German Committee for Steel Construction Reports from Steel

DASt

FOSTA Forschungsvereinigung Stahlanwendung e. V.

Issue 2020/3

Lateral-torsional buckling as compression flange buckling - consistent verification for welded girders in cold and hot state AiF No.: 19439N

Summary of the research project AiF No.: 19439N

Compression flange buckling represents a clear and easily applicable model for lateral-torsional buckling in engineering practice (see Figure 1). EN 1993-1-1, paragraph 6.3.2.4 uses this simplified model for the design of bending girders in building construction. For bridge construction, EN 1993-2 adapts the verification with a conservative assumption for the plateau length „λ“ ¤_“c0“ and the adjustment factor kfl. A simplified fire resistance design of girders at risk of flexural-torsional buckling appears to be fundamentally possible, taking adequate account of temperature-dependent material properties. However, EN 1993-1-2 does not currently explicitly provide for such a simplified verification. In recent years, there have been some further developments of the "normal" lateral-torsional buckling analysis at normal temperature and in case of fire. Last but not least, in order to achieve a comparable level of safety and cost-effectiveness, even for the simple verification, it is worthwhile to take a closer look at the verification as a buckling compression belt. In addition, there are other decisive arguments in favor of further developing this detection method: On the one hand, the ease of use is impressive. In practice, this is a familiar intuitive form of proof. Depending on the maximum support distance of the compression flange Lc no further proof is required. In addition, the maximum distance allows for sensible construction and avoids the risk of flexural torsional buckling. On the other hand, there are a number of application cases for which the solution of the "complete lateral-torsional buckling problem" is very complex and time-consuming. In many cases, these are the cases of slender, simply symmetrical welded cross-sections, which are not adequately covered by the new developments of the usual lateral-torsional buckling analysis, which are more focused on rolled girders. The research project, carried out jointly by the Chair of Steel, Lightweight and Composite Construction at the Ruhr University Bochum and the Institute of Engineering and Design at the University of Stuttgart, examined the influence of residual stresses on the load-bearing capacity of welded steel girders at risk of instability. The relationships of girder height, flange width and flange thickness typical for bridge construction were the main topics of investigation. The experimental investigations within the research project can

Editor: German Committee for Steel Construction DASt e.V. | Managing Director: Gregor Machura
Sohnstraße 65, D-40237 Düsseldorf | Tel. (0211) 54012-094 or (0211) 54012-080
For further inquiries, please contact: forschungsmanagement@dast.deutscherstahlbau.de

be divided as follows: In the first part, residual stresses were determined on 15 different welded test specimens of steel grades S355J2 and S460M at the Ruhr University Bochum. For this purpose, both the innovative and non-destructive method of X-ray measurement and the proven disassembly method using water jet cutting were used. The second part dealt with lateral-torsional buckling tests carried out at the University of Stuttgart. The same test specimens were used for which the corresponding residual stress measurements from Bochum are available. These investigations were carried out as three-point bending tests with ideal fork bearings at the girder ends. The theoretical part of the research project deepened the findings of the experiments using numerical simulation. In particular, the load-bearing capacity-reducing influence of the residual stress approaches available in the literature was compared with the measured residual stress curves on lateral-torsional buckling. Using the FE model validated in the tests, simulations were carried out for different loading types, slenderness and other parameters that were not covered by the experimental test program. The compression flange buckling model was systematically investigated. In the first step, the derivation and implementation in different generations of standards were examined, applicability to the next version of EN1993-1-1 was checked, and deficiencies were identified. The compression flange buckling model was further developed to better represent the load-bearing behavior by taking into account the cross-sectional geometry and load application points. Furthermore, the model was consistently developed for a fire design. Based on the parameter study, the further developed compression flange buckling model was statistically evaluated for both normal temperature and fire conditions. The further developed model was prepared in a practical manner and as a standard proposal. The application was explained using practical examples. The further developed compression flange buckling model is a consistent verification method of the lateral-torsional buckling resistance for both building and bridge construction at normal temperature and in the event of fire. The simple compression flange buckling format was maintained and, by taking into account the torsional stiffness and the load application point, produces conservative and at the same time cost-efficient results. This provides engineering practice with an easy-to-use and intuitive design method for structural design.

