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Research Article

Assessment of Seismic Resistance of a Frame Building With Energy-Efficient Enclosures

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ABSTRACT

Annotation. The paper presents the results of calculations of a two-story building with conventional and energy- efficient external fences for a special combination of loads, taking into account seismic forces. The results of calculationsare compared and the changes in the values of seismic forces, internal forces and deformations in the case of energy-efficient fencing are evaluated.

Keywords: energy-efficient fences, seismic resistance, frame building, seismic force, internal forces.

INTRODUCTION

One of the ways to enhance the energy efficiency of buildings is by employing enclosing structures with high thermal insulation parameters. Materials known for their insulating properties exhibit porosity and have a lower bulk density compared to traditional materials used in building enclosure structures.

In accordance with the decrees of the President of the Republic of Uzbekistan aimed at improving the conduct of research in the field of seismology, seismic-resistant construction, and fundamental enhancement of the seismic safety system for populated areas"Republic of Uzbekistan [1], [2], when utilizing new materials and structural solutions in the construction of buildings and structures in high seismicity areas, it is necessary to scientifically substantiate their application and ensure adequate seismic safety of the under-construction objects.

All calculations and structural solutions must be executed in accordance with KMK 2.01.03-19 "Construction in Seismic Regions" [3] and KMK 2.01.07-96 "Loads and Effects" [4] considering a specific combination of loads. The book [5] presents various options of energy-efficient enclosures recommended for use in seismically hazardous areas. The works [6], [7] explore new variants of energy-efficient enclosures developed by scientists from the Tashkent Institute of Architecture and Construction.

In article [8], the influence of applying energy-efficient enclosures in a frame building on the

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Research Article

magnitude of seismic force was studied. It was revealed that when using an energy-efficient wall consisting of a single brick with a thermal insulation layer instead of the traditional filling of the frame with a wall of 1.5 bricks, the building's own weight decreases by 8-9%.

This article presents the calculation results of this building with traditional and energy-efficient enclosures, considering a specific combination of loads with seismic load, and their comparison.

Main Part. The building's plan scheme with the cargo area and the structural scheme are illustrated in Figure 1.

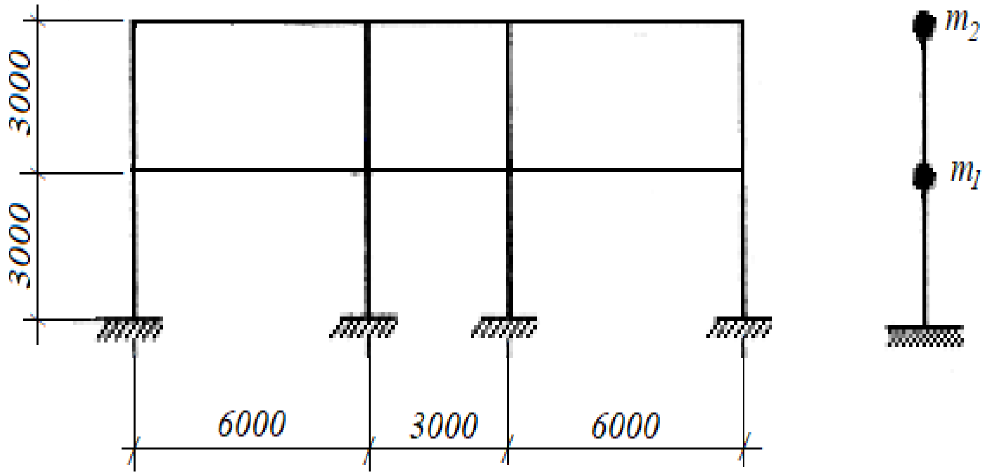

Figure 1. Schematic calculation

Cross-sections of columns and intermediate beams are provided in Figure 2, while the options for exterior wall arrangements, as per [5], are depicted in Figure 3

