Assessment of spatial rigidity and stability of a building when replacing reinforced concrete ribbed plates with lightweight coating

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Abstract. The tasks of restoring and ensuring the normalized parameters of the operational qualities for building structures, as well as their further safe operation in the development of capital repair and reconstruction projects, in most cases include the replacement of existing heavy coating structures with alternative lightweight ones that meet the regulated modern standards.

1 Introduction

When carrying out the industrial buildings and structures' reconstruction, the question of replacing the coating arises very often. This is due not only to the limited operational state of the coating structures themselves, but also to the limited bearing capacity of vertical structures (columns, walls). The most widely used alternative solution today is the replacement of heavy reinforced concrete plates with lightweight sandwich panels. However, when developing a project for a new coating of industrial buildings, it is necessary to take into account the overall spatial rigidity and stability of the entire building [1-4].

Let us consider this problem using the example of an industrial building's typical single-span. The simplified design scheme of the structure is a spatial system consisting of bezel trusses with a span of 24 m, columns with a pitch of 12 m and ribbed coating plates 12 m long. All structures are reinforced concrete [5-9].

Comparative assessment of spatial rigidity and stability was carried out taking into account both spatial design schemes of the building:

- design scheme with a design solution for coating the building with ribbed large-size reinforced concrete plates (option -1).

- design model with an alternative coating, profiled sheet on steel lattice girders (option - 2).

In both versions of the design schemes in the figures, the enclosing wall panels are conventionally not shown [10 - 12].

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When calculating the system for the schemes horizontal displacement, the effect on the spatial streng[illegible] change in coating structures can be assessed [13-15].

To assess this effect, it is therefore necessary to take into account the horizontal wind force and the cranes' braking.

The static analysis of the spatial system is performed based on the loads collected above. With the following loading options:

- dead weight of system elements.
- crane D_{max}, D_{min}.
- brake T (in the plane of the frames).
- brake T (along graphic axes).
- wind loads on digital axes.
- wind loads along graphic axes.

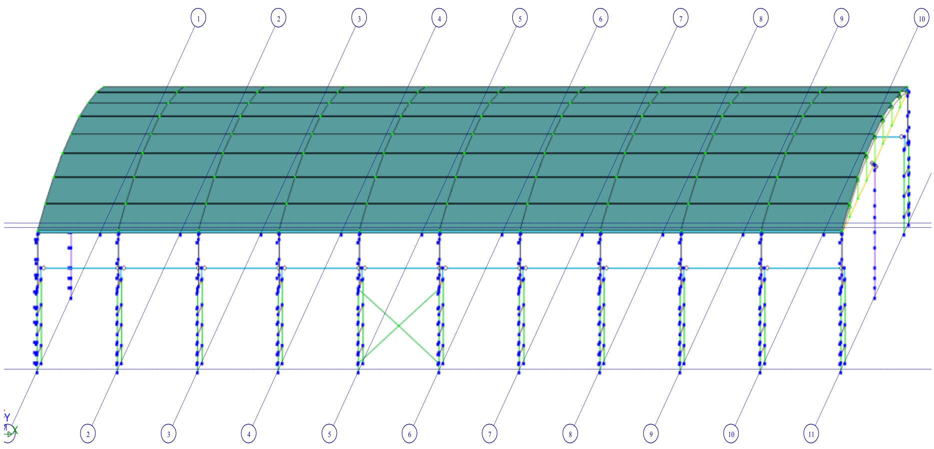

Fig. 1. Finite element discretization scheme (FE).
Option-1.

