EFFICIENCY OF APPLICATION OF FRAME-SHEATHED ENCLOSING STRUCTURES IN MULTI-STOREY FRAME BUILDINGS IN SEISMIC AREAS

UDC 624.94.012.45 + 692.231.3

Abbos Agzamovich Khodjaev
Doctor of Technical Sciences, Professor, Turin Polytechnic University in Tashkent (TPUT)

Ibrokhim Soibjonovich Karimjonov
2nd year master student, Tashkent Institute of Architecture and Civil engineering (TIACE)

Abzalkhon Akmalovich Saidakromov
2nd year PhD doctoral student Tashkent Institute of Architecture and Civil engineering (TIACE)
https://doi.org/10.5281/zenodo.6560867

Annotation: The article is devoted to the review and calculation on the topic of using external walls made of various materials, such as: brick and frame-sheathed walls - used as enclosing structures in multi-storey reinforced concrete frame buildings. Frame-sheathed walls today have broad prospects for introduction into mass construction in Uzbekistan and abroad and can be used in the construction of a number of buildings and structures for various purposes. The rapid pace of scientific and technological progress, as well as the emerging trends towards the rationalization of design and installation work, assign frame-sheathed walls made of light steel thin-walled structures and sheet materials to one of the main roles in modern civil and industrial construction.

The review of works contains both theoretical, based on shell modeling of the work of structures, and experimental results of research. Attention is drawn to the comparison of analytical and experimental results.

Key words: seismic area, external wall, frame-sheathed wall (FSW), lightweight steel thin-walled structure (LSTS), brick, fitting, reinforced concrete frame building, multi-storey reinforced concrete building.

Introduction. The beginning of the 21st century was marked by the active formation of innovative efficient technologies in the construction and reconstruction of buildings and structures. Solving the problems of lightening the enclosing structures of external walls in seismic areas, resource saving and increasing productivity in the construction of buildings is one of the important areas for increasing the efficiency of construction. This determines the relevance of research in this direction in our country.

Today, a significant share in the construction of housing and public buildings in Uzbekistan is occupied by buildings and structures using such materials for external walls as: brick, foamed blocks, and aerated blocks.

The most progressive today is enclosing frame-sheathed walls (FSW) with a frame made of lightweight steel thin-walled structures (LSTS), using galvanized steel profiles and board materials. Their main advantage is to lighten the structures of the building, especially multi-storey buildings.

Frame-sheathed wall (FSW) is a multilayer combined structural system consisting of a frame (skeleton), materials for insulation / sound insulation that fill the cavity of the frame, wall sheathing (external and internal), fasteners, vapor barrier and wind protection, external cladding (facade), as well as a set of technical and technological solutions that determine the rules and procedure for installing this system in the design position.

FSW with the use of LSTS - frame-sheathing walls, the frame of which consists of steel bent galvanized profiles.

The external FSW, developed on the basis of a frame made of LSTS, consists of the following elements:

- bearing perforated profile ("thermoprofile"), located in vertical (racks) and horizontal (crossbar, bed) position, interconnected by screws and self-tapping screws;
- effective insulation located in the space between the steel profiles;
- internal covering from board materials. Gypsum boards, sement boards or other materials are mainly used);
- vapor barrier and diffusion membrane;
- outer cladding. It is made of board materials, or using the technology of a hinged ventilated facade.

However, these structures have not yet been used in Uzbekistan. For their wide application in the construction of buildings in our country, it is necessary to carry out experimental and theoretical studies with enclosing structures made of FSW with the development of scientific-based recommendations for their use.

The most used bricks and multi-layer bricks for walls in construction are made from clay with or without the addition of additives to easily soluble soils. Such bricks are mainly used in the construction of external and internal walls of buildings from brick blocks and panels. Ordinary clay bricks are available in sizes 250×120×65 mm and 250×120×88 mm. When erecting a wall, the size of the seam between the bricks should not exceed 12 mm. When planning, the productivity of factories is calculated based on the volume of bricks, a wall with a capacity of 1 m^3 is built from 400 bricks, the weight of a brick is about 4 kg, and the average density is 1600–1800 kg/m^3.

According to this data, in buildings with an average floor height of 3.3 meters, the outer wall of which is made of brick, for each meter of load-bearing beams, there are about 2 tons of load from the outer wall.

In accordance with the building codes and regulations which are valid in Uzbekistan, it is advisable to build external walls from lightweight materials.

