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THE IMPORTANCE OF DYNAMIC AND SPECTRAL METHODS IN EARTHQUAKE CALCULATION OF HIGH-STOREY BUILDINGS

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Аннотация: *Мазкур мақолада зилзила таъсирига ҳисоблашнинг динамик ва спектрал усулининг афзаллик ва камчиликлари реал бинолар мисолида кўриб чиқилган ва ушбу икки усул ёрдамида ЛИРА САПР дастурида ҳисоблаш натижалари келтирилган.*

Аннотация: *В этой статье обсуждаются преимущества и недостатки динамического и спектрального метода расчета последствий землетрясения на примере реальных зданий и представлены результаты расчетов в программе ЛИРА САПР с использованием этих двух методов.*

Abstract: *This article discusses the advantages and disadvantages of the dynamic and spectral method of earthquake impact calculation on the example of real buildings, and presents the results of calculations in the LIRA SAPR program using these two methods.*

Калит сўзлар: *Динамик усул, спектрал усул, зилзила, кўчишлар, темирбетон каркас*

Ключевые слова: *Динамический метод, спектральный метод, землетрясение, смещения, железобетонный каркас*

Key words: *Dynamic method, spectral method, earthquake, displacements, reinforced concrete frame.*

Introduction: While ensuring the strength and priority of buildings and structures, it is important to correctly calculate them for seismic impact. The current normative document on the seismic calculation and design of buildings and structures on the territory of Uzbekistan provides for two basic methods for calculating earthquakes [1]. This normative document establishes that buildings and structures up to 40 meters high can be used for dynamic and spectral seismic calculations, Buildings and structures above 40 metres must be calculated using real or synthesized seismic effects.

In the Construction Norms and Rules (QMQ), the spectral seismic calculation of a building or structure is carried out mainly using the following expression [1].

$$S_{ik} = K_0 K_n K_{эт} K_p S_{oik}$$

$$S_{oik} = \alpha\, Q_k W_i K_\delta \eta_{ik}$$

S_{oik} - the force of inertia generated when the structure is assumed to be elastically deformed;

α- the coefficient obtained from Table 2.7 of this document, depending on the seismicity of the construction site.

Q_k- in the calculation history (Figure 2.2) is the weight of the building accumulated at point K, the calculated loads on the structure;

W_i- Spectral coefficient determined according to item 2.14 of QMQ;

K_δ- The dissipation coefficient determined according to item 2.16 of the QMQ;

K_p- The regularity coefficient of QMQ determined according to item 2.25;

K_0- Liability coefficient of QMQ determined from Table 2.3;

$K_{эт}$- A coefficient that depends on the number of storeys of the building determined in accordance with paragraph 2.17 of the QMQ;

η_{ik}- is the coefficient depending on the shape of the specific variation of the building on tone i and the location of the loads as determined in accordance with SQP 2.18 and 2.19;

$K_п$- is a coefficient that takes into account the frequency of the earthquake and is determined from Table 2.4 of the QMQ.

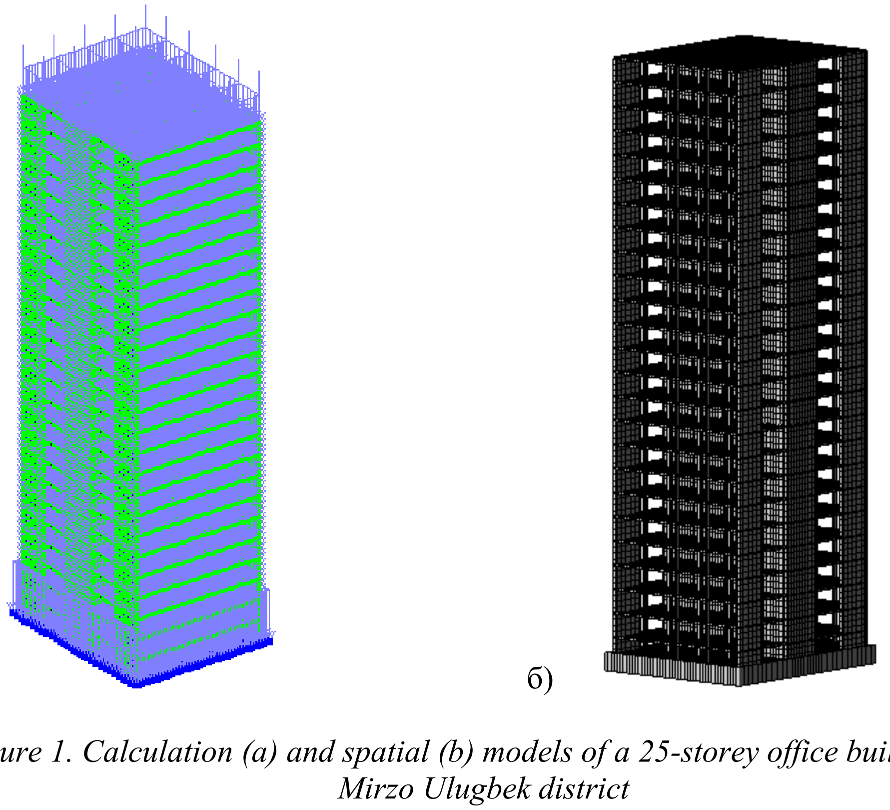
The spectral method is also called the conditional-static method.

