Pull-out of hooked end steel fibre from epoxy matrix: Experimental & Numerical study.

by

Christian M. Kangaj

Supervisor: Ms Helen M. Inglis

Co-supervisor: Prof Schalk Kok

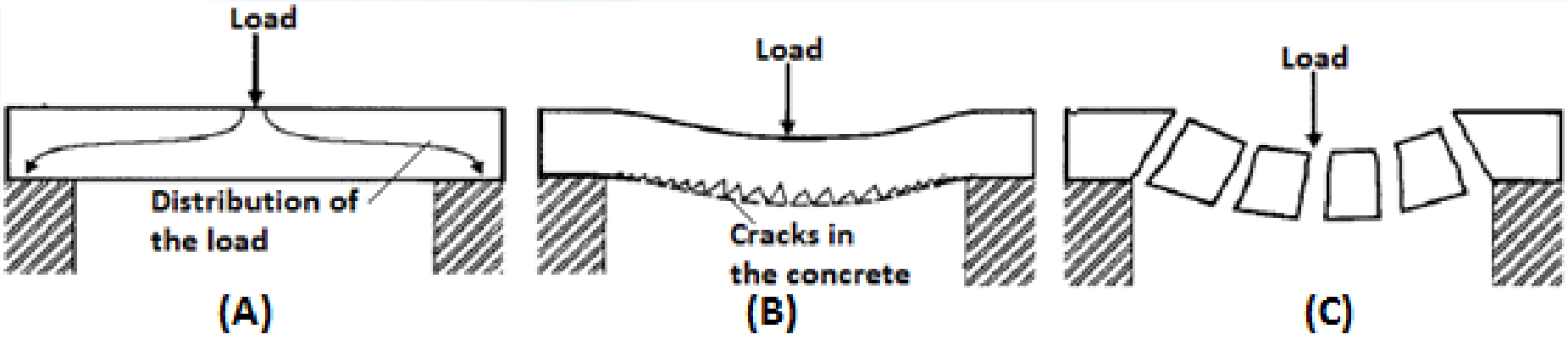
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Department of Mechanical and Aeronautical Engineering

Steel Fibre Reinforced Concrete (SFRC)

Why reinforce concrete with steel fibre?

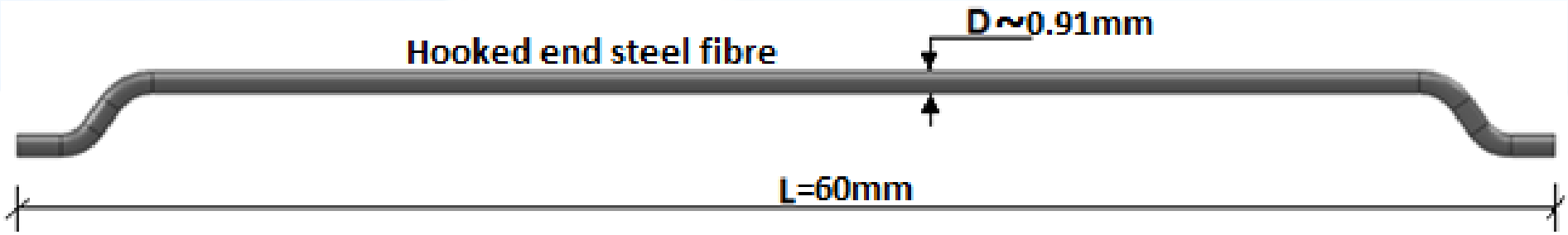
- Control of crack opening
- Increase the energy absorption (toughness)
- Change the failure from brittle to pseudo-ductile



Steel Fibre Reinforced Concrete (SFRC)

One of the following failure mode will occur:

- Crack opening followed by pull-out of fibre
- Fibre rupture



Aim of the research

Understand the pull-out behaviour of hooked end steel fibre by using:

- **Experimental studies**

  -Direct visualisation of plastic deformation of the fibre during pull-out process

