Regulation of Stresses in Structures of Buildings Located in Extreme Wind Conditions

Mihail Moskalev and Dmitriy Charnik

Abstract The Arctic and the Antarctic areas are characterized by extreme wind loads that exceed the standardized by SP. These areas are characterized by a significant distance from material and raw material bases and road transport arteries. Under these circumstances, the problem of perception of extreme wind loads must be solved with a minimum consumption of building material. One of the ways to minimize the consumption of building materials is to use an innovative approach to regulate stress in building structures The software package SCAD++ is used for the calculation. 1. Metal columns—column I-beam 23K1 GOST 26020-83, I-beam wide-flange 26SH1 GOST 26020-83, I-beam wide-flange 23SH1, I-beam norma 23B1. Covering load due to its own weight—0.15 t/m^2. Snow load—0.19 t/m^2. Wind load: upwind side 0.87 t/m^2, leeward side—0.55 t/m^2. Change in the value of displacement along the x-axis in the first version of the wind load and an increase in the tension of steel ropes from 1 to 25 t. Due to the tension of the ropes, it is possible to reduce the horizontal movement from 24.171 to 20.84 mm, the difference was 3.31, the movement decreased by 14%.

Keywords Active control structures · Actuators and smart structures · Active · Active control · Control algorithms · Structural control · Steel · Steel constructions

1 Introduction

The Arctic and the Antarctic areas are characterized by extreme wind loads that exceed the standardized by SP [1, 2]. These areas are characterized by a significant distance from material and raw material bases and road transport arteries [3]. Under these circumstances, the problem of perception of extreme wind loads must [3–6]

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be solved with a minimum consumption of building material [7–9]. One of the ways to minimize the consumption of building materials [10] is to use an innovative approach to regulate stress in building structures [11–13]. In this work the survey of the effectiveness of applying this approach to the design of a modular building located in the Antarctic conditions [14] with the following characteristics was conducted [15]:

- Length—54 m.
- Width—from 18 to 30 m.
- Number of storeys—2, the height of the first and second floor is 3390 and 3110 mm respectively.
- The height of the building is 8.31 m.
- The building is installed on piles buried below the freezing depth.
- According to the constructive solution, the frame of the building was adopted as a frame-braced one [16].
- The appointment of the building is a scientific laboratory, with office, communal and residential premises.

The solution to the problem of voltage regulation is assumed in the nodes of building structures using puffs [5, 13, 17–20].

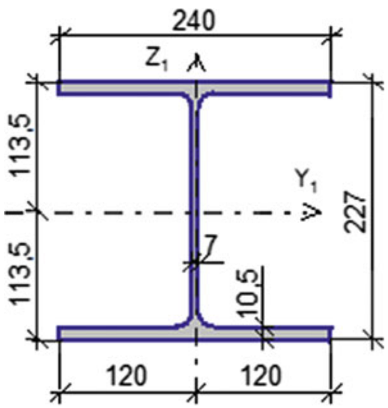
2 Methods

The software package SCAD++ is used for the calculation [21].

Structural elements:

1. Metal columns—column I-beam 23K1 GOST 26020-83 (Figs. 1, 2, 3, 4, 5, 6 and 7).

Fig. 1 Column I-beam 23K1



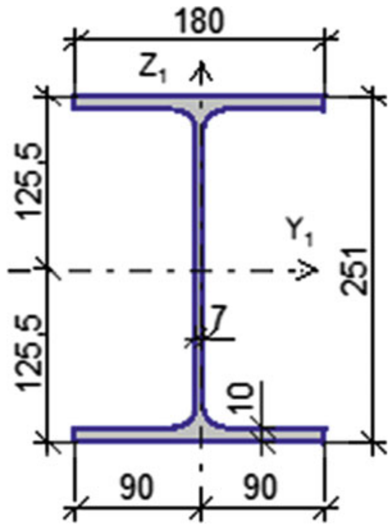


Fig. 2 I-beam wide-flange 26SH1 GOST 26020-83

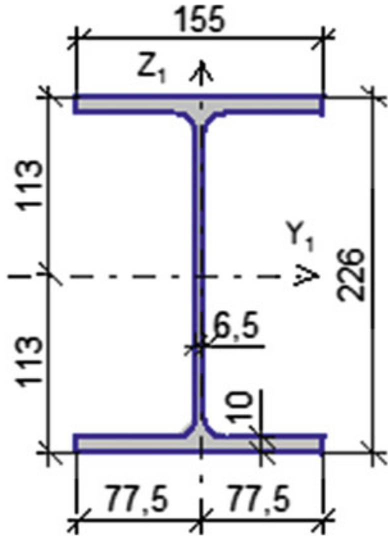


Fig. 3 I-beam wide-flange 23SH1

Covering load due to its own weight—0.15 t/m^2. Snow load—0.19 t/m^2. Wind load: upwind side 0.87 t/m^2, leeward side—0.55 t/m^2.