In the dynamic method of calculating seismic effects, the construction is based on an axellogram of actual or synthesized seismic effects corresponding to the description of the terrain.

The main disadvantage of dynamic calculation is the emergence of a system of complex equations. Today, however, the development of information technology and computer software has made it possible to overcome this shortcoming.

By calculating dynamic and spectral methods of seismic calculation of two buildings under construction in Tashkent in the program LIRA SAPR, the advantages and disadvantages of the calculation of the above two methods can be further investigated. At the same time, public buildings were chosen, which were being built in the 9-point seismic zone of Tashkent, with a shape close to square shape.

№	**Building name**	**Dimensions**	**Structural system**
1	25-storey office building in Mirzo Ulugbek district	On axes 1-4 - 27 meters On the A-E axes - 31 meters Height - 98 meters	Reinforced concrete frame with diaphragms on either side whose walls are not involved in seismic impacts
2	4-storey office building in Yashnabad district	On axes 1-3 - 12.8 meters On the A-V axes - 12.8 meters Height - 14 meters	Reinforced concrete frame, whose walls are not subject to seismic effects



a) б)

Figure 1. Calculation (a) and spatial (b) models of a 25-storey office building located in Mirzo Ulugbek district

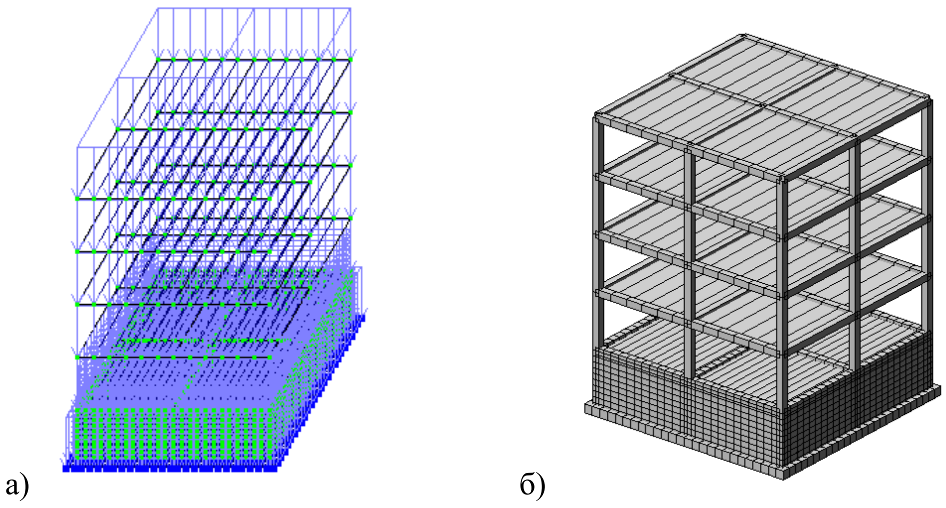


Figure 2. Calculation (a) and spatial (b) models of a 4-storey office building in Yashnabad district.

