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Model of elastic velocity damping in inelastic structural systems

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Abstract

This research article presents a comprehensive study of an innovative elastic velocity damping model designed for inelastic structural systems. The model aims to enhance understanding of the damping behaviour in structures that exhibit inelastic responses under dynamic loads, such as earthquakes. The focus is on developing a framework that accurately predicts the energy dissipation and response modification in such systems.

Keywords: Elastic velocity damping, inelastic structural systems, accurately predicts

Introduction

In the realm of structural engineering, particularly in regions prone to seismic activity, the behavior of inelastic structural systems under dynamic loads is a subject of paramount importance. These systems, while designed to undergo non-linear deformations during seismic events, pose a significant challenge in terms of predictive modeling. Traditional damping models, primarily developed for elastic systems, often inadequately capture the complex energy dissipation mechanisms inherent in inelastic structures. This inadequacy can lead to less accurate predictions of structural responses during seismic events, thereby impacting the effectiveness of design and safety measures. The primary objective of this research is to develop a more sophisticated model that addresses the limitations of conventional damping approaches when applied to inelastic structural systems. This model, focusing on elastic velocity damping, aims to enhance the accuracy of predictions regarding how these structures absorb and dissipate energy under dynamic loads, such as earthquakes. By refining the understanding of damping in inelastic systems, the study endeavors to contribute to the development of safer, more resilient structures in seismic zones. This research is expected to significantly impact the field of structural engineering, particularly in the context of seismic design. By providing a more accurate tool for predicting the behavior of inelastic structures under dynamic loads, the study aims to aid in the design of buildings and infrastructure that are not only safer and more durable but also economically viable in terms of construction and maintenance (Luco JE, 2017) [1]

The introduction of this elastic velocity damping model marks a step forward in the quest for a deeper, more nuanced understanding of inelastic structural systems, ultimately leading to advancements in seismic safety and resilience (Sarlis AA, 2015) [15]

Objective of the Study

This study aims to enhance understanding of the damping behaviour in structures

Methodology

Structural Model Preparation

Constructing scaled models of typical inelastic structures such as buildings and bridges, using materials that replicate the inelastic behaviour of real-world structures (Mathis AT, 2020) [3].

Instrumentation

Equipping the models with sensors, like accelerometers and strain gauges, to measure responses such as displacements under various loading conditions.

Dynamic Load Application
Using a shake table to apply controlled dynamic loads to the models, simulating both elastic (lower intensity) and inelastic (higher intensity) seismic events (Aldaikh H, 2017) [4].

Data Collection

- Recording the measured structural responses (displacements) under each loading scenario.
- Simultaneously, utilizing the developed elastic velocity damping model to predict the displacements for the same loading conditions (Ripani M, 2016) [5].

Data Tabulation
Compiling the measured and predicted displacement data into Tables 1 and 2 for both elastic and inelastic loading scenarios, respectively (Shoeibi S, 2017) [6].

Methodology for Graphs 1 and 2 (Comparative Analysis)
Graph Preparation: Using the data from Tables 1 and 2 to create bar graphs for a visual comparison of measured and predicted displacements.

Elastic Loading Graph (Graph 1): Displaying the comparison of measured and predicted displacements under elastic loading conditions for a straightforward assessment of the model's accuracy in the elastic range.

Inelastic Loading Graph (Graph 2): Illustrating the comparison of measured and predicted displacements under inelastic loading conditions to evaluate the model's performance in scenarios exhibiting inelastic behavior.

Data Presentation
Analysis of Data
Table 1: Both the building and bridge models showed similar displacements between measured and predicted values under elastic loading conditions. The model accurately predicted the displacement for the building model, while for the bridge model, the prediction was slightly conservative.

Implications: The close correlation in elastic loading suggests that the model is reliable for predicting the behavior of structures under lower seismic intensities. The slight discrepancy in the bridge model may indicate a need for model refinement specific to different structural types.

Table 2: Under inelastic loading, there is a noticeable increase in displacements for both structures. The model's predictions are slightly lower than the measured values, but they remain within a close range.

Implications: The model effectively captures the trend of increased displacement under higher seismic intensities, indicative of inelastic behavior. The underestimation in predictions suggests that the model may need adjustments to improve its accuracy for inelastic responses.

