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BLWT APPROACH A WIND EXPOSURE AS MEASURED ON TOPOGRAPHY

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Summary: *Wind exposure acting on planned group of tall buildings has been investigated at field and laboratory observations with respect of the uphill position behind the steep river bank or behind shallow valley, from where two most frequent wind come. An attempt has been done to approach the wind exposure indicated on modelled topography through an adaptation of standard simulation for plane surface, in scaling suitable for modelling of building pressure response*

1. Introduction

Through ten years lasting BLWT performance, wind simulations over three terrains categories have been developed, as well as routines of inspection their turbulence properties [1]. Besides the standard simulations that show a scaling from 1:300 to 1:500, some experiences were obtained with much smaller scaling as topical at dispersion modelling or at boundary layer generation to enter a rugged topography being highly scaled, as in the following case.

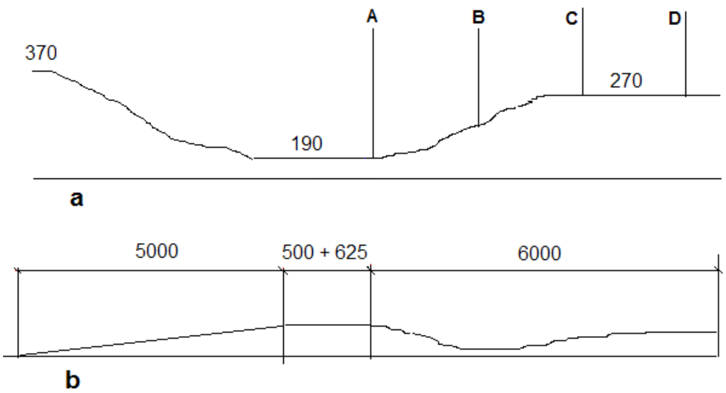

Figure 1
a) Section of Vltava valley (in the west wind direction), A, B, C, D … position of measurement sections, being 600 mm distant between
b) Wind tunnel installation of the topographical model

2. Modelled topography and velocity measurement

Group of tall buildings, as planned to be constructed on southern part of Prague-city would be exposed by winds, that after crossing broad valley of Vltava river were further formed over mouth of shallow, slowly raising valley of Krč (NW winds), or violently on steep rock Kavčí hory, causing a separation zone behind its edge (W winds). Both cases establish the reason for exacting experiment. Wind exposure on the locality and on near defined positions has been investigated on topography modelled in scale 1:1250, as the first experimental step. This model was of 6 m overall length and of 1.75 m span (wind tunnel cross-section was of 1.8 x1.5 m, working part length of 17 m).

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Material for the contours was 8 mm thick plates of extruded polystyrene, representing 10 m step of the full scale height. The model has been produced in two variants for W and NW wind directions, each set consisted of 5 sections of 1200 mm length.

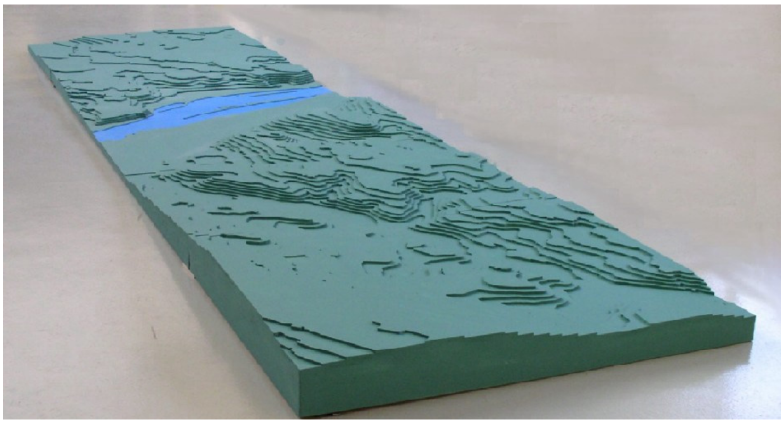

Figure 2. The model for Nord-West wind (sight in the wind direction)

Fig. 2 shows the complete model set for NW wind, before its installation into wind tunnel. An adjustment of oncoming BL for extremely small scaling was associated with installation of the incli-ned platform with slope of 2,063° in front of the model to attain the difference of height as it was needed and to reduce the boundary layer thickness (Fig.1).