From this point of view, the calculation of structures of external walls with different weights and the choice of the most optimal of them in a certain multi-storey reinforced concrete frame building located in a seismically hazardous zone are always relevant.

Object of the research. Frame-sheathed walls of multi-storey reinforced concrete frame buildings.

Subject of the research. Conditions for the use of external FSW in the design and construction of residential and public buildings.

Main part. The calculation of the external wall structures in various weight options in a multi-storey reinforced concrete frame building, in a seismically hazardous area, can be seen on the example of the following research object:

As an object of the research, a residential 12-storey reinforced concrete frame building was chosen at the address: Tashkent city, Yunusabad district, the intersection of Yangi Shakhar and Chinabad streets.

Characteristics of the construction area.

- Construction area – Tashkent city, Republic of Uzbekistan;
- Climatic construction area - 4, according to KMK 2.01.01-94;
- Normative value of snow cover per 1 m^2 of the horizontal surface of the earth - 50 kgf / m^2 for the first snow area;
- Normative value of wind pressure - 38 kgf / m^2 in the 3rd wind region;
- The construction site is located outside the mudflow zone of the city;
- The construction site is seismic, according to KMK 2.01.01-96;
- Seismicity of the site according to the construction and installation works map of Tashkent city - 8 points;
- Soil category by seismic properties - 2.

Bearing structures and structural elements of the building.

- Structural solution - frame;
- Foundations for the supporting structures of the building - a monolithic foundation slab. Concrete class B 25 on conventional cement. Under the foundation slabs, concrete preparation is carried out with a thickness of 0.1 m from concrete of class B 7.5;
- The section of the column and crossbars have dimensions from 600×600 mm and 500×500 mm and 400×500 (h) mm from ordinary concrete class B 25;
- All internal partitions made of bricks;
- External walls in the underground parts of the building - from a monolithic wall, reinforced with a mesh of reinforcement 12A3;
- External walls on the above-ground parts of buildings - from brickwork from ordinary brick M100 on cement-sand mortar grade 75;
- The building is rectangular in plan, with dimensions in the axes - 21.3 × 21.3 m;
- Floors of the building - 12 floors;

ISSN: 2181-3132

- Height of floors (from floor to floor) of the 1st floor - 4.2 m;

- Height of floors (from floor to floor) from floors 2 to 12 - 3.3 m;