Calculations were carried out by the method of finite elements using the program LIRA SAPR 2019, based on the normative document QMQ 2.01.03-19 "Construction in earthquake zones" and the axellogram developed for the city of Tashkent, and the following results were obtained:

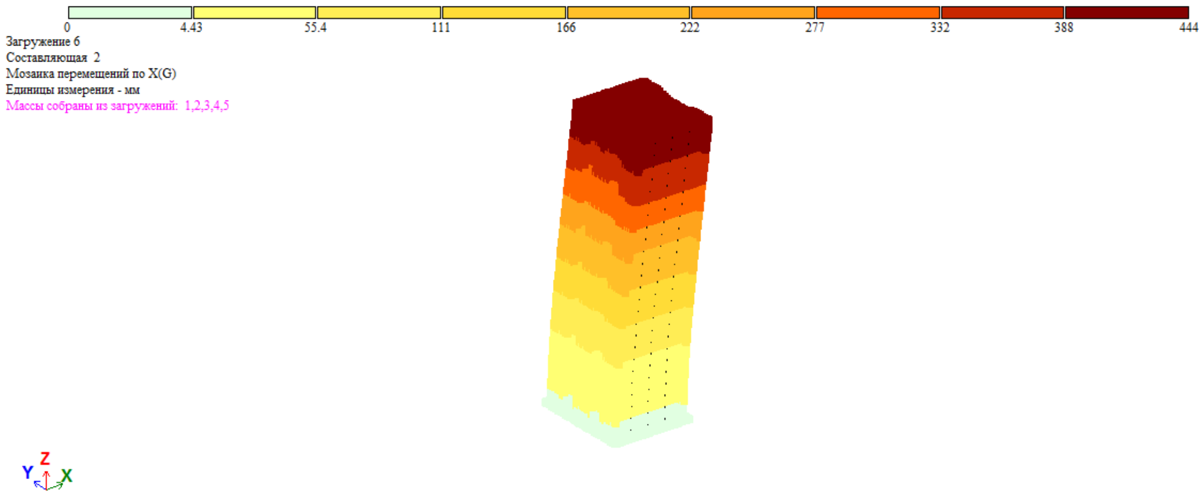


Figure 3. The result of displacements along the X-axis in the calculation of the building using the dynamic method

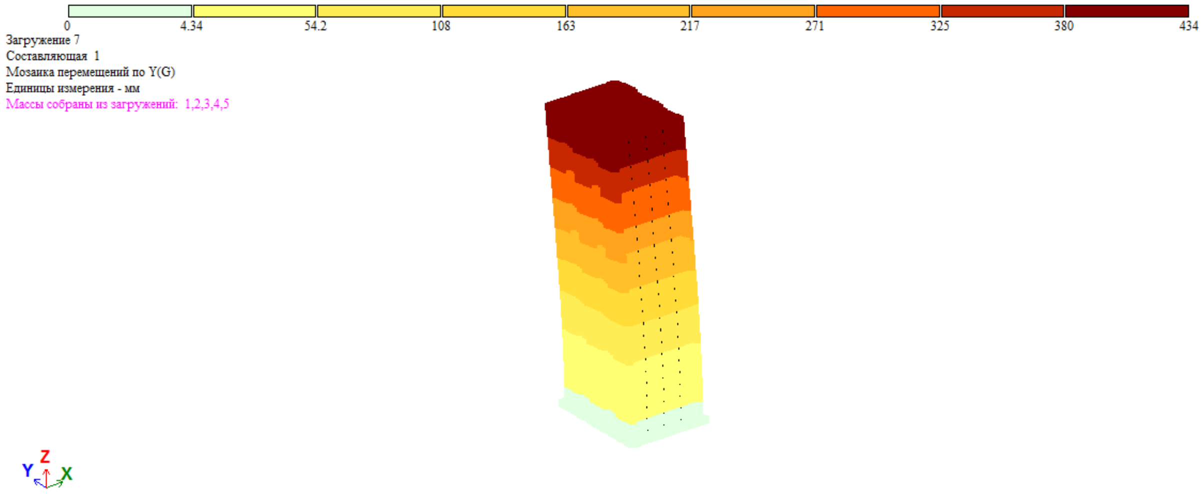


Figure 4. The result of displacements along the Y-axis in the calculation of the building using the dynamic method