The whole platform was covered by netting of 1 mm wire at 12.5 mm mesh in total fetch of 5.5 m. Rectangular fence (its height was optimized) was mounted ahead it, as a stimulating device. Adjustable ceiling above all working section enabled to adjust nearly constant longitudinal distribution of static pressure along the development part of the wind tunnel. So produced boundary layer showes roughness length of z_{om}=0.145 mm that referred to suburbian value z_o= 0.181 m on prototype. Roughness Re-number value u^*z_o/ν= 3.56 at used reference velocity U_R= 8 m/s was above the limit of similarity with atmospheric flow. It was supposed within the lower part of the boundary layer.

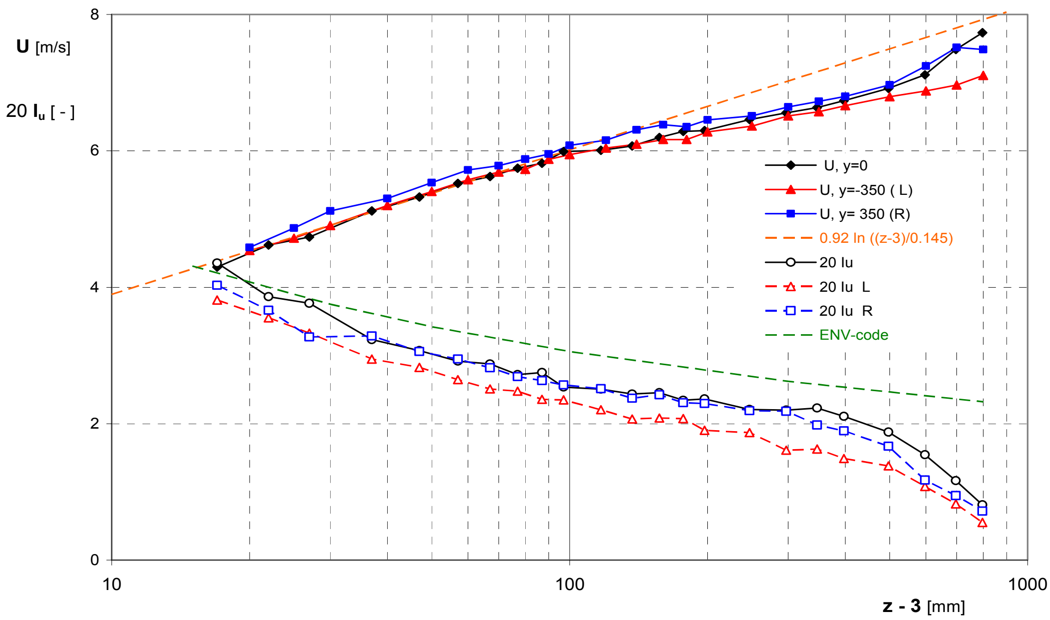

Figure 3. The mean velocity and turbulence intensity across the boundary layer, as it enters the topographic model.