- The height of the basement floor is 2.9 m

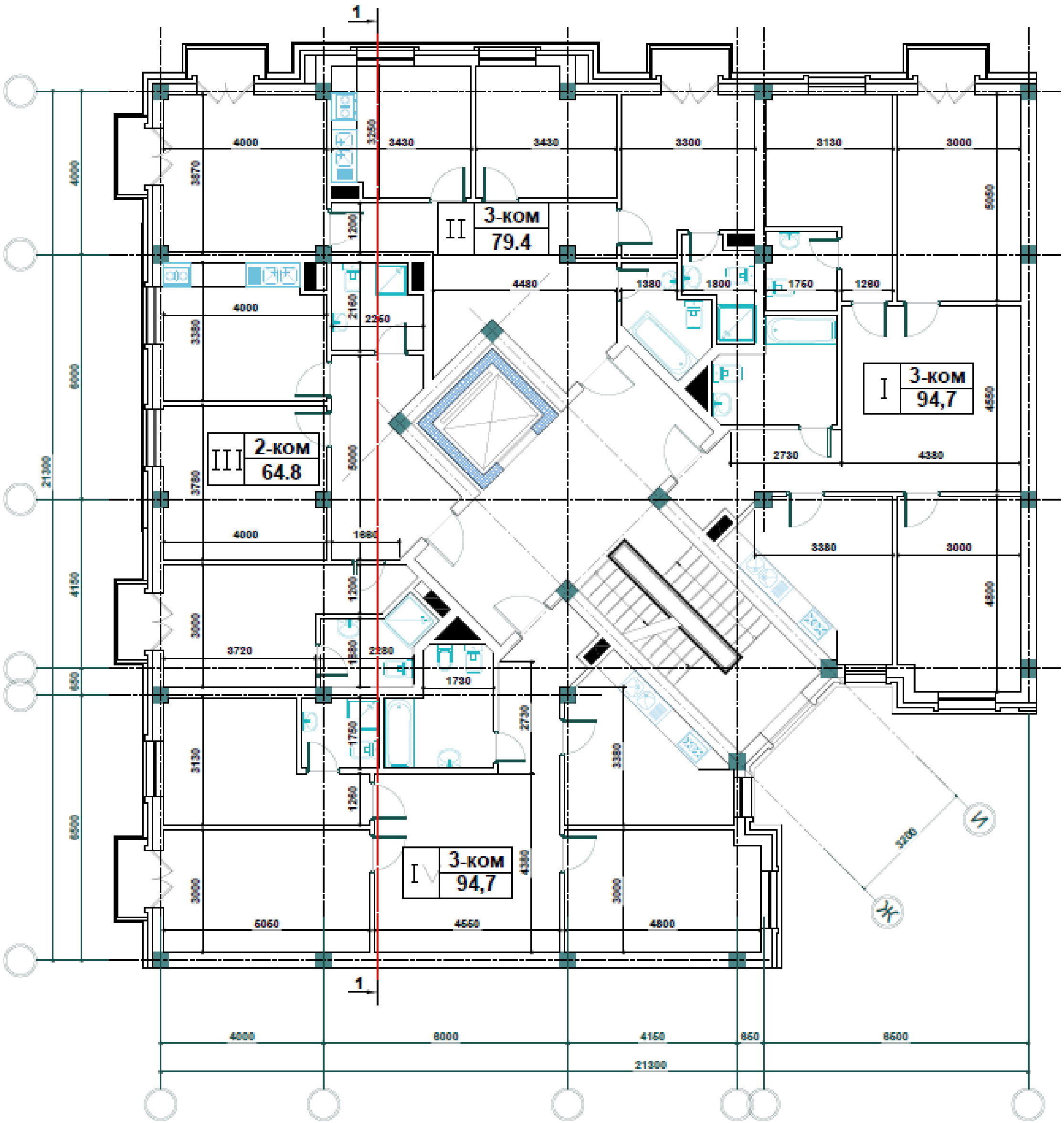
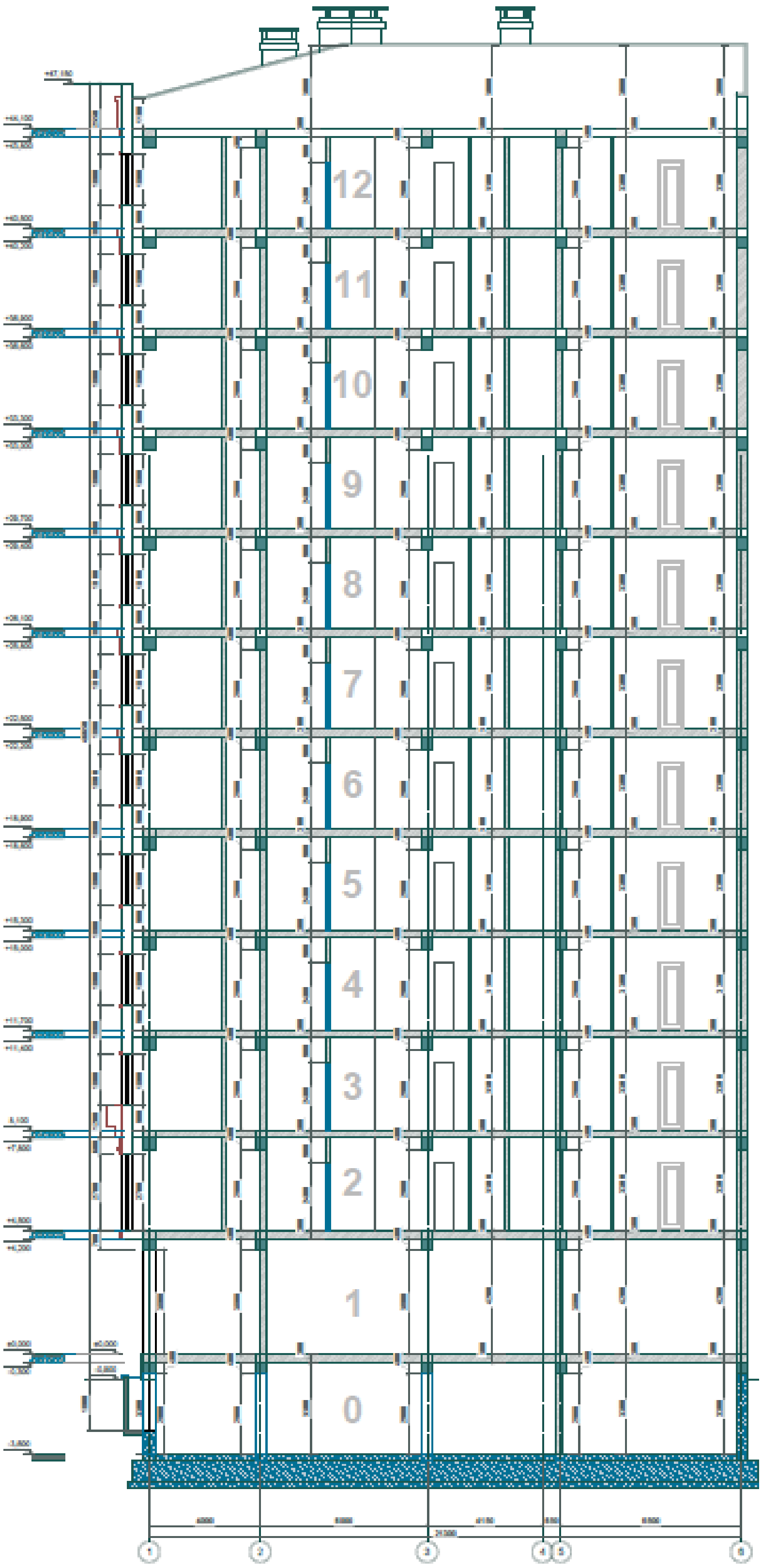