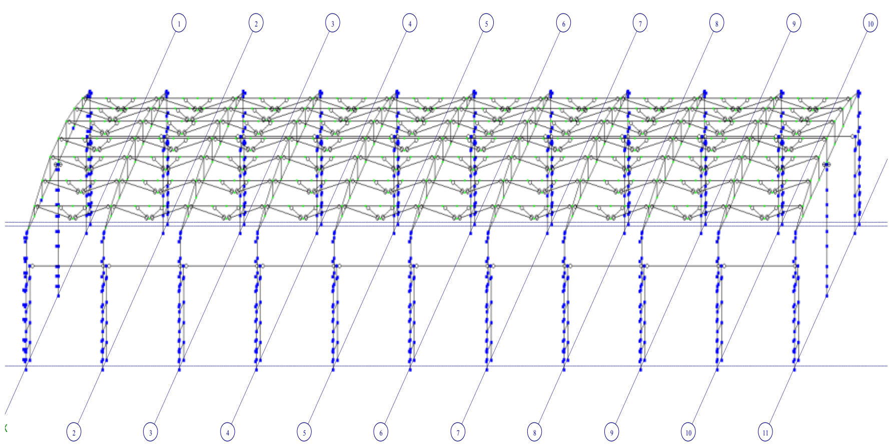

Fig. 2. Finite element discretization scheme (FE).
Option-2.

Figures 1 and 2 clearly show two options for self-weight loading.

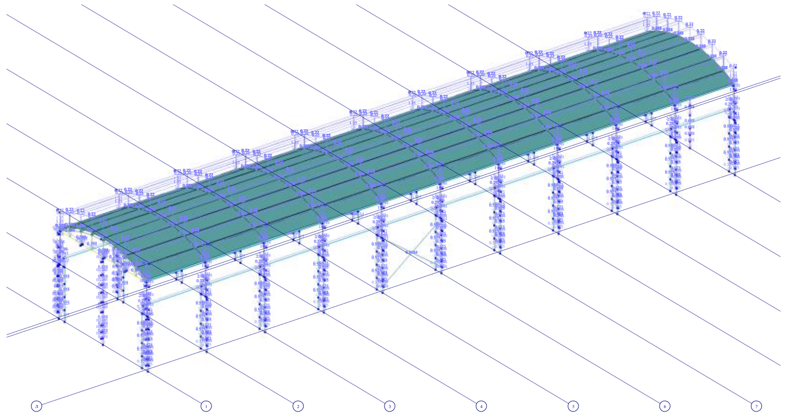

Fig. 1. The structures' own weight (according to option 1).

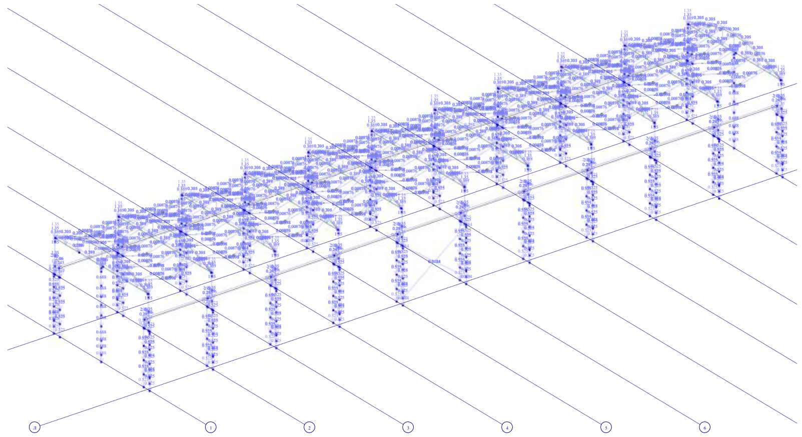

Fig. 2. The structures' own weight (according to option 2).

2 Results obtained in studies

Figures 3-6 show the results for the first option.