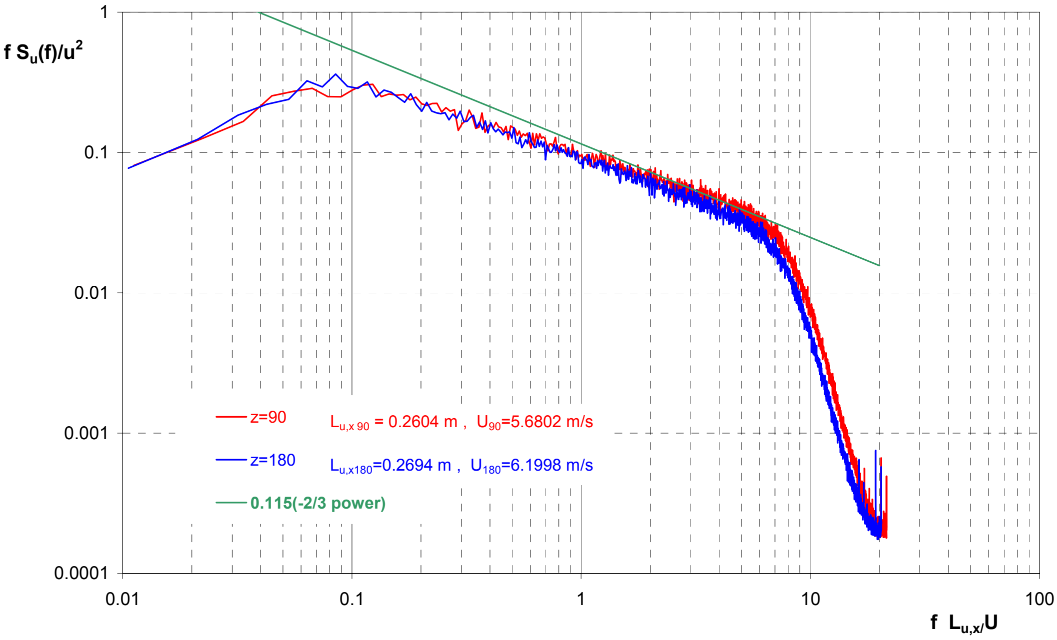

Figure 4. The power spectral density on two heights, proper to oncoming flow

The flow structure entering the model answered the profiles of U and u and the power spectrum, as they are shown in Figs. 3 and 4. A structure scaling has been evaluated as 1:920, from z_{om}=0,145 mm and $L_{u,x,m}$=0,2694 m on height z_m=180 mm, supposing $L_{u,x}(z)$ distribution according ENV-code. The scaling was accepted as favourable because the boundary layer is subjected to further development, passing across roughly 4 m fetch of topography afore the first measurement positions (section A, being partially above the river).

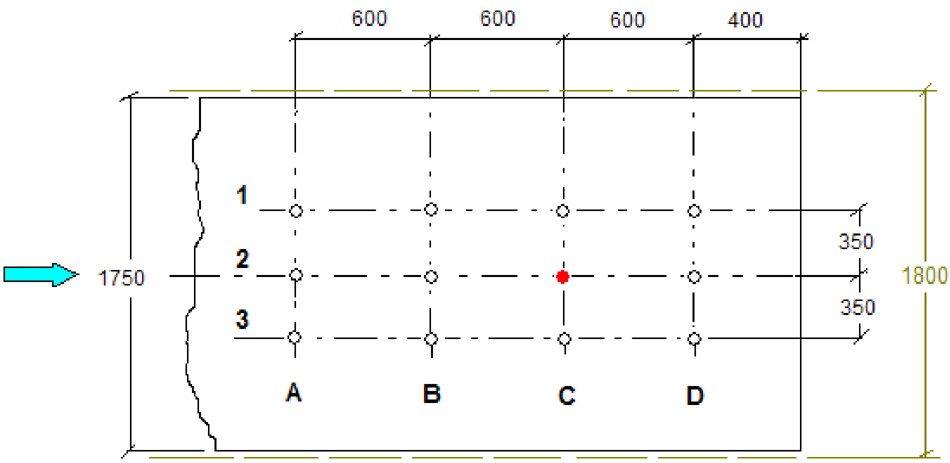

Figure 5. Localities where the U and u profiles were measured.

Wind profiles were measured on each of defined positions with single-wire Dantec 55P11 or 55P13 probe. Moreover, the measurements above 3 points of C section were doubled using X-probe Dantec 55P61. An enlarged sample volume was recorded on two heights above the central C position for both models, to be evaluated to spectral density distributions.

