleration data involves a step-by-step procedure:

b) Story Acceleration Data Extraction
Model Creation: Create a detailed model of the RC structure in ETABS, specifying all structural elements, materials, and loading conditions.
Dynamic Analysis: Perform dynamic analyses within ETABS, subjecting the structure to various dynamic loading scenarios.
Display Table: After running the analysis, navigate to ETABS' display table, which provides a comprehensive overview of the structure's dynamic response. Extract the story acceleration data from this table.

c) Response Data Extraction
Export Function: Utilize ETABS' export function to extract the response data, which includes the spectral data and other relevant information related to the structure's dynamic response.
Data Analysis: Further analyse the exported response data to calculate parameters like natural frequency and peak acceleration**.**

IV. MODEL DETAILS

S 1) Sizes of structural elements used while modeling
Column size-
•230X750 mm
Beam Sizes –
•150X380mm
•150X450 mm

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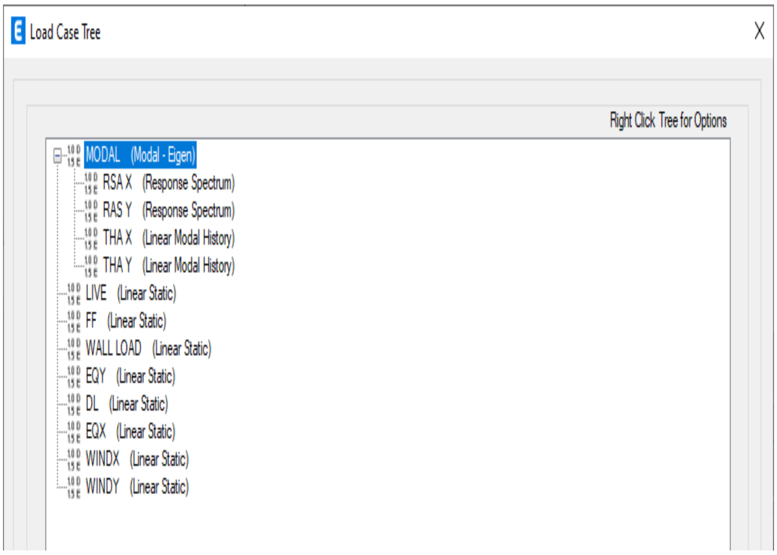
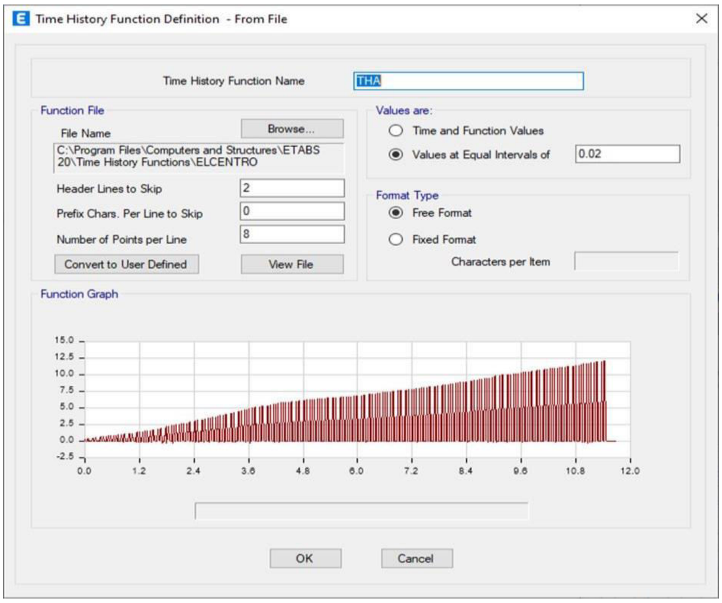
•230X380 mm
•230X450 mm
•230X530 mm
•230X600 mm
•230X750 mm

