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Future viability of cold-formed steel profiles in construction | AiF No.: 19964N

Summary of the research project AiF No.: 19964N

Cold-formed steel profiles are used in a wide range of applications, from industrial steel construction and shelving construction to special applications such as viticulture. The variety of possible applications requires an equally large number of individual profile shapes with various cross-sectional stiffeners such as beads, flanges or lips. Depending on the area of application, the profiles are also continuously perforated.

However, the great advantage of the individual, project-specific cross-sectional design is offset by great difficulties in dimensioning for use in construction. In Europe, EN 1993-1-3 is a design standard for thin-walled, cold-formed profiles. However, it was mainly developed for C- and Z-shaped cross sections. Its applicability to individual cross-sections is limited. In the case of perforations, dimensioning according to EN 1993-1-3 is usually completely impossible. In addition, designing even simple profile types is complicated, time-consuming, error-prone and produces conservative results due to the complex stability behavior. The complexity of this design method is essentially based on the effective cross-section method, which is used to determine the cross-sectional load-bearing capacity due to the stability phenomena of plate buckling and shape instability. For this reason, manufacturers of cold-formed profiles, which are usually SMEs, resort to complex component testing or obtain building authority approvals when developing profiles. Current standardization thus prevents simple and cost-effective further development and optimization of cold-formed steel profiles.

At this point, the research project „Future Viability of Cold-Formed Steel Profiles in Construction“ by the Research Association for Steel Application e.V. (FOSTA, P1328) was initiated. Its goal was to develop a new Eurocode-compliant design method for thin-walled, cold-formed steel profiles.

The basic idea of this new design concept was to transfer the Direct Strength Method (DSM), a design method that is part of the American standard AISI, into the concept of EN 1993-1-3.

The great advantage offered by DSM is the determination of the cross-sectional load-bearing capacity at the gross cross-section. The critical stability loads required for this

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purpose are determined using user-friendly and freely available finite strip programs. The determination of effective cross-sections, as required in EN 1993-1-3, is completely eliminated. Therefore, a new, combined design method was implemented with transfer of the cross-sectional load-bearing capacity determined according to DSM into the verification concept of the overall stability of EN 1993 1-3.

The DSM and EN 1993-1-3 differ significantly in the design process and in the consideration of the interaction of local and global stability phenomena. By calculating effective cross-sections and the resulting shift of the center of gravity from the gross to the effective cross-section, EN 1993-1-3 takes into account the non-linear stress distribution and the shift of the stress resultant due to plate buckling and form instability. This effect is not taken into account in the DSM, whose concept is based exclusively on the gross cross-section.

In order to verify the applicability of the new, combined design method and to make necessary adjustments, component tests were carried out on various C-, Z- and Ω-shaped cross-sections as part of the research project, some with perforations under compression, bending around the major axis and under combined compressive and bending stress.

In addition, numerical models of the FE software ANSYS were calibrated for the tests, which could then be used for parameter studies. This meant a large data set of ultimate loads for thin-walled steel cross-sections was available for verifying the combined design approach.

Both the experimental and numerical investigations showed that adjustments to the combined design method were necessary. A new reduction factor was introduced to take into account the effects of shifting of the stress resultant due to plate buckling and shape instability for short and medium-length components.

In summary, the new, combined design method represents an efficient and safe design method for thin-walled, cold-formed steel profiles.

The process is user-friendly, less error-prone and time-saving. It therefore represents a good alternative to the current concept of EN 1993-1-3. Integration into the European standard concept is being sought.

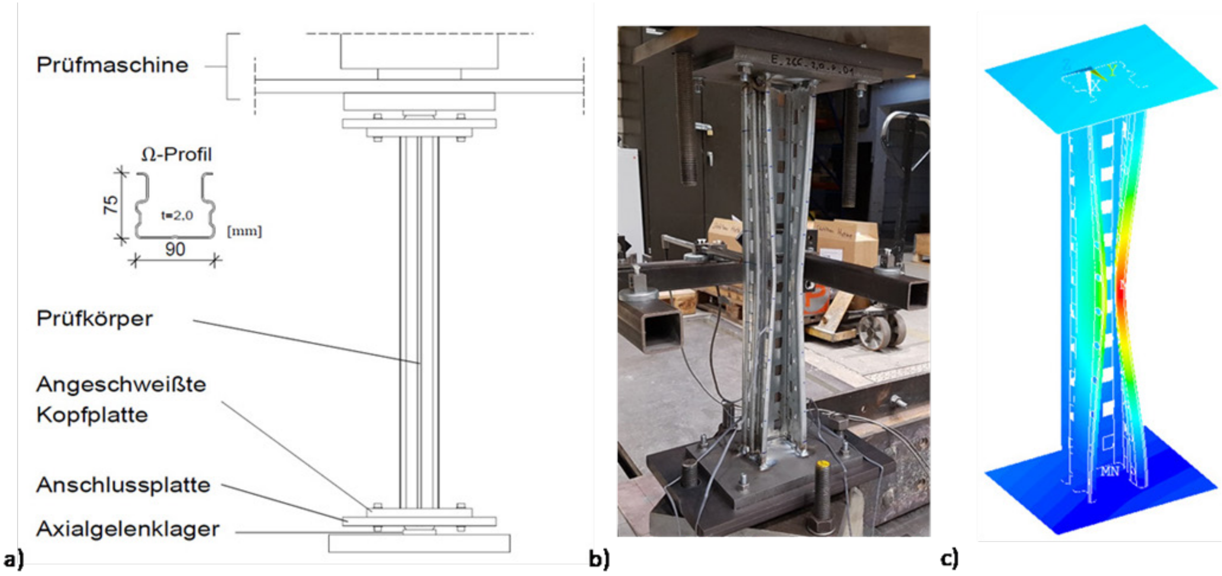

Image 1: Investigation of Ω-profiles under compressive loading to verify the combined design method a) Test setup b) Test specimen after unloading
c) Failure figure of the numerical simulation

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