Effective Shear Modulus of Perforated Steel Purlin Surrounded by Polyurethane

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Abstract:
Light-weight steel elements made of cold-formed perforated steel studs in interaction with polyurethane insulations have good thermal properties and provide an efficient construction method in modular construction. Researches on the interactions of cold-formed steel purlins and polyurethane insulations have been carried out in recent years for the purpose of developing building element products. This paper studies the effects of polyurethane insulations on the shear stiffness of perforated steel purlins in order to investigate the serviceability of perforated steel purlins.

Shear stiffness of perforated steel purlins is characterized by reduced shear modulus. In this study two test methods have been applied to measure the reduced shear modulus of perforated steel purlin without and with polyurethane insulations: longitudinal shear test and bending test of a short beam. Besides, the finite element (FE) model to simulate longitudinal tests using COMSOL software has been developed and validated for studying deflection and stress inside insulation and also effects of parameters, such as thickness of purlins, on the reduced shear modulus. Further, analytical equations for calculating the reduced shear modulus and shear strength have been proposed.

Test results have shown that the reduced shear modulus of perforated steel purlin is not improved when the interaction of polyurethane insulations is considered. However, the shear strength is improved greatly because the polyurethane insulations improve the flexural- and lateral-torsional buckling of perforated web in shear. Reduced shear modulus predicted by FE methods show good consistence with those from tests, while the shear strengths by FE methods are more dispersed compared with those from tests at this moment.

The proposed analytical equation for determining the reduced shear modulus in this study is valid for the profiles with similar sheet metal thicknesses and perforation geometry under short-term loading. Also the proposed analytical method can be used for determination of shear strength of the purlin surrounded by polyurethane insulations but the result is more approximate.