



**6th INTERNATIONAL CONGRESS ON
INNOVATIVE SCIENTIFIC APPROACHES**

PROCEEDINGS BOOK

**December 19-20, 2021
SAMSUN, TURKEY**

Editor

Assoc. Prof. Dr. Aynur NOGAEVA

**ISBN: 978-625-8423-61-7
IKSAD PUBLISHING HOUSE**

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by

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IKSAD GLOBAL Publications – 2021©

Issued: 30.12.2021

ISBN: 978-625-8423-61-7

CONGRESS ID

CONGRESS TITLE

**6th INTERNATIONAL CONGRESS ON INNOVATIVE
SCIENTIFIC APPROACHES**

DATE and PLACE

December 19-20, 2021/Samsun, Turkey

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IKSAD INSTITUTE

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TOTAL NUMBER OF INTERNATIONAL PAPERS

Turkey (67), Other Countries (70)

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RESERVOIRS SEISMIC RESISTANCE**Elena SIERIKOVA***PhD., National University of Civil Defence of Ukraine, Kharkiv, Ukraine
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The treatment relevance to determine the seismic resistance of equipment elements for various purposes is the condition of intensive new facilities building in seismically unsafe areas. Often storage tanks for flammable and explosive liquids are the such objects. Their destruction could lead to negative ecological consequences, environmental pollution, personnel death [1]. Nowadays, strength calculations under seismic loads have become the mandatory requirement in design. Carrying out field experiments to determine seismic resistance is the unsafe and expensive procedure. Therefore, computer modeling of such processes seems to be the reasonable alternative. In this case, the computer experiment results could be applicable for the whole series of similar objects.

In the paper, the seismic strength calculation has been provided as follows. At the first stage, the frequencies and modes of natural vibrations of the reservoir structure have been determined using the methods developed in [2], [3].

It has been assumed that the structure behavior could be described within the framework of the elasticity linear theory. Furthermore, modal inertial seismic loads on the structure have been determined for the given impact direction. It has been assumed that the direction cosines of the seismic load and acceleration vector in each direction have been given.

To calculate the forced vibrations of the structure, it has been synthesized accelerogram CA-482 [4] applied, which corresponds to the earthquake with the magnitude of 6 on the Richter scale. The use of this accelerogram makes it possible to ensure the reliability of equipment in case of real earthquakes with the probability of 80%.

The storage tank of explosive liquids has been modeled in the paper by the cylindrical shell with the following parameters: filling level $H = 1\text{m}$, shell radius $R = 1\text{m}$, shell thickness $h = 0.01\text{m}$, Young's modulus $E = 2 \cdot 10^5\text{MPa}$, Poisson's ratio $\nu = 0.3$, shell material density $\rho = 7800\text{ kg / m}^3$, liquid density $\rho_0 = 1000\text{ kg / m}^3$. It has been assumed that the shell is rigidly fixed along the contour, thus, the boundary conditions are follow: $u_r = u_z = u_\theta = 0$ at $z = 0$ and $r = R$, Fig.1.

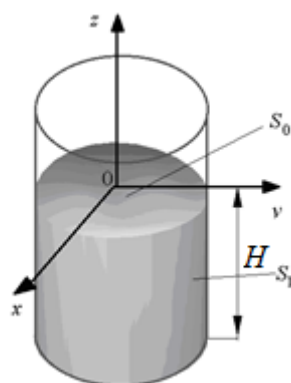


Fig. 1. Liquid reservoir diagram

It has been also assumed that the fluid is ideal and incompressible, and its motion, which began from the rest state, is irrotational according to the Kelvin theorem.

The calculation of frequencies and modes of natural vibrations of such reservoir has been carried out.

As in [5], it has been determined that the lowest frequencies of oscillations of reservoir with the liquid in given mechanical and geometric characteristics are the splashing frequencies. The frequency spectra of vibrations of the free surface and elastic walls have been separated.

Forced vibrations of the reservoir at the given seismic load have been treated. To determine the acceleration at the given earthquake strength it could be used Table 1 [4].

Table 1. Acceleration level depending on seismicity.

Seismicity, points	5	6	7	8	9	10
The maximum level of acceleration (in fractions of g)	0.025	0.05	0.1	0.2	0.4	0.8

For a 6-point earthquake, It has been got the acceleration of 0.05 g.

Table 2 shows the lowest vibration frequencies of the tank free surface and walls.

