Engineering Structures 124 (2016) 539–548

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Wind tunnel tests of two free-standing lighting protection masts in different arrangements with surroundings roof objects and roof conditions

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ARTICLE INFO

Article history:
Received 30 November 2015
Revised 23 June 2016
Accepted 24 June 2016

Keywords:
Wind tunnel test
Masts
Aerodynamic coefficients

ABSTRACT

The paper presents results of wind tunnel experiments of wind action on two free-standing lighting-protection masts with additional supporting ballast placed on building roofs. Aerodynamic laboratory studies were accomplished in a boundary layer wind tunnel. The main objective of the research was to determine extremal values of aerodynamic coefficients. A cantilevered mast and a tripod mast were tested in different roof conditions and different arrangements with surroundings roof objects. A big influence of aerodynamical interference phenomena between masts and adjacent objects was revealed. Moreover, detailed analysis of the experimental results as well as practical approach to design of such kind of structures with respect to wind action was made.

1. Introduction

In the case of communication broad casting towers, wind action is usually one of the most important actions in their design. Problems of aerodynamics of such type of structures were considered in many publications e.g.: [1–12] in the case of free-standing/self-supporting towers; [13,14] in the case of guyed masts. Totally different aerodynamic and stability problems take place in the case of light small free-standing lightning protection masts placed on the building roofs, together with additional supporting ballast [15]. In trade catalog one can find basic information dealing with mechanical and structural solutions which can be assumed in their practical design (comp. e.g. [16,17]).

The main goal of this paper is performing wind tunnel tests of such kind of structures and working out practical approach to their design. For each mast model, fixing aerodynamic moments M_x and M_y and fixing aerodynamic forces W_x and W_y have been measured using four component aerodynamic balance based on electric resistance wire strain gauges. Obtained values of aerodynamic coefficients can be used at determining design aerodynamic forces and moments acting on the bases of free-standing lighting protection masts.

2. Characteristics of the wind tunnel tests

Wind tunnel tests and aerodynamic calculations of the cantilevered and tripod free-standing masts of 4.0 m and 6.0 m high (comp. Fig. 1) were done in a boundary layer wind tunnel of the Wind Engineering Laboratory at the Cracow University of Technology.

The masts models used in wind tunnel tests were made in a scale of 1:6. The scale of model was determined by the dimensions of the masts provided by the investor. The height of model masts were 0.66 m (cantilevered made of aluminum pipe) and 1 m (tripod made of steel rods). The models consist of three different parts: (1) flat roof of the building tested in two situations: air inflow normal to the roof edge and air inflow is along to the roof corner diagonal; (2) the blocks situated on flat roofs; (3) the masts (cantilevered and tripod). The flat roof of the building was made of a fiberboard thickness 18 mm cut mechanically with holes for mounting masts to the vertical aerodynamic balance. Mounting of the masts to the aerodynamic balance was made of steel pipes jointed with screws (Fig. 2). Big or small blocks representing the adjacent object as well as upper part of a flat roof were made of plywood thickness 6 mm cut with precise technique.

The basic dimensions of the wind tunnel working section are: 2.20 m (width), 1.40 m (height), 10.00 m (length). Formation of the mean wind velocity profile and atmospheric turbulence takes place in the first part of the working section at the length of 6 m by use of respective turbulence generators: barriers, spires and

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http://dx.doi.org/10.1016/j.engstruct.2016.06.040
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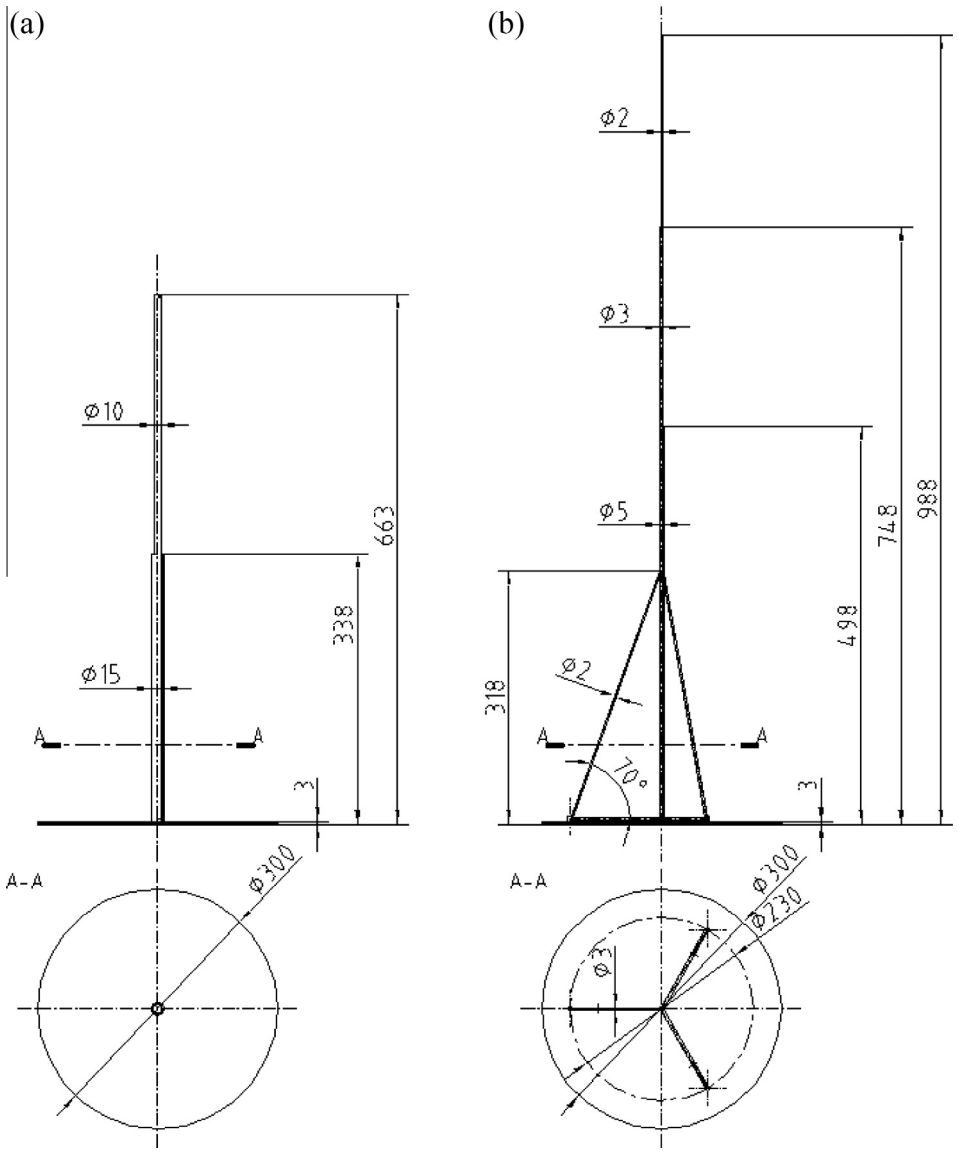

Fig. 1. Geometry and basic dimensions of cantilevered (a) and tripod (b) masts analyzed in the paper (dimensions in mm).

Fig. 2. The view of masts mounting to the aerodynamic balance.

blocks of respective geometry and a mechanically controlled height. In the working section of the tunnel, there is a round rotational table of 2 m in diameter which makes possible the change of a wind inflow direction on the examined model.

The measurements of aerodynamic moments and aerodynamic forces were taken at following measuring conditions and situations:

- Two terrain roughness category: flat open terrain and flat urban terrain (i.e. respectively without and with blocks and spires in front of the models in wind tunnel working section);
- Two situations of surroundings: small or big neighboring (adjacent) object modeled by a block;
- Five wind attack directions (taking into account symmetry of investigated objects);
- Two directions of inflowing air with respect to building: perpendicular to roof edge and along to roof corner diagonal. It gives 40 measuring cases for each mast.

On the basis of the measured data, aerodynamic coefficients were calculated. A view of the tested model in the wind tunnel working section is presented in Fig. 3.