BUILDING STRUCTURES, BUILDINGS AND CONSTRUCTIONS

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STUDY OF THE INFLUENCE OF ADJACENT CONSTRUCTION WORKS ON A CHANGING WIND FLOW OF A HIGH-RISE BUILDING[1]

Statement of the problem. Building codes as far as wind loads are concerned do not make any provisions for the impact of a nearby construction area. The objective is to study the influence of the nine-floor building on wind loads that a high-rise building nearby is subjected to using the simulation in the wind tunnel of the Research Institute of Mechanics of Moscow State University.

Results. In this paper, a comparative analysis of the results concerning the four experiments with the flow around a square prism is presented. The analysis of the experimental results obtained in the flow around the model under eighteen different angles is represented.

Conclusions. The objects located a short distance away from each other make the structure of the air flow more complicated, when conlateralring such systems a detailed experimental study should be carried out of the wind pressure on structures using the results of the field experiments and modeling in wind tunnels. The models placed in the flow model of high-rise and relatively low buildings have a mutual effect on each other.

Keywords: building aerodynamics, aerodynamic pipe, aerodynamic experiment, wind load, high-rise building, pressure sensor, pressure coefficient.

Introduction

In order to determine how a wind flow affects three-dimensional objects, numerical and physical modelling is currently used due to an analytical study being not possible to carry out.

1 [1]The research was carried out as part of the state contract № 16.552.11.7025 from April 29, 2011 “Collective use of scientific equipment “ГР ЦКП МГСУ” (Head Regional Collective Use Centre of the Moscow State Architectural University) of researcg scientific work in energy-saving and energy-efficiency of buildings and structures” in the program “Research and development in top-priority fields of the scientific and technological complex of Russia in 2007-2013”.

This paper describes physical modelling of an air flow on a complex consisting of three-dimensional objects, i.e. is regarded not only as the effect a flow has on a body but also as the interaction of bodies in the flow. This type of problems is tackled in the fields of aerodynamics, building aerodynamics being one of those. A distinctive feature of building aerodynamics is the treatment of poorly streamlined objects. Since in civil construction the shape of an object is also determined by design considerations and not only by those regarding aerodynamics. In the close proximity to the examined building structures there are often other objects and due to a great excitement of the flow it is therefore necessary to take their interaction into account.

Fig. 1 shows a three-dimensional model of a building complex which was blown on with an aerodynamic tube in the Scientific Research Institute of Mechanics of the Moscow State University. The experiment was carried out on the A-6 device. The aerodynamic tube A-6 is the major device in the general aerodynamics laboratory for experimental studies in small subsonic speeds. 24 pressure sensors were placed on the model. 18 angles of attack (-22; -18; -12; -6; 0; 6; 12; 18; 22; 161; 165; 171; 177; 183; 189; 195; 201; 205) were investigated in the experiment of blowing a two-building complex. The experiment is described in the paper [1].

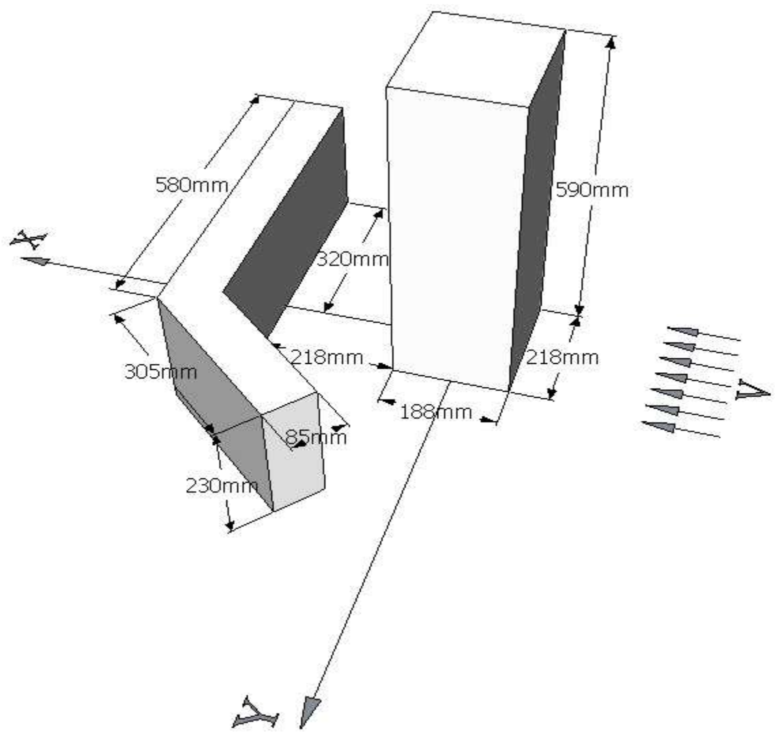

Fig. 1. Three-dimensional model of a building complex

1. Analysis of the experimental results with flowing past a square prism

Let us compare the results of the experiment with flowing past a square prism. This study enables the assessment of the effect an adjacent construction site has on a high-rise building. In this case lateral faces are almost equally long and can therefore be conlateralred equal in the first approximation.