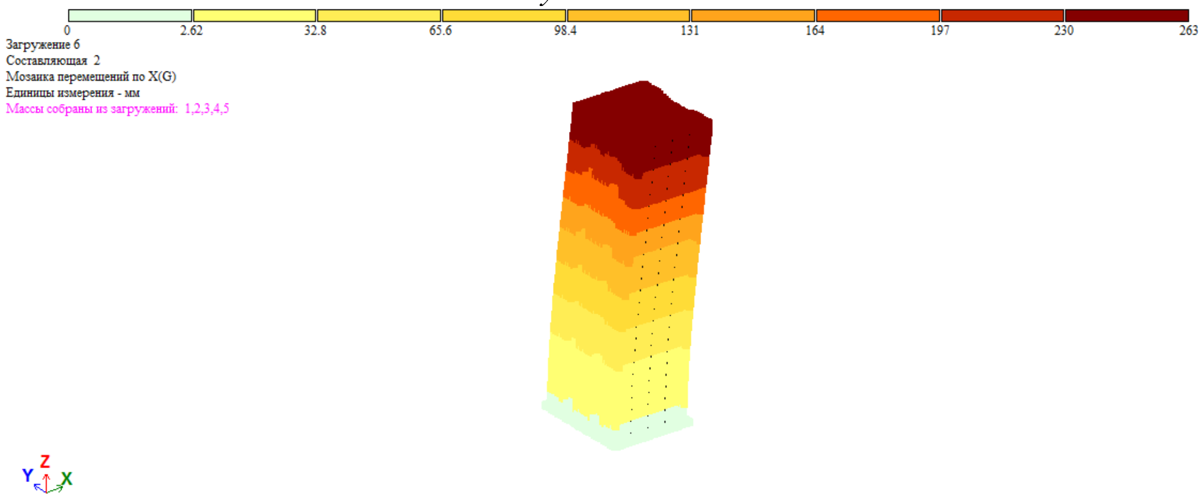


Figure 5. The result of displacements along the X-axis in the calculation of the building using the spectral method

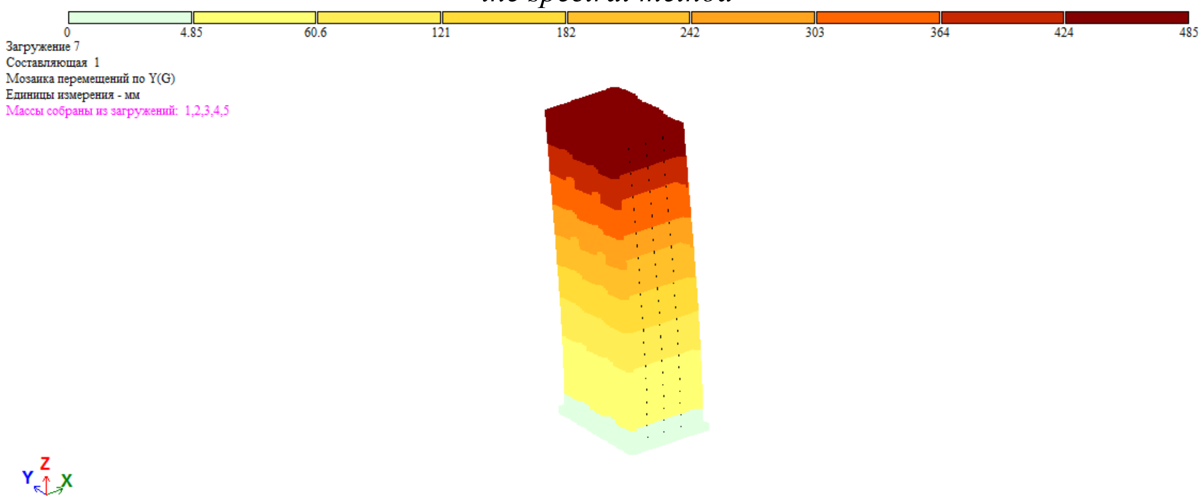


Figure 6. The result of displacements along the Y-axis in the calculation of the building using the spectral method