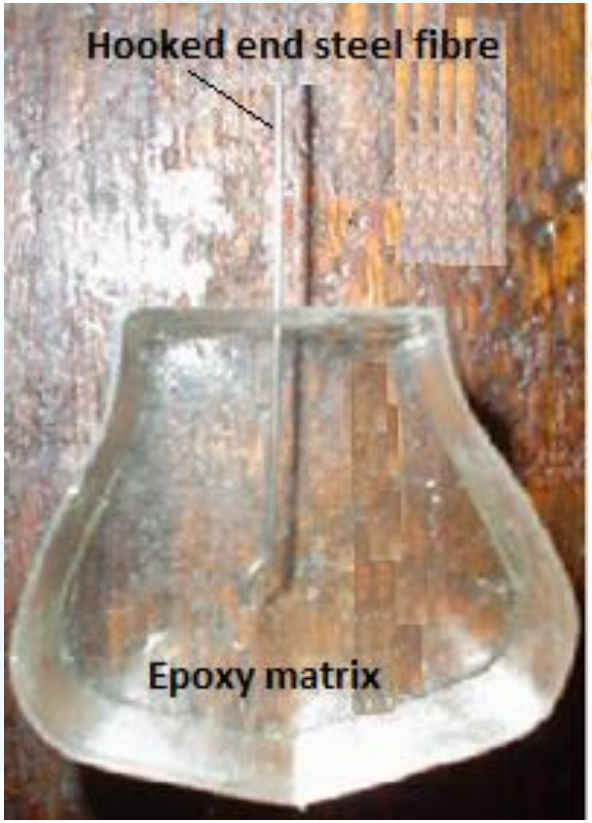
  -Experimental pull-out curves (load vs fibre slip)

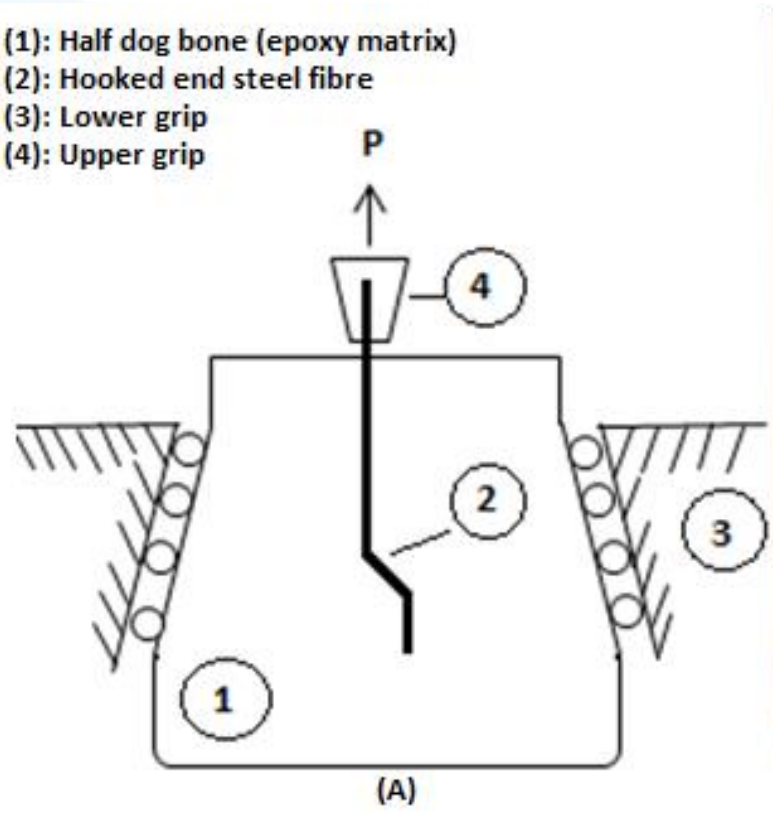
- **Numerical studies**

  -Numerical pull-out curve (load vs fibre slip)

