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Numerical and experimental investigation of rotational stiffness of zed-purlins connection with sandwich panels

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ABSTRACT

A rotational resistant stiffness of the zed-purlins connection with sandwich panels is investigated. A simple finite element method model of the connection is proposed. The numerical analysis of the model performed by ABAQUS software, in physically linear and geometrically nonlinear ranges, leads to the rotational resistant stiffness sought. The numerical solution obtained is verified experimentally. Two variants of distribution of screws connecting the purlin with the sandwich panel are taken into investigation. A good agreement of both, theoretical and experimental, results should be noticed. Conclusion related to possible application in design practice is formulated.

1. Introduction

Sandwich panels are widely used in construction, particularly in the fields of civil engineering and vehicle structures. Sandwich panels on thin-walled cold formed elements recently became a very popular kind of roofing, for their high cost efficient, comparing to traditional techniques of roof or wall construction. Low self-weight and high mechanical durability are the most important features of these structures. Attention should be paid to the book [1] written by Davies and a group of European experts in lightweight construction. This book provides guidance on materials used in manufacturing, thermal efficiency, air- and watertightness, acoustic performance, structural ultimate and serviceability limit state design, test procedures, additional structural considerations including fastenings, the effect of openings and the use of sandwich panels as load-bearing walls. It is worthy of noting the European cooperative programme – EASIE (Ensuring Advancement in Sandwich Construction through Innovation and Exploitation) [2] and a number of papers and studies related directly or indirectly to the project [3,4]. Noteworthy are also two doctoral theses created between 2009 and 2012. The first one, [5] concerns only connections between the zed-purlin and the sheeting but the second one, [6] is closely linked with the paper subject.

Anyway, there is still a lack of knowledge on the influence of sandwich panels on the behaviour of thin-walled structures. This is mainly due to the complexity and diversity of approach in the construction of sandwich panels and the types of connections between purlins and sandwich panels. In addition, standardized design stored in Eurocode 3 [7] seems to be too complicated and unclear in the description of screw connections between purlins and sandwich panels.

Nowadays still the purlin-sheeting system has been developed by full-scale testing [8,4]. A short description of the experimental investigation of the basic types of roof systems, connections between panels and construction details of the attachment may be found in a paper by Chung and Quinton [9]. However, due to an increasing number of new design features and the high cost of testing, there is a real need for the development of analytical and numerical design procedures.

At this time, the behaviour of connections in steel sheeting and sandwich panels [10,11] have been modelled, using the FEM (finite element method) and FSM (finite strip method) [12,13], including large inelastic strains and contact problems. However, the numerical results are usually validated by the experimental results.

The most important issue in the design of this type of structures is to determine the rotational restraint stiffness of purlins by sandwich panels. The rotational resistant stiffness plays an important role in the lateral torsional bucking behaviour of the attached purlin. A main purpose of the paper is to create a numerical model to determine the rotational resistant stiffness.

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The proposed numerical model is simpler than the models used previously by other researchers [14,15] and one does not need to use extremely powerful computers to do the work. Particularly noteworthy is modelling of connectors (screws) linking the sandwich panels with the purlins. Modelling of the connection, regardless of its simplicity, allows for an accurate determination of the investigated rotational restraint stiffness.

2. Finite element model

Let us consider the problem of rotational restraint stiffness of a connection between a zed-purlin and a sandwich panel. A number of tests were performed on purlin-sandwich panel systems shown in Fig. 1. Numerical analysis was done using ABAQUS software [16]. The model consists of a zed-purlin, a sandwich panel and

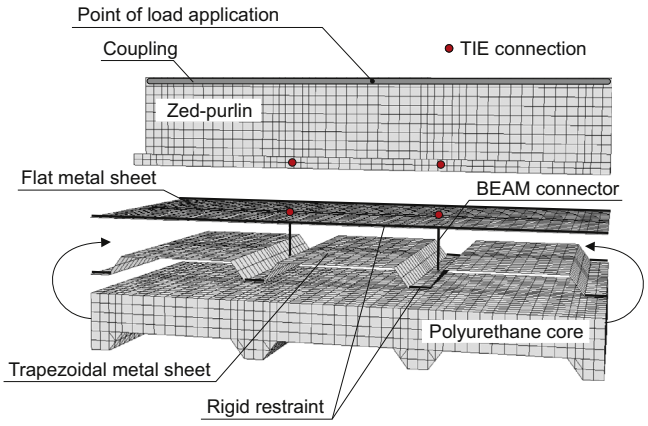

Fig. 2. Finite element test model of sandwich purlin system.

