Investigation of concrete structures in Serviceability limit state using energy principles

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Summary

In this paper, a method concerning analysis of reinforced concrete structures in the serviceability limit state (SLS) is discussed. The method is based on elastic energy principles, combined with simple assumptions with respect to concrete mechanics.

This approach allows for a direct implementation of the choices, made in relation to the design of the structure with respect to the ultimate limit state (ULS). Hence, a rational link between the two states is established.

The approach is appropriate for the design of new structures and assessment of existing structures.

The method and the link between the choices made regarding the ULS and the state of stress in the SLS is compared with tests on reinforced concrete disks and beams, respectively. Fairly good agreement between theory and tests is achieved.

Keywords: Reinforced Concrete, Serviceability Limit State, Elastic Energy, Continuous Beams, Disks

Comparison with tests

a) Tests with continuous beams

The procedure outlined has been compared with tests on nineteen two-span continuous reinforced concrete beams of two different load configurations, see Fig. 1. The only variation between the test-specimens was the ratio (A_{st}/A_{sb}) between the top-reinforcement A_{st} in the hogging region and the bottom-reinforcement in the sagging region, A_{sb}.

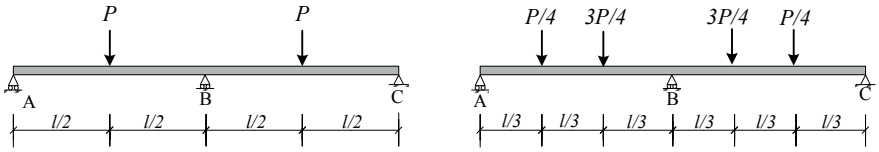

Fig. 1: Test setup according to [2] and [3].

$P_{y,calc}$ at which reinforcement yielding is initiated has been estimated and compared with the experimental observed load-level $P_{y,test}$. The result is displayed in Fig. 2.

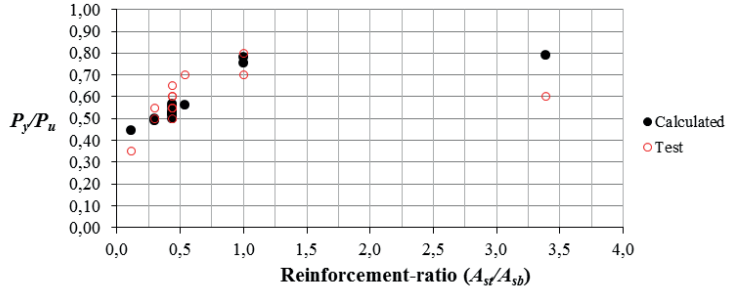

Fig. 2: Yield-load vs. reinforcement-ratio. Left load-configuration in Fig. 1.

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In Fig. 3 the comparison between test and theory in the case of the right load-configuration (Fig. 1, right) is displayed. In the case, the ratio *i* between the support moment and the moment at the section underneath the outermost point-load has been compared.

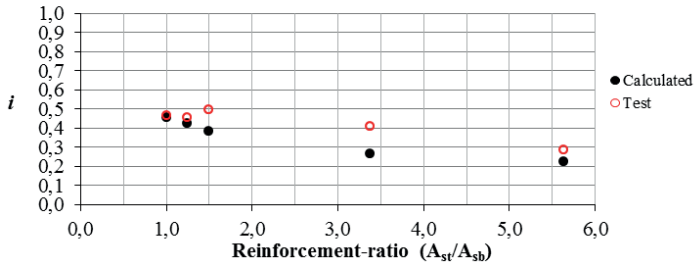

Fig. 3: Bending moment distribution, vs. reinforcement-ratio. Right load-configuration in Fig. 1.

b) Test with homogenously reinforced concrete disks

The procedure has also been compared with a total of ten tests on homogenously reinforced concrete disks subjected to pure shear [4].

Fig. 4 displays the ratio between the load at first yielding and the ultimate load of the disks.

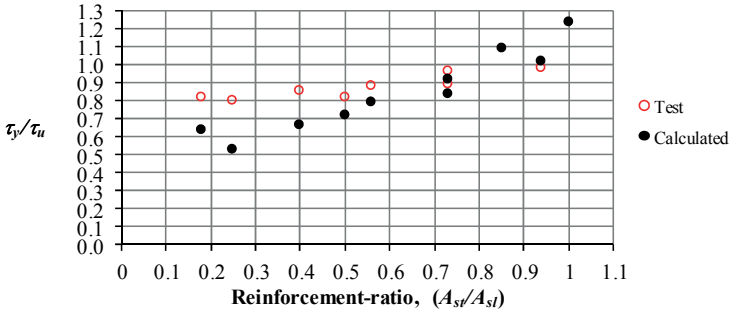

Fig. 4: Yield-load vs. reinforcement-ratio

The method has also been used to estimate the orientation of the inclined concrete strut. Also in this case fairly accurate determination is achieved.

References

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