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Longitudinally stiffened buckling fields under multiaxial stress AiF No.: 20455N

Summary of the research project AiF No.: 20455N

As part of the research project, six large-scale tests on longitudinally stiffened sheets were carried out at the Technical University of Munich, see Image 1. Numerical finite element models were validated based on the test results. With these, extensive parameter studies on the buckling behavior of the buckling fields under multiaxial loading for the reduced stress method were carried out at the University of Stuttgart, see Image 2. Based on the numerical investigations on unstiffened buckling fields, an interpolation equation between platelike and buckling-bar-like behavior was proposed. The new proposal provides very good agreement with the numerical results, especially for single spans subjected to transverse stresses. According to DIN EN 1993-1-5, the torsional stiffness must be neglected in the buckling analysis. In order to be able to take torsional stiffness into account in the future, stiffened buckling fields with closed longitudinal stiffeners under pure constant longitudinal stress were investigated in this work. It was found that neglecting the torsional stiffness of the stiffeners leads to conservative results. However, if the torsional stiffness is taken into account, the interpolation equation between plate-like and buckling-bar-like behavior according to DIN EN 1993-1-5 leads to results that are on the uncertain side. Therefore, a new interpolation equation was proposed. It was shown that the torsional stiffness of the closed longitudinal stiffeners can be taken into account using the reduction curve according to Section 12.4 (5) prEN 1993-1-5 or DINEN 1993-1-5 Annex B. Buckling fields under pure constant transverse pressure were investigated. The focus of the investigation was on the buckling-bar-like behavior of the entire field in the transverse direction. It was found that the numerical results correspond to the kink curve. For this reason, it is recommended that no interpolation between plate-like and buckling-bar-like behavior is performed in the z-direction during the total field analysis.

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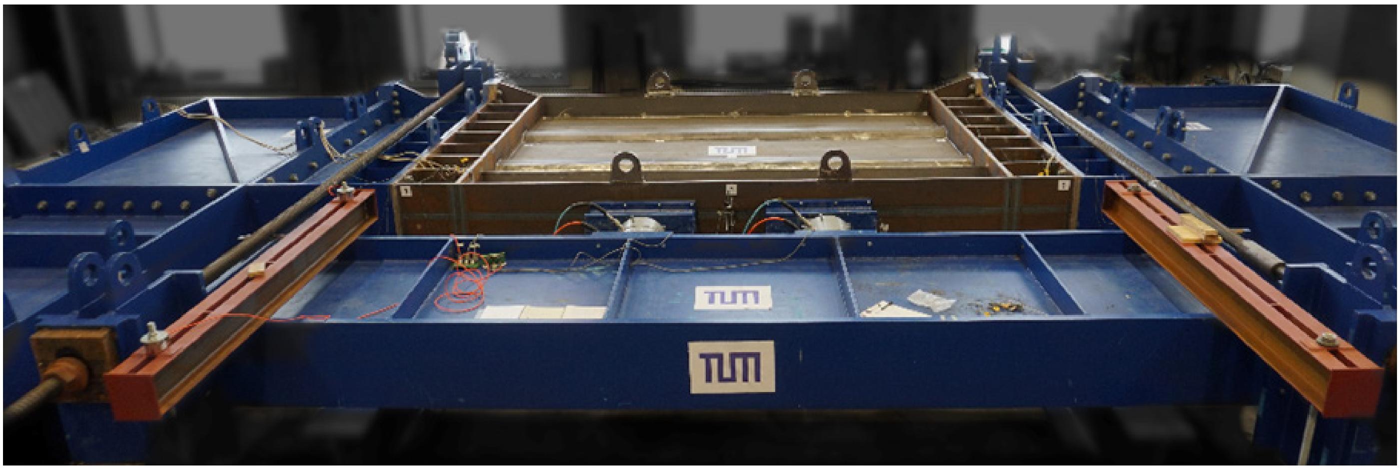

Image 1: Test bench.