  -Investigating plasticity of different regions of the fibre

Experimental pull-out - setup

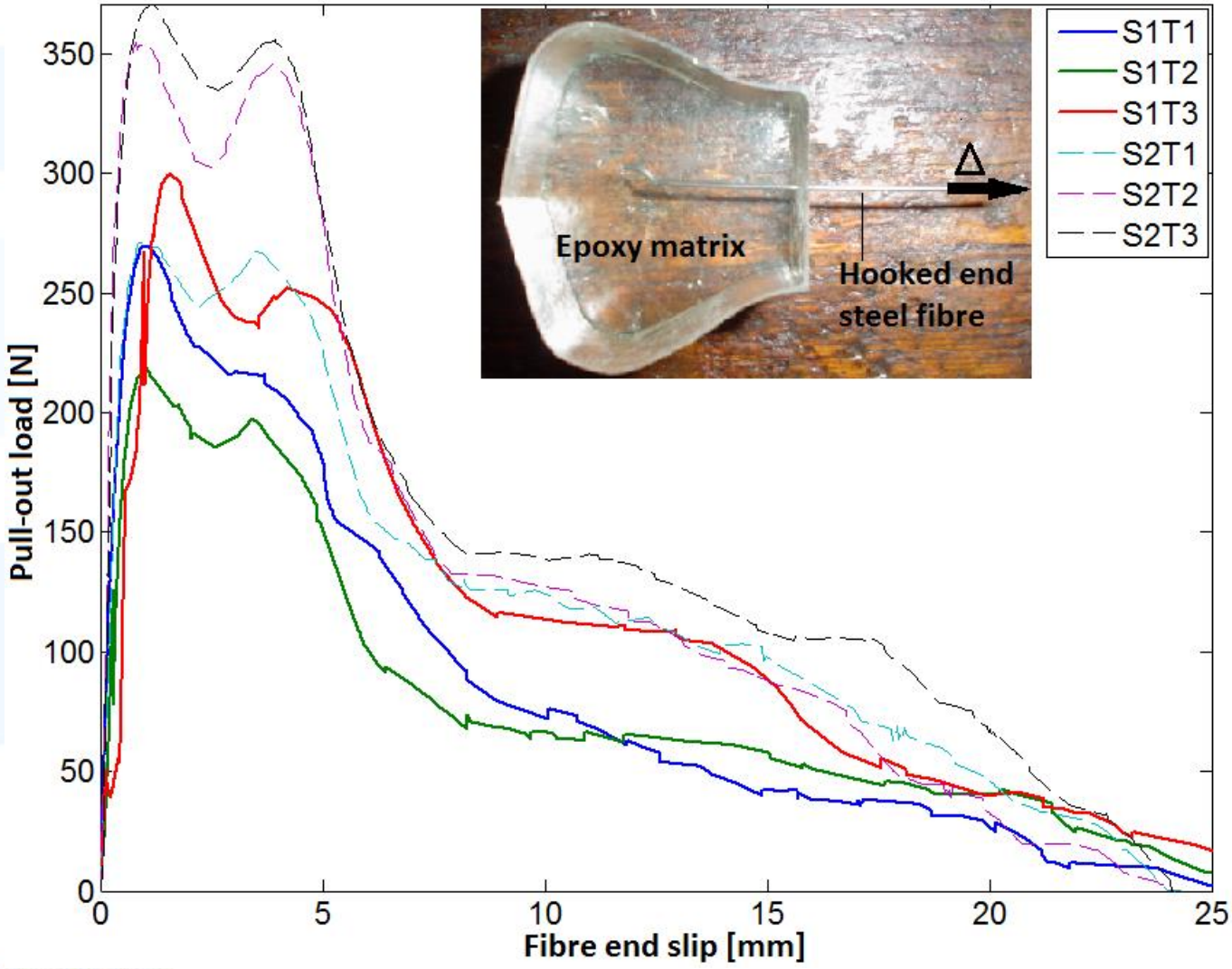




(A)

