AMERICAN JOURNALS
Open Access, Peer Reviewed Journals

American Journal of Technology and Applied Sciences
ISSN (E): 2832-1766 Volume 48, May - 2026

ASSESSMENT OF SEISMIC STRENGTH OF RESERVOIRS INTENDED FOR OIL PRODUCTS

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ABSTRACT

This study presents engineering solutions aimed at reducing the seismic vulnerability of reservoirs intended for petroleum products. Scientific and practical proposals have been developed to increase the seismic resistance of the reservoir and structural strengthening measures have been proposed based on numerical analyses performed in the LIRA-SOFT 10.12 software package.

KEYWORDS

LIRA-SOFT 10.12 program, seismic loads, equivalent stresses, cylindrical steel tank, ribs, load cases, buckling indices, dynamic analysis, seismic resistance.

Introduction

In recent years, the number of devastating earthquakes in the world has increased, seriously affecting the lives of the population and the socio-economic infrastructure of countries. Therefore, as part of the continuous improvement of seismic safety, it is important to strengthen the interaction of government bodies and organizations in ensuring the seismic strength of existing and under-construction buildings and structures, earthquake forecasting, monitoring, and preparation for them.**(This article was prepared within the framework of the project of the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan on the topic of determining the level of seismic resistance of reservoirs in the oil and oil and gas industry and developing measures to reduce seismic risk, scheduled for implementation in 2024-2025)**

Despite the development of the construction industry from year to year, earthquakes are still a dangerous natural disaster, causing many serious accidents. Among the structures that suffer various damages during earthquakes, sometimes with fatal consequences, vertical tanks for storing fuel products stand out. The development of the oil and gas industry has led to the construction of many tanks for storing products even in seismically hazardous areas.

Calculations for seismic effects were carried out in accordance with the requirements of clause 2.6 a) of QMQ 2.01.03-19. In this case, the settlement and equivalent stress values of the reservoirs were calculated based on the regulatory documents SHNQ 2.02.01-19 and SHNQ 2.03.05-23. The

distribution of equivalent stresses generated in the plates of a cylindrical metal reservoir structure, calculation models for the state of filling the liquid with petroleum products by 50%, 75% and 100% of the volume were created in the Lira Soft 10.12 program, static and dynamic calculations were performed.

The area where the reservoir is located is considered an area with a high probability of a strong earthquake, i.e., an 8-point earthquake, as defined in Appendix 1 of the QMQ 2.01.03-19.

The RSV No. 2 reservoir selected for the study was put into operation in 2010. According to the conclusions of the industrial safety examination, its technical condition was considered satisfactory. It underwent defectoscopy in 2023. Currently, this reservoir is being used. Table 1 presents the technical parameters of the reservoir.

Reservoir technical indicators Table 1

No.	Naming	Quantity	Unit of measurement
1	Height	5.2	m
2	Diameter	5.48	m
3	Wall thickness	4	mmm
4	Bottom part	2.6	mmm
5	Roof part	2.9	mmm
5	Size	200	m3

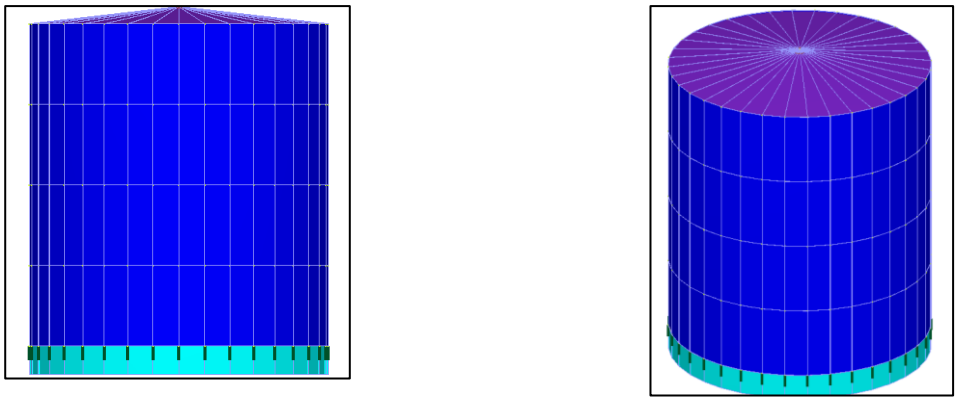

Figure 1. Overview of the reservoir computational model

The calculation is carried out for the following loads:

Download 1- static load (Specific weight of the structure). This load is considered as a permanent load.