We calculate the average transverse

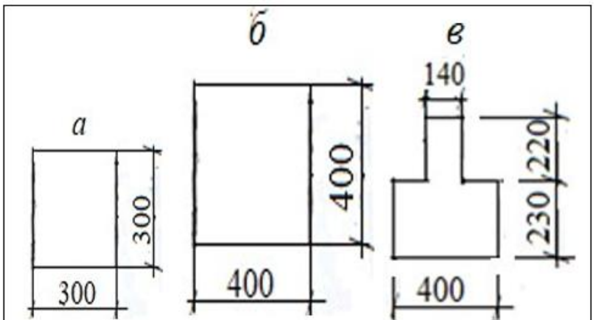

Fig. 2. a - outermost column; b - middle column; c - middle beam

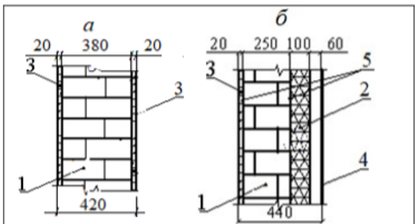

Fig.3 Traditional. Energy efficient
1–brick wall;
2–mineral wool board;
3–cement-sand mortar;
4–facade screen;
5–layer boundary.

$m_1 \delta\delta_{11} \omega^2 - 1 \qquad m_2 \delta\delta_{12} \omega^2$

frame of the building, as the most loaded. The calculated scheme of the frame with loads is shown

$m_1 \delta\delta_{21}$

Here: ω^2

$m \ \delta\delta \ \ \omega^2$

on figure 4.

In accordance with clause 2.6 of KMK 2.01.03-19 [3], the building calculation will be performed by the spectral method. As it is known, to calculate seismic forces using this method, it is necessary to determine the natural frequency and mode shape of the building's vibrations. To do this, let's determine the unit displacements of the computational scheme. Since the building under consideration is two-storey, the degree of freedom of the computational scheme is taken as two. The centennial frequency equation for this m_1, m_2 – respectively, the masses of the building at the level of the floor and the ceiling;

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Research Article

ω – frequency of natural vibrations;

$\delta\delta_{11}$, $\delta\delta_{22}$, $\delta\delta_{12} = \delta\delta_{21}$-unit displacements of masses in the direction of vibrations.

To calculate the unit displacements, we will use the "Lira" software [10]. The computational schemes for calculating displacements are shown in figure 4. The calculation results are presented in figures 5, 6. the system's centennial equation will have the following form [9]:

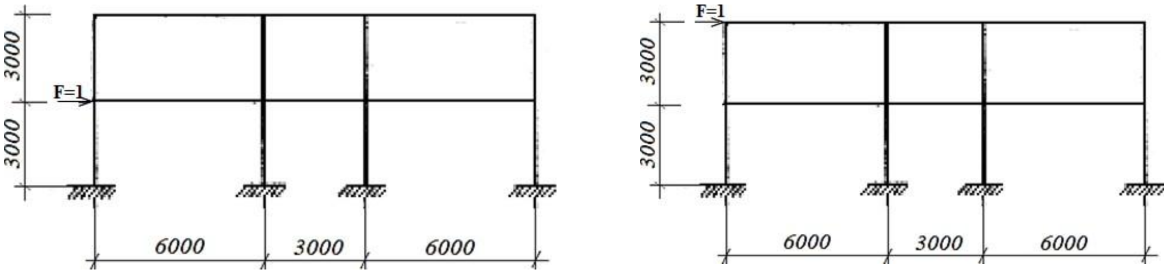

Figure.4

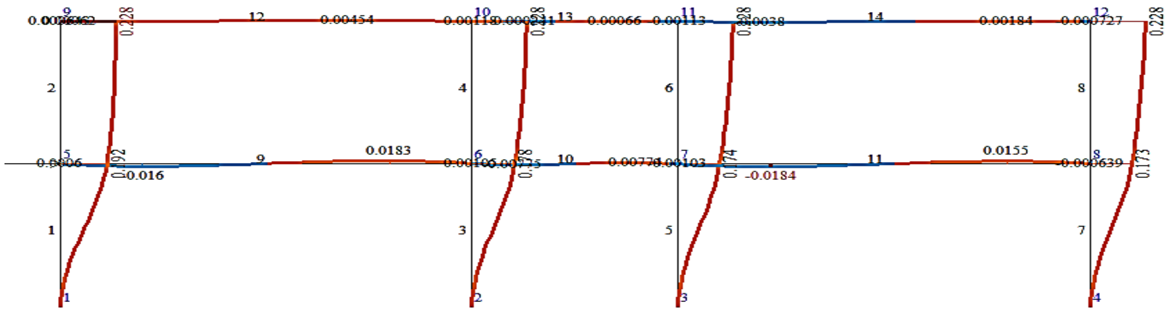

Figure. 5.The diagram of displacements from a unit force F=1 applied at the floor level of the 2nd floor

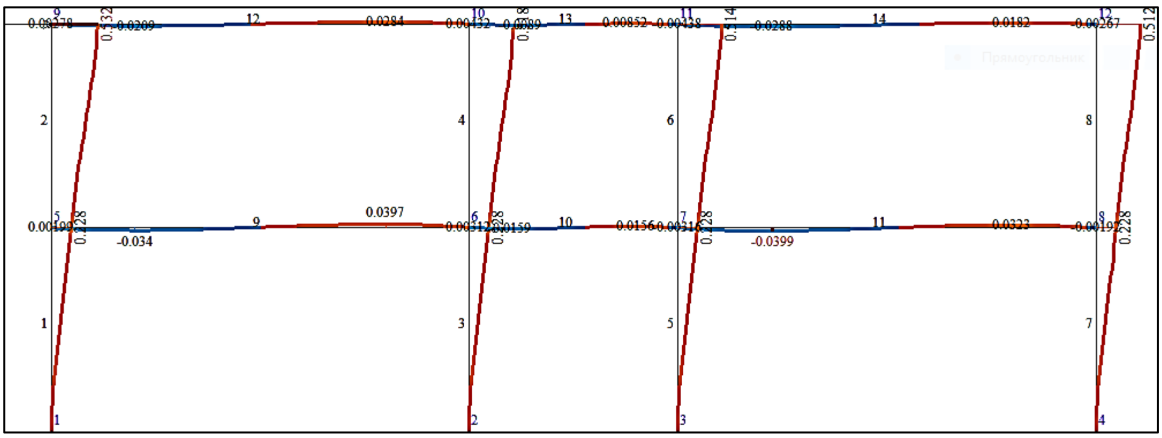

Figure.6. The contour of displacements caused by a unit force (F=1) applied at the floor level.

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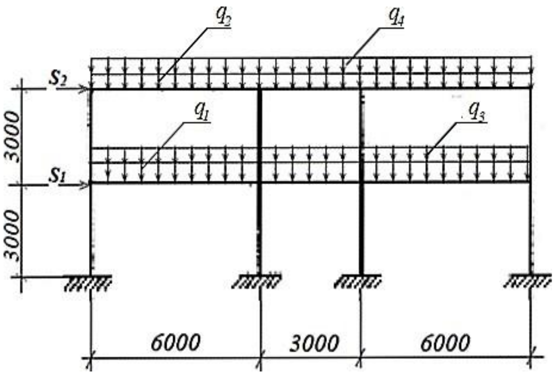


Figure. 7. *qq11, qq33* ***- permanent load; qq22, qq44 – temporary load; SS11, SS22 -seismic***

-for the regular wall QQ^{II} =73,72 t. m^{II}=227,515· 10³ t·sec² ;

m-for the energy-efficient wall QQ^{IIII} =67,925 t. m^{IIII} = 6,924 t·sec² .

