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Influence of Uplift Load on Torsional Restraint Provided to Steel Thin-Walled Purlins by Sandwich Panels

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Abstract

The sandwich panels have been widely used as members of roof and wall cladding. In addition to their primary function, they can provide lateral and torsional restraints to the supporting members and therefore contribute to their buckling resistance. The availability of the provided restraints is influenced by the direction of the load applied to the surfaces of the panels. For the uplift load, no torsional restraint is conservatively considered due to reduction of the contact area between the panels and the supporting metal members. Possible small rate of the torsional restraint should be verified by experimental investigation.

The paper focuses on the experimental verification of the torsional restraint provided to steel purlins of thin-walled cold-formed cross-sections by adjacent sandwich panels. For the first series of tests a simple test set-up with no external load applied to the surface of the panel was utilized. The second series comprises tests of the torsional restraint provided to steel purlins by sandwich panels under uplift load. A complex test set-up taking into account the external load applied to the surfaces of the panels was used. The results of both test approaches are compared and the influence of the uplift load on the torsional restraint for the tested specimens is evaluated.

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Keywords: Buckling; experiment; purlin; sandwich panel; stabilization; thin-walled beam; torsional restraint

1. Introduction

Planar members of roof and wall cladding (e.g. sandwich panels) are in most cases supported by metal members of thin-walled cross-sections (purlins, girts). Due to connection of cladding, a metal member can be fully or partially

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restrained against lateral displacement and rotation. The prevention of the deformation of the metal member contributes to its buckling resistance [1,2]. Correct consideration of the restraint along its span can positively influence the efficiency of the structural design. The adjacent members of cladding can provide lateral restraint (effected by certain shear stiffness given by the planar member) and torsional restraint (effected by certain rotational stiffness) for the thin-walled member [3,4]. The lateral restraint provided by the planar members of cladding to both hot-rolled and cold-formed members can be utilized for downward as well as uplift load applied to the surfaces of the sandwich panels. The torsional restraint can standardly be considered in case of the downward load only [5]. Due to the uplift load applied to the surfaces of the panels, the reduction of the contact area between the panels and the metal members between the fasteners occurs which can result in rotation of the metal member between the fasteners or along its length and decrease in the rotational stiffness [5]. For this reason, the zero rotational stiffness is conservatively considered for the uplift load on the sandwich panels. According to [6], certain values of the rotational stiffness might be available when metal members of thin-walled cold-formed cross-sections are utilized. Due to lack of data regarding the torsional restraint provided to thin-walled members by sandwich panels under uplift load, experimental research in this field is necessary and the values of the rotational stiffness should be provided by testing. The standard [7] gives a simple test set-up for experimental verification of the torsional restraint provided to thin-walled beams by planar members. As it does not take into account the external load applied to the surfaces of the planar members, it is not suitable to investigate the effect of the uplift load on the torsional restraint. Moreover, it is assumed, due to the absence of external load, that the test set-up according to the standard [7] gives overestimated values of the rotational stiffness [6]. The document [6] provides a more complex test set-up with external load applied to the surfaces of the panels.

The paper presents results of two series of tests performed at the Testing Laboratory of the Institute of Metal and Timber Structures, Faculty of Civil Engineering, Brno University of Technology. The first series contains the tests according to the standard [7] (with no uplift load). The second series comprises tests of the torsional restraint provided to steel thin-walled purlins by sandwich panels under uplift load with the use of the principle of the test set-up according to [6]. The test results obtained using both approaches are compared and discussed.

Nomenclature

C_D	rotational stiffness
E	modulus of elasticity
F	point load applied at midspan of the flange of the purlin
F_T	force on lever arm causing the rotation of the purlin
K	total combined lateral spring stiffness
K_A	lateral spring stiffness corresponding to the rotational stiffness of the connection
K_B	lateral spring stiffness due to distortion of the cross-section of the purlin
K_C	lateral spring stiffness due to the flexural stiffness of the planar members
K_{adj}	adjusted value of the total lateral spring stiffness
K_{obs}	total lateral spring stiffness obtained from a test
R	lever arm
a	distance of a fastener and the web of the purlin
b	width of the flange of the purlin
h	depth of the purlin
h_δ	distance of the point of the lateral displacement measurement from the bottom flange of the purlin
l_A	width of a planar member adjacent to the purlin
l_B	length of the purlin
p	uniformly distributed areal load
t	thickness of the purlin
δ	measured displacement of the purlin
μ_R	ratio between actual and nominal thickness of the purlin
v	Poisson's ratio