Figure 1. Plan view of the building.

ISSN: 2181-3132



ISSN: 2181-3132

Figure 2. Sectional view of the building.

Models of objects for design. When carrying out a numerical analysis, calculation work will be done with the following external walls of the building in question:

Table 1.

№	Types and thickness of the external walls of the building	Characteristics of the external walls
1	Brick: - 380 mm	Brand of brick: - M 100. Solution grade: - 75. ρ= 1800 kg/m^3.
2	FSW - 240 mm	ρ= 300 kg/m^3.

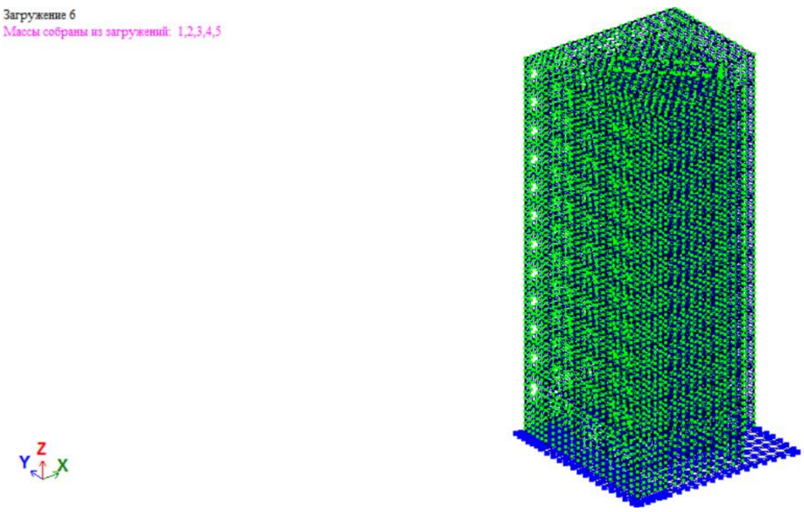


Figure 3. Calculation model of the building.

ISSN: 2181-3132
Yosh Tadqiqotchi Jurnali

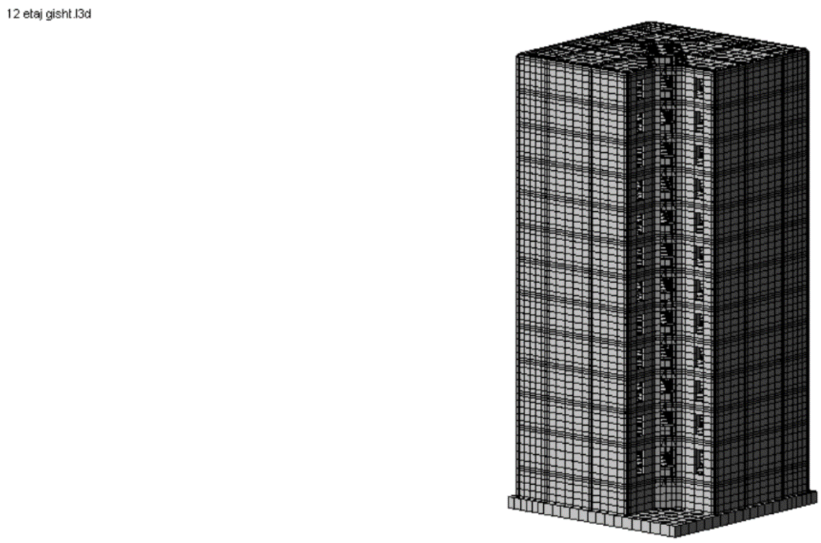


Figure 4. 3D model of the building.

