14th INTERNATIONAL CONFERENCE ON ENGINEERING & NATURAL SCIENCES

July 18-19, 2022 / Sivas, TURKEY
Sivas Science and Technology University

(THE PROCEEDINGS BOOK)

EDITOR
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FUZZY METHODS FOR SLOSHING MODELLING IN RESERVOIRS

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ABSTRACT

The deeper understanding of the seismic hazard uncertainties is associated with the use of the interval-valued probability concept [1][1]. In this approach, opportunity distributions applied to determine lower and higher probabilities (measures of necessity and opportunity). This approach has been used in seismic hazard analysis. The natural extension of interval probability is the concept of fuzzy probability. The concepts of fuzzy parameter and fuzzy logic have been first proposed by Zadeh, and since then they have become the powerful tool for modeling uncertainties of various practical engineering problems [2,3][23].

In fact, the probability distributions could never been assumed as known. They always assumed, as a hypothetical, and the observational data processed by statistical methods, including expanded sampling and modeling methods. It is possible to check the extent of assumptions about the distribution were correct. It should be noted, that for such mathematical modeling it is necessary to use fuzzy differential equations. Fuzzy approaches can't replace probabilistic models in seismic risk studies, but they could enrich them and expand their scope.

In the paper, liquid storage tanks have been considered under seismic loads using fuzzy vibration analysis. Relevant here is the description of the perturbation of the liquid free surface in the vessel during sloshing caused by the earthquake [4, 5][45].

[1] E. Strelnikova, D. Kriutchenko, V. Gnitko, K. Degtyarev, "Boundary element method in nonlinear sloshing analysis for shells of revolution under longitudinal excitations," Engineering Analysis with Boundary Elements, vol. 111, 2020, pp. 78-87. DOI: 10.1016/j.enganabound.2019.10.008.

[2] E. Strelnikova, N. Choudhary, D. Kriutchenko, V. Gnitko, A.Tonkonozhenko, "Liquid vibrations in circular cylindrical tanks with and without baffles under horizontal and vertical excitations," Engineering Analysis with Boundary Elements, vol. 120, 2020, pp. 13-27. DOI: 10.1016/j.enganabound.2020.07.02m

[3] N. Smetankina, A. Merkulova, D. Merkulov, O. Postnyi, "Dynamic Response of Laminate Composite Shells with Complex Shape under Low-Velocity Impact," Integrated Computer Technologies in Mechanical Engineering, Springer: Cham 2020. vol. 188, 2021, pp. 267-276. DOI: 10.1007/978-3-030-66717-7_22.

[4] N. Smetankina, I. Kravchenko, V. Merculov, D. Ivchenko, A. Malykhina, "Modelling of bird strike on an aircraft glazing.". In: Nechyporuk, M., Pavlikov, V., Kritskiy, D. (eds) Integrated Computer Technologies in Mechanical Engineering. Advances in Intelligent Systems and Computing, Springer, Cham, vol. 1113, 2020, pp. 289–297. DOI: 10.1007/978-3-030-37618-5_25

5 Sierikova E. Strelnikova E. Gnitko V. Kryutchenko D. "Reservoirs seismic resistance", Proceedings book of 6th International Congress on Innovative Scientific Approaches. December 19-20, 2021, Samsun, Turkey. IKSAD GLOBAL Publishing House. 2021. pp. 264-267.

For numerical simulation, the tank for storage of explosive liquids was modeled by a cylindrical shell with the following parameters: filling level H = 1m, shell radius R = 1m, shell thickness h = 0.01m, Young's modulus $E = 2 \cdot 10^5$ MPa, Poisson's ratio ν = 0.3, shell material density ρ = 7800 kg/m3, fluid density ρ_0 = 1000 kg/m3. It is assumed that the shell is rigidly fixed to its contour. The characteristic frequency of seismic loading at magnitude 6 earthquake is equal to 2 Hz.
The rise dynamics of the free surface during the first 240 s of the earthquake has been shown on Fig. 3b).

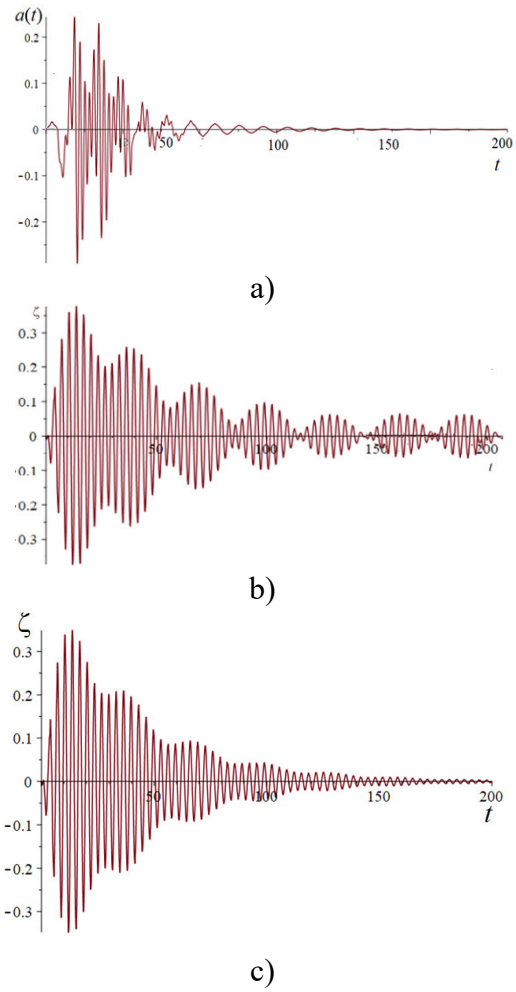

Fig. 3. Accelerogram and time-histories of the free surface elevation

The rise dynamics of the free surface during 240 s has been shown on fig. 3c). In this research, it has been assumed that the horizontal and vertical components of the seismic excitation have been described in the same way as shown on Fig. 3a).
It should be noted that the elevations of the free surface in time have been calculated at the point $\rho = 1, \theta = 0, z = \zeta(\rho, \theta)$ in a cylindrical coordinate system.
Presented data indicate the separation of the frequency spectra of fluid vibrations and elastic wall vibrations. While the lowest frequency of wall vibrations is not close to the characteristic frequency of seismic action during the earthquake of magnitude 6. So, it is permissible to restrict ourselves to considerate the rigid reservoirs. However, the careful modal analysis is required in each specific case.
Keywords: fuzzy method, sloshing, reservoirs, earthquake.