(B)

Experimental pull-out - results

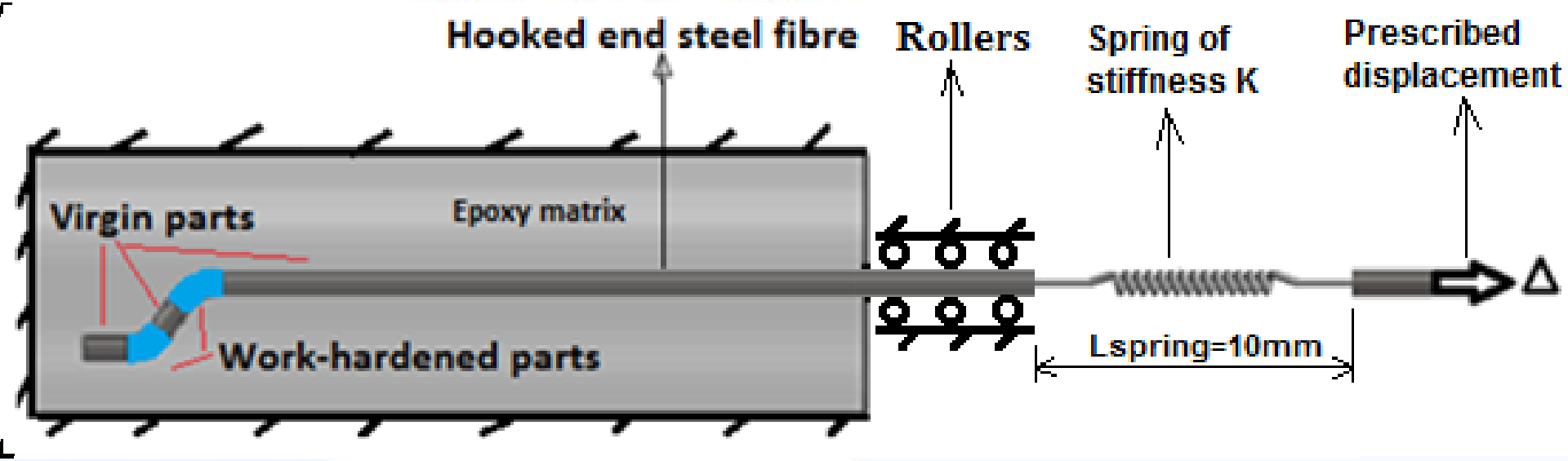


Numerical modelling in ANSYS

The numerical model was informed by the following key experimental observations:

- The steel fibre undergoes extensive deformation (straightening of the hook)
- The epoxy matrix has remained intact without large deformation