As a rule, buildings in seismic areas are designed according to schemes in which the walls of these buildings perceive the seismic load as load-bearing structures, or are not load-bearing, and the building frame perceives the seismic load. However, it is not recommended to increase the height of buildings, the external walls of which perceive seismic loads, by more than 5-7 floors. Therefore, according to paragraphs E and Ж, Table 3.1 KMK 2.01.03-19, the calculation of external walls in the model of a multi-storey building considered in this article is carried out without the participation of seismic effects and without the participation of their rigidity in the building.

Methods of calculation. The calculations were carried out using the normative document KMK 2.01.03-19 "Construction in seismic regions" and dynamic method in the LIRA CAD (SAPR) program by the finite element method.

The cross section and percentage of reinforcement of the building frame columns under consideration in numerical experiments are reproduced by the LIRA ARM modular program, depended on for calculating the reinforcement cross section of the PC LIRA CAD (SAPR) program. Below are the figures with the percentage of fittings of reinforced concrete frame elements.

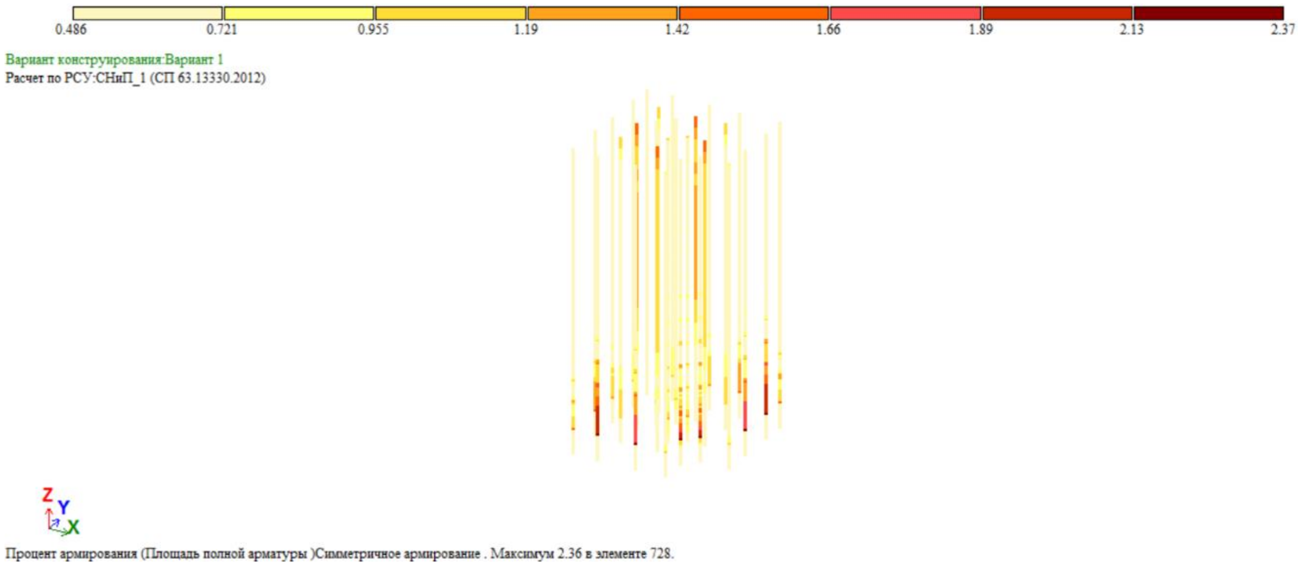


Figure 5-a. The percentage of reinforcement in the columns of a building with brick exterior walls.