The research project was financially supported by the German Federation of Industrial Research Associations „Otto von Guericke“ e. V. (AiF), Cologne, within the framework of the Program for the Promotion of Collective Industrial Research (ICR) with funds from the Federal Ministry for Economic Affairs and Energy based on a resolution of the German Bundestag. The German Committee for Steel Construction (DASt) provided technical support for the work. We would like to take this opportunity to thank our sponsors for their support. Special thanks go to the project partners Astron Buildings S.A. and Goldbeck Bauelemente Bielefeld GmbH for the free supply of the steel material and the production of the test specimens as well as schlaich bergermann und partner (sbp GmbH), KREBS+KIEFER Ingenieure GmbH and Ian Palmer (Chairman of WG13) for their technical advice. We would also like to thank the staff of the Materials Testing Institute in Stuttgart and the Design Testing Department of the Ruhr University of Bochum and Prof. Dr. Müller from the Bochum University of Applied Sciences.

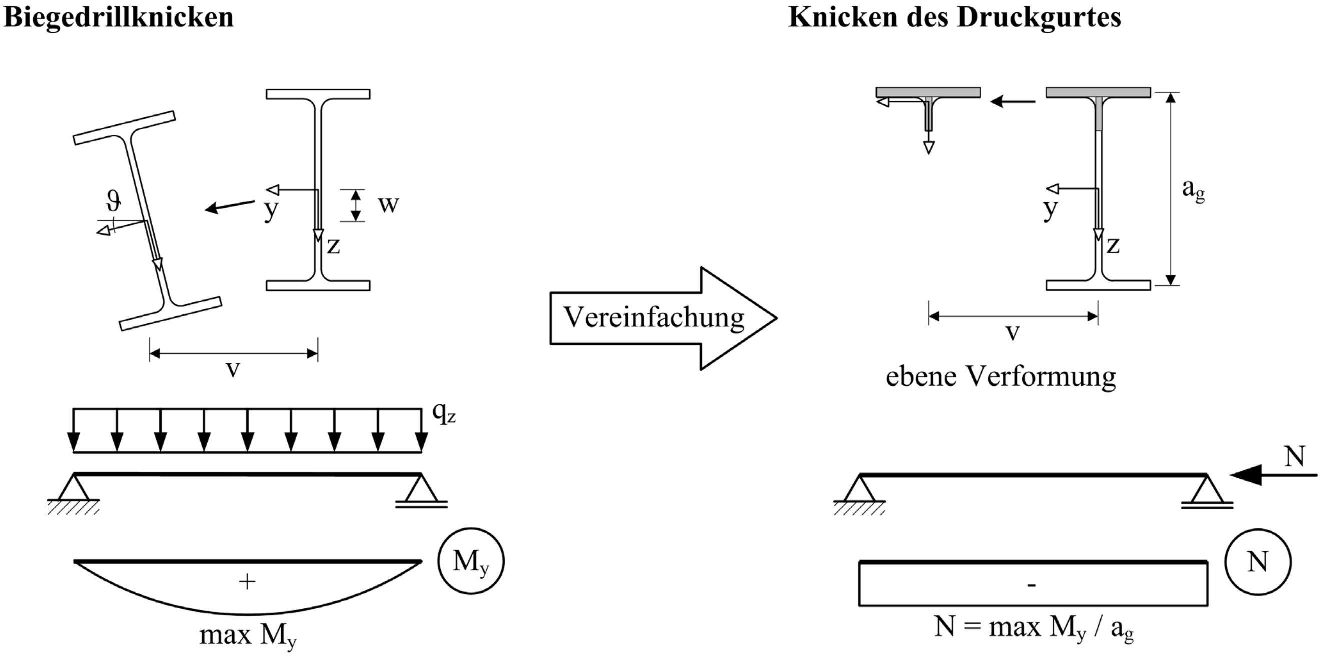

Image 1: Compression flange buckling model as proof against lateral-torsional buckling.

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages