Abstract

Assessing the strength of existing reinforced concrete members has become a relevant task for structural engineers. This is justified by the relatively large number of existing works where the design loads have been increased due to updated actual loads or code requirements or by modifications of the original structure such as enlargements. Several codes of practice are based for design of such structures on consistent approaches such as the stress field or the strut-and-tie method. Such design approaches are simple enough to be used for design purposes, but may have in-built safe assumptions to cover a wide number of cases. The actual strength of a structure may thus be underestimated by using simplified design approaches. However, these consistent theories, and particularly the stress field method can be refined and adapted to a particular case in order to provide a more realistic estimate of its strength and to avoid unnecessary retrofitting.

In this research project, refined strategies for shear design and assessment of reinforced and prestressed concrete members based on stress fields are investigated. The research particularly focuses on the analysis of existing structures using elastic-plastic stress fields.

The actual shear behavior of existing girders and the limits of applicability of the stress field methods have been studied on the basis of a testing campaign on twelve post-tensioned, reinforced concrete girders. The test specimens represent the situation of continuous prestressed girders with low amounts of shear reinforcement, which is the usual case in existing structures. All specimens have been modeled and analyzed by elastic-plastic stress fields. The test series allows describing and quantifying the different shear-carrying actions, the influence of girder flanges and the increase in prestressing force of inclined tendons. Furthermore, several codes of practice have been validated on the basis of the test results and their applicability on girders with low amounts of shear reinforcement is verified.

The stress field approaches used currently for design show rather coarse model simplifications (rigid-plastic stress fields) or need a substantial effort for modeling and computation (elastic-plastic stress fields solved by means of the finite element method). In this research work, a new approach for shear design is presented. The method also assumes elastic-plastic material behavior and shows fewer model simplifications than the rigid-plastic stress field methods. Compared to the existing elastic-plastic stress field approach based on finite elements, the modeling effort and the computing time of the method are clearly reduced. In addition, the method accounts for the increase in prestressing force of inclined tendons and for the flange influence by means of separate analytical approaches. The presented method is validated using 57 specimens of different test series. A comparison of the analysis results and the test results show an excellent accuracy of the presented approach.

Keywords: reinforced concrete, prestressed concrete, structural design, shear force, girder, stress field, post-tensioning, shear reinforcement, girder flange, shear test, existing structure.