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AEROELASTICITY OF SLENDER FACADE SHEETS

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Abstract: *The analysis of linear and nonlinear aeroelastic behavior of slender façade sheets is the focus of intense efforts because of pressing problems of disaster prevention of such structures. Theoretical analysis is interesting but the brain washing in the wind engineering is inevitable. Due to irregularities and inhomogenities in the facade as well as in the wind forcing the item „garbage in, garbage out“ appears there as significant option in modeling. Calculations are to be based on theoretical approach and be confronted with experimental results in order to satisfy the model similarity with reality and to develop suitable virtual models for the assessment of the problem.*

Keywords: Aeroelasticity, Boundary layer, Database, Façade, Virtual model, Wind tunnel.

1. Introduction

The development of suitable techniques for assessment of wind turbulences in ultimate aeroelastic behavior of slender facade walls equipped with thin glass or plexiglass sheets is the focus of efforts in this paper. Theoretical and experimental analysis of ultimate dynamic behavior of such slender facades is studied because of pressing problems of sound insulation and disaster prevention of such structures. In order to avoid the general problem „garbage in, garbage out“ in the analysis, the treatment uses the database of input data obtained by experimental tests in the wind canal.

Fig. 1: Cheese House in Nitra, Slovakia.

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2. Tests in Wind Canal

The application of the problem studied was made on the plexiglass facade of the building „Cheese House“, erected in Nitra, Slovakia (Fig. 1). The facade is made of yellow plexiglass sheets and is modeling architectural configuration of the Emmenthaler Cheese. The research was made in the wind tunnel of the Institute of Construction and Architecture, Slovak Academy of Sciences, Bratislava.

Studied was the facade panel in scale 1:1, made of plexiglass sheet and attached by joints into supporting steel frame. The width of the plexiglass sheet is 15 mm. Its maximal dimensions are 1100 x 812 mm. The views of the model are in Figs. 2 and 3. The panel is a part of actual facade sheet and therefore no treatment of the model similarity was required. Due to the wind forcing the sheet acts with quasi-static displacements combined with horizontal vibrations of supporting steel structure. The tests were made via strains and accelerations measured in the sheet in the wind tunnel.

Fig. 2: View of the model.

Fig. 3: View of the model in wind canal.

The sheet was subjected to laminar and turbulent wind forcing until velocity 40 m/sec. Measured were three accelerations (A1, A2 and A3) and four relative displacements (T1, T2, T3 and T4), respecting the air velocity (Vel) in the wind canal.

Used was the modul of the canal with cross-section 1200 x 1200 mm. The testing was made in accordance with the wind forcing on actual facade in situ with plexiglass sheets distanced 400 mm from the surface brick wall of the building. In scope of testing the brick wall was modeled by the floor of the wind canal and the plexiglass sheet was located in the height 400 mm above it.

The tests in wind canal were made for three experimental configurations:

a) plexiglass panel in horizontal level 0° – shear wind acting parallel along the facade,
b) plexiglass panel in skew level –15° – suction due to fall down wind,
c) plexiglass panel in skew level +15° – pressure due to skew wind and face uplift wind.

Some results obtained are illustrated in Figs. 4, 5 and 6.

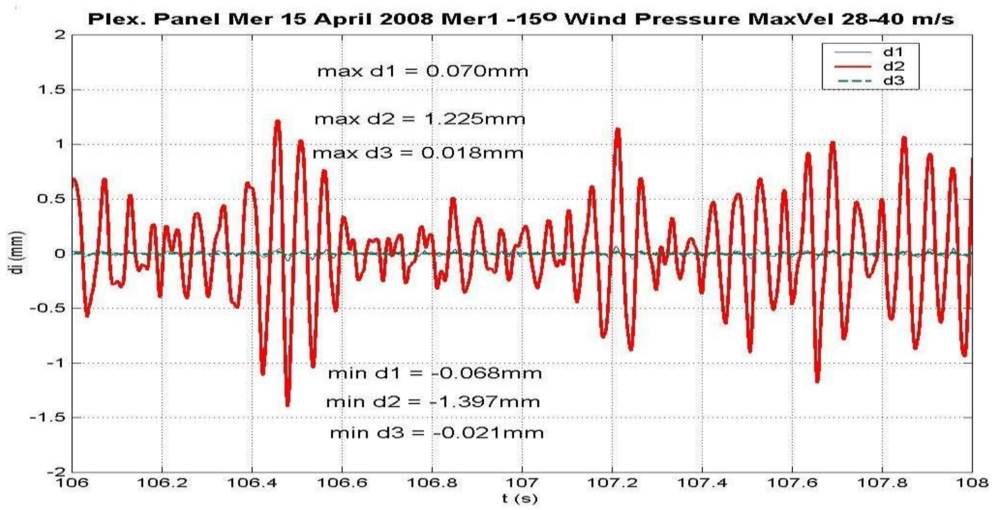

Fig. 4: Horizontal (d1), vertical (d2) and shear (d3) deformation amplitudes in configuration 0°.