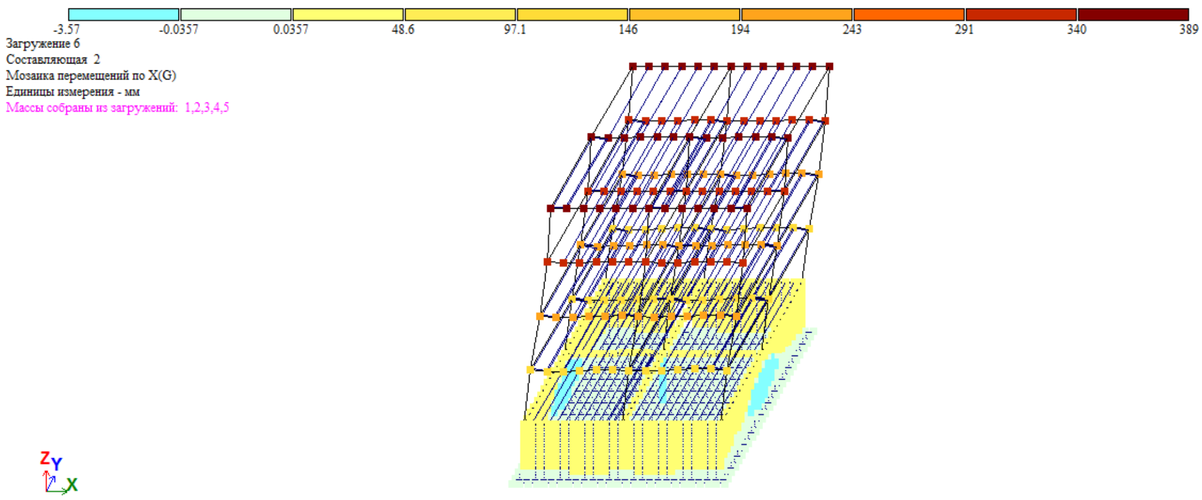


Figure 7. The result of displacements along the X-axis in the calculation of the building using the dynamic method

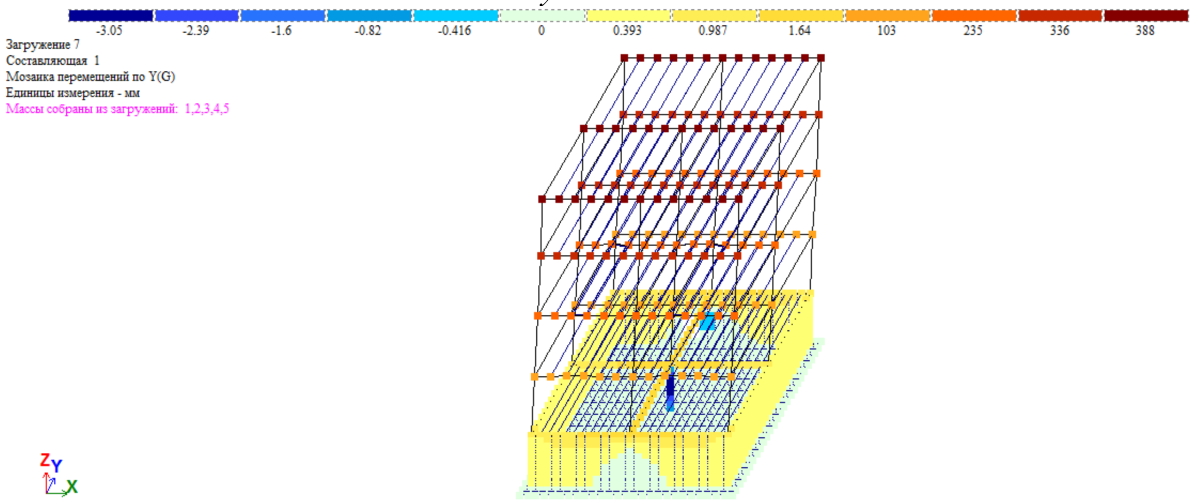


Figure 8. The result of displacements along the Y-axis in the calculation of the building using the dynamic method