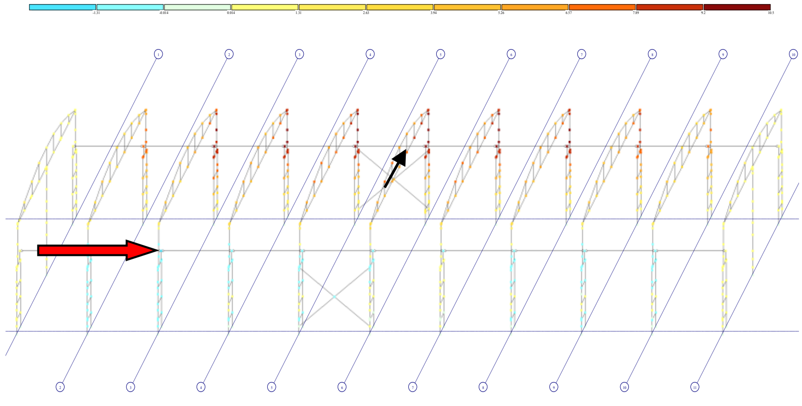

Fig. 3. Horizontal movements along digital axes (wind along graphic axes, brake along digital axes).

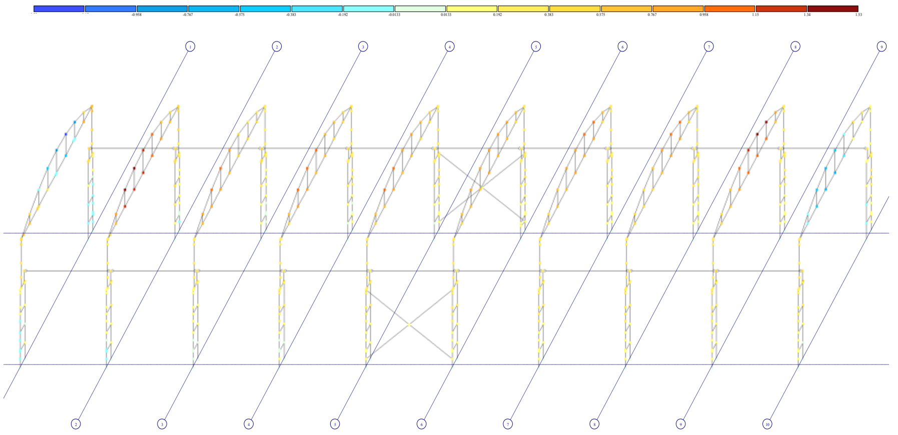

Fig. 4. Horizontal movement along graphic axes (wind along graphic axes, brake along digital axes).

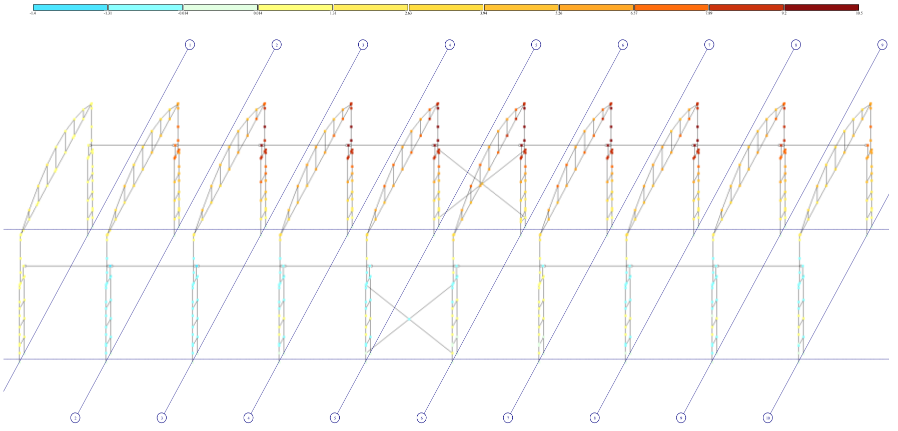

Fig. 5. Horizontal movements along digital axes (wind along graphic axes, brake along graphic axes).

