Estimation Of Wind Pressure Acting On The New Palm House in Gdansk

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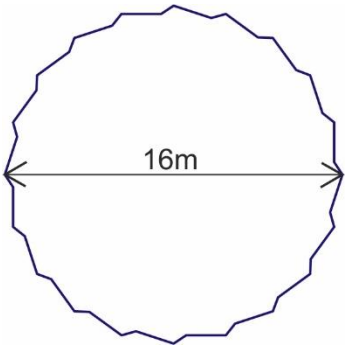
Abstract. This paper deals with the problem of a proper estimation of wind load acting on a Palm house with unusual shape. Flow simulations with aid of CFD and FVM in ANSYS Fluent are performed to check if the pressures for the structure are greater than those calculated assuming that the Palm house is a cylinder, as it was done during the design.

INTRODUCTION AND AIM OF THE PAPER

A lot of new structures with unusual shapes are built nowadays to emphasize the status and character of some institutions, museums, offices, etc. and to attract or impress people. The new Palm house in Gdansk is an example of such a building. Its visualization and cross section of the external glass façade at the connection with hemispheric roof are shown in Fig. 1.

(a)



(b)

FIGURE 1. (a) Visualization of the Palm House (photo available at www.trojmiasto.pl, visualization created by RYSY Architekci), (b), cross section of the external glass façade at the connection with hemispheric roof

As it is shown in Fig. 1 the structure has complex form. The glass panels of the façade, supported by steel structure, have different shapes and are mounted at different angles. Since the Palm house is located near the coast and it is not surrounded by obstacles, wind action should be considered with care, as high velocities of wind gusts are expected here. A question arose during the design verification, if some simplified approaches to estimate pressures acting on the façade, available in [1], for silos or cylinders can be used to enable safe life and exploitation of the object. Consideration of this aspect is the aim of this paper.

CFD CALCULATIONS AND CONCLUSIONS

Computational fluid dynamics is used in the framework of the Finite Volume Method (FVM) (see [2]) implemented into ANSYS FLUENT ([3]) to calculate the pressures acting on the façade. Due to the preferences and resources of the contracting authorities only two dimensional (2D) unsteady simulations with k-ε turbulence model were made, including different angles of wind attack. The mesh was created in accordance with the chosen analysis parameters and consisted of ~1100000 nodes in all the considered cases. The maximum design velocity of wind impacting the Palm house V=38m/s was calculated on the basis of [1]. Three structure cross sections at the: ground level, mid-height and at the connection with the hemispheric roof were considered. The results were compared with the pressures calculated for a cylinder using CFD and procedures available in [1]. It is worth to mention here that nearly the same results for cylinder were obtained with aid of [1] and FVM, thus the analysis parameters are correctly assigned. Comparison of the extreme pressures acting on the façade of the Palm house (cross section at the connection with the roof) and on the cylinder for a one, chosen design situation is depicted in Fig. 2.

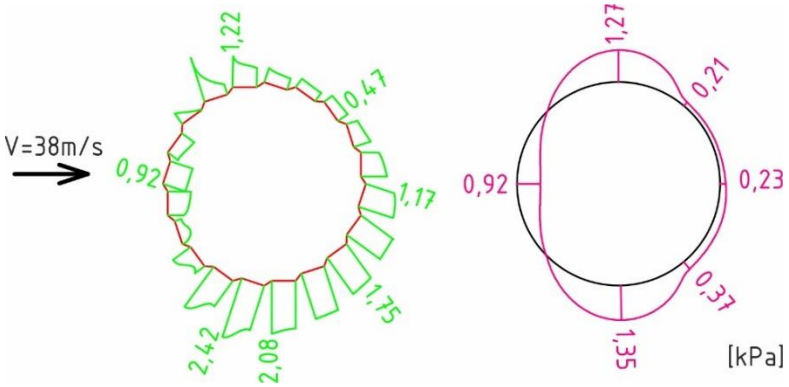


FIGURE 2. Comparison of the extreme pressures acting on the Palm house façade and on the cylinder for a single design sitation

Figure 2 reveals that the pressures observed on the façade of Palm house are significantly greater (nearly 1.8 times in the shown case) than the ones calculated assuming that the façade is a cylinder. Therefore a simplification of the shape and the use of [1] procedures for silos can lead to underestimation of the wind load effects.

Consequently, the results of 2D flow calculations at different cross sections were applied to 3D structural model of the supporting structure. As a result of our calculations the steel structure supporting the glass façade was strengthen to ensure that it can sustain all the wind load, which intensity increases due to the complex shape of the façade.

REFERENCES

1. PN-EN 1991-1-4:2008 Eurocode 1: Actions on strucutres - Part 1-4: General actions – Wind actions.
2. H. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method (2nd Edition) (Longman Group Ltd, Burnt Mill, Harlow, 1995).
3. ANSYS Fluent 16.0 documentation.