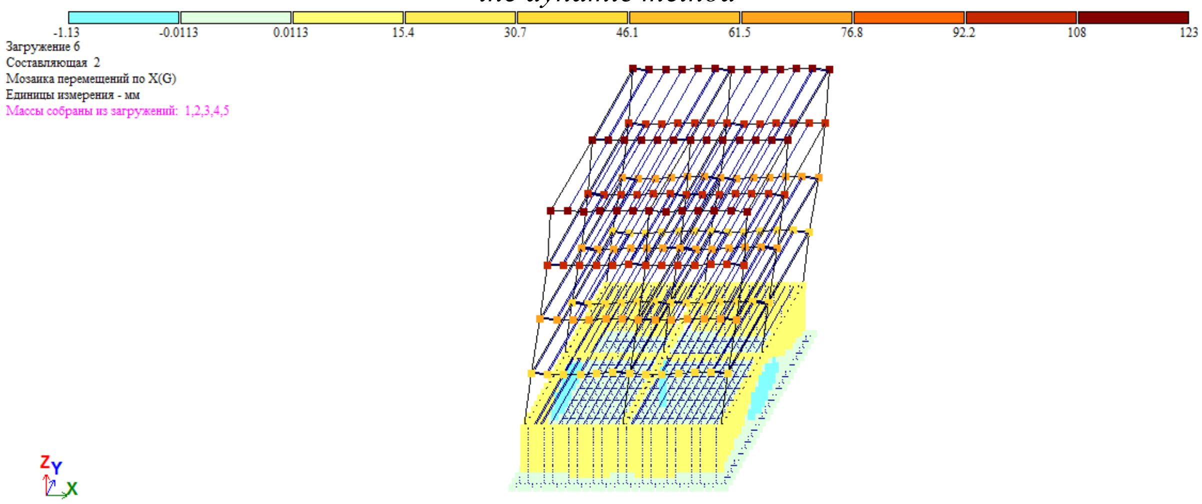


Figure 9. The result of displacements along the X-axis in the calculation of the building using the spectral method

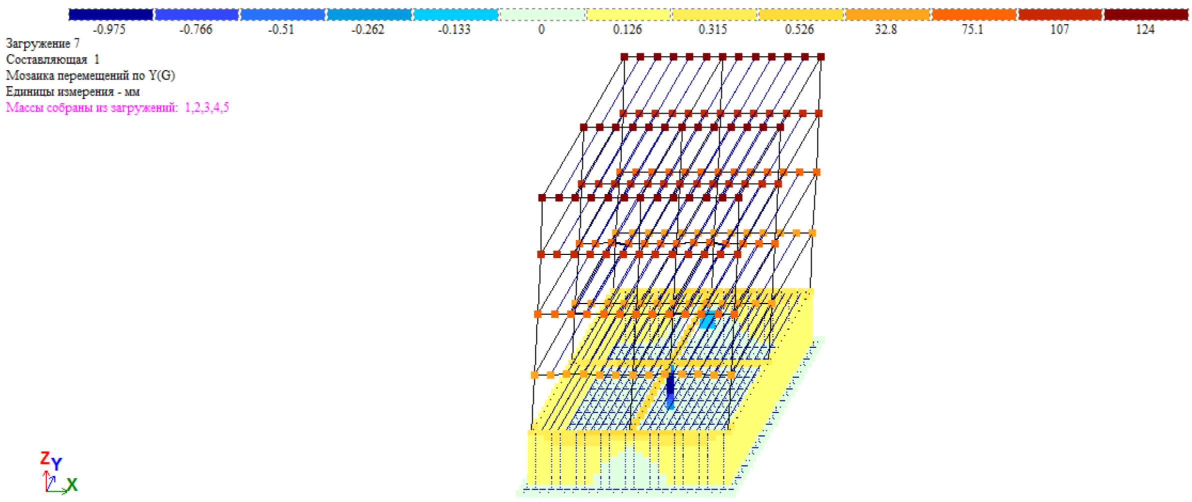


Figure 10. The result of displacements along the Y-axis in the calculation of the building using the spectral method

Summarizing the results of the calculation can be summarized as follows:

№	Building name	The result of calculations using the dynamic method	The result of calculations using the spectral method
1	25-storey office building in Mirzo Ulugbek district	Movements on the X-axis - 444 mm Movements along the Y-axis - 434 mm	Movements on the X-axis - 263 mm Movements along the Y-axis - 485 mm
2	4-storey office building in Yashnabad district	Movements on the X-axis - 389 mm Y-axis displacements - 388 mm	Movements on the X-axis - 123 mm Movements along the Y-axis - 124 mm

Conclusions.

1. The results of the calculations show that the results of displacements on the X and Y-axes under the seismic influence of the building are slightly less in the spectral method than in the dynamic method. Also, in buildings with a building height of more than 40 meters, although the plan view is close to the square shape, the result of the displacements along the two axes is not spectrally close to each other. In the dynamic method, however, these figures are almost the same.

