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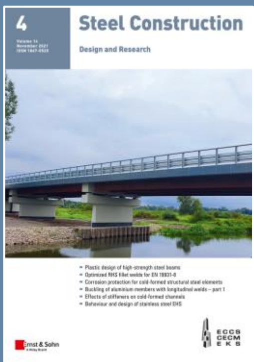

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Topics

Bureau, Alain; Snijder, Bert; Knobloch, Markus; Kuhlmann, Ulrike; Gardner, Leroy; Taras, Andreas; Da Silva, Luis
Design rules for member buckling

In the framework of the revision of Eurocode 3 Part 1-1, several amendments have been proposed and accepted in order to improve the rules for the resistance to member buckling. For clarification, a flow-chart connecting the global analysis (1st or 2nd order), the imperfections and the type of verification has been implemented for ease of use. Since the publication of the standard in 2005, many research projects have been carried out across Europe on this topic and their results have contributed to provide appropriate answers to problems identified in practice. Therefore, the revised code provides new design rules for stability. Important works of calibration have been performed in these different projects to derive appropriate values of the partial factor on the resistance side.

For example, a new formulation for lateral torsional buckling has been introduced for the calculation of the reduction factor. The consequence is a reduction of the discrepancy between the results obtained by these new methods and those from experimental or numerical tests. In order to extend the scope of Eurocode 3 Part 1-1, additional methods have been implemented in an annex to cover the stability of members with mono-symmetric cross-section under compression axial force, biaxial bending, with or without torsion. The format of the resistance criteria remains similar to the format of the current interaction formulae so that the designers can easily identify the evolution of the rules. This paper presents in a systematic way the new implementations in prEN 1993-1-1.

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Topics

Stroetmann, Richard; Fominow, Sergei
Imperfections for the LTB-design of members with I-sections

For the stability assessment of members and structures according to EN 1993-1-1 the equivalent member method, the geometrical nonlinear calculation with equivalent geometrical imperfections or the GMNIA analysis with geometrical imperfections and residual stresses can be used alternatively. The second possibility requires a corresponding model for the cross-section resistance. For the verification of lateral torsional buckling, bow imperfections e0 out of plane are defined, which lead in combination with the given loading in plane and the geometrical non-linear analysis to bending Mz and torsion of the members. The amplitudes of the imperfections are highly dependent on the nature of the approach (e.g., scaling of the buckling shape, assumption of bow imperfections) and the resistance model for the members. Within the framework of the scientific work supervised by the TU Dresden and the TU Darmstadt, extensive parameter studies were carried out to calibrate imperfections for lateral torsional buckling based on the GMNIA. After determining the nature of imperfections and the design models for section resistance, this paper presents results of these parameter studies and shows the calibration of imperfections for a standardisation proposal based on EN1993-1-1. The evaluation of the data in combination with the necessary simplifications for the design practice leads to appropriate definitions of imperfection values e0, LT and the necessary differentiations.

Pourostad, Vahid; Kuhlmann, Ulrike
Buckling resistance of longitudinally stiffened panels with closed stiffeners under direct longitudinal stresses

The buckling behaviour of panels may be determined according to EN 1993-1-5. Most of the design rules relating to stiffened panels in EN 1993-1-5 were derived on the basis of open-section stiffeners. Several recent investigations have shown that the application of the design rules according to EN 1993-1-5 taking into account the torsional stiffness of the stiffeners may overestimate the resistance of the panels. Therefore, the recent Amendment A2 to EN 1993-1-5 states that the torsional stiffness of stiffeners should generally be neglected in determining critical plate buckling stresses. In addition, prEN 1993-1-5 provides rules for considering the torsional stiffness of stiffeners. However, in this paper it will be shown that even the rules of prEN 1993-1-5 are not reliable as far as torsional stiffness is concerned. The paper focuses on the investigation of the buckling behaviour of stiffened panels with closed section stiffeners sub-jected to constant longitudinal compression stresses and shows improved rules to consider the torsional stiffness of the stiffeners. For this purpose, a new interpolation equation between col-umn-like and plate-like behaviour is proposed, based on an extensive numerical parametric study. The proposal provides a safe and economic solution, as it considers the torsional stiffness of stiffeners when applying the rules of prEN1993-1-5.