In 2 [2] an experiment with flowing past a square prism is described, coefficients of frontal resistance of an infinitely long square prism and extension $\lambda = 5$ depending on the angle of attack where λ is the ratio of the height to the length of the face of the model. In this experiment the Reynolds number was $\mathrm{Re} = 1.8 \cdot 10^5$. As the data analysis suggests, an infinitely long square prism has a frontal resistance coefficient C_x is greater than that of a prism with extension $\lambda = 5$; an infinitely long prism also has a minimum C_x at the angle of attack $\alpha = 20^0$, and a prism with extension has $\lambda = 5$ at $\alpha = 25^0$.

Paper [3] shows the experimental coefficients of frontal resistance and lateral force C_y of an infinitely square prism depending on the angle of attack at $\mathrm{Re} = 1.4 \cdot 10^5$ and coefficient of frontal resistance for an inifinitely long prism and with extension $\lambda = 5$ at $\mathrm{Re} = 10^6$. Also, as in [2], it is greater in an infinitely long prism C_x than that of a prism with extension. Similarly, the greater λ is, the smaller the angle of attack α that the coefficient of frontal resistance min [C_x] is placed on. It can also be noted that at equal coefficients λ in square prisms min [C_x] on a smaller angle of attack is in the experiment with a smaller Reynolds number.

2. Analyzing the effect of an adjacent construction site on a changing wind flow around a high-rise building

Let us look at the results that were obtained in the experiment that we carried out. In analyzing the data, we investigate pressure coefficients at the angles of attack of 22^0 to 22^0, i.e. a model of a high-rise building is above the flow.

The Reynolds number and the ratio of the height of the model to its lateral face is

$$\mathrm{Re} = \frac{Vb}{\nu} = \frac{25 \text{ м/с} \cdot 0,218 \text{ м}}{14,6 \cdot 10^{-6} \text{ м}^2/\text{с}} = 3,73 \cdot 10^5,$$

where V is the speed of a remote flow; b is some characteristic initial size of a structure; v is the kinematic viscosity of the medium.

$$\lambda = \frac{l}{b} = \frac{0,59}{0,218} = 2,7,$$

where l is the height of the model of a high-rise building.

The above curves of dimensionless coefficients are significantly different in their nature especially at the angles of -22^0 to 0^0. It is obvious that at such angles the effect of a complex model of the second building manifests itself in a significant way. This effect can be made visual using a linear approximation of the data obtained in the experiment, angles near the horizontal straight lines is due to the model rotating at 130^0.

Let us look at the pressure coefficients at the angles of 0^0 to 22^0, the curves of dimensionless coefficients are significantly different but are similar in nature. An assumption can be made that the model of a nine-storey building does manifest itself but its complex shape (asymmetry in relation to Ox) does not seem to have a large effect.

The obtained curves of the coefficients of frontal pressure are typically lower at a small angle of attack and tend to increase afterwards. A relatively low pressure at a zero angle of attack can be accounted for with a small coefficient $\lambda = 2.7$. A rapid reduction and rapid increase in the coefficient it takes on is accounted for with a building model behind.

The curves of the lateral pressure coefficients in the given experiment [3] are also of similar similar in nature (Fig. 2). A non-zero coefficient at a zero angle of attack is accounted for with a non-symmetrical building behind, min [C_y] at a greater angle is due to a smaller λ.

Let us further examine the pressure coefficients at the angles of 161^0 to 205^0, i. e. a model of a high-rise building is below the flow.

Dimensionless pressure coefficients are of similar nature. An assumption can be made that a model of a nine-storey building does manifest itself but its complex shape is of less significant importance.

A relative small coefficient of lateral pressure is accounted for with the effect of the model of a nine-storey building and a relatively small $\lambda = 2.7$. The curves of the coefficients of lateral pressure are proportional to the data from [3], a little change in small angles followed by a rapid rise are caused by the effect the first model has (Fig. 3).