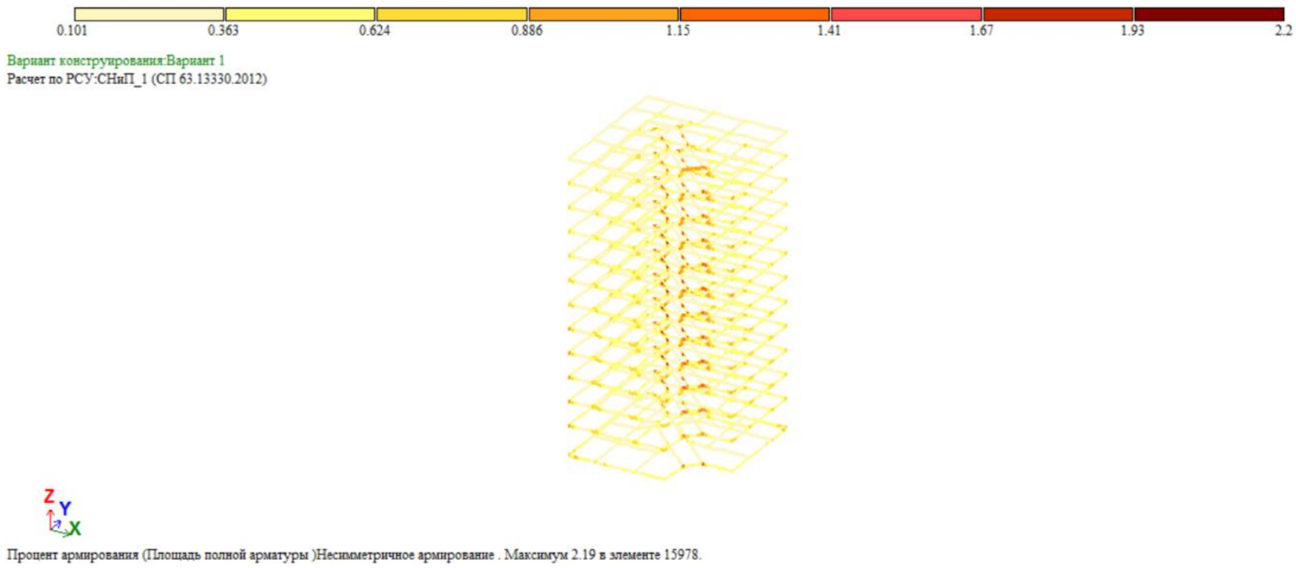


Figure 5-b. The percentage of reinforcement in the transoms of a building with external walls made of bricks.

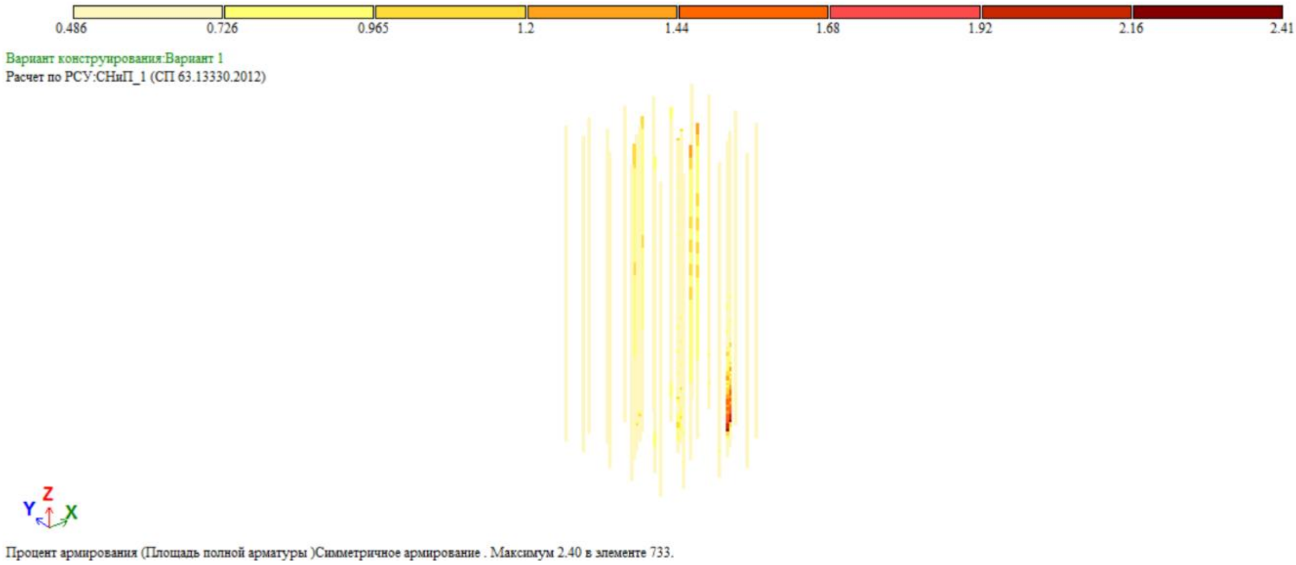


Figure 6-a. The percentage of reinforcement in the columns of a building with external walls made of frame-sheathed walls.

