



DETERMINING THE REINFORCEMENT CONSUMPTION OF THE COLUMNS AND BEAMS OF BUILDINGS WITH SWIMMING POOLS OF VOLUMES 168 M³ AND 336 M³ IN THE SLAB SECTIONS USING THE LIRA-SAPR PROGRAM, AND COMPARING THEM IN PERCENTAGES.

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Abstract: *In this article, the variation in reinforcement consumption in the columns and beams of multi-story reinforced concrete buildings with swimming pools of 168 m³ and 336 m³ located on the roof was analyzed using the LIRA-SAPR PK 9.6 program. A 13-story frame designed for the 9th seismic zone of Uzbekistan was analyzed using the LIRA-SAPR PK 9.6 software. The model simultaneously accounted for the cross-sections of columns and beams, floor heights, the water pressure from rooftop pools, and temporary loads.*

Keywords: *Multi-story buildings, reinforced concrete frame, seismic zone, roof structure, non-conventional loads, dynamic effect inertia forces, spatial model, LIRA-SAPR PK 9.6, LIRA-ARM module, reinforcement cross-sectional area, reinforcement percentage, static and dynamic loading, seismic design, engineering analysis, numerical experiment.*

Introduction

In recent years, the construction of multi-story residential and public buildings in the major cities of Uzbekistan—Tashkent, Andijan, Namangan, Bukhara, and Samarkand—has been increasing significantly. In line with modern architectural standards, it has become common practice to create recreational areas, swimming pools, technical spaces, fitness zones, and entertainment facilities on the upper floors of such buildings. Additionally, changes in people's lifestyles and the growing demand for recreational infrastructure are also necessitating the construction of functional facilities on the roof. However, such structures introduce unconventional

loads that are considerably more hazardous and complex than conventional structural loads.

The fact that much of Uzbekistan's territory falls within seismic zones 8–9 also requires additional caution when designing reinforced concrete frame buildings. Seismic vibrations dynamically interact with the pool water located in the roof area, imposing additional inertial forces on the structural elements. Therefore, in seismic zones, the calculation of buildings with swimming pools in their roof structures is more complex than that of ordinary buildings, and precise calculation methods are required to ensure their stability.

Today, modern computer programs, particularly LIRA-SAPR PK 9.6, are widely used to solve such complex structural problems. This program enables the comprehensive consideration of all types of loads, including water pressure, dead and live loads, seismic effects, and floor-to-floor connections. Additionally, the LIRA-ARM module within LIRA-SAPR helps to accurately determine the required reinforcement cross-sections in structural elements and to optimize the elements in accordance with regulatory requirements.

During the scientific research and practical work, automated calculation suites for the static, dynamic, and non-traditional load calculations of multi-story building structures were studied and analyzed. In this regard, it was decided to use the “Lira PK” software suite, which is currently widely employed in our country's building and structure design practice. Using this software package, a numerical experiment was conducted on the structural systems of a multi-story building subjected to non-traditional loads. The numerical experiment was carried out using a variational program.

Initial data and methodology for the calculation

The buildings' plan layout is a regular rectangle, with a length of 21.6 meters and a width of 10.8 meters, column spans of 3.6 m and bay lengths of 1.2; 4.2; 2.4; 4.2; 1.2 meters, 13-story reinforced concrete. Structural parameters: number of

stories – 13; column section – 400×400 mm; beam section – 400×400 mm; region – seismic intensity level 9 in Tashkent.

The calculations were performed in LIRA-SAPR PK 2017 (9.6). A three-dimensional spatial model of the building was created, and all loads were transferred to the structural elements. The following normative and design parameters were used as a basis:

In the numerical experiments, the reinforcement cross-sectional areas and reinforcement percentages in the columns and beams of the considered frames were determined using the Lira ARM module of the Lira PK 9.6 software, which is designed for calculating reinforcement cross-sectional areas. The reinforcement percentages for the elements of the reinforced concrete frames are shown in the following figures.

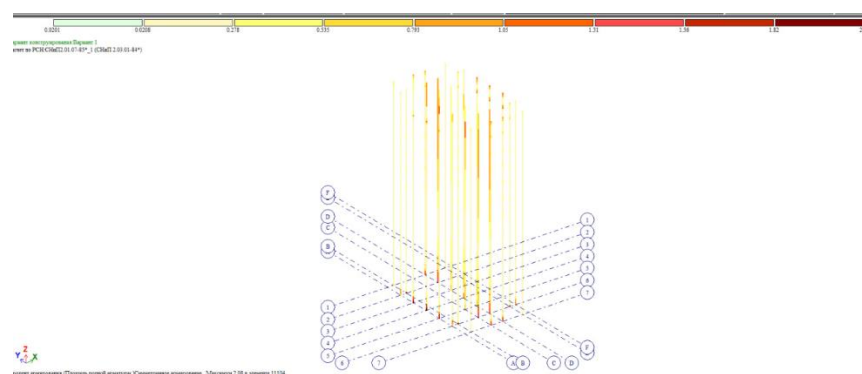


Figure 1. Percentage of column reinforcement for a building with a 168 m³ water reservoir in the roof slab.

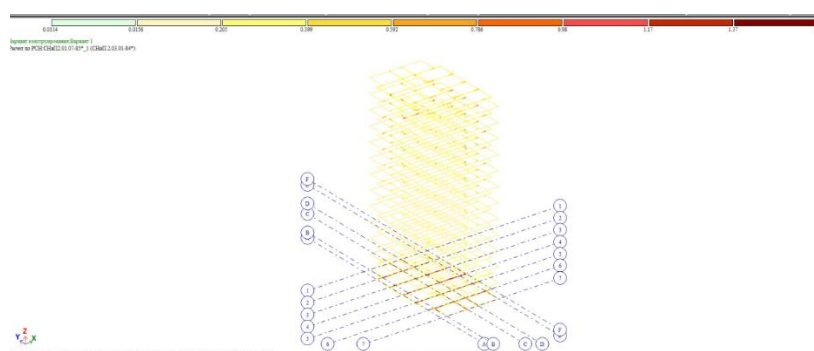


Figure 2. Percentage of reinforcement in the beams of a building with a 168 m³ water reservoir in the roof slab.

