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IN-PLANE DESIGN OF NON-CIRCULAR TRIANGULATED TENSILE SPOKE WHEELS

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ABSTRACT

This paper provides a new method to define the in-plane design of non-circular triangulated tensile spoke wheels with two perpendicular symmetry axes, like those used for roofing big sports stadiums. The proposed method describes how to define the in-plane shape and the necessary pre-stressing so that the outer ring behaves like a funicular polygon which has equal-length sides and is uniformly compressed. All in all, this method solves the problem of non-circularity by equalising the cross section sizing conditions of the outer ring to the sizing conditions that a circular structure would have.

Keywords: *Triangulated tensile spoke wheels, non-circular shape, homothetic deformation*

1. APPROACH

1.1. Introduction

Spoke-wheel-like roof structures are formed by pre-stressed spokes which are connected to inner tension rings and outer compression rings, where the supports are located. The spokes are usually organised into two layers: top and bottom. These two spoke layers are not parallel to each other, but usually converge at one of the rings. Thus, these structures can be classified into two subtypes: those which have two outer compression rings and one inner tension ring, and those which have one outer compression ring and two tension inner rings. In the former case, the two outer compression rings are separated by masts located at the outer end of the spokes. In the latter case, the masts are located between the two inner tension rings at the inner end of the spokes, and thus they are suspended in the air [1]. The profile of the spokes, biconcave or biconvex, determines the use of intermediate ties or floating masts respectively between the inner and the outer ring.

If spans are long and live loads are small, the ratio between the self-weight and the whole of the loads of a spoke-wheel-like structure is usually much smaller than any other type of structure [2].

The cross section sizing of the tensile spokes and inner tensile rings is only conditioned by the material's strength. This is why, if the material is very resistant to tension forces, it can have a very small cross section and the material consumption is kept to a minimum. Masts are jointed at their ends. This prevents bending moments and shear forces. These masts are slender and might suffer from buckling, however, they do not need a big cross section because the compression forces which they bear are relatively small. Therefore, the material consumption for masts is not often relevant. By contrast, the outer ring is subject to great compression forces. The variation of these forces around the ring's perimeter depends mainly on the variation of the curvature radius and the asymmetry of the live loads. Besides, the mismatch between the geometric shape of the outer ring and the in-plane reaction forces due to the spoke pre-stressing results in the occurrence of great bending moments and shear forces. For all these reasons, the cross section size of the outer ring (and also the material consumption) is usually much greater than for the rest of constructive elements of the wheel. Consequently, optimizing the design of the outer ring is essential in order to avoid compromising the efficiency of these structures.