Title:

Analysing UHPFRC beams with the help of ANSYS

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Summary:

This Master thesis is about analysis of Ultra High-Performance Fibre Reinforced Concrete (UHPFRC) beams with the help of the Finite Element Analysis (FEA) software ANSYS.

The research question and the operational questions are:

How can we analyse UHPFRC beams with the help of ANSYS?

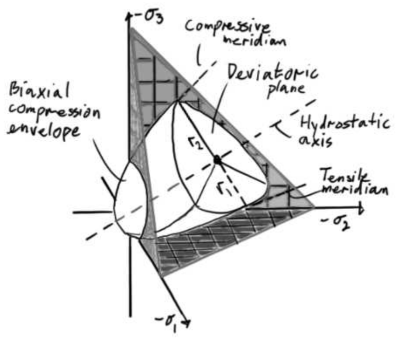
- How does the built in concrete material model in ANSYS work?
- How can the concrete material model in ANSYS simulate behaviour of UHPFRC beams?

The results from the tests in ANSYS show that the concrete model can predict the behaviour of relatively small UHPFRC beams with flexural- and shear reinforcement.

Theory:

ANSYS can simulate normal concrete behaviour by using its concrete material model and element type SOLID65. This material model is based on the William-Warnke yield criterion, but with “cutoff” in tension.

Similarities in behaviour of normal concrete and UHPFRC lead us to believe this could be used for UHPFRC as well.

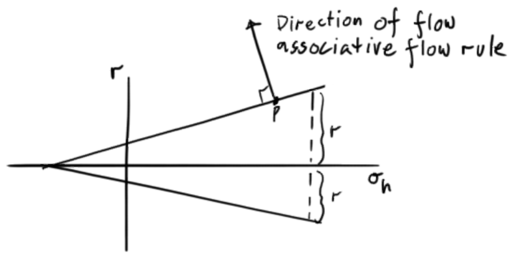


William-Warnke yield surface

Addition of fibre-reinforcement complicates modelling of the behaviour. We assume uniform distribution and random orientation to give an isotropic fibre effect.

To simulate a ductile behaviour due to fibre reinforcement we need to establish a post-crack model to predict its behaviour.

To accomplish this, the Drucker-Prager yield criterion with an accompanying flow rule and elasto-plastic hardening rule is applied.



Drucker-Prager yield criterion

Method:

Two beams from external research were modelled and tested in ANSYS. The results from these tests were used to refine theory and the workflow in ANSYS. This has been an iterative process with the goal of modelling the behaviour of UHPFRC beams.

Conclusion:

The concrete material model in ANSYS is based on the William-Warnke 5-parameter constitutive model for triaxial behaviour of concrete with “cut-off” in tension. In biaxial compression the failure surface is adjusted for the magnitude of tensile stress

The concrete model in ANSYS works in conjunction with the element type SOLID65. This element type can simulate cracking and crushing of the concrete. This is done by reducing components of the stiffness matrix to a low value and redistribute stresses to the stiffer nearby elements.

This redistribution causes stress concentrations which facilitate more cracking, and will this way simulate crack propagation.

The concrete material model itself can only be used to define the yield criterion of the material. To simulate UHPFRC behaviour a linear elastic model and a post-crack model must be implemented.

The Drucker-Prager plasticity model is used in this regard. This model allows a flow rule and an accompanying hardening rule. The drawback of this model is that the hardening rule is fixed to be of an elasto-plastic type.

The SOLID65 elements with incorporated smeared reinforcement can be used to model the fibre reinforcement explicitly. The challenge is to adequately define a material model that can simulate the behaviour of the fibres.

The concrete material model can predict the behaviour of small UHPFRC beams with shear and longitudinal reinforcement. Without shear reinforcement the shear strength is overestimated.

Adding the Drucker-Prager plasticity model to the concrete model improves the accuracy of the post-crack behaviour of UHPFRC. To further increase the accuracy of the models, a hardening rule must be defined. This will allow analysis of UHPFRC beams in ANSYS. The built-in concrete model and the Drucker-Prager plasticity model are found too inflexible.