Experimental investigations on the shear bearing capacity of UHPFRC beams with compact cross-section

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1 Introduction

Up to now, extensive test series on the shear bearing behaviour of UHPFRC beams have been carried out [1-6]. Various cross-sectional dimensions, fibre volume fractions, and prestressing were investigated focusing on I-shaped cross-section. As the shear bearing mechanisms significantly differ for beams with compact cross-section, the findings on beams with I-shaped cross-section may, however, not be generally applicable.

In the present study, a series of shear tests on UHPFRC beams with compact cross-section, different fibre volume fractions, and prestressing was performed, in order to examine the influences on the formation of the critical shear crack as well as on the shear bearing capacity.

2 Experimental programme

Varying the fibre volume fraction (0 %, 1 % or 2 %) and the prestressing of the tendons (0 MPa, 720 MPa or 1440 MPa) resulted in a total of nine specimen configurations with one specimen each. The specimen's geometry as well as the arrangement of reinforcement and prestressing tendons are shown in Fig. 1. The total length of the beams was 3,000 mm to enable at least two shear tests per specimen. The three-point tests were performed displacement controlled with shear span-to-depth ratios *a/d* between 3.5 and 5.5. Displacements including crack widths were measured by digital image correlation (DIC).

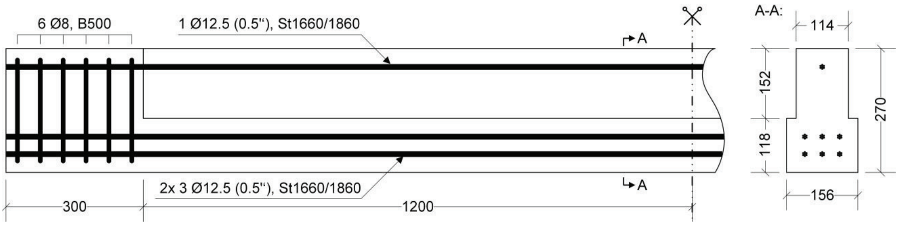

Figure 1: Specimen's geometry and arrangement of reinforcement and prestressing tendons.

Before manufacturing the beams, a measuring system was installed for recording the specimen's deformation due to shrinkage and creep in order to derive the loss of prestress.

A concrete mixture with a maximum aggregate size of 8 mm was used. The smooth and straight steel fibres had a length-to-diameter ratio of 20 mm/0.40 mm. The average 28-day cube compressive strength of the concrete was 154 MPa, 164 MPa, and 168 MPa for fibre volume fractions of 0 %, 1 %, and 2 %, respectively. The residual flexural tensile strength, which was obtained in three-point tests on accompanyingly fabricated notched beams, showed mean values of 11.1 MPa and 17.6 MPa for fibre volume fractions of 1 % and 2 %, respectively.

3 Test results

Figure 2 shows the load-displacement curves of selected tests, which failed in shear after formation of the critical shear crack. A DIC image of a typical crack pattern is depicted in Fig. 3.

Due to the specimens' compact cross-section, the critical shear crack developed from a flexural crack in all tests, irrespective of the fibre volume fraction or prestressing. This behaviour differs from beams with I-shaped cross-section where the shear crack starts at the thin web.

The critical shear crack was inclined by 21 to 35 degrees with respect to the longitudinal axis of the beam.

The specimens without fibres showed a brittle failure, while the fibre reinforced specimens showed some higher deformation capacity. The shear bearing capacity of the specimen without fibres and without prestressing (0 %; 0 MPa) was the smallest (63 kN). As expected, the ultimate shear load increased with increasing fibre volume fraction and/or prestressing resulting in a shear bearing capacity of 218 kN for the specimen with 1 % of fibres and tendons prestressed to 1440 MPa.

For the fibre reinforced specimens with the highest level of prestressing it was difficult to provoke a shear failure before flexural failure, however, an initiating shear crack could be observed via DIC in all cases. The specimens showing this behaviour will be further evaluated.

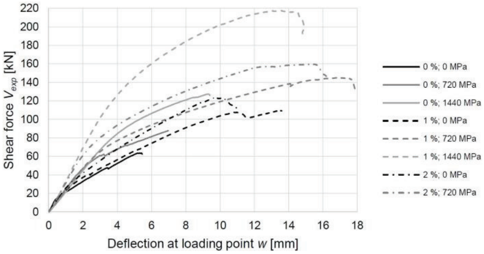

Figure 2: Load-displacement curves of selected tests.

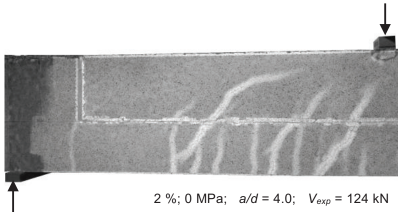

Figure 3: Crack pattern measured by DIC.

4 Conclusions and outlook

Based on the current evaluation the following conclusions may be drawn:

- For the specimens without fibres the inclination of the critical shear crack decreases with increase of prestressing. The fibre reinforced specimens show no clear trend in this respect.
- The increase in shear bearing capacity between the specimens with 1 % and 2 % of fibres is less than proportional to the increase of the associated residual flexural tensile strengths.
- The shear bearing capacities of the specimens without fibres is well predicted by Eq. (6.2.a) in Eurocode 2.

In the next step, fibre distribution and orientation will be examined by optoanalytic method in order to identify the actual residual tensile strength contributing in the critical shear crack. This may help to perform parameter studies by FEA investigating the influence of various parameters on the shear crack propagation as well as on the shear bearing capacity.

References

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