Warranty of sufficient bearing capacity of headed studs used in trapezoidal steel sheetings

Origin:

Based on 17 own push-out tests, it could be shown that the current approach in DIN 18800-5 to determine the bearing capacity of headed studs in troughs (transverse to the supporting beam) possibly leads to insufficient results. DIN 18800-5 does not consider sufficiently the main factors as anchoring depth, sheeting geometry, stud position in the trough. Existing models in the literature determine the bearing capacity using these factors and considering the different failure modes of headed studs in a trough. The comparison of own push-out tests support the assumption that these models to determine the bearing capacity of headed studs provide better values regarding safety aspects and precision. However, some of these models are quite complex and hence not practicable. However, for a final assessment of these models as well as DIN 18800-5, the current number of 17 push-out tests is not enough.

Investigations:

For the statistical assessment of the current approach in DIN 18800-5 as well as existing models in the literature, a data base of 300 push-out tests was created which serves to evaluate DIN 18800-5 as well as to compare the test results with the existing approaches form the literature. For this purpose, the basics of the models in literature will be elaborated. Due to a strictly limited field of application of the approach in DIN 18800-5, the presented models should be assessed regarding the possibility to increase the field of application. Therefore, the models will be compared with all push-out tests in the data base as well as with push-out tests within their specific field of application. Furthermore, a numerical parameter study is planned using the FE program ABAQUS® to quantify the main factors of the bearing capacity of headed studs used in trapezoidal steel sheetings. The FE-Model will be verified through a comparison with the results of own push-out tests (load-deflection curves, bearing capacity) as well as with typical failure images as found in literature. The aim is to propose an alternative reduction factor to determine the bearing capacity of headed studs in the trough. Finally, the assessment of this proposal using the data base and the definition of practical design approach complete the investigations.

Results:

It could be demonstrated that the approach of DIN 18800-5 overestimates the bearing capacity of push-out tests with transverse trapezoidal sheetings as already assumed by the comparison of own push-out tests. The mean value of the quotient observed test bearing capacity P_e and predicted bearing capacity P_t was determined to 0.87 in the field of application of DIN 18800-5. The variation coefficient VarK was 0.23. The comparison of the different models revealed that the models had a better correlation test results and predicted bearing capacities regarding the mean value of the quotient P_e/P_t. The variation coefficients were similar to DIN 18800-5 in their respective field of applications. Interestingly, the models which determine the bearing capacity “directly”, considering the possible failure modes, were the models which displayed the highest variations. Furthermore, it became obvious that the models with the best correlations tend to a highly limited field of applications as well as the approach in DIN 18800-5. The numerical calculation of the own push-out tests using ABAQUS® showed good results for the tests with opened trapezoidal steel sheetings. Hence, simplified equations regarding the main influence factors could be defined using the results of a numerical parametrical study. These equations have a mean value of the quotient P_e/P_t of 1.00 and associated variation coefficient of 0.13, based on a reduced database of 100 tests, in their respective field of application. Without considering some outliers and by increasing the field of application (number of studs, undercutted sheetings, sheetings with holes), a design proposal could be defined with a mean value P_e/P_t of 1.01 and a variation coefficient of 0.14. Compared to the statistical values of headed studs in full concrete plate, this represents a good estimation.