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Müller, Andreas; Taras, Andreas

Contribution to lateral torsional buckling of girders with rotational restraints

The instability case of lateral torsional buckling (LTB) under bending load My is known to be of decisive importance in the design of beams with open cross-sections. This instability case is expressed by a lateral displacement and simultaneous torsion (or twisting) of the member axis. The restraint of one or both of these deformation components represents an effective and practice oriented method to stabilize beams against LTB. In practice, therefore, use is made of regulations from the current version of EN 1993-1-1:2010, Annex BB, which allow for the consideration of the stabilizing effect of continuous and planar components directly connected to the compression chords of the beams. This paper presents the results of a study that investigated the effects of the innovations introduced in the draft standard for the 2nd generation of EN 1993-1-1 for the LTB verification of beams with I and H cross-sections on the regulations for the calculation of the minimum stiffness of a rotational restraint to avoid LTB. In the first part of the paper, the background of the existing and new regulations is discussed together with previous proposals for adapting the definition of the minimum rotation bedding. In addition, a comparison is made with current specifications for the minimum rotational stiffness contained in the National Annex of DIN EN 1993-1-1. Subsequently, the regulations of the minimum rotational stiffness in prEN1993-1-1, Annex D are assessed.

Da Silva, Luís Simões; Tankova, Trayana; Rodrigues, Filipe

Design buckling resistance of high strength steel members

EN 1993-1-1 gives stability design rules for columns, beams and beam-columns up to S460, whereas EN 1993-1-12 gives additional guidance for S500 up to S700 (based mainly on numerical work available at the time). Recent studies on flexural buckling of welded H, I and box columns in steel grades S460 to S960, even though limited, show that improved curves can be used for members in high strength steel (HSS). The research project RUOSTE also reported improved buckling curves for HSS box and tubular sections compared to those in Table 6.2 of EN 1993-1-1. This improved behaviour is usually attributed due to the improved material properties but mainly due to the more favourable residual stress distribution. Recently, within the European Project STROBE evaluation of the European stability design rules was carried out covering columns, beams, and beam-columns. The research was based on experimental programme covering 20 full-scale tests, residual stress measurements, advanced numerical models, analytical derivations, and statistical evaluation. Finally, it was possible to provide new, more relaxed recommendations for the buckling curve selection for HSS members. This paper provides a summary of the project conclusions regarding the stability design of steel members in high strength steel, where firstly a brief overview of the experimental results is presented, followed by the numerical parametric study, results evaluation, and discussion

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Topics

Schaper, Lukas; Tankova, Trayana; Knobloch, Markus; Da Silva, Luís Simões

A novel residual stress model for welded I-sections and the influence on the stability behaviour

Residual stresses have a marked influence on the stability behavior of steel members. Previous studies have shown that the structural behavior depends on both the distribution and the size of residual stresses. The residual stress distribution is affected by the cross-section geometry, the steel grade and the manufacturing process, e.g. flame cutting and the welding procedure. A realistic consideration of residual stresses is necessary for economic models for design purposes and a safe design of steel structures.

This paper presents an experimental and numerical study on the influence of residual stresses on the stability behavior of structural members, i.e. steel columns and beams. A novel residual stress model for welded I-shaped sections was developed and evaluated using test data. This model takes into account the main influencing parameters, i.e. the cross-sections geometry, the steel grade as well as manufacturing process with thermal cuts or non-thermal cuts of the steel plates. The novel residual stress model is then used to investigate the structural stability behavior in terms of a numerical simulation study. The result of the study allows to propose an improvement of the buckling curve selection for welded high strength steel columns and beams.

Unterweger, Harald; Kettler, Markus; Zauchner, Paul

Calibrated design model for the compression capacity of angle members with welded joints including accurate joint stiffness

Due to the commonly eccentric connection on only one angle leg (bolted or welded), additional bending moments are acting on the member, leading to a complex load carrying behavior with flexural and/or lateral torsional buckling phenomena. Furthermore, type and size of rotational restraints at the member's ends (provided by the adjacent structure) significantly influence the compression member capacity of these members.

Within this paper, a recently developed design model for angle members in compression is introduced. The presented method allows for calculating the internal forces based on elastic second order theory for an individual member with eccentricities and rotational spring stiffness at both ends. This calculation can be carried out by means of conventional structural analysis software. Detailed analytical equations for the estimation of appropriate spring stiffness values for several practical applications in buildings with two-bolt connections have recently been presented by the authors. This relationship is now enhanced by means of additional formulae for angle members welded to the adjacent structure. Detailed background information on the derivation of these newly developed spring stiffness formulae is given. Finally, the accuracy of the design model for this enlarged range of application for welded angle members is shown through comparison with sophisticated finite element calculations, code provisions and experimental tests from literature.

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