Before the calculation, the following load combinations cases were compiled (Fig. 8).

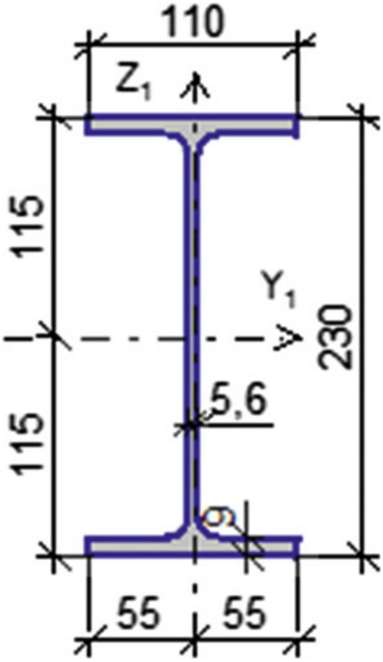


Fig. 4 I-beam norma 23B1

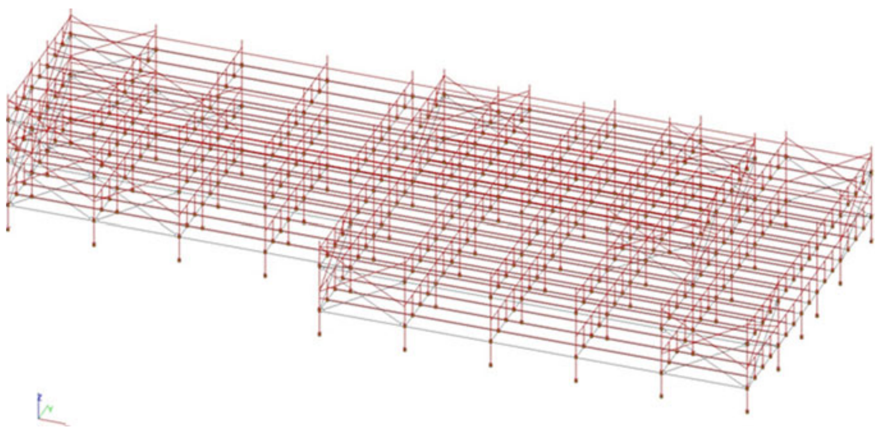


Fig. 5 Self-weight loading scheme. Coating load—0.15 t/m^2

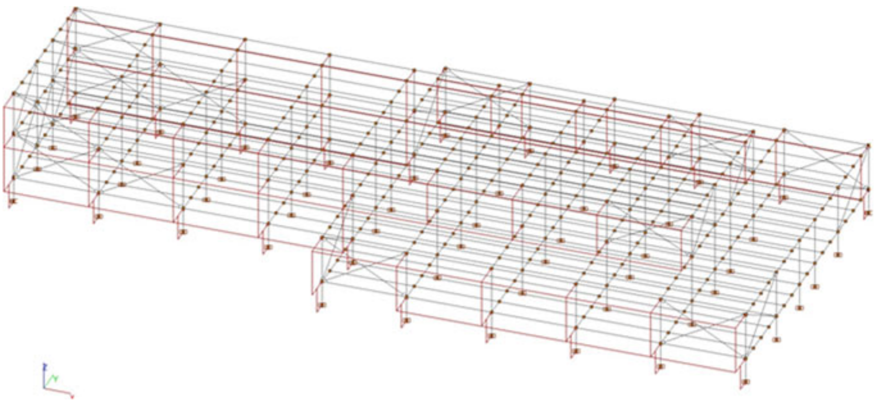


Fig. 6 Wind load scheme option 1

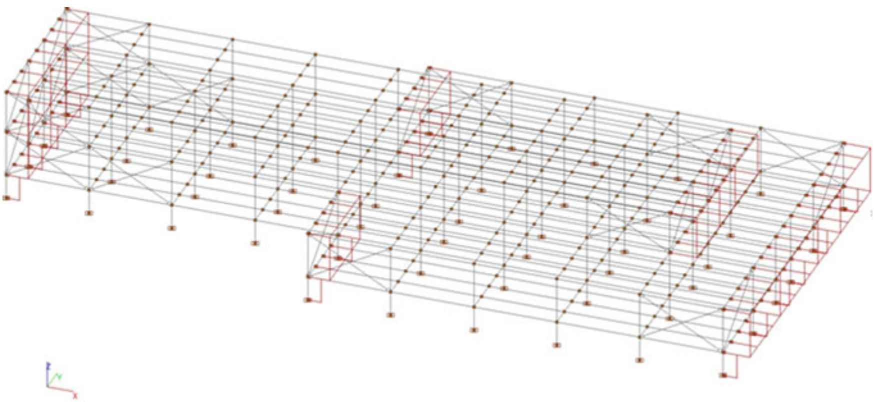


Fig. 7 Wind load scheme option 2

3 Results and Discussion

Change in the value of displacement along the x-axis in the first version of the wind load and an increase in the tension of steel ropes from 1 to 25 t [22] (Figs. 9, 10 and 11).

In Fig. 13 the columns in which the internal forces were checked are marked in red (Fig. 12).

	Load combinations	name
1	(L1)*1+(L4)*1+(L5)*1	constant load