Download 2- static load (static pressure of the liquid on the bottom and walls of the tank). This load is considered a constant load.

Download 3- Dynamic loading (accelerogram along the X-axis).

Download 4- Dynamic loading (accelerogram along the Y-axis).

Calculation features for dynamic effects

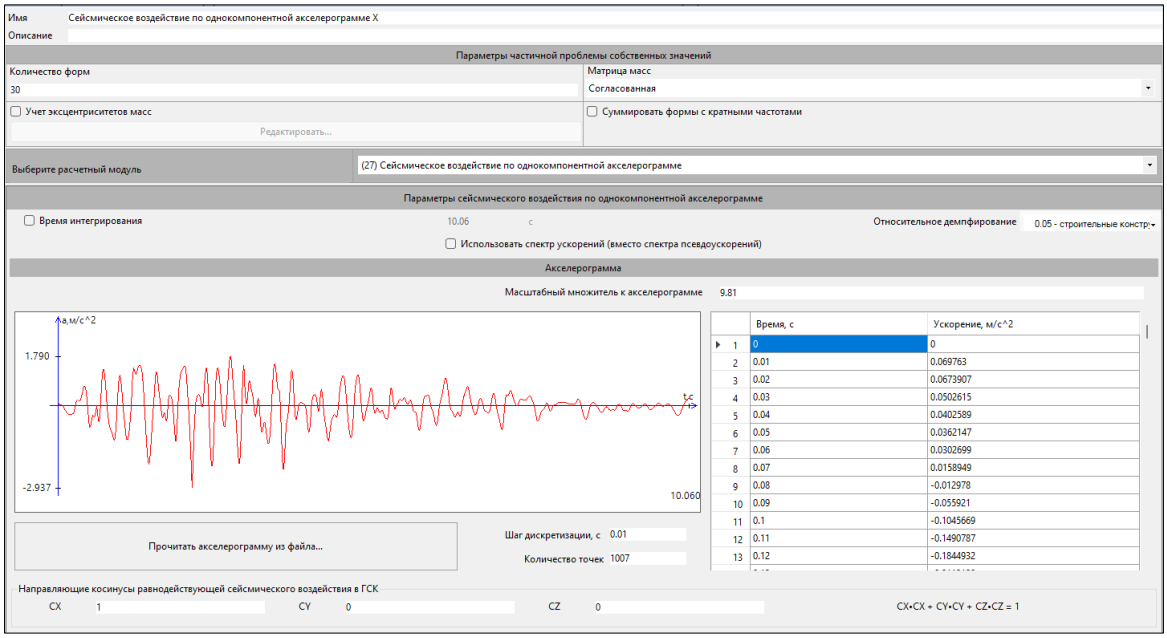

Figure 2. Dynamic effect along the X-axis direction

Periods and frequencies of oscillations Table 2

Loading	Vibration form	Private value	Frequency (rad/s)	period (s)	Dynamic coefficient βx	Distribution coefficient	Model mass (%)	Total model mass (%)
3	1	0.0125448	8.9283	0.70374	21.2855	-5.2738E-08	0	0
3	2	0.00104811	30,888	0.20342	84.1553	-2.33728E-05	0	0
3	3	0.00097826	31,972	0.19652	91.6814	-5.79571	12.6667	12.6667
3	4	0.00097826	31,972	0.19652	91.6814	-12.4166	58.1375	70.8041
4	1	0.0125448	8.9283	0.70374	21.2855	1.13555E-07	0	0
4	2	0.00104811	30,888	0.20342	84.1553	-1.14655E-05	0	0
4	3	0.00097826	31,972	0.19652	91.6814	12.4166	58.1375	58.1375
4	4	0.00097826	31,972	0.19652	91.6814	-5.79572	12.6667	70.8041