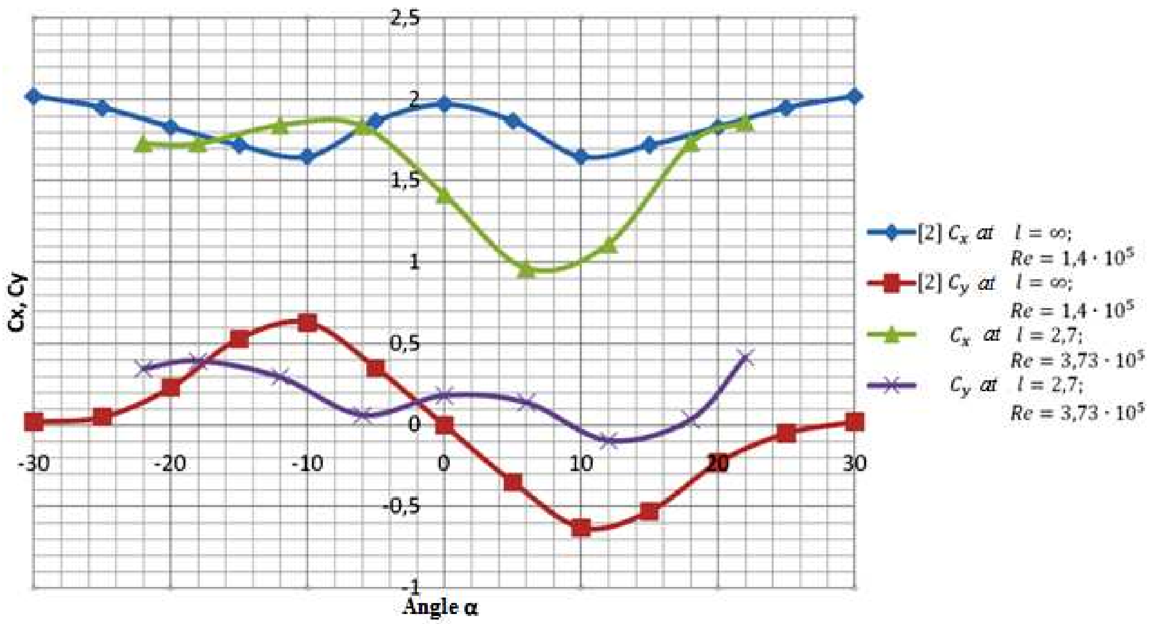

Fig. 2. Dimensionless coefficients in the rotation of the flowed model at $-22^0 \ldots 22^0$

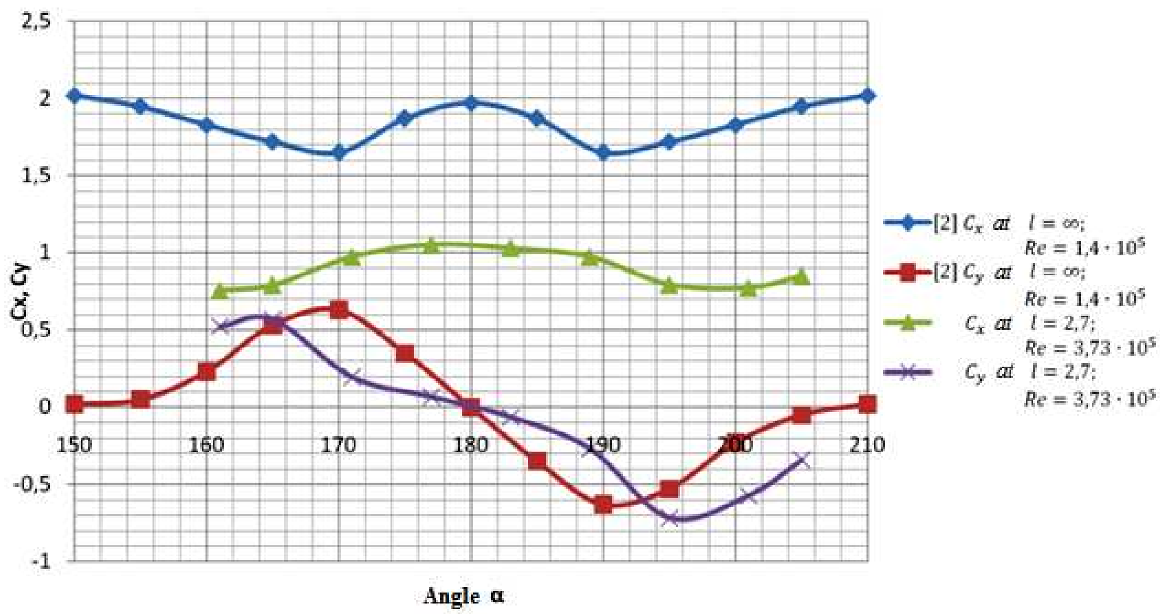

Fig. 3. Dimensionless pressure coefficients in the rotation of the flowed model at $161^0 \ldots 205^0$

Conclusions

1. The articles discusses a three-dimensional task and it s objective was to determine wind loads using physical modelling in the aerodynamic tube. Dimensionless pressure coefficients were obtained at varying rotation angles in relation to a complex of the models and to the flow.
2. The curves of dimensionless pressure coefficients for a model of a high-rise building next to another object are significantly different from the data obtained in flowing around an individual building. No symmetry in the obtained results is accounted for with a complex shape of the model of a nine-storey building.
3. According to the experiment, objects which are not too far from each other make the structure of airflows more complex and a detailed experimental study into the wind pressure on the structures is therefore necessary while investigating those systems using the results of natural experiments and aerodynamic tube modelling. The models of high-rise and relatively low buildings are mutually influential.

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