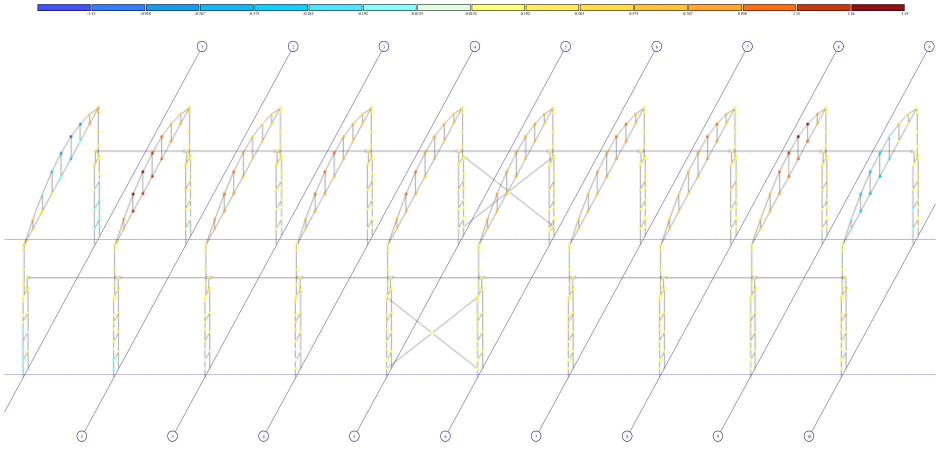

Fig. 6. Horizontal movement along graphic axes (wind along graphic axes, brake along graphic axes).

Figures 7-10 show the results for the second option.

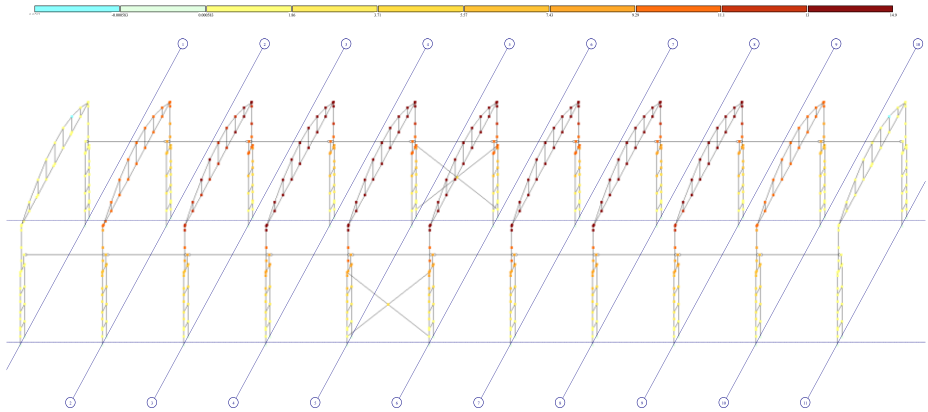

Fig. 7. Horizontal movements along digital axes (wind along graphic axes, brake along digital axes).

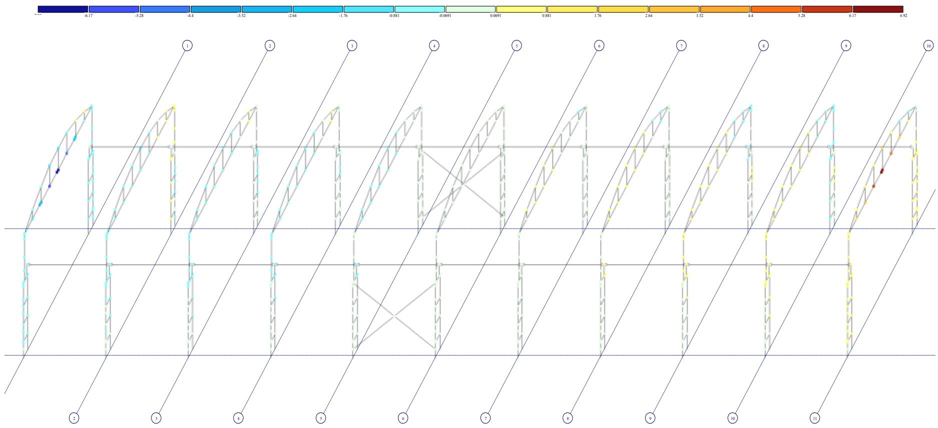

Fig. 8. Horizontal movement along graphic axes (wind along graphic axes, brake along digital axes)