CALCULATION RESULTS OF RESERVOIR CONSTRUCTION

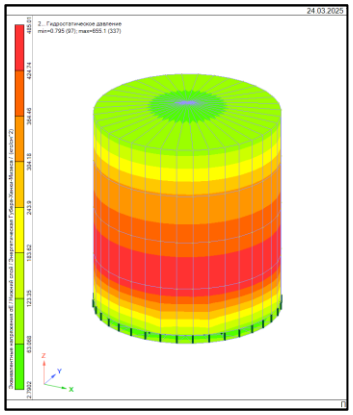

Figure 3. Equivalent stress in the lower layer σE [Hydrostatic pressure], kgf/cm2. (liquid filled 50% condition)

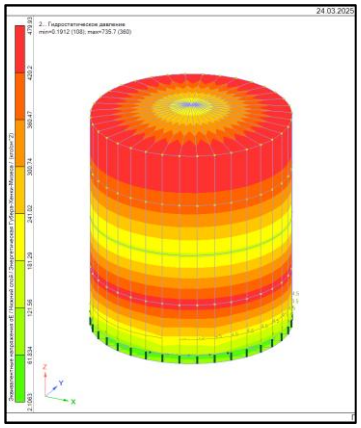

Figure 4. Equivalent stress in the lower layer σE [Hydrostatic pressure], kgf/cm2. (liquid filled 75% condition)

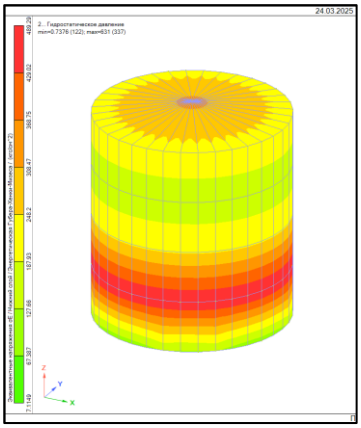

Figure 5. Equivalent stress in the lower layer σE [Hydrostatic pressure], kgf/cm2. (liquid 100% filled condition)

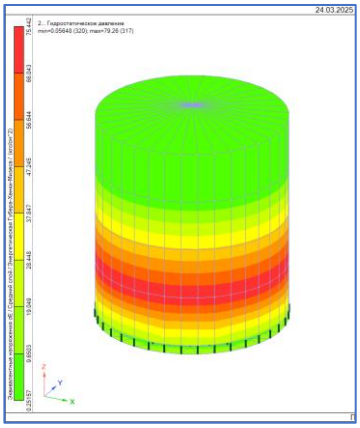

Figure 6. Equivalent stress in the middle layer σE [Hydrostatic pressure], kgf/cm2. (liquid filled 50% condition)

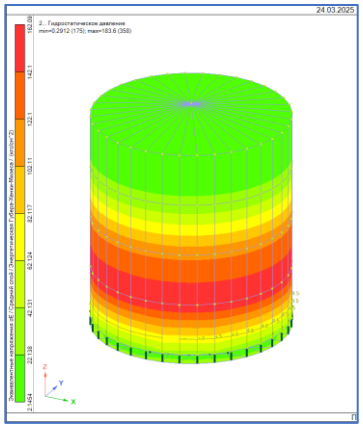

Figure 7. Equivalent stress in the middle layer σE [Hydrostatic pressure], kgf/cm2. (liquid filled 75% condition)