2. In buildings less than 40 meters in height, the results of calculations using the spectral and dynamic methods are the same on both axes, but differ from each other almost 3 times. This suggests that the calculation methods need to be more precise.

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TURLI XIL YUKLANISHLAR UCHUN YUK KO‘TARUVCHI KONSTRUKSIYA ELEMENTLARNI – RIGELNI KUCHLANGANLIK-DEFORMATSIYALANGANLIK HOLATINI HISOBLASH VA BAHOLASH

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Annotatsiya. *Ushbu maqolada turli xil yuklanishlar uchun rigel tipidagi yuk ko‘taruvchi konstruksiya elemenlarining kuchlanganlik-deformatsiyalanganlik holatlarini aniqlash, hamda ularni ishlash qobilyatini baholashning dasturiy ta’minotlar: Lira va ANSYSlardan foydalangan holda amalga oshirilish keltirilgan.*

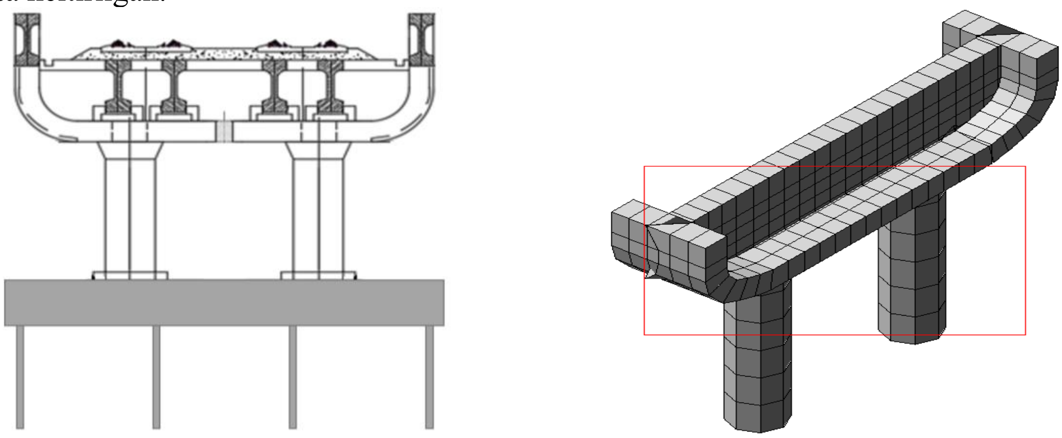
Аннотация. *В данной статье определено напряженно деформированное состояние несущих элементов конструкций - типа ригеля и оценена их работоспособность при различных нагрузках с использованием программных средств Лира и ANSIS.*

Annotation. *This article describes the determination of the stress-strain state of load-bearing elements of beam-type structures under various loads, as well as the assessment of their performance using the software: Lira and ANSYS.*

Kalit so‘zlar. *yuklanishlar, yuk ko‘taruvchi konstruksiya, rigel, kuchlanganlik, deformatsiyalanganlik, Lira, ANSYS.*

Estakada-metroda rigel tipidagi konstruksiyalarni loyihalashda, belgilangan me’yoriy qiymatlarga muvofiq (QMQ, ShNK), inshootlarni qurish va ishlatish bosqichlarida yuzaga keladigan turli xil yuk va ta’sirlarni hisobga olish kerak. 1a-rasmda rigelli konstruksiya varianti ko‘rsatilgan.

Rigel–estakada temirbetondan iborat: B25 betoni, A-400 armaturasi (A - III). Hisobiy seysmiklik darajasi – 8 ball. PK LIRAda temirbeton rigelni fazoviy hisoblash sxemasi 1.b-rasmda keltirilgan.



a)   b)

1-rasm. Rigel tipidagi tayanch (a) va konstruksiyaning chekli elementli ko‘rinishi (b).

Bajarilgan hisoblashlar natijasida ko‘chishlar va kuchlar komponentlari qiymatlari olinib, bunda, seysmik ta’sirlar uchun tegishli yuklanish turlari hisobga olingan [1,2]. 2-rasmda 5- yuklanish turida ko‘chishlar mozaikasi keltirilgan.