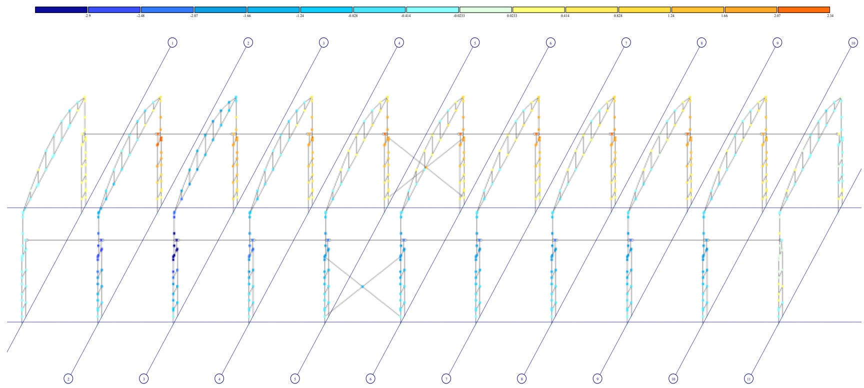

Fig. 9. Horizontal movements along digital axes (wind along graphic axes, brake along graphic axes)

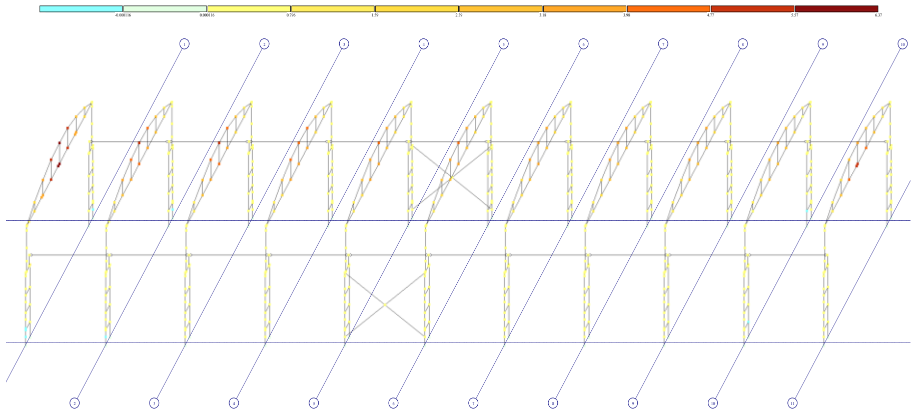

Fig. 10. Horizontal movement along graphic axes (wind along graphic axes, brake along graphic axes)

3 Conclusion

The main results are presented in Table 1 and only the maximum and minimum values for the construction are given.

Table 1. Main results

Spatial schema			Planar diagram (axis 3)		
Scheme 1 (design)					
RSN1	Y=10.5	X=1.53	RSN1	Y=8.21	X=1.33
RSN2	Y=10.5	X=1.53	RSN2	Y=5.52	X=1.14
Scheme 2 (with binding rafters)					
RSN1	Y=14.9	X=6.92	RSN1	Y=13.3	X=0.715
RSN2	Y=10.5	X=6.37	RSN2	Y=13.3	X=0.715
Scheme 3 (with binding rafters, without fencing panels)					
RSN1	Y=20.1	X=18.9	RSN1	Y=20.0	X=3.65
RSN2	Y=20.1	X=18.9	RSN2	Y=4.44	X=38.9

The results of spatial rigidity and building stability mathematical modeling gives a possibility to state that with the operation of one crane, the horizontal movements along the digital axes in both versions of the building coating differ insignificantly and practically do not condense the operational parameters, i.e., the joint work of rigid, in their plane, transverse frames, crane beams, longitudinal braking trusses, vertical braces, enclosing wall panels and coating binding rafters provide the normalized longitudinal stability of the building structures. The discrepancy in the results is due to the fact that the spatial scheme contains timber framing structures.

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