Table 2. Lowest vibration frequencies of the "shell-liquid" system.

frequency N	Frequency, Hz	harmonic	Vibration type
1	0.6418	1	splashing
2	0.9739	0	splashing
3	1.1509	1	splashing
4	1.3208	0	splashing
5	1.4564	1	splashing
6	1.5909	0	splashing
7	1.7054	1	splashing
8	1.9212	1	splashing
9	2.0249	0	splashing
10	7.6591	0	bottom fluctuations

According to [4], with the amplitude of 6 points, the defining frequency will be $\Omega = 2$ Hz. Therefore, in the calculation for the level of free surface rise and the velocities potential in the rigid reservoir, the following terms have been taken into account:

$$\zeta = \sum_{n=0}^1 \cos n \theta \frac{1}{g} \left[\sum_{k=1}^M \chi_{nk}^2 d_{nk}(t) \phi_{nk}(r, 0) \right]$$

$$\Phi = \sum_{n=0}^1 \cos n \theta \sum_{k=1}^{M_1} \dot{d}_{nk}(t) \phi_{nk}(r, z)$$

As the first approximation, it has been assumed that $M = 1$. Differential equations obtained in [4] have been used to determine $d_{nk}(t)$. The dynamic condition on the free surface has been considered in the follow form:

$$\sum_{n=0}^1 \cos n \theta \sum_{k=1}^M \ddot{d}_{nk}(t) \phi_{nk}(r, z) + (g + a_z(t)) + \sum_{n=0}^1 \cos n \theta \left[\sum_{k=1}^M \chi_{nk}^2 d_{nk}(t) \phi_{nk}(r, 0) \right] + a_x(t) r \cos \theta = 0$$

The reservoir has been assumed to be rigid, $N=M=1$, $a_x(t) = a_h \cos \omega_h t$, $a_z(t) = a_v \cos \omega_v t$. In this case, the determining amplitudes and frequencies have been taken in the form

$$a_h = a_v = 0.2 \text{ m}, \omega_h = \omega_v = 2 \text{ Hz}.$$

Fig. 2 shows the change in the level of the free surface as the function of time during the first 100 seconds.

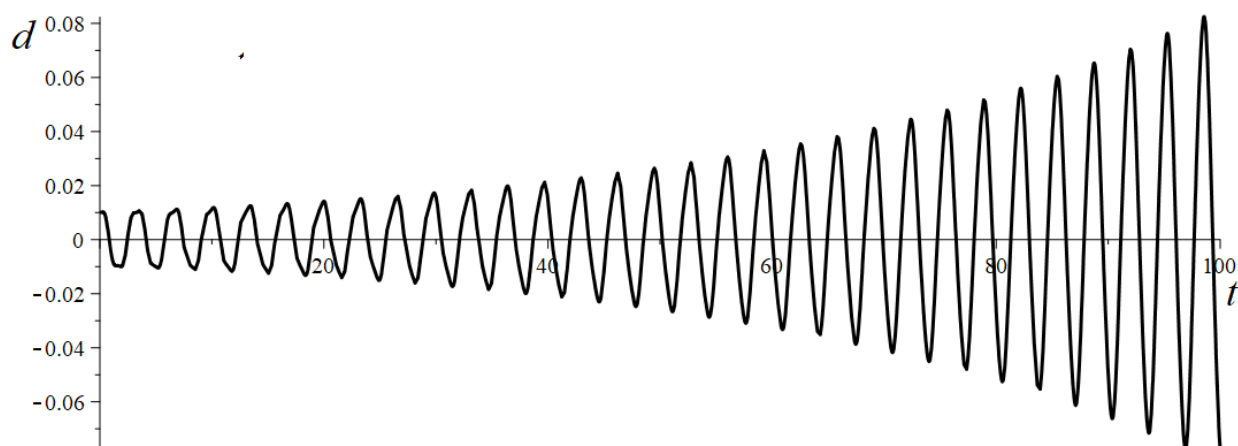


Fig. 2. Change in the rise level of the liquid free surface in the tank.

The amplitude increasing occurs due to the fact that the determining frequency of the earthquake of 2 Hz is close to two frequencies of splashing - the eighth and the ninth. In order to avoid negative consequences, it is necessary to implement damping elements inside the tank, which will lead to detuning from the dangerous frequency and prevent hazardous contents from spilling out.

CONCLUSION

Calculation method of the level of aggregate rise in reservoirs under seismic action has been proposed in the paper. The implementation of damping elements inside the tank will prevent the emergency concerned with hazardous contents spilling out.

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