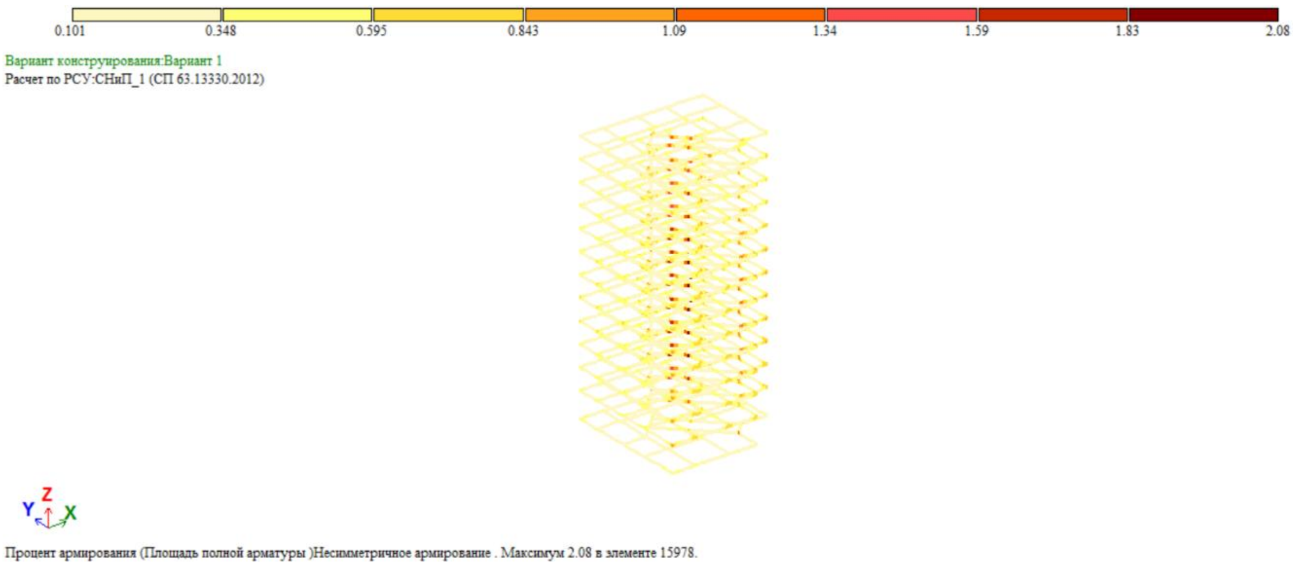


Figure 6-b. The percentage of reinforcement in the transoms of a building with external walls made of frame-sheathed walls.

The results are expressed in the table below:

Table 2.

№	Structural system and size of the reinforced concrete frame	Maximum percentage of reinforcement in columns, %	Maximum percentage of reinforcement in transoms, %
1	Frame building with external brick walls, with dimensions of 21.3×21.3 m	2,37	2,2
2	Frame building with external walls made of frame-sheathed walls, with dimensions of 21.3 × 21.3 m	2,41	2,08

Below, Table 3 shows the results of fitting consumption in reinforced concrete building structures with various external walls:

Table 3.

№	Structural system and size of the reinforced concrete frame	Column markings	Reinforcement area in columns, cm^2	Consumption of reinforcement of the 1st element	Quantity	Total consumption of reinforce-ment, t.
1	Frame building with external brick walls, with dimensions of 21.3×21.3 m	K1	59,1	2,09	6	38,18
		K2	41,6	1,47	4	
		K3	35,8	1,27	13	
		K4	18,4	0,65	5	
2	Frame building with external walls made of frame-sheathed walls, with dimensions of 21.3 × 21.3 m	K1	60,1	2,13	2	24,44
		K2	41,6	1,47	4	
		K4	18,4	0,65	22	

Table 4 shows the results of the total weight of the building using various external enclosing walls:

Table 4.

№	Structural system and size of reinforced concrete frame	Mass of the building, t
1	Frame building with external brick walls, with dimensions of 21.3×21.3 m	10 779,7
2	Frame building with external walls made of frame-sheathed walls, with dimensions of 21.3 × 21.3 m	8 707,26

General conclusions.

1. A three-dimensional model of a multi-storey reinforced concrete frame building was created using the FSW by means of the LIRA-SAPR software and digital experiments were carried out.

