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Calculation of guyed masts in accordance with EN 1993-3-1 standard taking into account mast shaft geometrical imperfections

Monika Matuszkiewicz *

Koszalin University of Technology, Department of Steel Structures, Śniadeckich 2, 75-453 Koszalin, Poland

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ABSTRACT

Selected problems concerning designing of guyed masts with lattice shaft in accordance with the "EN 1993-3-1: Design of steel structures. Part 3-1: Towers, masts and chimneys – Towers and masts" European standard have been described in this paper. The method of application of the mast shaft geometrical imperfections in calculations has been discussed. Based on the performed comparative analysis of a certain mast, the influence of such imperfections on the ultimate values of internal forces in the mast shaft has been demonstrated.

1. Introduction

According to the European standard [1] the guyed masts and chimneys are analysed with consideration of influence of deflections on the equilibrium conditions (according to the second order theory). However, in global analysis the perfect type structure is considered i.e. a structure without influence of initial geometrical imperfections of the mast shaft on the internal forces and deflection values. In Annex F to the above-named standard concerning mast structure execution, limitations regarding the maximum initial deflections of the mast shaft between two guy levels have been indicated, among other things. Those deflections should not exceed the $L/1000$ value (L—span length). In the case of mast structures featuring relatively small distances between adjacent guy fixing levels taking into account that the influence of the permissible assembly deviations in mast spans has no significant influence on the structural analysis results and can be neglected in calculations. However, in the case of considerable distance between two guy levels and significant normal forces in the mast shaft, the influence of the initial mast shaft imperfections may have a considerable impact on the internal force values.

The simplest method of taking into account of the geometrical imperfections in the mast static calculations is replacement of the real curvilinear bars with straight ones but loaded with a certain substitute load, influence of which on the status of internal forces in the mast shaft is equivalent to the influence of initial span curvature. The best way is, in practise, to apply the geometrical imperfections described by a parabolic function because such curvature features a permanent value of the substitute load along the bar length Fig. 1 [2].

According to this assumption the substitute load value in a span can be defined by the following equation:

$$q = \frac{8Ne_0}{L^2}, \tag{1}$$

where:

N—mast span normal force,

e_0—maximum imperfection amplitude value,

L—span length.

In the case of contra-positioned initial mast shaft curvatures the substitute load in particular spans should be applied with opposite senses (Fig. 2). Values of substitute load caused by the imperfections may constitute a significant fraction of the span wind load in the masts with slender shafts and considerable distances between the guy fixing levels.

To show the influence of initial imperfections on the values of internal forces in mast shaft, static calculations of a certain antenna mast (Fig. 3) located at the Przysucha–Kozłowiec Radio and Television Broadcasting Centre were done. To simplify the matter only the mast structure without the aerials and other equipment was considered in the calculations. The calculations were accomplished using *Mast1* software, described in [3], according to the second order theory. The nonlinear elastic analysis applied in this study pertained both to the guys and mast shaft.

* Tel.: +48 606 558 430.
E-mail address: m.mat@wbiis.tu.koszalin.pl.

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