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Tesis

Analysis of Structural Behavior in Elevated Tanks through the Configuration of Viscous Fluid Dissipators

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Para optar el Título Profesional de
Ingeniero Civil

Huancayo, 2024

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Título:
Analysis of Structural Behavior in Elevated Tanks Through the Configuration of Viscous Fluid Dissipators

URL / DOI:
https://www.scopus.com/record/display.uri?eid=2-s2.0-85206578307&origin=resultslist&sort=plf-f&src=s&sid=5a6ff09911978225d26b53bdfca33011&sot=b&sdt=b&s=DOI%2810.13189%2Fcea.2024.120604%29&sl=29&sessionSearchId=5a6ff09911978225d26b53bdfca33011&relpos=0 / 10.13189/cea.2024.120604

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Civil Engineering and Architecture 12(6): 3772-3796, 2024 http://www.hrpub.org
DOI: 10.13189/cea.2024.120604

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Received May 29, 2024; Revised July 25, 2024; Accepted September 13, 2024

Cite This Paper in the Following Citation Styles

(a): *[1] Julio Cesar Neyef Jurado Almonacid, Esther Thalia Quispe Cardenas, Jack Eloy Palomino Hinostroza, Niel Iván Velásquez Montoya , "Analysis of Structural Behavior in Elevated Tanks Through the Configuration of Viscous Fluid Dissipators," Civil Engineering and Architecture, Vol. 12, No. 6, pp. 3772 - 3796, 2024. DOI: 10.13189/cea.2024.120604.*

(b): *Julio Cesar Neyef Jurado Almonacid, Esther Thalia Quispe Cardenas, Jack Eloy Palomino Hinostroza, Niel Iván Velásquez Montoya (2024). Analysis of Structural Behavior in Elevated Tanks Through the Configuration of Viscous Fluid Dissipators. Civil Engineering and Architecture, 12(6), 3772 - 3796. DOI: 10.13189/cea.2024.120604.*

Abstract Storage tanks are critical structures that must remain operational following seismic events to supply water for human consumption and firefighting. However, past events such as the Loma Prieta earthquake in 1989, the Kocaeli earthquake in 1999, and the Northridge earthquake in 1994 have led to the collapse of these tanks due to the dynamic effects of liquids, especially the convective mass at the top of the tank. To address these challenges, various researchers have proposed adding components to dissipate energy and reduce lateral displacements of elevated tanks. This study focuses on analyzing the structural behavior of these tanks by incorporating viscous fluid dissipators. An analysis was conducted according to relevant regulations, including the Peruvian seismic-resistant design standard E.030 for the city of Huancavelica, Peru, which is located in a soft soil zone. Additionally, guidelines established in the ACI 350.3-20 standard for the design of concrete structures containing liquids were used to obtain parameters for a 100 m^3 elevated water tank with a total height of 21.4 m from ground level to the roof. Five configurations of viscous fluid dissipators were considered: diagonal, enhanced chevron, horizontal chevron, horizontal chevron type 2, and toggle brace. These configurations underwent a nonlinear seismic history analysis, following the moderate performance methodology with a target drift of 0.0058, according to the Hazus 2010 standard. The study's results revealed that the horizontal chevron type 2 model exhibited better dynamic behavior, reducing floor drift by 52.72%. Additionally, the enhanced chevron model reduced floor acceleration by between 19% and 23%. Regarding tank walls, a 5% reduction in moment relative to the design envelope was observed. In the total system, an energy dissipation of 61.15% was achieved, with a maximum dissipator displacement of 16 mm along its local axis.

Keywords Energy Dissipation, Element Configuration, Impulsive Mass, Convective Mass, Liquids, Elevated Tank, Drifts, Accelerations, Hysteretic Curve

1. Introduction

Storage tanks are essential structures that require their operation after a severe seismic event, to extinguish the fires generated and supply water to health institutions and the population, due to the fact that in the case of houses they usually present partial damage and collapse, which does not allow the use of their sanitary facilities to supply water, and also at some points damage to water lines has been noted [1], [2]. The main damage generated in elevated tanks was in the 1989 Loma Prieta, 1999 Kocaeli and 1994 Northridge earthquakes, where they failed mainly due to buckling and failure of anchorages in the support structure, leading to collapse. This was caused by the sloshing effect of the liquid contained in the elevated tank, with the convective mass being the main cause of the damage,