Load-bearing reserves of existing bridges

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Summary

In the same way as the Technical Bending Theory (*TB*) for linear-elastic materials, the Extended Technical Bending Theory (*ETB*) makes it possible to calculate the state of strain of reinforced and pre-stressed concrete cross-sections stressed by any combination of the stress resultants M_y, M_z, T, V_z, V_y and N. When using the *ETB*, no additional models are required to determine the shear-bearing capacity of these cross-sections. Furthermore, the theory describes the serviceability limit state (*SLS*) as well as the ultimate limit state (*ULS*).

In the first part of the paper, the differences between the *ETB* and the classical calculations based on the *TB* and empirical truss models will be explained. Additionally, comparisons of test results and calculations with the *ETB* will point out convincing correspondence in *SLS* as well as in *ULS*.

In some specific cases, the more realistic results obtained using the *ETB* identify additional load bearing reserves in existing bridges. Because of this, the *ETB* sometimes makes it possible to verify the structural integrity of existing bridges even when the classical dimensioning concept has failed. As the maintenance and repair of bridges becomes more and more important, the *ETB* can help to keep bridges in service. In the second part of the paper, some current examples for the application of the *ETB* will be presented. The theory has made it possible to save several bridges without the need for expensive repair and alteration work.

Keywords: extended technical bending theory; cross-section dimensioning; shear-bearing capacity; load-bearing reserves; maintenance of bridges; concrete bridges.

1. Introduction

For the calculation of concrete bridges according to [1], the linear elastic analysis of the stress resultants is decoupled from the subsequent verifications of the cross-sections in *ULS* and *SLS*. A plastic or non-linear analysis is not yet allowed in bridge design. The advantage of this decoupling is that it makes it possible to superpose the stress resultants of the numerous load cases.

For verifications of the cross-sections, there are normally two main combinations of stress resultants which have to be analysed: bending moments and/or normal force (M+N) and shear forces and/or torsional moment (V+T). This differentiation is shown in Fig. 1. The reasons for these separate verifications are the non-linear material behaviour of reinforced concrete and the restricted capabilities of the theories on which these verifications are based. For linear elastic materials, the assumption of a plane state of the longitudinal strains (Bernoulli Hypothesis, *TB*) delivers the distribution of the longitudinal stresses inside the cross-section. By using equilibrium conditions, it is then possible to determine the corresponding distribution of the shear stresses. Because the principle of superposition is allowed for linear elastic materials, it is possible to subsequently determine the resulting state of stress and state of strain. But for non-linear materials like reinforced concrete, superposition of these separate results is not allowed. This is why the *TB* can only deliver the corresponding state of stress and state of strain for the combination M+N.

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