Influence of spatial variability on the shear capacity of RC members without shear reinforcement

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Summary

The experimental program presented in this paper deals with the influence of the spatial variation of the concrete strength in width direction on the shear capacity of one way slabs. Two test series are designed, in which the spatial variation of the concrete strength is exaggerated. The influence of the concrete strength variation on the inclined cracking load, failure mode, crack development and other aspects of one way slabs is examined in the tests.

Keywords: shear capacity, concrete slab, weak spot, inclined cracking load

1. Introduction

The shear capacity of concrete structures without shear reinforcement is often considered to be critical for the structure. In most cases shear failure is brittle, and the scatter of the shear capacity observed in experiments is large. Therefore the evaluation procedure regarding the bearing capacity given by the codes assumes that the weakest spot, defined by the characteristic lower bound of the strength, also determines the shear capacity of the structure. For the design of a new structure this principle works out well, since the scatter of the concrete strength of newly casted concrete members is normally low. On the other hand, the concrete strength of existing structures, which is determined by testing cores drilled from the structure, often shows a rather large scatter, indicating a large spatial variability of the concrete strength within the structure. In such a case the aforementioned design principle will result in a low prediction of the bearing capacity of the existing structure. However, it can be argued that the bearing capacity of a sufficient wide structure, such as a solid slab bridge deck, is higher than the load at which the concrete in the weakest spot fails, because of redistribution of stresses. Therefore, even in case of shear failure a higher overall capacity can be expected than given by the statistically weakest part of the slab.

A series of experiments on solid slabs without shear reinforcement has been carried out in the Stevin Laboratory at Delft University of Technology to investigate the influence of the concrete strength variation on the shear capacity of the slabs. The test program and several conclusions derived from the results are presented in this paper.

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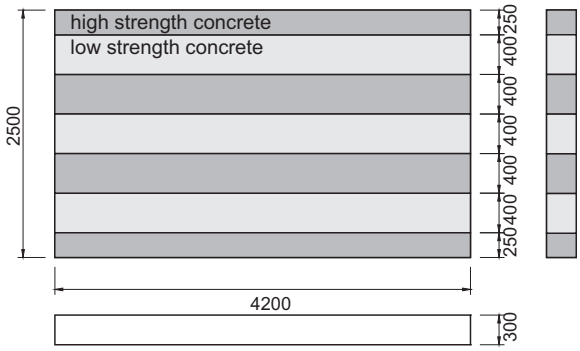

Fig. 1: Dimensions and layout of test specimens

2. Test Specimens

The dimensions and the arrangement of the concrete strips for the chosen layout are shown in Fig. 1. The slabs are 4,2 m long, 2,5 m wide and 0,3 m thick. They are composed of seven strips with of alternating strength. That makes the volume ratio between high strength concrete and low strength the ratio between approximately 50%-50%. The reinforcement ratio of the longitudinal bottom bars in is 0,97%. The strength of the high strength concrete is about 70 MPa, and that of the low strength concrete is around 30 MPa, see the long version paper for more detailed information. The specimens are simply supported and loaded by a hydraulic actuator. The centre to centre distance of the setup is 3.6 m.

3. Test Results

All the five specimens are tested at both ends in the experimental program. Among them, three slabs are mixed slabs with different concrete strength strips. The other two are reference slabs with homogeneous high or low strength concrete. These ten tests are subdivided into two test series with different shear span: Series 1 with a shear span of 600 mm, Series 2 with a shear span of 800 mm.

The so called inclined cracking load V_{cr} is used as the failure criteria. This value is defined as the load level at which unstable cracks inclined in diagonal direction. In most cases, for the mixed slabs, the inclined cracking load is in line with the mean concrete strength of the slab. Besides, the strips of different concrete strengths in the mixed slabs behave as if it were homogeneous slabs.

4. Conclusions

The experimental program presented in this report mainly deals with the influence of spatial variation of concrete strength in width direction on the shear capacity of one way slabs. Two test series are designed, in which the spatial variation of concrete strength is exaggerated. The influences of concrete strength variation on the inclined cracking load, failure modes, crack development and other aspects of one way slab structures is examined in the tests. Based on the test results, the following conclusions can be drawn.

- The inclined cracking load V_{cr} can be considered as the lower bound of the shear capacity of a reinforced concrete structure without shear reinforcement.
- Based on the presented test results the shear capacity of a mixed concrete slab shall be evaluated by considering the mean concrete strength.
- In the tests, the slabs with strips of alternating concrete strength retained the structural integrity.
- Although there is rather few data to draw a solid conclusion, the test results clearly show that for structures like slabs with a large width compared to the depth, the shear capacity may be higher than for beam structures and the design formula in Eurocode. More work is still needed to confirm this tendency.