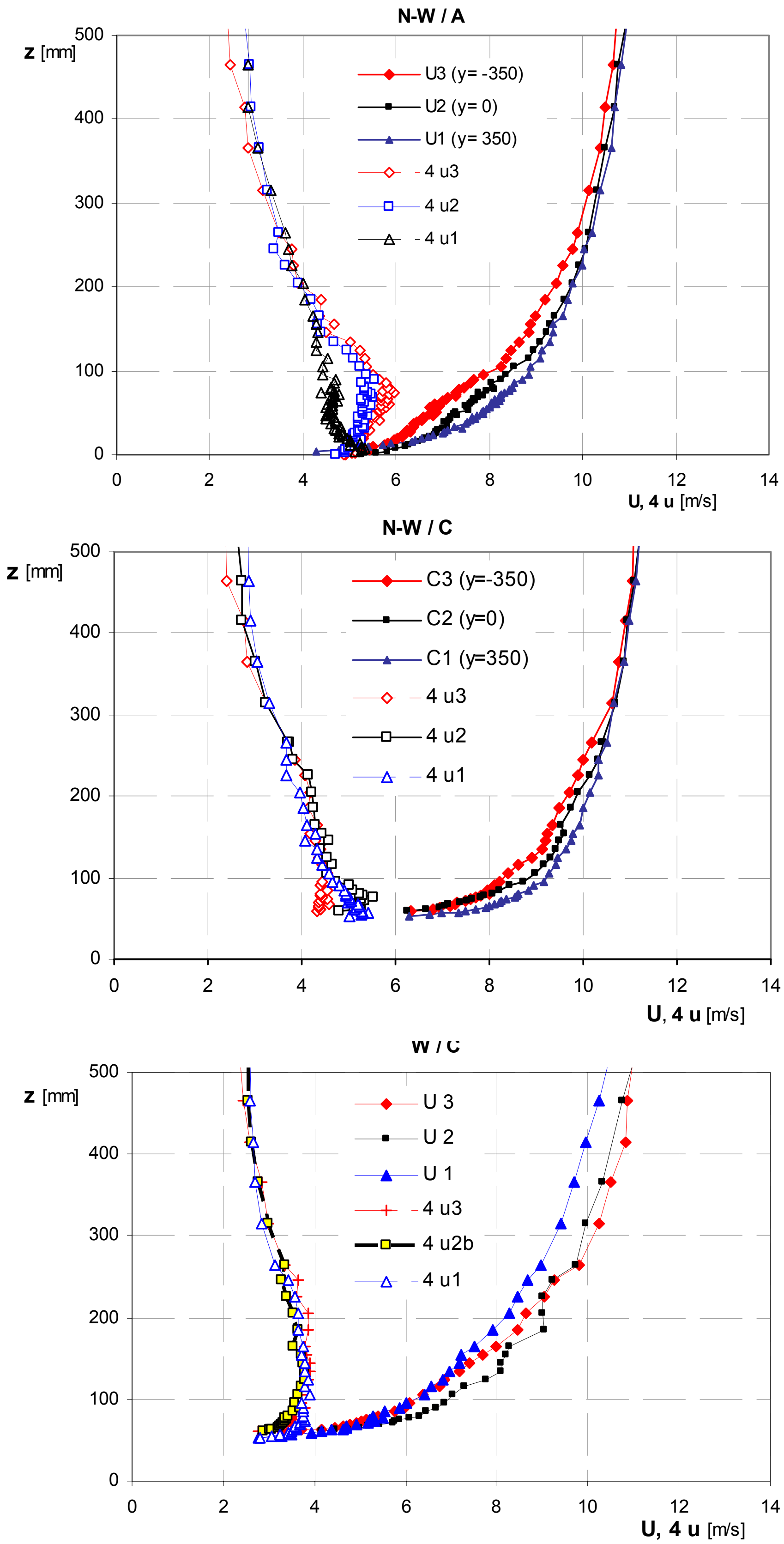

Figure 6. The mean velocity and standard deviation distributions as measured on model of topography in scale 1:1250 (only for the selected sections, designated according to Fig.5. Here z coordinate denotes the height above the river level.

2. The adaptation of standard simulation

As it would be complicated to realize a building model containing the equipment for pressure measurement as small as it should correspond the topography, an adaptation of standard suburb simulation (it uses the folio roughness, see Fig. 7 and rectangular fence ahead, yielded boundary layer with z_{om}=0.8 mm) was found to approach the wind exposure adequate to that in point C2 on the model. Two means of supplementary obstacles were tested, namely four 19 cm cubes located 5 m ahead the building axis as the first, and a barrier with slits as the second, situated at the same position in development part of the wind tunnel. The barrier which has been described in literature as the part of the Counihan simulating combination (Fig. 8) was modified in its height and angle of attack. Including the group of cubes mentioned above, ten modifications have been tested, on the whole.

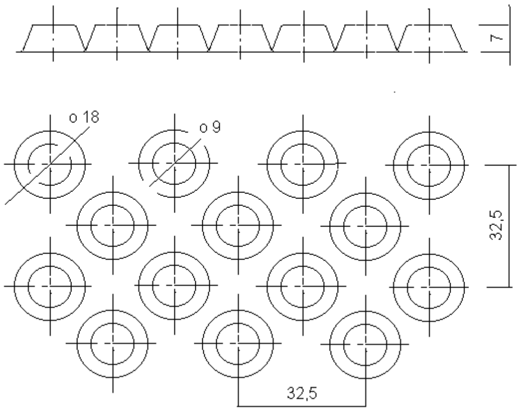

Figure 7. The hydro-insulated folio, exploited as roughness field at the current used simulation of suburb wind exposure

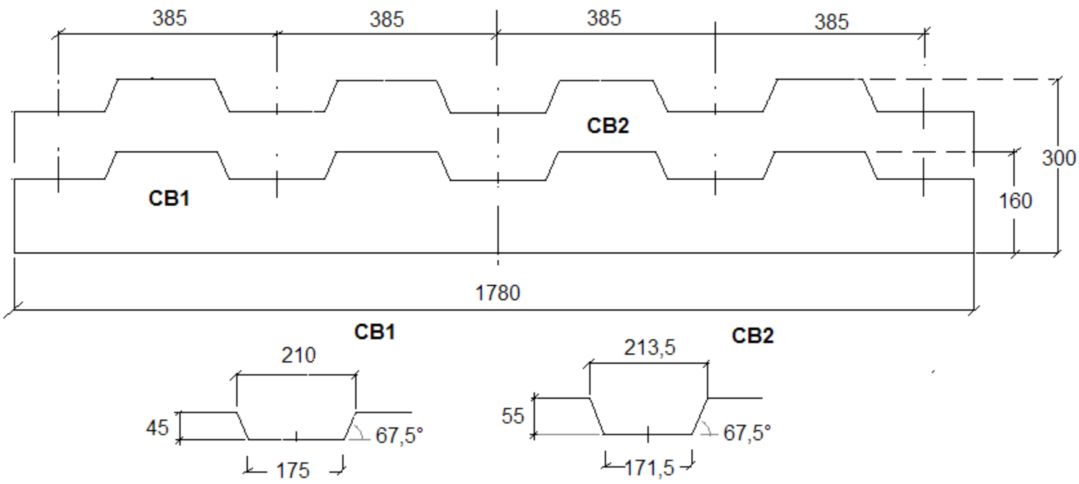

Figure 8. The barriers shaped after Counihan, giving the best results for BL adaptation.

The Counihan barriers (castellated walls), with alternative heights of 160 and 300 mm have shown satisfactory results at the trials, while the cubes could be considered only for NW wind situation. Two best adjustments of the lower barrier were adopted then to be applied for flow simulation at pressure measurement on building, modelled in scale 1:400. Slopes of the barrier were chosen of 30° and 45° for the NW and W wind simulations, respectively. Fig. 9 compares the results produced so way with those as indicated above models for NW and W wind on the C2 position. Vertical coordinate z is related to local level of terrain surface. Points denotes the target distributions, curves their simulation.

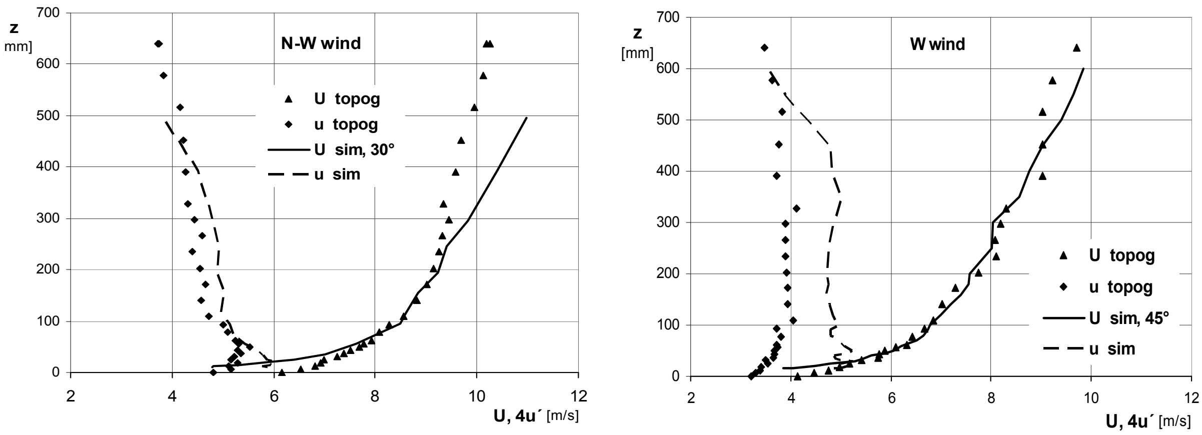

Figure 9 The mean velocity (*U*) and the standard deviation (*u*) distributions on the main position in scale 1:400. The curves are proper to the simulated flow.

Fig. 10, 11 compare cases of simulation by different means (selected). They do it through values related to those indicated on C2 position above N-W and W models separately. Here K1 denotation is of 4 cubes with edge of 19 cm concerned, at their dislocation formed as an arrow showing against the flow direction (giving better results than opposite arrow orientation), CB1 is the smaller and CB2 the higher Counihan barriers, angle of attack is added. The K1 case is absent in Fig. 11 for West wind, not giving satisfactory results.