Numerical modelling in ANSYS

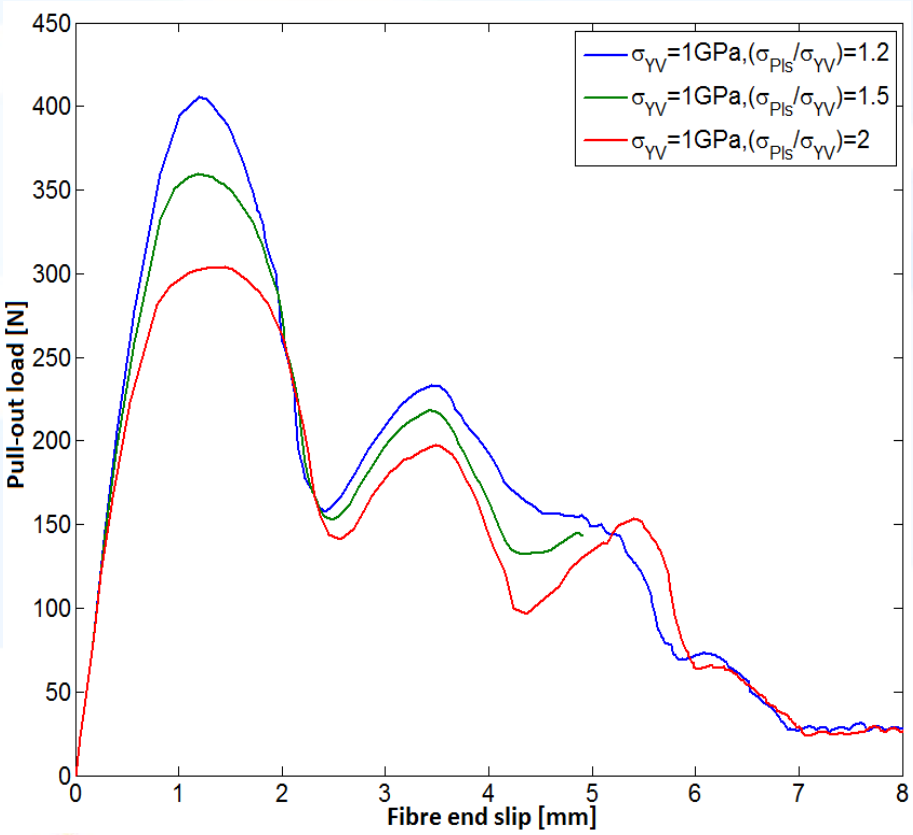


Numerical modelling in ANSYS

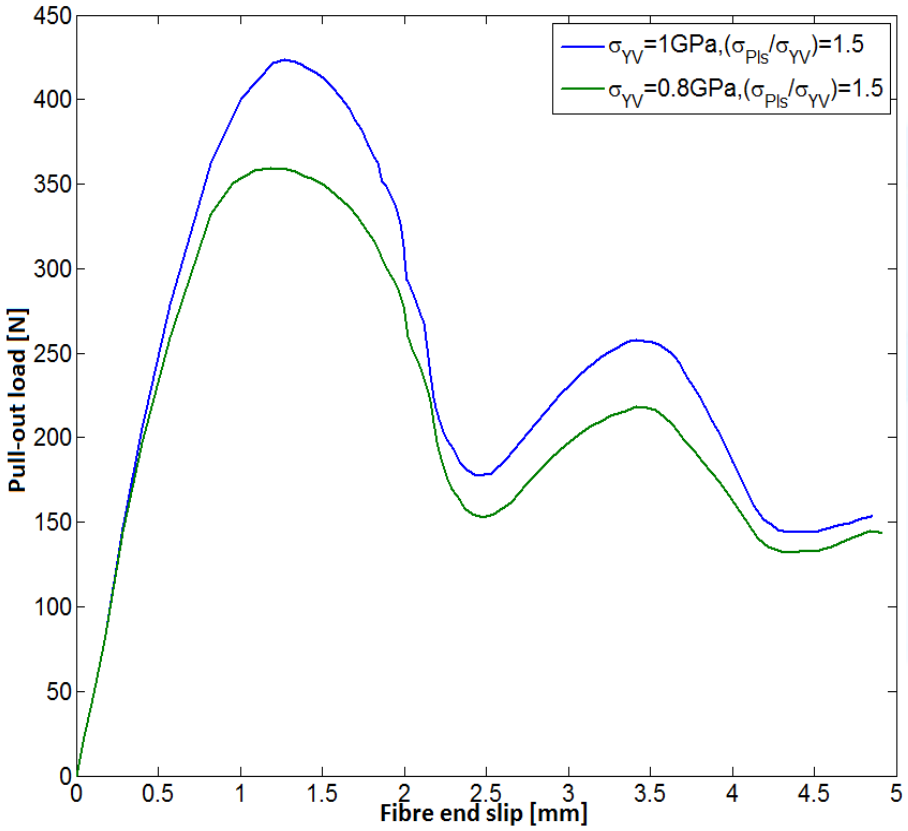
Property	Symbol	Value
Fibre elastic modulus [GPa]	E_f	196
Fibre tangent modulus [GPa]	E_T	0.1
Virgin yield stress [GPa]	σ_{YV}	1
Plasticized yield stress [GPa]	σ_{Pls}	1.2
Coefficient of friction [-]	μ	0.05
Spring stiffness [kN/mm]	K	1
Epoxy elastic modulus [GPa]	E_m	3

