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Determination of Actual Damping of RC Structure & It's Effect on Design

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ABSTRACT: This research project delves into the seismic behavior of RC (Reinforced Concrete) structures, with a specific focus on the profound influence of actual damping and its potential impact on design parameters within the widely used ETABS software. The primary objectives of this study encompass a thorough analysis of the structure's response to seismic forces, an exploration of its inherent actual damping properties, and an investigation into the consequences of adjusting damping values during analysis.
Modal analysis and response spectrum analysis techniques are employed to extract the actual dynamic characteristics of the RC structure, providing a comprehensive understanding of its natural frequencies and mode shapes. The critical aspect of actual damping is meticulously examined using the logarithmic decrement method, enabling precise determination of actual damping ratios for various floors within the structure.

KEYWORDS: Reinforced concrete, damping, ETABS, actual damping ratio, seismic design, structural analysis, seismic behavior.

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 behaviour of structures subjected to external forces. This comprehensive introduction delves deep into the multifaceted realm of damping, unravelling its various dimensions, the rationale behind ETABS software's default damping ratio, and the imperative need for further research. Furthermore, it lays out the stages of structural design using ETABS, elucidating a step-by-step procedure for extracting data to determine actual damping.

1.1 OBJECTIVES

The need for research into the intricacies of damping and its effects on structural behaviour arises from several compelling factors. These factors underscore the significance of advancing our understanding of actual damping characteristics and their implications for structural design.

II. METHODOLOGY

This 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. The chapter elucidates the importance of response data, particularly story acceleration data, in calculating actual damping.

i) Log Decrement Method

One of the widely accepted methods for calculating actual damping is the Log Decrement Method. This method involves analyzing 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 $\xi = (1 / \sqrt{(1 + (2\pi / n)^2)}) * (\log(A1 / A2) / n)$

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Where:
ξ: Actual damping ratio.
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.'
ii)Utilizing Response Data and Story Acceleration Data
Response data, particularly story acceleration data, plays a pivotal role in the determination of actual damping. It provides crucial insights into how the structure responds to dynamic loads and vibrations, which are essential for calculating several key parameters:
a) 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.

b)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. Peak Acceleration=max(Story Acceleration Data)

III. ROLE OF ETABS

ETABS, as 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.

3.1 DATA EXTRACTION PROCEDURE

The extraction of response data and story acceleration data involves a step-by-step procedure:

I. 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.

II. 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 analyze the exported response data to calculate parameters like natural frequency and peak acceleration.

3.2 MODEL DETAILS

Sizes of structural elements used while modeling
Column size- 230X750 mm
Beam Sizes –150X380 mm,150X450 mm, 230X380 mm,230X450 mm, 230X530 mm, 230X600 mm, 230X750 mm
Slab thickness –150 mm

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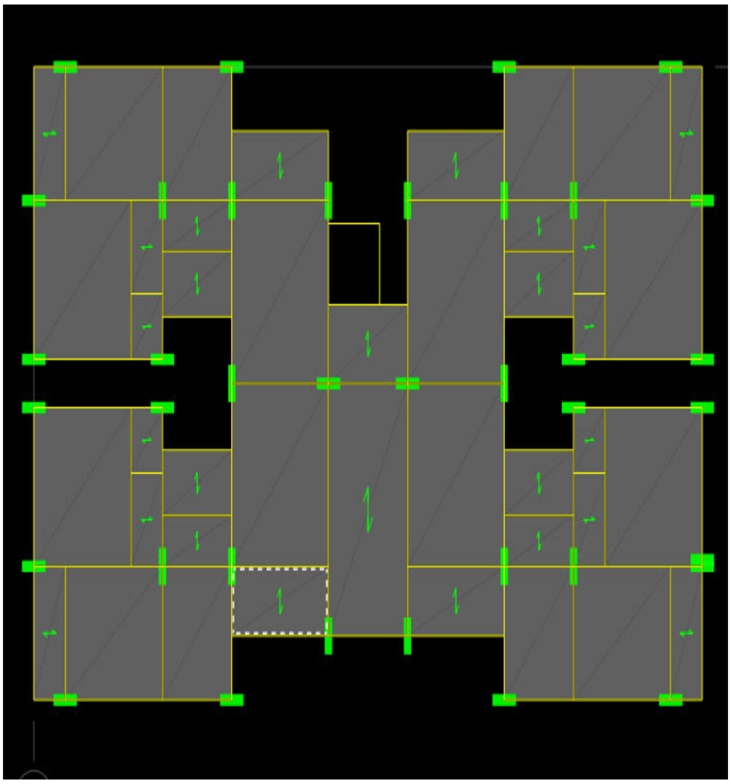
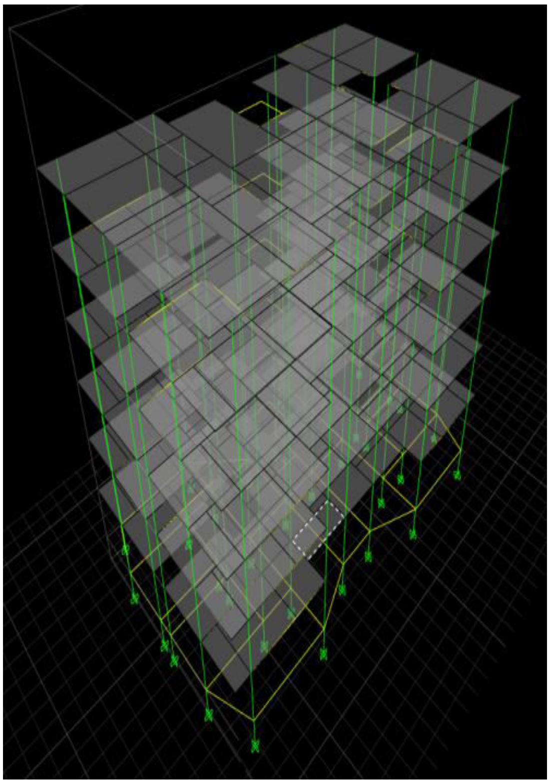