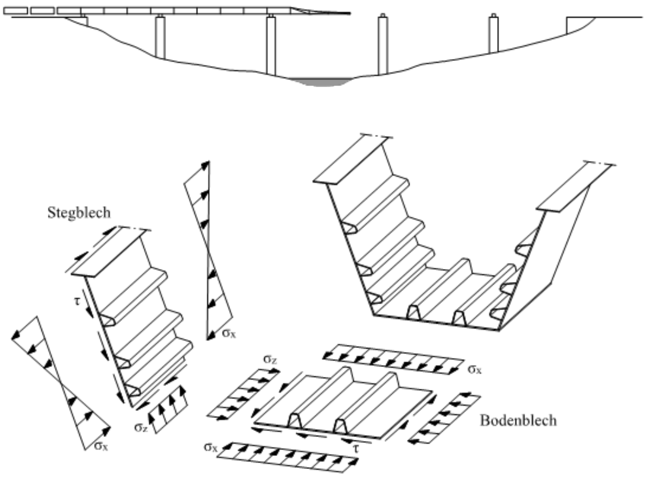

Image 2: Incremental launching method and schematic representation of the stress states in web plates and base plates.

Furthermore, it was demonstrated that an additional verification of the longitudinal stiffeners according to theory II. Order taking into account the output forces is not required. Furthermore, buckling fields were investigated under simultaneously constant longitudinal and transverse stresses. It was shown that the interpolation equation according to prEN 1993-1-5 overestimates the load-bearing capacity of squat buckling fields under simultaneous longitudinal and transverse loads. In addition to the new interpolation equation, it is therefore proposed that each stress component for individual and total fields under biaxial compressive loading must be verified individually so that the stresses from the individual actions do not exceed the limit stresses. Buckling fields under pure bending and one-sided transverse loading, such as those that occur when bridges are pushed into place, were also investigated. It was found that the asymmetric loading in the transverse direction causes additional longitudinal stresses. These additional stresses from asymmetric loa-

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ding must be taken into account in the design equation to ensure that the results are on the safe side. To take into account the influence of asymmetric stress, it is proposed to increase the slenderness ratio by a factor of 1.3 for the total span analysis. The proof of longitudinal stiffness according to second-order theory is not required when applying this proposal. The numerical investigations with eccentric load introduction of the transverse load show that for displacement with spherical bearings or bearings with the same degrees of freedom in the buckling analysis according to the current regulation according to DIN EN 1993-1-5, eccentricities of up to ± 20 mm can be tolerated if the rotation point is simultaneously not further than 310 mm away from the flange base plate (z-direction). An additional stiffness proof according to second-order theory is not necessary. For larger eccentricities up to ± 30 mm, individual results exceed the permissible stresses if the rotation point is simultaneously further than 200 mm away from the flange base plate (z-direction). For eccentricities of this size, the rotational stiffness of the flange or base plate must be verified, or the distance between the rotation point of the spherical bearing and the flange or base plate must be selected to be correspondingly small. Failure of the flange or base plate must then be checked and ruled out separately. The proposal of the new interpolation formula with simultaneous increase of the global slenderness λ ¤_p leads to reliable results. When moving with rockers, eccentricities can generally be neglected using the buckling analysis according to DIN EN 1993-1-5. The evaluation was carried out for eccentricities up to ± 30 mm. The prerequisite is that no failure of the flange or base plate occurs. The results show that small modifications to the existing rules, such as new interpolation functions between plate-like and buckling-bar-like behavior and the choice of the buckling curve, not only allow for safe but, above all, more cost-efficient verifications by taking the torsional stiffness of the longitudinal stiffeners into account. In particular, the proposed verification method eliminates the need for a separate verification of the longitudinal stiffeners according to second-order theory , whilst also taking into account the downforces from transverse loads, which is very complex. Helpful recommendations are also given for the verification of the load eccentricity of the transverse loads during insertion.

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