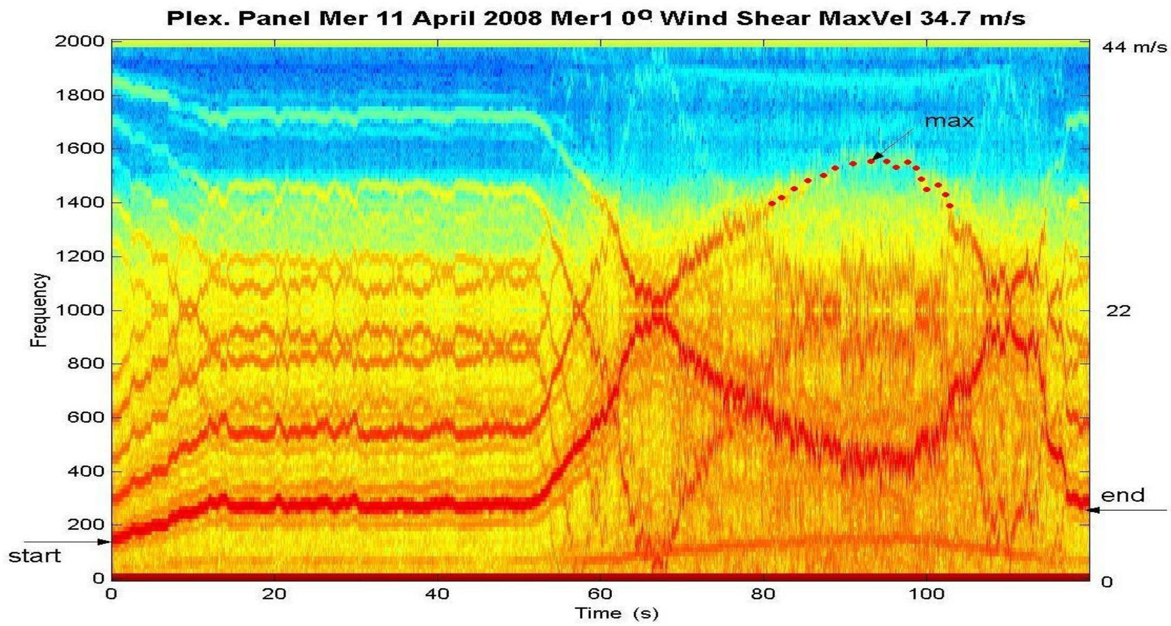

Fig. 5: Configuration 0° - wind velocity Vel (m/s).

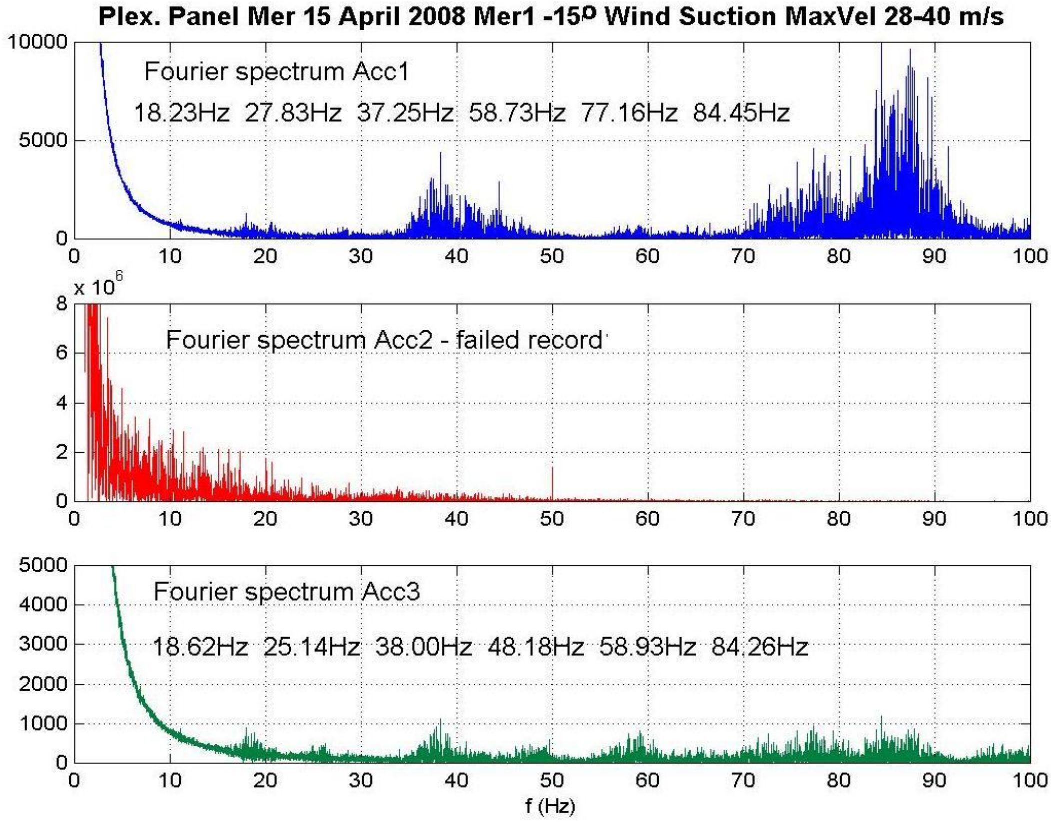

Fig. 6: Configuration -15 ° - Fourier spectrum of accelerations A1, A2 and A3.

3. Conclusions

The evaluation of time response and of extreme values of the data summed up has brought the conclusion that resultig response of the plexiglass sheet is dominated by dynamic displacements with pressure and sucking of the wind The displacements have irregular distribution along the surface of the sheet. The turbulences of the air flow influence deformations and vibrations of the plexiglass sheet and of supporting members (see Tesar, 2006, 2011, 2012, 2012a). All results evaluated were summed up in the database of input data for tuning and creation of virtual models with numerical analysis made in advance. The confrontation of numerical and experimental data resulted in satisfactory agreement of both approaches. In order to avoid the discrepancy of numerical results and in situ measurements (garbage in, garbage out) there was established the database of the results obtained. Such database contains all significant input data for virtual testing and assessment of the problem. On the basis of evaluation of the results obtained was specified the reliability of the plexiglass facade sheet, its supporting steel structures and joints for in situ implementation.

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