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TURBULENCES IN ARTIFICIAL BOUNDARY LAYER OF FOTOVOLTAIC POWER PLANTS

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Abstract: *The aeroelastic assessment of turbulences appearing in artificial boundary layer of fotovoltaic power plants is treated in present paper. The approach suggested takes into account multiple functions in the analysis of skew flat plates of solar panels subjected laminar and turbulent wind forcing. Analysis and experimental assessment in the aerodynamic tunnel are presented. Some results obtained are presented.*

Keywords: ***Aerodynamic tunnel, aeroelasticity, artificial boundary layer, fotovoltaic power plant, mechanics of turbulent wind motion.***

1. Introduction

The topic of present paper is the assessment of ultimate aeroelastic behaviour of skew plates of solar panels in fotovoltaic power plants subjected to laminar and turbulent forcing of wind (see Fig. 1). The skew flat plates of solar panels are supported by metal structures anchored into terrain. The panels create the active fields of the power plants studied. The fotovoltaic power plants are located in territories where the wind loads represent the dominant environmental forcing. The forcing is to be unified into maximal design values for given territory. All structural elements are to be designed in accordance with valid standards and their aeroelastic assessments are required, for example, due to the recommendations of the EUROCODE 1, Loads on Structures, Part 1.4, General Loads, Wind Loads.

2. Analysis

The idea of application of the flat plate aerodynamics in the field of preliminary structural design was introduced by Bleich (1950). Selberg and Hjorth-Hansen (1961 and 1966) carried out an experimental investigation of a number of cross-sections presented an approximate expression for the flutter velocity of a plate acted upon by Theodorsen´s forces (1935).

In this paper the wind induced structural phenomena are treated by transient dynamics (Tesar, 1978 and 1988). Laminar and turbulent wind forcing is studied adopting the wave propagation approach. The goal is to develop the approach based on transient dynamics combined with wave propagation forcing and adopted for the analysis of aeroelastic response of skew flat plates of fotovoltaic power plants on the basis of results obtained in scope of experimental testing in the wind tunnel.

3. Experiments in aerodynamic tunnel

The testing was made with the model set-up of typical skew flat plate in scale 1:10, developed on the basis of the model similarity with actual structure. The aerodynamic testing was made in the wind tunnel of the Institute of Construction and Architecture of Slovak Academy of Sciences in Bratislava, Slovakia. For testing was used the modul section with cross-sectional dimensions 1200 x 1200 mm and length 6000 mm. Maximal wind velocity obtained was 51 m/sec. The model of the skew flat plate was made of aluminium with dimensions 1000 x 300 mm and width 4 mm. The plate was supported by steel supports Jäckl 20/20/2 and anchored into the floor of the tunnel. The view of the experimental set-up in the tunnel is in Fig. 1.

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Fig. 1. Side view of the skew plate studied in aerodynamic tunnel

The averaged increase of speeds and pressures of wind flows on the upper, lower and side edges of the plate were given by aerodynamic coefficients α = 1.4255, 1.6532 and 1.4080, respectively. The averaged increase of the wind pressure on the plate due to change of wind direction and due to turbulences appearing was given for wind sucking by multiplicator –1.65 and for the wind pressure by multiplicator 1.43 of the standard values valid for the face action of the wind on the model. Due to appearance of the wind gusts was initiated ultimate response of the model. There appeared combined axial and shear amplitudes of vibration parallel with the plane of the skew plate.

4. Conclusions

On the basis of evaluation of virtual results obtained in active fields of fotovoltaic power plants has been found that ultimate displacements and stress states appear in boundary regions of the fields where the wind flows have a distinctly turbulent character. In real structures such regions are created by boundary strips having 3 m width along the periphery of the field studied.

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