

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Civil

Tesis

**Impact of Height and Volume on the Seismic Reduction
Coefficient for Elevated Tanks in Loreto: A Proposal for
the Peruvian Standard E.030**

Mirella Alexandra Camarena Verastegui
Gustavo Quispe Paitan
Percy Julio Quispe Paitan
Manuel Laurencio Luna

Para optar el Título Profesional de
Ingeniero Civil

Huancayo, 2025

INFORME DE CONFORMIDAD DE ORIGINALIDAD DE TRABAJO DE INVESTIGACIÓN

A : Decano de la Facultad de Ingeniería
DE : Manuel Ismael Laurencio Luna
Asesor de trabajo de investigación
ASUNTO : Remito resultado de evaluación de originalidad de trabajo de investigación
FECHA : 15 de Setiembre de 2025

Con sumo agrado me dirijo a vuestro despacho para informar que, en mi condición de asesor del trabajo de investigación:

Título:

Impact of Height and Volume on the Seismic Reduction Coefficient for Elevated Tanks in Loreto: A Proposal for the Peruvian Standard E.030

URL / DOI:

<https://www.scopus.com/pages/publications/105002466580/10.13189/cea.2025.130314>

Autor(es):

1. Mirella Alexandra Camarena Verastegui – EAP. Ingeniería Civil
2. Gustavo Quispe Paitan – EAP. Ingeniería Civil
3. Percy Julio Quispe Paitan – EAP. Ingeniería Civil
4. Manuel Ismael Laurencio Luna – EAP. Ingeniería Civil

Se procedió con la carga del documento a la plataforma "Turnitin" y se realizó la verificación completa de las coincidencias resaltadas por el software dando por resultado 17 % de similitud sin encontrarse hallazgos relacionados a plagio. Se utilizaron los siguientes filtros:

- | | | |
|---|-----------------------------|--|
| • Filtro de exclusión de bibliografía | SI ☐ | NO ☒ |
| • Filtro de exclusión de grupos de palabras menores
Nº de palabras excluidas (en caso de elegir "SI"): | SI ☐ | NO ☒ |
| • Exclusión de fuente por trabajo anterior del mismo estudiante | SI ☐ | NO ☒ |

En consecuencia, se determina que el trabajo de investigación constituye un documento original al presentar similitud de otros autores (citas) por debajo del porcentaje establecido por la Universidad Continental.

Recae toda responsabilidad del contenido del trabajo de investigación sobre el autor y asesor, en concordancia a los principios expresados en el Reglamento del Registro Nacional de Trabajos conducentes a Grados y Títulos – RENATI y en la normativa de la Universidad Continental.

Atentamente,

La firma del asesor obra en el archivo original
(No se muestra en este documento por estar expuesto a publicación)

Impact of Height and Volume on the Seismic Reduction Coefficient for Elevated Tanks in Loreto: A Proposal for the Peruvian Standard E.030

Mirella Alexandra Camarena Verastegui, Gustavo Quispe Paitan, Percy Julio Quispe Paitan, Manuel Ismael Laurencio Luna*

Faculty of Civil Engineering, Continental University, Peru

Received December 9, 2024; Revised February 19, 2025; Accepted March 17, 2025

Cite This Paper in the Following Citation Styles

(a): [1] Mirella Alexandra Camarena Verastegui, Gustavo Quispe Paitan, Percy Julio Quispe Paitan, Manuel Ismael Laurencio Luna, "Impact of Height and Volume on the Seismic Reduction Coefficient for Elevated Tanks in Loreto: A Proposal for the Peruvian Standard E.030," *Civil Engineering and Architecture*, Vol. 13, No. 3, pp. 1624 - 1646, 2025. DOI: 10.13189/cea.2025.130314.

(b): Mirella Alexandra Camarena Verastegui, Gustavo Quispe Paitan, Percy Julio Quispe Paitan, Manuel Ismael Laurencio Luna (2025). *Impact of Height and Volume on the Seismic Reduction Coefficient for Elevated Tanks in Loreto: A Proposal for the Peruvian Standard E.030*. *Civil Engineering and Architecture*, 13(3), 1624 - 1646. DOI: 10.13189/cea.2025.130314.

Copyright©2025 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract The Loreto region of Peru faces a severe crisis in access to drinking water, with a large part of the population without adequate supply. Elevated tanks are a common solution, but present significant structural challenges in a seismically active area. The Peruvian standard E.030 does not specify a seismic reduction coefficient (R) for these tanks, leading to the use of foreign standards that do not fit local conditions. This increases the risk of structural failure, especially in inverted pendulum type geometry tanks, which endangers the safety and functionality of the water supply. This study proposes a new equation to estimate the most appropriate seismic reduction coefficient according to the height of the tank, taking into account the seismic conditions in Loreto. Simulations of seismic loads were carried out using the pushover method, evaluating the structural behaviour of 63 elevated tank models. The results show that as the tank height increases, the seismic reduction factor decreases, indicating a lower capacity of the structure to dissipate seismic loads. Models with larger volumes and heights exhibit more plastic behaviour, while smaller and stiffer tanks have lower ductility and reduction factor. The proposed equation, with a linear regression of the form $y = -0.064X + 9.598$, provides an accurate tool to adjust the seismic reduction coefficient as a function of tank height.

This proposal can be incorporated into the E.030 standard, improving the seismic design of elevated tanks in Loreto and other seismically active regions, and reducing the risk of structural failure during seismic events, ensuring a safer and more sustainable water supply.

Keywords Elevated Tanks, Seismic Reduction, Pushover, Creep, Collapse, Ductility, Over Strength

1. Introduction

The water access situation in the Loreto region of Peru is critical. Currently, 43.7% of the population does not have access to drinking water through a public water network or water taps, which highlights the urgency of improving the water infrastructure [1]. In this context, the use of elevated tanks is common in the region, as they guarantee a continuous supply of water 24 hours a day [2], [3], [4]. It should be noted that these structures are considered essential category A buildings, according to Peruvian standard E.030, which establishes strict design, strength and stiffness requirements [5]. However, the design of these tanks faces significant challenges that put