2	(L2)*0.9+(L6)*1+(C1)*1	wind 1 without tension
3	(L2)*0.9+(L6)*1+(L14)*1+(C1)*1	wind 1 – 1 t
4	(L2)*0.9+(L6)*1+(L15)*1+(C1)*1	wind 1 – 3 t
5	(L2)*0.9+(L6)*1+(L16)*1+(C1)*1	wind 1 – 7 t
6	(L2)*0.9+(L6)*1+(L17)*1+(C1)*1	wind 1 – 10 t
7	(L2)*0.9+(L6)*1+(L18)*1+(C1)*1	wind 1 – 17 t
8	(L2)*0.9+(L6)*1+(L19)*1+(C1)*1	wind 1 – 20 t
9	(L2)*0.9+(L6)*1+(L20)*1+(C1)*1	wind 1 – 25 t
10	(L2)*0.9+(L3)*1+(C1)*1	wind 2 without tension
11	(L2)*0.9+(L3)*1+(L7)*1+(C1)*1	wind 2 – 1 t
12	(L2)*0.9+(L3)*1+(L8)*1+(C1)*1	wind 2 – 3 t
13	(L2)*0.9+(L3)*1+(L9)*1+(C1)*1	wind 2 – 7 t
14	(L2)*0.9+(L3)*1+(L10)*1+(C1)*1	wind 2 – 10 t
15	(L2)*0.9+(L3)*1+(L11)*1+(C1)*1	wind 2 – 15 t
16	(L2)*0.9+(L3)*1+(L12)*1+(C1)*1	wind 2 – 20 t
17	(L2)*0.9+(L3)*1+(L13)*1+(C1)*1	wind 2 – 25 t