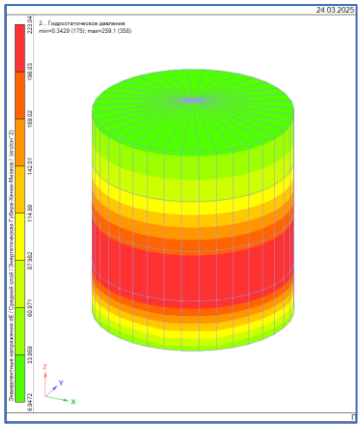

Figure 8. Equivalent stress in the middle layer σE [Hydrostatic pressure], kgf/cm2. (liquid 100% filled condition)

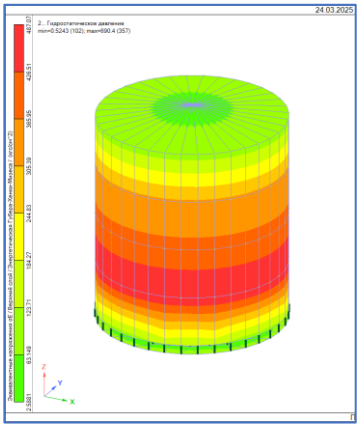

Figure 9. Equivalent stress in the upper layer σE [Hydrostatic pressure], kgf/cm2. (liquid filled 50% condition)

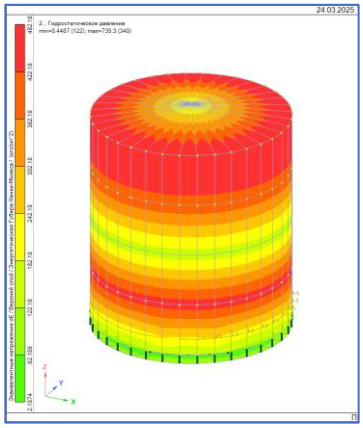

Figure 10. Equivalent stress in the upper layer σE [Hydrostatic pressure], kgf/cm2. (liquid filled 75% condition)

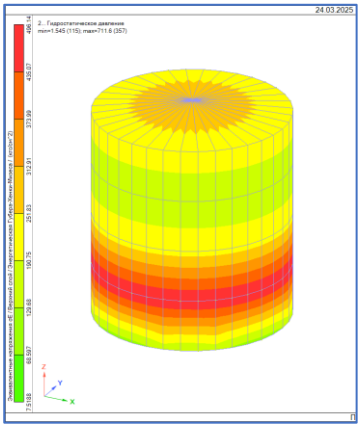

Figure 11. Equivalent stress in the upper layer σE [Hydrostatic pressure], kgf/cm2. (liquid 100% filled condition)

LIMIT STATE ASSESSMENT OF RESERVOIR STRUCTURE Table 3

Analysis of the calculation results of the reservoir structure					
Liquid filling level	%	50	75	100	Ry
Bottom layer	σE	485,01	479,93	489,29	2450
Middle layer	σE	75,442	162,09	223,04	2450
Top layer	σE	487,07	482,18	496,14	2450
Sinking	mmm	8,0663	8,6971	11,819	80

Reservoir design limit state assessment chart

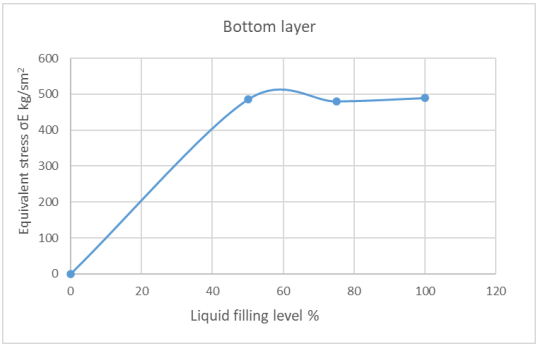

Figure 12.Diagram of the dependence of the equivalent stress in the lower layer on the level of liquid filling