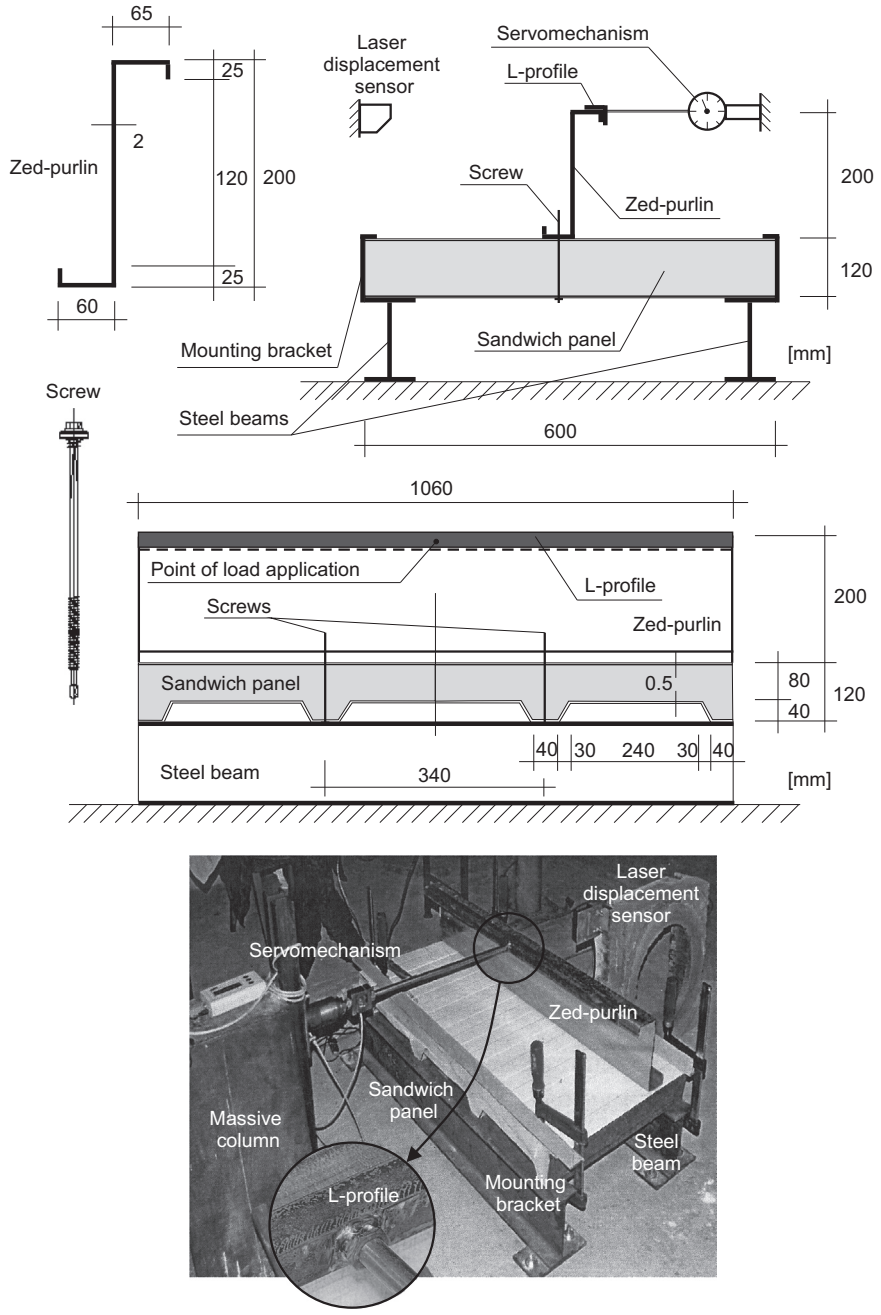

Fig. 1. Stand to determine the rotational restraint stiffness.