2D Plan from Etabs



3D Model from Etabs

IV. ACTUAL CALCULATION

After analyzing the response data, story acceleration data we get

Modal	U1 Acceleration (A1)	U2 Acceleration (A2)
1	516 mm/sec²	516 mm/sec²
2	522.41 mm/sec²	522.41 mm/sec²
3	560.25 mm/sec²	560.25 mm/sec²
4	1792.54 mm/sec²	1792.54 mm/sec²
5	1820.4 mm/sec²	1820.4 mm/sec²
6	1820.4 mm/sec²	1820.4 mm/sec²
7	1820.4 mm/sec²	1820.4 mm/sec²
8	1820.4 mm/sec²	1820.4 mm/sec²
9	1820.4 mm/sec²	1820.4 mm/sec²
10	1820.4 mm/sec²	1820.4 mm/sec²
11	1820.4 mm/sec²	1820.4 mm/sec²
12	1820.4 mm/sec²	1820.4 mm/sec²

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Table 1 for A1.A2 of Acceleration

Story	A1 (UX)	A2 (UX)	Period	Number of Cycles	Actual Damping (%)
			(seconds)		
6th slab	2827.95	-1798.2	2.378	2.646	0.150
5th slab	2023.82	-1227.3	2.352	2.675	0.161
4th slab	1256.34	-772.27	2.196	2.858	0.140
3rd slab	755.68	-517.99	0.682	9.244	0.060
2nd slab	799.78	-246.65	0.658	9.536	0.073
1st slab	743.58	-137.41	0.655	9.604	0.082
Plinth	310.41	-78.03	0.337	18.698	0.028
Base	522.41	0	0	0	0.000

From Table 2 we got this data for Actual damping

Now we have Table for Story mass data for each story

Story		**6th slab**	**5th slab**	**4th slab**	**3rd slab**	**2nd slab**	**1st slab**	**Plinth**	**Base**
Mass	**(kg)**	415049.6	415049.6	415049.6	415049.6	415049.6	415049.6	115775	6702.35

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%

V. CONCLUSION

From this we can get idea about how we can calculate actual damping with the use of Etabs .

5.1 DESIGN OF STRUCTURAL ELEMENTS:

a)Increase in Base Shear: Higher damping can lead to a reduction in the peak accelerations, which might result in a higher base shear demand. Structural elements, especially the foundation and lateral force-resisting elements like shear walls and bracing, will need to be designed to withstand the increased forces.

b)Thicker Shear Walls and Columns: To accommodate the higher forces, designers may need to increase the dimensions of shear walls and columns, leading to thicker and possibly heavier structural elements.

c) Reduction in Drift and Displacement: Higher damping can reduce the lateral displacement and drift of the structure during an earthquake. While this can be advantageous in terms of occupant comfort and non-structural damage, it might lead to stiffer structural elements to meet drift limits.

5.2 ECONOMY:

a)Material Costs: Thicker structural elements with increased dimensions will require more construction materials, leading to higher construction costs.

b)Construction Costs: Larger and heavier structural elements might be more challenging and expensive to construct, transport, and install.

c)Foundation Costs: Increased base shear may necessitate stronger and more extensive foundations, adding to the overall cost.

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5.3 EFFICIENCY:

a)Reduced Resilience: While higher damping can reduce drift and displacement, it might also reduce the structure's ability to dissipate energy, potentially making it less resilient to strong earthquakes.

b)Damping Devices: In some cases, engineers may opt to include damping devices like tuned mass dampers or base isolators to control the increased forces and maintain structural integrity. However, these devices come with their own costs and maintenance requirements.

5.4SEISMIC SAFETY:

a)Improved Structural Performance: Higher damping can provide better control over structural response, potentially reducing damage and improving seismic safety.

b)Overdesign: If the structure is designed with the assumption of 8.8% damping but actual damping is lower (closer to 5%), there may be overdesign, which could lead to inefficiencies and unnecessary construction costs.

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