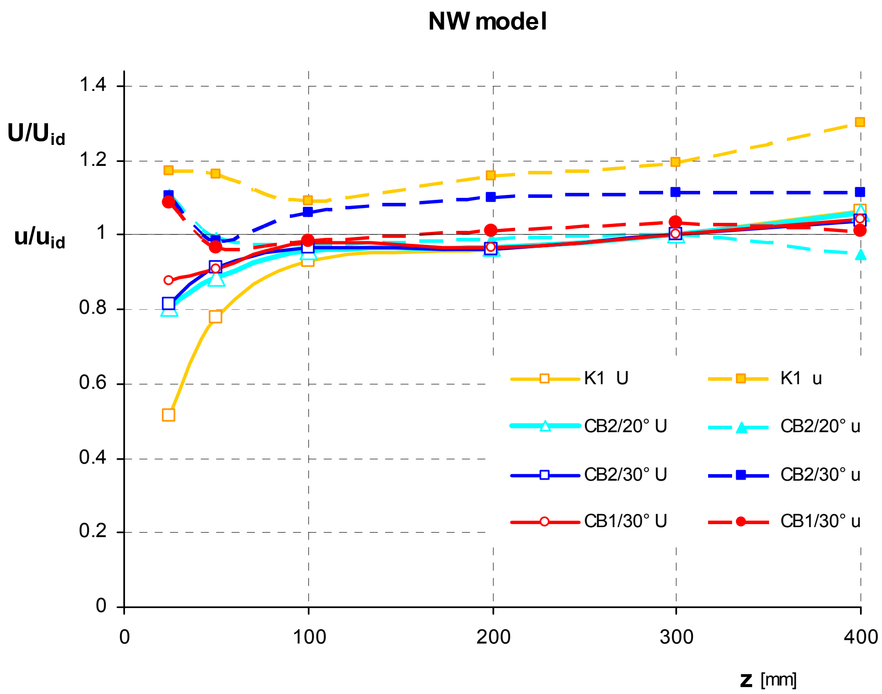

Figure 10. Comparison of selected modifications of simulation means with the wind exposure indicated on C2 position at North-West wind direction.

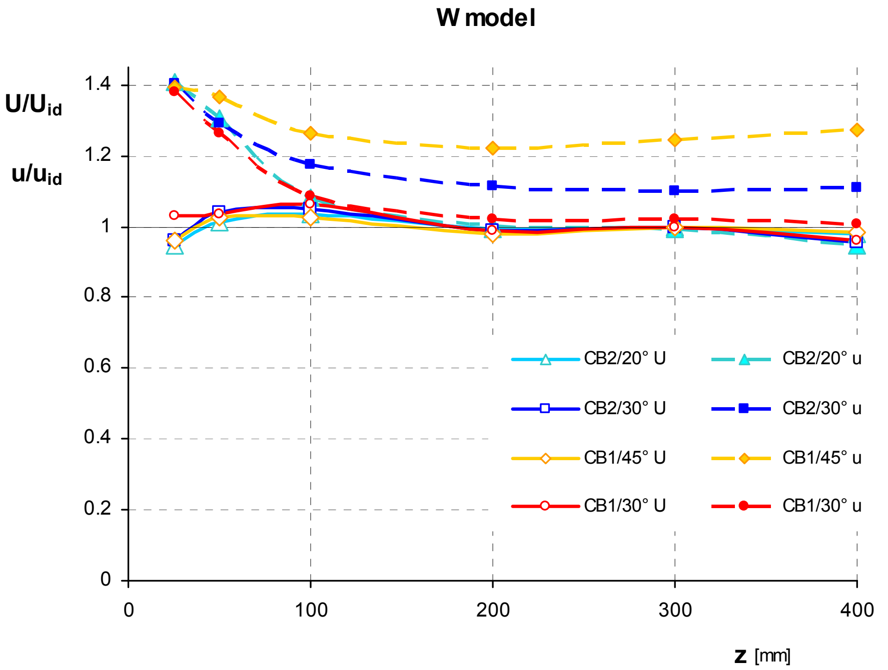

Figure 11. The same comparison as in Fig.10 for West wind direction.

3. Conclusion

Chain of experiments has been outlined, showing mutually combined wind tunnel use, aimed at wind loading on buildings modelling. It should be noted, that all possibilities of the special exploitation of Counihan barrier haven´t been yet fully enquired, even at procedure focusing on the specific site position which is of practical importance and where it seems be quite perspective - the wind exposure on sites finding behind windward slope, with a separation on its edge and with definite grade of re-attachment. It could be adjusted by the barrier distance from a model.

4. Acknowledgement

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5. References

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