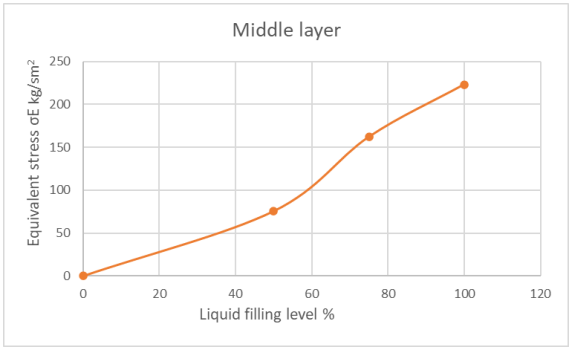

Figure 13. Mediumdiagram of the dependence of the equivalent stress in the layer on the degree of liquid filling

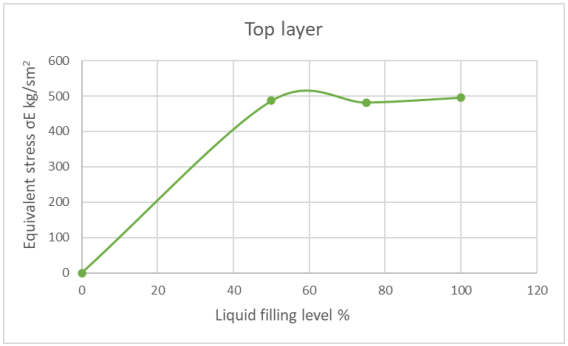

Figure 14. Topdiagram of the dependence of the equivalent stress in the layer on the degree of liquid filling

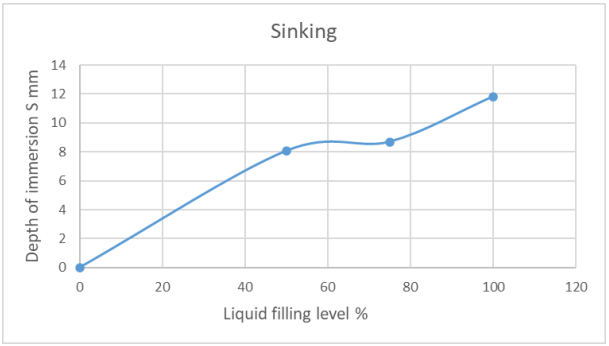

Figure 15.Diagram of the dependence of the depth of immersion on the level of liquid filling

CONCLUSIONS

1. The distribution of equivalent stresses in the plates of a cylindrical metal reservoir structure, calculated models in the case of filling the liquid with petroleum products by 50%, 75% and 100% of its volume, were created in the Lira Soft 10.12 program, static and dynamic calculations were performed. Calculations for seismic effects were carried out in accordance with the requirements of

clause 2.6 a) of QMQ 2.01.03-19. In this case, the settlement of the reservoirs and the equivalent stress values were calculated based on the regulatory documents SHNQ 2.02.01-19 and SHNQ 2.03.05-23.
2. According to the calculation results, when the reservoir is filled with 50% of the volume with the product, the equivalent stress σE is 485.01 kgf/cm2 in the lower part of the reservoir, 75.442 kgf/cm2 in the middle part, and 487.07 kgf/cm2 in the upper part, andIt was determined that the limit values do not exceed the values given in Table 3 of Appendix 3 of the normative document SHNQ 2.03.05-23 “Steel structures. Design requirements”.
3. According to the calculation results, when the reservoir is filled with 75% of the volume with the product, the equivalent stress σE is 479.93 kgf/cm2 in the lower part of the reservoir, 162.09 kgf/cm2 in the middle part, and 482.18 kgf/cm2 in the upper part, andIt was determined that the limit values do not exceed the values given in Table 3 of Appendix 3 of the normative document SHNQ 2.03.05-23 “Steel structures. Design requirements”.The results of this article were carried out within the framework of the project of the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan on the topic of determining the level of seismic resistance of reservoirs in the oil and oil and gas industry, developing measures to reduce seismic risk, scheduled for implementation in 2024-2025.

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