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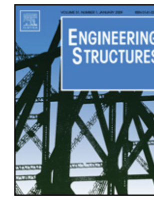

Experimental and analytical studies on the rotational stiffness of joints for single-layer structures

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ABSTRACT

In the design of single-layer structures, the hypothesis of pinned joints leads to structures with low capacity in terms of stability and resistance. Therefore, one of the main concerns of structural designers in recent years has been to find an appropriate joint design which would endow the joint with sufficient stiffness. In this paper, the results of experimental tests conducted with the aim of establishing geometrical parameters for a semi-rigid joint that may be used in single-layer structures are presented. They showed how the combination of different parameters can improve the stiffness of the joint and its rotational capacity. At the same time, the experimental tests provided the initial rotational stiffness of the tested joints which is to be introduced into the analysis of the structure. The paper presents an analytical method for the determination of the initial rotational stiffness of the joint. The method follows a technique similar to the component method of Eurocode 3 part 1.8, although it has been adapted to the geometry of this particular joint.

1. Introduction

In the design of reticulated space structures, the common practice over the years has been to consider the joints as being pinned. However, when moving onto single-layer structures, pinned joints are of no help in achieving the required stability and resistance [1]. Obviously, they cannot be regarded as rigid joints either. Therefore, the innovations of Eurocode 3, part 1.8 [2], which allow taking into account the actual stiffness of joints are of great help in the design of single-layer spatial structures.

The main concern of structural designers in recent years is not so much a problem of adequate structural design methods or analysis assumptions, but rather how to find an appropriate joint design which can provide the structure with enough stiffness and meet, at the same time, other important requirements such as ease of erection and economic advantages. In this respect, Makowski [3] collected information on the different joint systems developed during the years and commented on their advantages and disadvantages.

This paper presents the results of a number of experimental tests developed at the School of Engineering of the University of Navarra (Spain). They were aimed at establishing the geometrical parameters of a semi-rigid joint that may be used in single-layer structures. They showed how the combination of different parameters can improve the stiffness of the joint and its rotational capacity.

Although they are not included here, tests have also been conducted to verify the resistance of the joints under axial and shear load. The experimental results presented in this paper deal only with the behaviour of the joint in bending, which is one of its most relevant characteristics [4]. Following the test results, design parameters were established. At the same time, the experimental tests gave the rotational stiffness of the tested joints, which is needed for the analysis of the structure.

The paper also presents a procedure for the analytical determination of the rotational stiffness of the joint as a more practical way of characterising the joint which can be easily implemented in everyday design. As Yee and Melchers [5] pointed out, after having examined different ways of modelling the joint rotational behaviour, a physically based approach is desirable. Accordingly, in this paper, the initial rotational stiffness of the joint is derived from the geometry of the components of the joint. The results obtained analytically are compared to the experimental values. Since in the test the beams were loaded under pure bending, the influence of axial force is not considered. However, when analysing real single-layer structures, this influence cannot be forgotten [4,6].

The approach presented here follows in some way the philosophy of the so-called *component method* presented in Eurocode 3, part 1.8 [2]. However, the provisions in Eurocode 3 are particularly intended for joints connecting H and I sections. These are the most widely used sections in framed structures. Many experimental tests and guidelines have been developed ([7–9] *inter alia*) and the literature on this type of joints is extensive. The authors hope

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