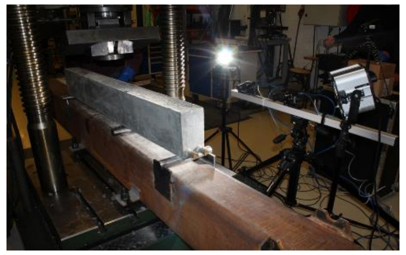
BYG508 Master thesis



Tittle:

Experimental and finite element analysis of the shear behaviour of UHPC beams

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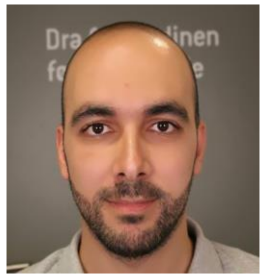

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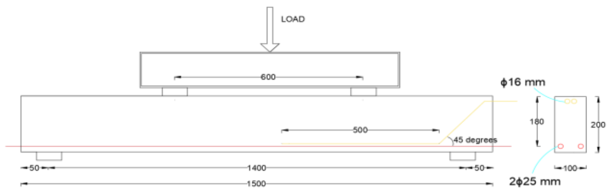
Summary

The flexural behavior of reinforced concrete beams is obviously defined and can be managed with reasonable accuracy. However, a solution has not been obtained for the shear capacity of beams, especially those without shear reinforcement, though numerous models have been established using different approaches. The reason is due to the complexity of shear behavior of RC-beams, where the load transfer through various components of concrete.

The uncertainties of these parameters are the reason for not having a principal shear model in the measurement of the shear capacity of reinforced or un-reinforced concrete beams.

This master thesis has therefore focused on enhancing the shear resistance of reinforced concrete beams, among a suitable fiber dosage, and the use of UHPC. Experiments, as well as numerical analyses, have been conducted in this thesis. The experiments were divided into 3 parts: cubic and cylinder specimens at different ages to determine the compressive strength, as well as the modulus of elasticity, a four-point bending test on beams to investigate shear strength, and lastly, a three-point bending test on small-scale prisms to determine the flexural tensile strength. In order to reach a deeper understanding of the shear behavior, finite element (FE) analyses were implemented utilizing the computer software ANSYS. Through ANSYS, several sets of analyses were completed on the simulation of four-point beam bending tests.

The large-scale beams were all tested at the mechatronic laboratory at the University of Agder, using the four-point bending test as shown in figure below. The midspan deflection was measured based on the available machines and a computer was used to register the values. The digital image correlation technique was used to extract the load- deflection curve of several points near to the diagonal shear crack.



Research question

How to analyze the steel fiber content effect on the shear behavior of Ultra-High-Performance Concrete (UHPC)?

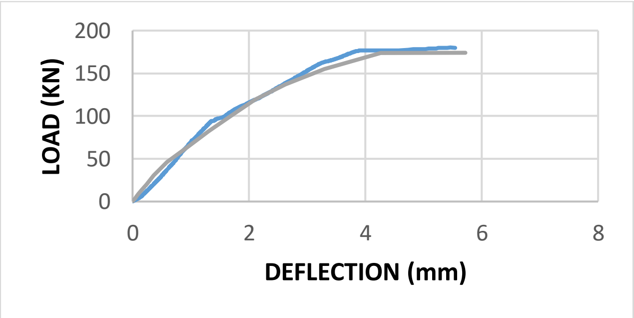
Sub-questions

- How does the different fiber contents by volume (V_f = 0%, 0,5% and 1%) influence shear behavior of UHPC?
- How to build in a numerical model of an UHPC-beam with the help of Ansys?
- To what extent can some of the available formulas in literature predict the shear strength of UHPC beams?

Results

The experimental results confirm that using the fiber in UHPC beams, will increase the shear strength and the ductility. Replacing stirrups completely with fibers, leads to a reduction of beam depth as well as a decrease in stirrup assembly time. The results were compared with the estimations by Australian guideline, ACI 522, Sharma, Ashour et al., Narayana et al. and Imam et al. The results show that Ashour et al. and Narayana et al. formulas gave the most accurate prediction, while the formula proposed by Sharma was the least accurate.

Most of the Finite element modeling results correlated well with our experimental results. Hence, using ANSYS may be the right solution in the future to investigate UHPC beams and to develop design theories of UHPFRC.



Conclusion

An experimental and numerical study was carried out on 102 specimens, which were made based on an UHPC developed recipe by the University of Agder (UiA). All the specimens were prepared and tested at the UiA. The only test variable was the fibre volume, where the type of concrete (UHPC), shear span - to - depth ratio (2) and reinforcement ratio (4.9 %) were kept constant. All specimens had the same lengths and cross-sections.

The influence of using steel fiber on UHPC capacity was presented in this thesis. The results prove that the ultimate shear strengths were enhanced as the steel fiber content increased. On average, the shear capacity of UHPC beams reinforced with 1% fiber, was 58.3% higher than UHPC beams reinforced with 0.5% fiber. Moreover, 1% fiber volume specimens experienced 42% higher deflection, than their 0.5% counterparts. In addition, the beam reinforced with 0% fiber, failed suddenly and explosively by shear- compressive failure. While the beams reinforced by 0.5% and 1% failed in diagonal- tension, this indicates the brittle behavior of UHPC and that as the fiber volume increases (up to 1% in this case), more ductility behavior can be obtained. This also let the structures achieve higher safety requirements.

Furthermore, test results indicate that the predictive models of both Ashour et al. and Narayana et al. are the nearest predictions to the experimental results for 0.5% and 1% beams, while ACI 544 following by Australian guideline equation is reasonably conservative. On average, for 0% fiber, all the formulas are remarkably conservative.

Finally, the failure mechanism of UHPC beams, is represented considerably well utilizing Finite element modeling, and the failure load predicted is quite near to the failure load measured near the shear crack during experimental testing by DIC technique.