Results – Sensitivity studies

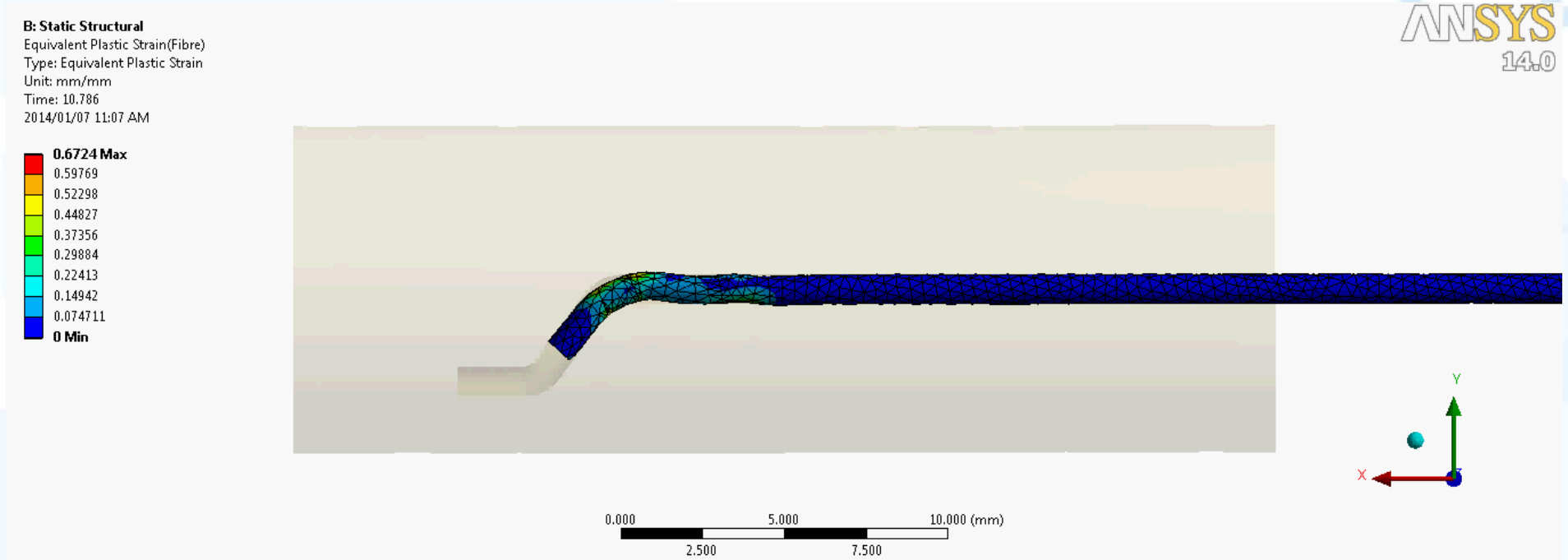
Impact of the ratio (σ_{YPl}/σ_{YV}).



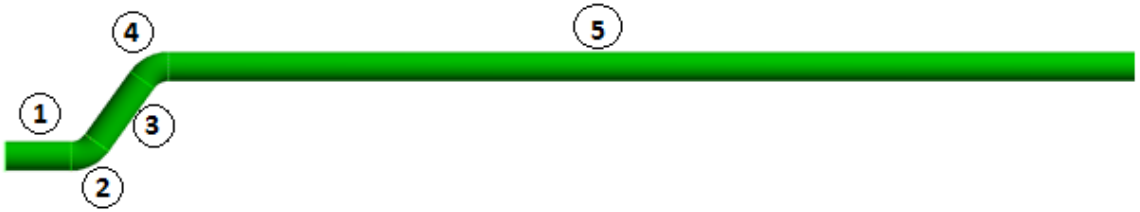
Impact of σ_{YV} or σ_{YPl} with a constant yield ratio r_σ=1.5.