2. The constrained-deformational states of a multi-storey reinforced concrete frame building were determined using the FSW.

3. A comparative analysis of the constrained-deformational state, under the influence of seismic and dynamic loads of buildings using FSW and other materials, was carried out. The consumption of reinforcement in the columns of a building using various external walls - brick, aerated concrete and FSW is different, and the consumption of reinforcement in a building using FSW is 36% less compared to using a brick outer wall. The total weight of a building with FSW is over 20% lighter compared to using a brick exterior wall.

Bibliography

1. KMK 2.01.03-19. “Construction in seismic areas”, T-2019.

2. Zhmarin E.N. International Light Steel Construction Association. Internet magazine "Construction of unique buildings and structures", 2012, No. 2, pp. 27-30.

3. Exterior walls with a frame made of light steel thin-walled structures (LSTC). Bezborodov Evgeny Leonidovich – Senior Lecturer of the Department of Design of Buildings and Structures, National Research Moscow State Civil Engineering University (NRU MGSU).

4. Light steel thin-walled structures in high-rise buildings. Sovetnikov D.O., Videnkov N.V., Trubina D.A. Peter the Great St. Petersburg Polytechnic University, 195251, Russia, St. Petersburg, st. Politekhnicheskaya, 29. Submitted on October 6, 2014, accepted on February 17, 2015.

5. Vatin N.I., Popova E.N. Thermoprofile in light steel building structures. St. Petersburg: SPbSPU Publ., 2006. 63 p.

6. Rybakov V. A., Gamayunova O. S. Stress-strain state of elements of frame structures from thin-walled rods. Construction of unique buildings and structures. 2013. No. 7(12). pp. 79-123.

7. Vatin N.I., Sinelnikov A.S. Long-span elevated pedestrian crossings from a light cold-formed steel profile. Construction of unique buildings and structures. 2012. No. 1. pp.47-52.,

8. Vatin N. I., Sinelnikov A. S. Cold-formed steel profile in small bridge structures. Construction of unique buildings and structures. 2012. №3. pp. 39-51.

9. Vatin N.I., Volodin V.V., Zolotareva E.A., Petrov K.V., Zhmarin E.N. Reconstruction of the roofs of St. Petersburg based on light steel thin-walled structures and an anti-icing system. .. Engineering and construction magazine. 2010. No. 2 (12). pp. 59-64.

10. Vatin N.I., Popova E.N. Thermal profile in light steel building structures. St. Petersburg: SPbSPU Publ., 2006. 63 p.

11. Rybakov V.A., Gamayunova O.S. Influence of wall perforation on the bearing capacity of thermal profiles. StroyPROFIL. 2008. No. 1. P. 128.

12. Kuzmenko D.V., Vatin N.I. The enclosing structure of "zero thickness" is a thermal panel. Engineering and construction magazine. 2008. No. 1. pp. 13-21.

13. Nazmeeva T.V. Bearing capacity of compressed steel thin-walled elements of solid and perforated section from cold-formed C-profile. Engineering and construction magazine. 2013. No. 5(40). pp. 44-51.

14. Rybakov V.A., Gamayunova O.S. Stress-strain state of elements of frame structures from thin-walled rods. Construction of unique buildings and structures. 2013. No. 7(12). pp. 79-123.

15. Zhmarin E.N. International Light Steel Construction Association. Construction of unique buildings and structures. 2012. No. 2. P. 27-30., 126 Davies J. M. (2000). Recent research advances in cold-formed steel structures. Journal of Constructional Steel Research. 2000 Vol. 55. Issue 1. Pp. 267-288.

16. Niu S., Rasmussen K. J., Fan F. (2014). Distortional–global interaction buckling of stainless-steel C-beams: Part II–Numerical study and design. Journal of Constructional Steel Research. 2014. Issue 96. Pp. 40-53.

17. De Miranda Batista E. (1989). Effective section method: A general direct method for the design of steel cold-formed members under local-global buckling interaction. Thin-Walled Structures. 2010 Vol. 48. Issue 4. Pp. 345-356.

18. Durable and moisture-resistant constructions for facades and interiors Construction systems Knauf AQUAPANEL.

19. Complete systems Knauf - frame-sheathing exterior walls Knauf AQUAPANEL Exterior wall.

20. Album of technical solutions Knauf AQUAPANEL External wall. External non-bearing frame-sheathing walls with a frame made of steel thin-walled cold-formed galvanized profiles using Knauf materials.