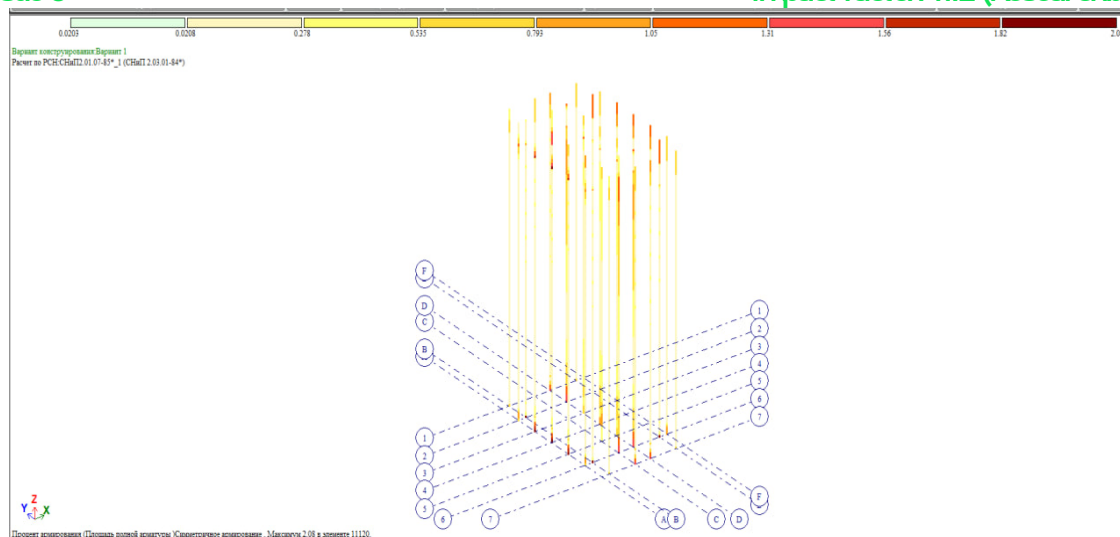


Figure 3. Percentage of column reinforcement for the building with a 336 m³ water reservoir in the roof slab.

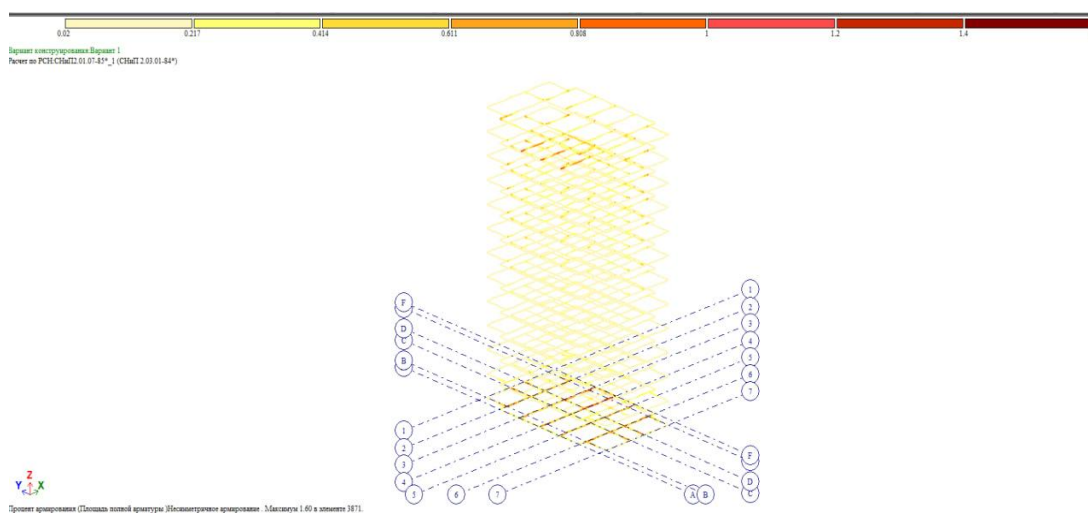


Figure 4. Percentage of reinforcement in the beams of the building with a 336 m³ water reservoir in the roof slab.

We summarize these results in the following table:

Table 1.

№	Structural system and dimensions of the reinforced concrete frame	Maximum reinforcement percentage in columns and beams, %
1	A building column with a 168 m ³ water reservoir on the roof.	2.08
2	The building's roof has a water reservoir with a capacity of 168 m ³ .	1.56
3	A building column with a 336 m ³ water reservoir on the roof.	2.08
4	The building's roof has a water reservoir with a capacity of 336 m ³ .	1.6

Conclusion

The research results showed that the loading of the columns and beams operating under swimming pools with volumes of 168 m³ and 336 m³, located in the basement, differ significantly. The data obtained using the LIRA-SAPR software confirm the following:

- When the pool volume was doubled, the column reinforcement remained almost unchanged, while the beam reinforcement increased by 0.04%.
- Since the beams are the most heavily loaded element of the structure, the rate of increase in reinforcement was higher, changing from 1.56% to 1.6%.
- These results indicate the necessity of detailed calculations in the LIRA-SAPR software when applying non-conventional loads to roof structures. Such analyses are crucial for ensuring the safety of the structure and for designing in compliance with regulations.

References

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