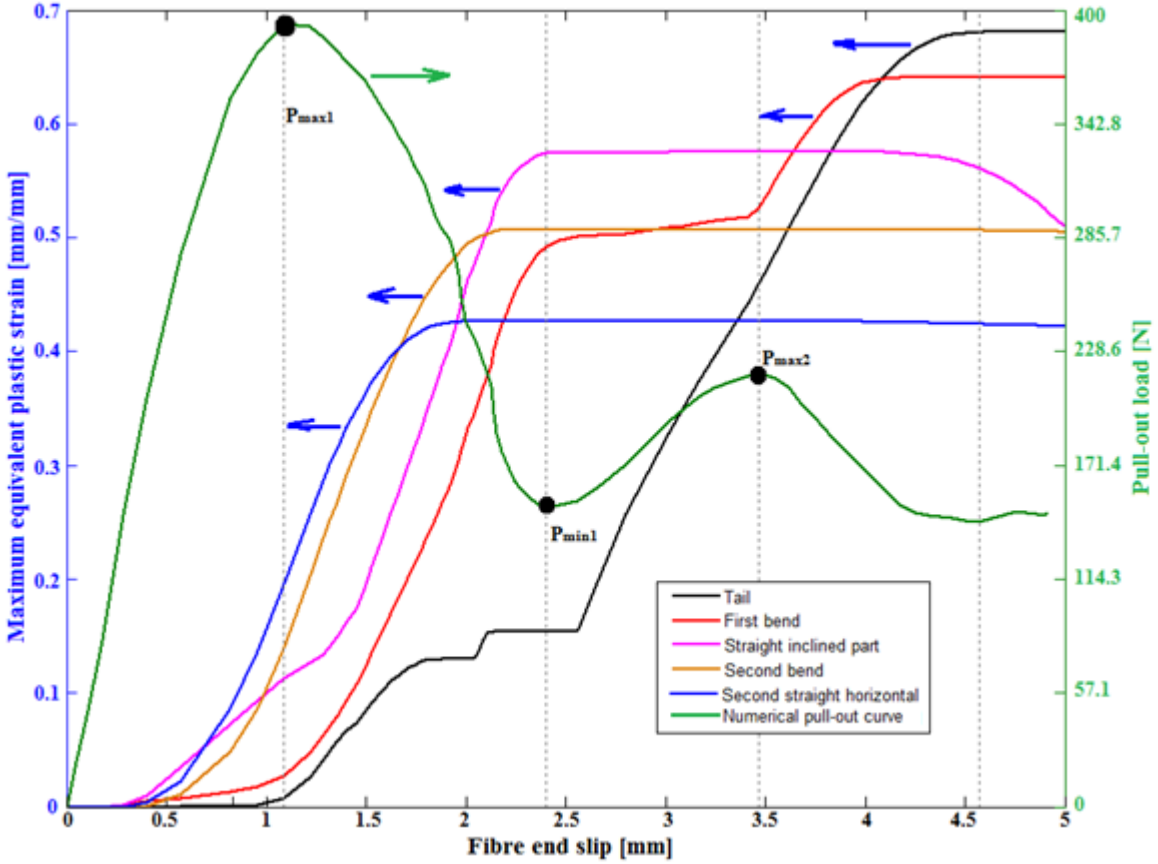
Simulation of the pull-out problem



Investigating plasticity of the fibre



1: First straight horizontal part (Tail) 2: First bend 3: Straight inclined part
4: Second bend 5: Second straight horizontal part



Conclusions & Suggestions

The following suggestions could improve the quality of the present study:

- Perform additional experiments
- Consider the debonding process in the numerical model
- Incorporate a dynamic coefficient of friction
- Study the effects of the pull-out rate
- Perform an optimisation study on different parameters involved in the model

Thank you.