

Simplified procedure for the design and optimisation of oval tensile spoke wheels for roof structures

This paper presents a simplified procedure for the design and shape optimisation of oval tensile spoke wheels to be used in roof structures for grandstands in sports stadiums. This procedure combines graphical methods with simple numerical methods to obtain the geometrical definition of an oval wheel and to estimate the prestressing forces. It also allows for the compression forces in the outer ring to be estimated and compared with those in a circular wheel. This makes it easy to make small geometrical adjustments for optimisation. Application examples are given for each step of the procedure. Several wheel designs are defined, showing how the shape of the inscribing oval determines the magnitude of the forces in the outer ring.

Keywords: Ovals, superellipses, tensile spoke wheels, graphic statics, roof structures.

1 Introduction

1.1 Ovals

Three ovals with two perpendicular axes of symmetry, formed by arcs of tangent circles, are considered (Figure 1). The simplest ovals of this type have four centres and four arcs with two different radii; they are commonly known as four-centered ovals and also as quadrarcs. The two centres of the arcs with the smaller radius lie on the x-axis line of the major axis, and the two centres of the arcs with the larger radius lie on the y-axis line of the minor axis. The next most complex ovals of this type have eight centres and eight arcs of three different radii, and are commonly known as eight-centered ovals. The geometric quality of the approximation of a given ellipse is higher using eight-centered ovals (with the arcs ordered from smallest to largest) than using four-centered ovals. A general and thorough discussion of this fact can be found in [1]. With the arcs