Solving the secular equation, we determine the natural frequencies and their corresponding oscillation periods:

ω^{II} =13,404 sec⁻¹; ω^{II} =34,212 sec⁻¹.

TT^{II} = 0,469 *sec*. TT^{II} = 0,184 *sec*;

ω^{IIII} =14,1316 sec⁻¹;ω^{IIII}=36,546 sec⁻¹.

TT^{IIII} = 0,444 *sec*; TT^{IIII} = 0,1718 *sec*.

Based on the calculation results, we determine $\delta\delta 11$ = 0.192 mm; $\delta\delta 12$ = 0.228 mm; $\delta\delta 22$ = 0.532 mm; $\delta\delta 21$ = 0.228 mm;

$\delta\delta_{22}$ = 0,532 mm; $\delta\delta_{21}$ = 0,228 mm.

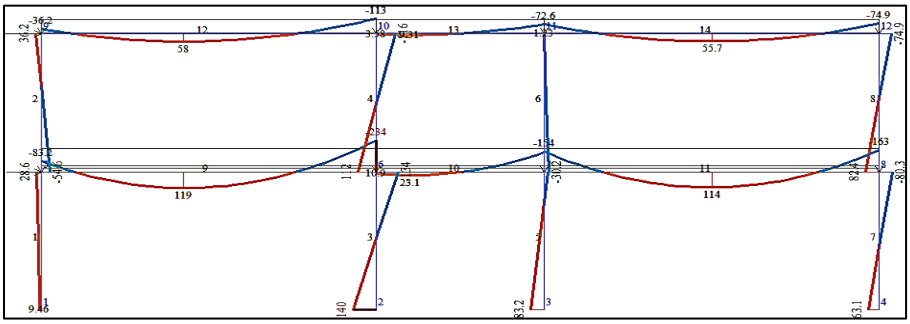
Weight and mass of the building falling on the average frame at the level of the floor:

-for a standard wall QQ^{II} =123,75 t. m^{II} =1/12,615 t·sec² ;

Adhering to the requirements of the Construction Norms and Regulations 2.01.03-19 [3] regarding seismic forces for the 9-point zone with soil of II-category and determining constant and temporary loads in accordance with the Construction Norms and Regulations [4], we perform the calculation of the frame (Fig. 7) for the specific load combination using the "Lira" software.

The calculation results, for both types of walls, in the form of diagrams of bending moments and displacements, are provided in Figures 1, 8, 9, 10, 11.At the same time, the seismic force values taken for the first vibration mode. A comparison of the maximum values of internal forces and deflections for the conventional and energy-efficient walls is presented in Table 1.-for the energy-efficient wall QQ^{IIII} =105,9 т. m^{IIII} =10,79 t·sec² .

The bending moment diagram for the variant with a conventional wall.