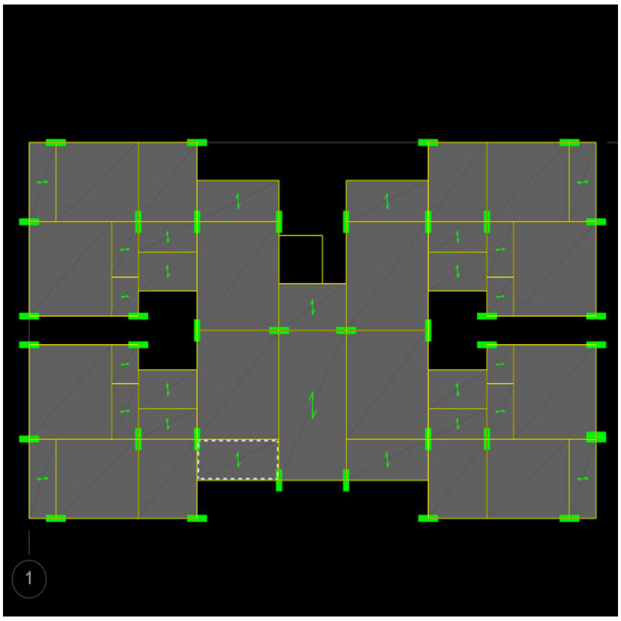
Slab thickness –
•150 mm

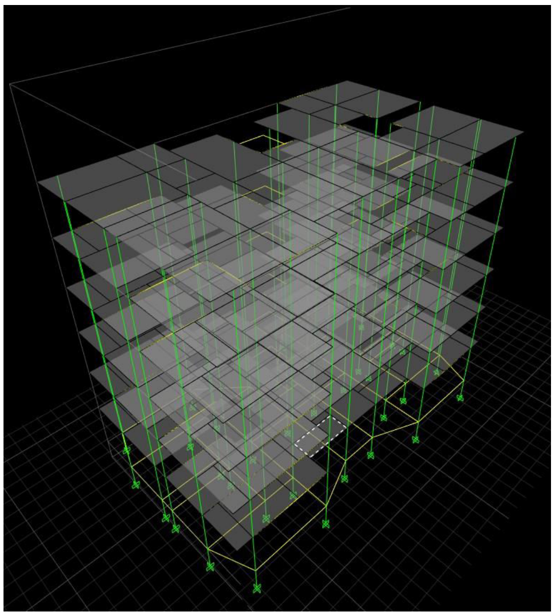




Loading details

Time History Function Details





2d plan of G+5 Building

3D Model of G+5 Building

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V. CALCULATION

Overall Damping= (0.150 * 415049.62 + 0.161 * 415049.62 + 0.140 * 415049.62 + 0.060 * 415049.62 + 0.073 * 415049.62 + 0.082 * 415049.62 + 0.028 * 115775.48 + 0.000 * 6702.35) / (415049.62 + 415049.62 + 415049.62 + 415049.62 + 415049.62 + 415049.62 + 115775.48 + 6702.35)
Overall Damping ≈ 0.088 or 8.8%

So, the overall damping for the entire structure is approximately 0.088 or 8.8%.
Therefore, the overall damping for the entire structure is approximately 0.088 or 8.8%..

VI. CONCLUSION

let's expand on the implications of the difference in actual damping (8.8%) versus assumed damping (5%) in ETABS on various structural elements and design considerations:
1.Footing:
•Seismic Forces: Higher damping results in smaller seismic forces acting on footings during an earthquake.
•Design Adjustments: Footing sizes may be reduced, potentially saving on material and construction costs.
•Reinforcement: Ensure that reinforcement detailing still complies with code requirements for ductility and strength.
2.Columns:
•Lateral Drift: Increased damping can reduce the lateral drift (displacement) of columns during seismic events.
•Dimensional Changes: Smaller cross-sectional dimensions of columns might be feasible, leading to cost savings.
•Code Compliance: Ensure that the reduced size still meets the code's minimum requirements for strength and stability.
3.Shear Walls:
•Seismic Response: Higher damping affects the response of shear walls, potentially reducing seismic forces.
•Thinner Walls: Thinner shear walls or fewer shear walls may be possible, but design should still ensure adequate strength and stiffness.
•Detailed Analysis: Carefully analyse shear wall designs to account for actual damping effects.
4-Beams:
•Lateral Deflection: Higher damping can reduce lateral deflection of beams during an earthquake.
•Possible Savings: Smaller beam sizes or spans might be used, which can lead to cost savings.
•Gravity Load Consideration: Ensure that beam sizes are still adequate to carry gravity loads without excessive deflection.
5.Slabs:
•Gravity Loads: Since slabs primarily carry gravity loads, the impact of damping on their design may be minimal.
•Code Requirements: Ensure that slab thickness and reinforcement meet minimum code requirements.
6.Water Tank:
•Seismic Design: Design water tanks considering the actual damping to accurately assess seismic forces.
•Supporting Elements: The design of supporting columns and connections may be affected by reduced seismic forces.
7. Steel Structures Over 6th Story (like solar panel supporting structure or telephonic steel tower)
•Reduced Lateral Forces: Higher damping can reduce lateral forces on steel structures.
•Member Size: Smaller members or fewer braces might be feasible, resulting in potential cost savings.
•Connection Design: Steel connections should still be designed to withstand the actual seismic forces.
8.Base Isolation:
•Effect on Benefits: The benefits of base isolation may be reduced with higher damping since some energy dissipation occurs within the structure.
•Evaluation Required: The use of base isolation should be carefully evaluated based on the specific project's seismic performance goals.
9.Cost Implications:
•Material and Construction: Smaller structural elements and reduced forces can lead to cost savings in terms of materials and construction.
•Detailed Analysis: The cost implications should consider detailed analysis and design adjustments, which may offset some savings.
10.Stiffeners:
Project Specific: The need for stiffeners depends on the structural elements and their response to lateral loads.
•Damping Influence: Higher damping might reduce the need for stiffeners in some cases, but this should be assessed by a structural engineer.

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