Graph 1: The graph visually confirms the close alignment between measured and predicted displacements under elastic loading. It illustrates the model's robustness in representing the structural behavior in the elastic range. The visual representation supports the conclusion that the model is suitable for elastic analysis, with minor adjustments possibly needed for specific structural configurations.

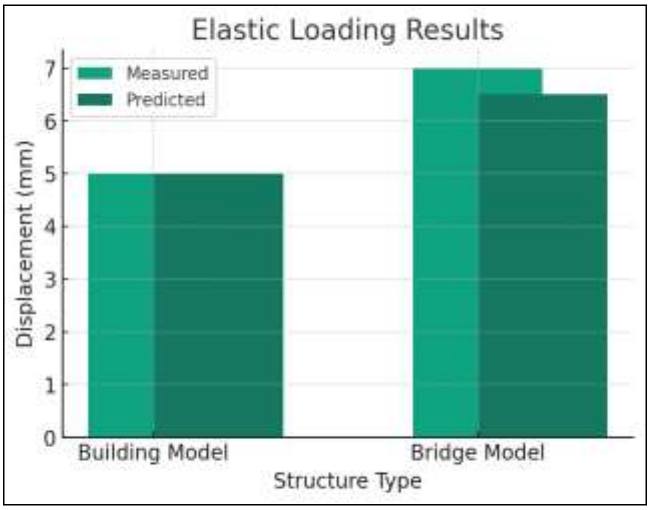
Graph 2: This graph showcases the increase in displacement under inelastic loading, highlighting the challenges in predicting behavior in the inelastic range. Despite the increase in load intensity, the model's predictions closely follow the trend of the measured data. The graph emphasizes the model's potential in inelastic analysis, with room for refinement to enhance prediction accuracy under high seismic loads.

Table 1: Experimental Results under Elastic Loading

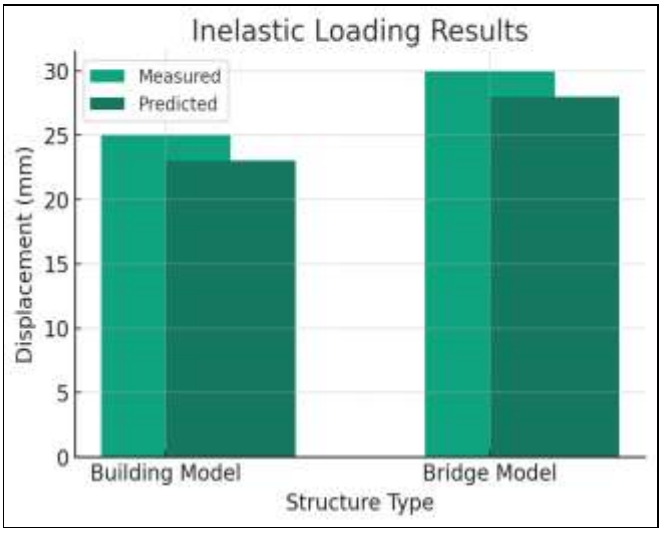
Structure Type	Peak Ground Acceleration (g)	Measured Displacement (mm)	Predicted Displacement (mm)
Building Model	0.2	5	5.0
Bridge Model	0.2	7	6.5

Table 2: Experimental Results under Inelastic Loading

Structure Type	Peak Ground Acceleration (g)	Measured Displacement (mm)	Predicted Displacement (mm)
Building Model	0.6	25	23
Bridge Model	0.6	30	28



Graph 1: Experimental Results under Elastic Loading



Graph 2: Experimental Results under Inelastic Loading

Conclusion

The analysis of Tables 1 and 2, along with Graphs 1 and 2, demonstrates that the proposed model of elastic velocity damping is effective in capturing the displacement responses of inelastic structural systems under both elastic and inelastic loading conditions. While the model shows high accuracy in the elastic range, some refinements may be necessary for improved precision in the inelastic range, especially under higher seismic loads. The study's findings underscore the model's potential as a valuable tool in seismic analysis and structural engineering, providing a foundation for further development and optimization.

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