Assessment of the influence of surrounding buildings on the wind impact on a high-rise residential complex

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Abstract. The paper considers the objects of a point structure in the study of wind effects on built construction objects. According to the presented algorithm, an experimental study of the wind effect in a wind tunnel designed in the city of Moscow was performed. The study was conducted taking into account the environmental impact. The result of the work is a comparative analysis of data on wind exposure.

1. Introduction

One of the acute problems in the construction industry is the consideration of the influence of natural components on buildings and structures [1, 2]. Among the effects of kinematic origin, there are wind effects, which play one of the most important roles in assigning loads to building structures during their design.

It is important to note that a systematic transition in architectural shaping is currently being observed: thanks to the capabilities of new building and construction design systems, they are increasingly taking forms that are far from the usual primitive parallelepipeds, prisms or cylinders. In turn, the number of storeys of construction objects is also growing: if earlier buildings with a height of more than 100 meters were considered exceptional objects, now in the conditions of land shortage, the construction of high-rises in megacities is becoming a necessity [3-5]. On the one hand, a change in height and shape allows each building or structure to be unique in its own way. On the other hand, deviation from standards adds a large layer of work to specialists at all stages of design, including at the stage of assigning loads in the calculation of building structures. The most important place at this stage is assigned to the study of the aerodynamic characteristics of the designed objects [6].

It should be noted that at present, in the territory of the Russian Federation, the wind impact on building structures during the design of buildings and structures is evaluated analytically in accordance with the methodology specified in SP 20.13330.2016 Loads and impacts [7]. The normative document regulates the determination of the wind effect on the basis of design studies and / or when testing models of construction objects in wind tunnels of the architectural type. To obtain the most reliable results in the world, it is customary to use two methods, the results of which are well correlated with each other.

However, one of the factors that have a significant impact on the aerodynamic characteristics of construction objects in addition to the architectural form and structural component is the presence of surrounding buildings in the area of the studied object. Taking into account the influence of the existing construction fund on the aerodynamic performance of new objects allows us to give more reliable results when conducting studies of wind effects. In turn, the aerodynamic coefficients obtained
during studies taking into account the surrounding buildings and without taking them into account, in some cases can have a significant difference. Consider this statement by example.

2. Experimental study
The residential complex projected in Moscow consists of three high-rise buildings with a stylobate part (Figure 1). The overall dimensions of the investigated object are presented in table 1.

![Figure 1. Object under investigation.](image-url)
Table 1. General dimensions of the studied object

| Value                          | Tower’s Dimensions 1 | Tower’s Dimensions 2 | Tower’s Dimensions 3 | Stylobate’s height |
|-------------------------------|----------------------|----------------------|----------------------|-------------------|
|                              | Height: 178.5 m      | Height: 195.05 m     | Height: 188.5 m      | 9.85 m            |
|                              | Dimensions: 26 * 29 * 44 * 24 m | Dimensions: 33 * 31 * 40 * 21 m | Dimensions: 39 * 31 * 32 * 22 m |                   |

Figure 2 presents a view of a residential complex with surrounding buildings for the study of wind exposure. In the first case, all existing objects were taken into account. In the second case, one of the objects of the surrounding development was excluded from the research. The aim of this work was to present the degree of influence of one of the existing objects on the designed objects.

Figure 2. Residential complex with surrounding buildings.

Researches of wind effects on the residential complex were carried out on the basis of the Big Research Gradient Aerodynamic Wind Tunnel of the Architectural and Construction Type (BIGAT NIU MGSU) by the specialists of the Educational Research and Production Laboratory for aerodynamic and aero-acoustic testing of building structures. The experiment was carried out according to the methodology that was developed by the specialists of the NRU MGSU methodology [8, 9].

At the first stage, which is common for both configurations of the studied model, the meteorological and topographic data were analyzed: based on the data of the meteorological station, the average annual wind speed of 1.5 m/s and the prevailing wind directions were determined for the construction area western and north-western directions. It was also revealed that the construction area belongs to the II-B construction climatic region, to the I wind district. In view of the foregoing, a three-parameter model of the overlying wind $U(z)$ was adopted in the work [10].

At the next stage, a model was produced on a reduced scale (1: 150 for both configurations of the model) for conducting experimental studies at the Bigat NIU MGSU [11]. Models are made of
plywood and sheet plastic. Dummies for research were installed on an automated rotary table located in the working area of the wind tunnel (Figure 3).

Figure 3. The model of the object under study in the working area BIGAT NRU MGSU.

To perform the experiment, pressure collection points were established on the surface of the models. From each hole, pressure is transmitted through copper and then through silicone tubes to differential pressure sensors. The pressure measured using strain gauges allows us to judge the distribution of the aerodynamic pressure over the facades of the objects at certain angles of attack of the air flow, which is subsequently converted to the average values of the dimensionless coefficient $C_p$ at control points on the surfaces of the models. As mentioned earlier, the experiment was carried out in 2 stages: taking into account all the objects (stage 1) and without taking into account the influence of one of the existing objects (stage 2). The obtained data were entered into table 2. In this paper, the values of the dimensionless coefficient are presented for the points located on building 1 with a wind angle of 0 degrees.

Table 2. Average values of the dimensionless aerodynamic coefficient $C_p$ at control points on the model surface (a - taking into account the surrounding buildings, b - without taking into account the influence of one of the objects of the surrounding buildings).

|   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| a | -0.02 | -0.92 | -0.85 | -0.92 | -0.89 | -0.38 | 0.04 | 0.43 | 0.41 | 0.34 | -0.10 | -0.37 |
| b | 0.21 | -0.67 | -0.69 | -0.75 | -0.72 | -0.43 | 0.25 | 0.53 | 0.70 | 0.55 | 0.19 | -0.22 |
3. Conclusion
Based on the results obtained, it was found that each of the objects of the surrounding development has a significant impact on the distribution of wind flows in the immediate vicinity of the studied object. The most significant adjustment of the aerodynamic coefficients is observed in the areas of the facades located at the height of the simulated buildings (due to the significant influence, the values may differ by 120% or more), while the values of the aerodynamic coefficients in the areas of the facades located significantly above the simulated buildings are adjusted within 15-20%, the nature of the distribution of aerodynamic coefficients is preserved [12, 13]. Accordingly, for a preliminary integral assessment of the wind impact on the object under study, it is permissible to carry out modeling without taking into account the surrounding buildings, provided that the building is $h<1/4h$ of the study object, the peak wind impact on the building envelope and facade systems should be estimated taking into account the surrounding buildings.

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