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Experimental investigations on combined resistance of corrugated sheets with strengthened cross-sections under bending and concentrated load

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Abstract

Multi-span corrugated sheets have lower resistance from single-span beams. This effect results from the combined bending moment and bearing load acting at the internal supports. It is a possibility to increase the resistance by means of local strengthening of critical cross-sections over the internal supports. The strengthening can be achieved by doubling of cross-sections (lap connection, applying an additional corrugated sheet). At present there is a lack of knowledge about the resistance of doubled cross-sections of corrugated sheets under concentrated load, bending moment or combined concentrated load and bending moment acting at the strengthened cross-section.

The results of experimental investigations on combined M–F relationship for corrugated sheets with doubled cross-section have been presented. For 35 tested models the following parameters have been changed: the length of strengthening a, span distance l, the way of a profile placement, the structure of strengthening, the number and placement of connectors. Obtained results have been compared with those received experimentally for unstrengthened models [Biegus A, Czepiżak D. Research on the interactive resistance of corrugated sheets under combined bending and contact pressure, Thin-Walled Struct 2006;44:825–831]. The conclusions leading to the optimal parameters of strengthening of corrugated sheets have been given.

Keywords: Web crippling; Multi-span sheeting; Strengthening; Experimental investigations

1. Introduction

The resistance of multi-span corrugated sheets is often lower than the resistance of single span systems since the designed cross-section results from the loading at the intermediate support. The effect is caused by the combined bending moment and concentrated load acting at the support. If the ultimate limit state condition is not satisfied at the intermediate support, the profile with higher thickness or depth is taken that leads to the additional steel consumption. This unbeneficial solution presents Fig. 1, where the bending moments envelope from external loads and the resistance of a cross-section are shown with the characteristic weakening over the central support area produced by the combined bending moment M and concentrated reaction load F.

Methods of the resistance increase of multi-span corrugated sheets resulting from the local strengthening of the critical intermediate bearing cross-sections have been introduced in [1]. The methods are based on:

- the change of a static scheme and local strengthening of intermediate bearings by lap connection of single span elements into multi-span systems (Fig. 2a),
- local strengthening of cross-sections over the bearing area of multi-span systems by the means of additional plate fixed from the bottom (Fig. 2b) or upper side (Fig. 2c). Thus the areas of intermediate supports have doubled cross-sections (Fig. 2, cross-section B-B) having higher resistance from the single middle span cross-sections.

Combined resistance of unstrengthened single cross-sections of corrugated sheets under bending and concentrated load have been analyzed by many researchers.

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Among the recent publication in this field of science you can read [2,3,6,11]. In the work the strengthened doubled cross-sections of corrugated sheets have been analyzed. Combined resistance of corrugated sheets with strengthened cross-sections is somewhat similar to combined resistance of cold-formed purlins strengthened by lap connection at intermediate support. An extensive tests and analyses of lapped connected purlins have been carried out by Ho i Chung [7–10]. In purlins combined bending and concentrated load is not present what is characteristic for corrugated sheets. Up to present the knowledge about strengthened corrugated sheets is poor recognized. The design rules concerning corrugated sheets with strengthened cross-sections are not given.

The work contains results of experimental investigations carried out on 35 corrugated sheets $T55 \times 188 \times 0.75$ having doubled cross-sections. The models present different: length of the strengthened zone a, beam span l, position of the corrugated sheet during tests, construction of strengthening with the number and connectors' position. The main purposes of the tests were: to find out the effect of the strengthening construction on the corrugated sheets' resistance, determination of the load-bearing capacity of the strengthened cross-sections under interactive loading by the bending moment and concentrated load, load–deflection relationship of the systems, recognizing of the way of load transmission at the area of doubled cross-section.

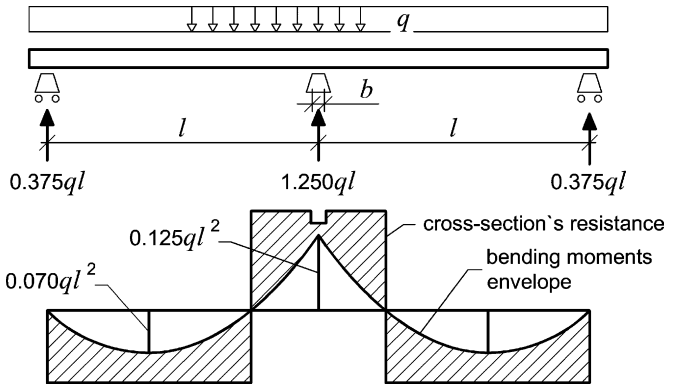

Fig. 1. Resistance envelope and moment diagram of double span corrugated sheet.

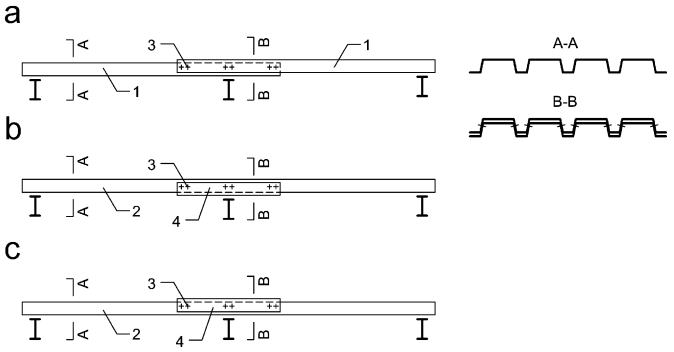

Fig. 2. Methods of resistance increase: 1—single span corrugated sheet, 2—double span corrugated sheet, 3—connectors, 4—strengthening element.

2. Methodology of tests of the interactive resistance *M–F* for strengthened corrugated sheets

The interactive load-bearing capacity *M–F* of the multi-span corrugated sheets' internal cross-sections (Fig. 3a) can be experimentally determined on simplified, single span models (Fig. 3b–e) [5]. The test span l of a substitutional model should be chosen to produce the appropriate ratio of support bending moment to shear force that represents this expected to occur in double span beams. The equivalent single span models (Fig. 3c–e) are loaded at the midspan by a concentrated load F to reproduce the way that the load would be applied in service. The behaviour of tested models have been forced by displacements in order to obtain the equilibrium curve beyond the peak load.

This manner of loading enabled to determine the real mode of failure (it does not occur rapidly as usually under loading in increments).

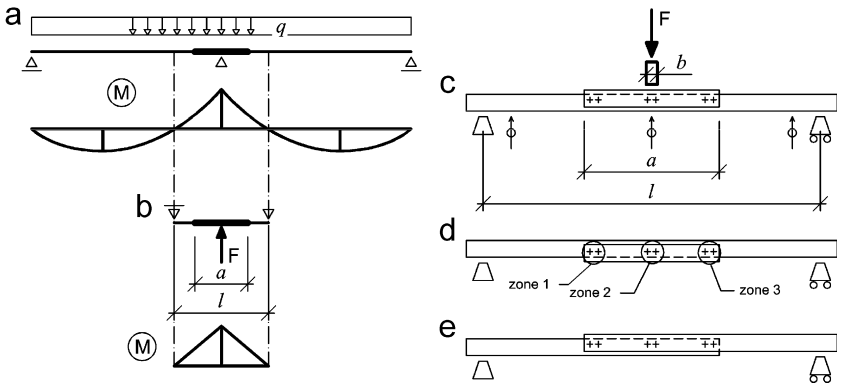

Fig. 3. Model schemes of the load–deflection test for critical cross-sections of the strengthened corrugated sheet.