Fig. 8 Load combinations

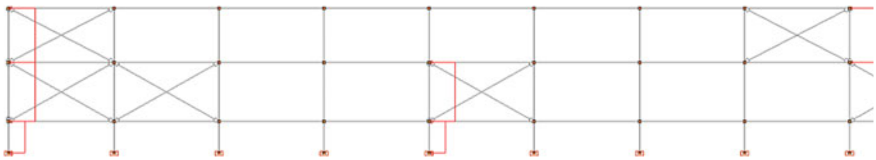


Fig. 9 Wind load direction

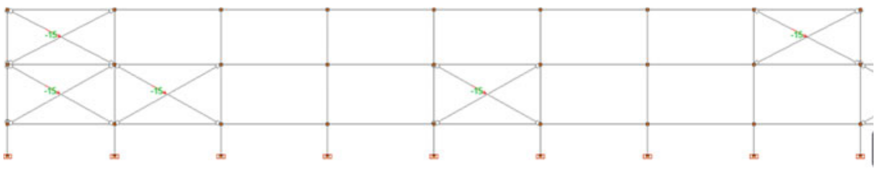


Fig. 10 Rope tension scheme

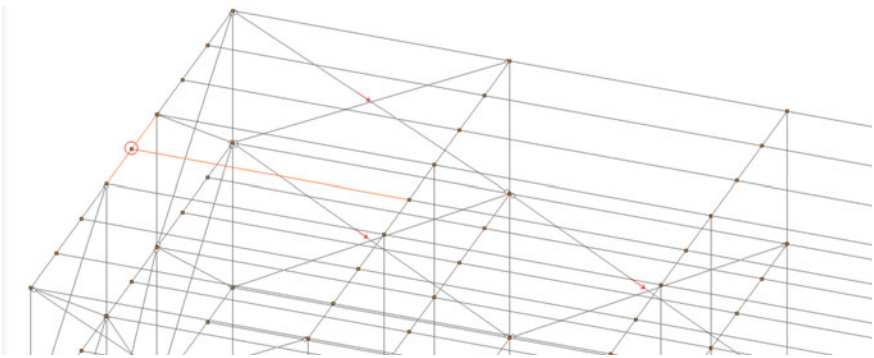


Fig. 11 Node location

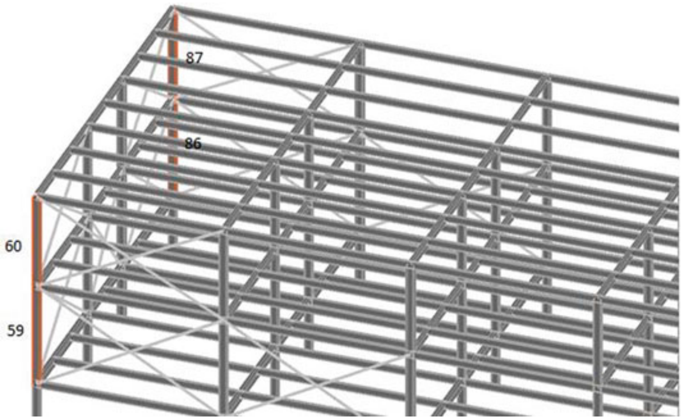


Fig. 12 Columns in which the internal forces were compared

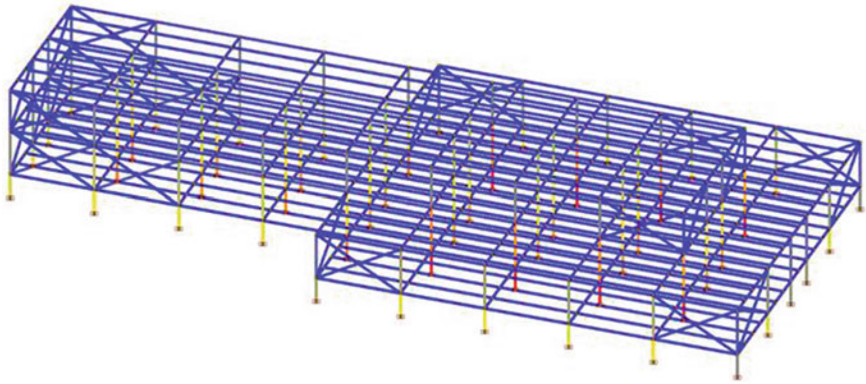


Fig. 13 Color display of efforts N t

4 Conclusions

See Tables 1 and 2.

Table 1 Move the node along the x-axis (Fig. 12)

Distance (mm)	Tensioning the ropes (tonne)
−24.171	0
−24.037	1
−23.727	3
−23.134	7
−22.689	10
−21.948	15
−21.206	20
−20.84	25

Conclusion: due to the tension of the ropes, it is possible to reduce the horizontal movement from 24.171 to 20.84 mm, the difference was 3.31, the movement decreased by 14% [16, 23]

Table 2 Move the node along the x-axis (Fig. 12)

Distance (mm) № 59	Distance (mm) № 60	Distance (mm) № 86	Distance (mm) № 87	Tensioning the ropes (tonne)
−27.346	−14.354	−27.444	−14.402	0
−26.998	−14.279	−27.179	−14.31	1
−26.3	−14.128	−26.397	−14.176	3
−24.905	−13.825	−25.002	−13.873	7
−23.859	−13.599	−23.956	−13.647	10
−22.115	−13.221	−22.212	−13.269	15
−20.371	−12.843	−20.469	−12.891	20
−20.371	−12.843	−20.469	−12.891	25

Conclusion: due to the tension of the ropes, it is possible to reduce the compressive force N in the columns from 27.346 t to 20.371 t mm, the difference was 6.975 t, the force decreased by 26%

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