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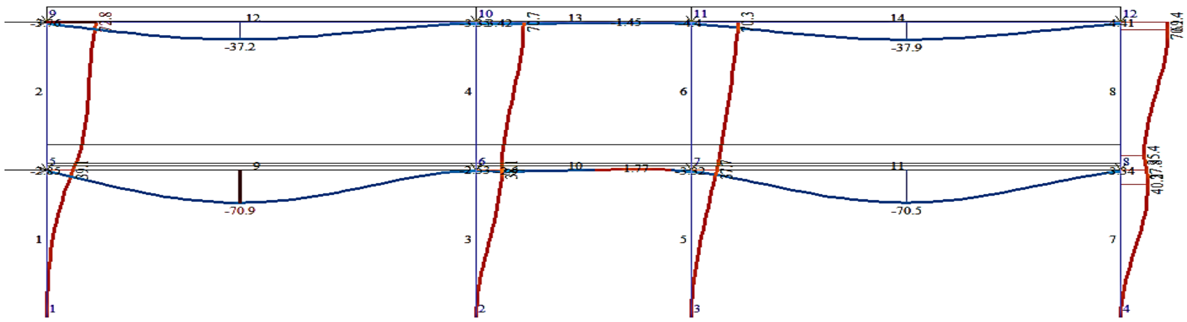
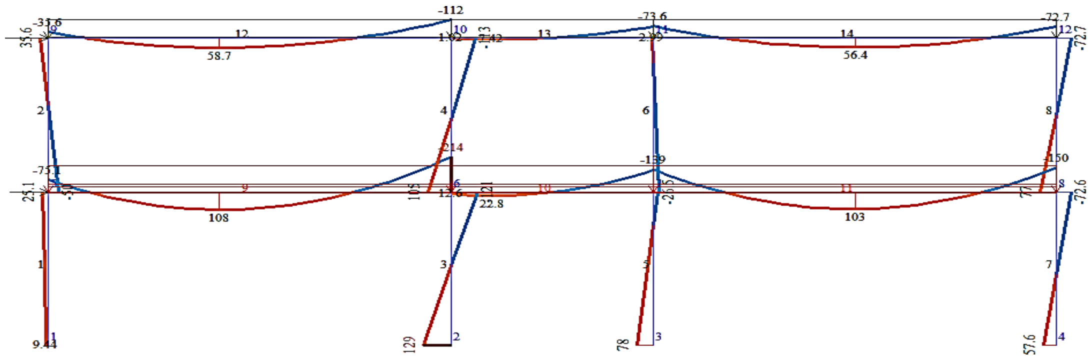


Fig. 9. Displacement diagram for the variant with a conventional wall.



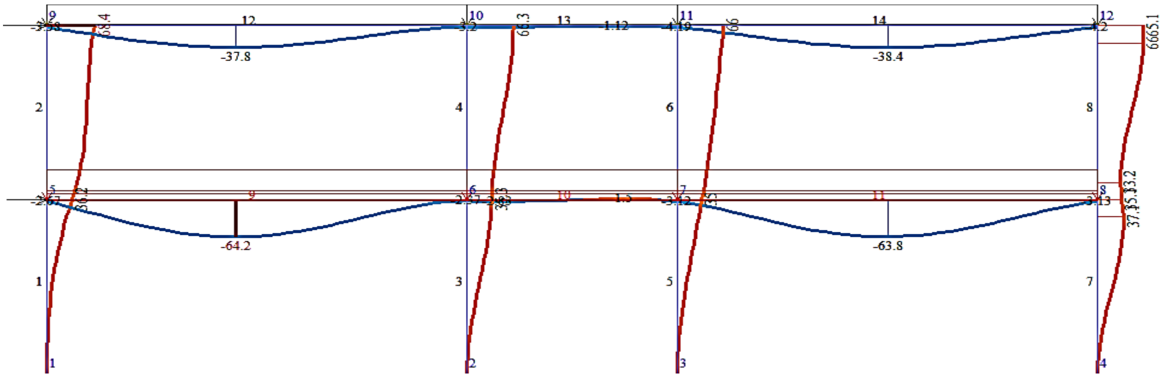


Fig. 10. -The bending moment diagram for the variant with an energy-efficient wall.

***Table-1.* The displacement diagram for the variant with an energy-efficient wall.**

Variants	Bending moments., tm	Shear forces, t	Normal forces, t	Deflection, mm
1-simple walls	129	207	479	70,9
2-energy efficient wall	119	188	450	64,2
Difference in %	7,75	9,18	6,05	9,45

Conclusion

Comparison of the results shows that when using the examined brick variant of energy-efficient walls, internal forces and deflections decrease by 6 to 10%. Therefore, it can be concluded that the use of lighter wall materials such as lightweight concrete blocks with a bulk densityless than 1000 kg/m3, this difference will be significant. However, the behavior of such structures, used as infill in framed buildings, during severe earthquakes has not been studied. Therefore, we consider it necessary to conduct theoretical and experimental research on the seismic resistance of buildings with energy-efficient enclosures.

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Research Article

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