University of BRISTOL

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The University of Nottingham

# Numerical Modelling of 3D Woven Composite Preform Deformations

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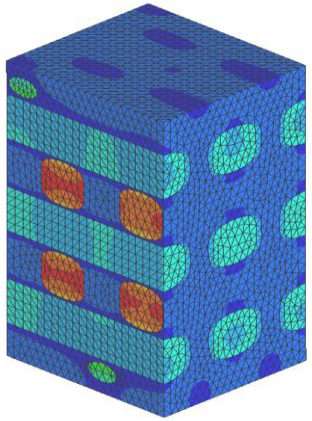
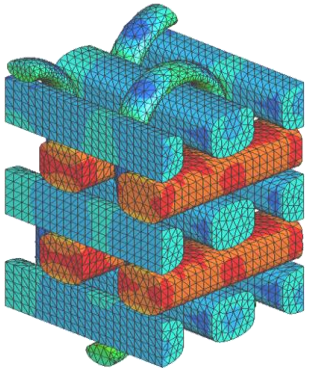
# Introduction

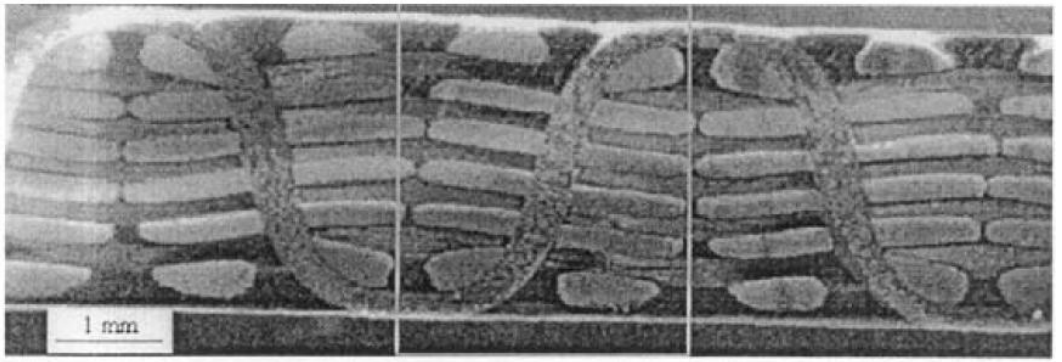
- Project overview
- Textile deformation modelling:
  - Background
  - Results and comparisons
- Mechanical performance modelling:
  - Overview
- Future Work

# Project Overview

- 3D woven composites:
  - Fibres in all three principal directions
  - Currently used in niche applications despite potential advantages over traditional 2D laminated composites
- Project aim:
  - Previous work considers idealised geometry
  - Develop a model for prediction of 3D woven composite properties considering realistic fibre architecture



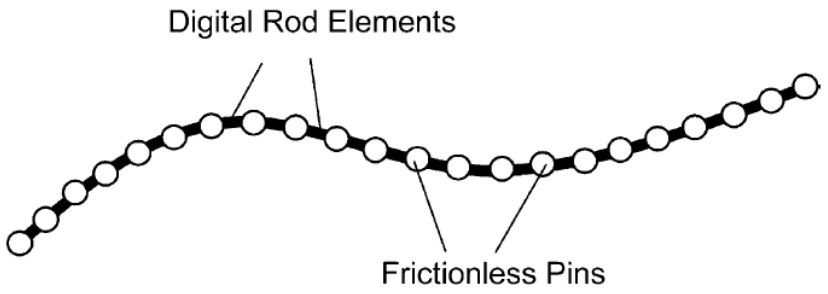


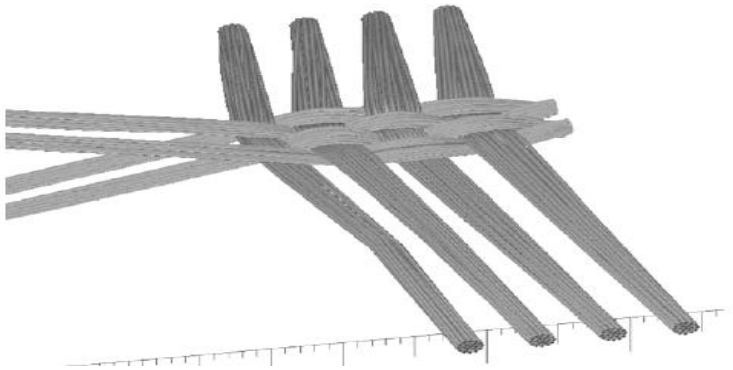



[1] *UoN Unit cell FE modelling,* J. J. Crookston, 3DSIMCOMS Dissemination Meeting, 24/11/2009
[2] *Dynamic Direct Numerical Simulation of Woven Composites for Low Velocity impact,* K. H. Ji et. al, 2005, Journal of Composite Materials

# Modelling Preform Deformations

- 'Multi-chain digital element' method:
  - Each chain is comprised of short 1D cylindrical rod elements connected by frictionless pins
  - Yarn is considered as an assembly of several digital chains
  - Contact between digital chains in yarn and between each yarn assembly



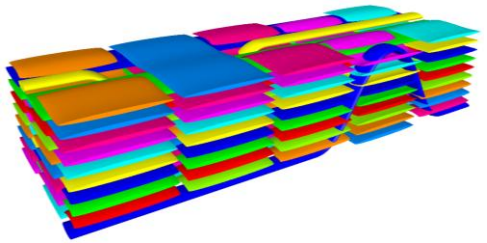



- Implemented in commercial FE code LS-DYNA
  - Modelled with beam elements
  - Elastic-plastic material to allow flexural deformation of chains

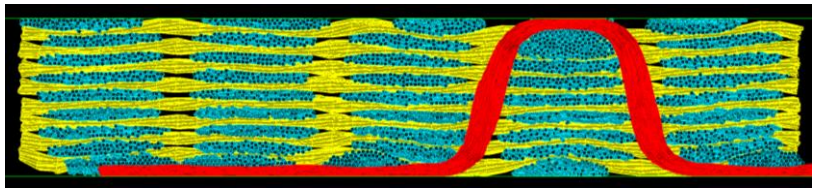
[3] *Digital-element simulation of textile processes*, Y. Wang and X. Sun, 2000, Composites Science and Technology, p 311-319

# 3D Woven Modelling: Overview

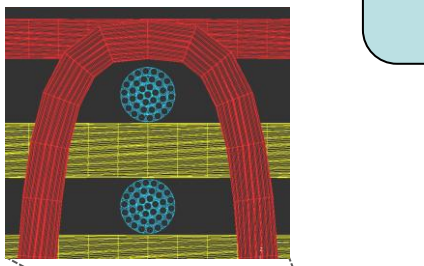
Idealised TexGen model

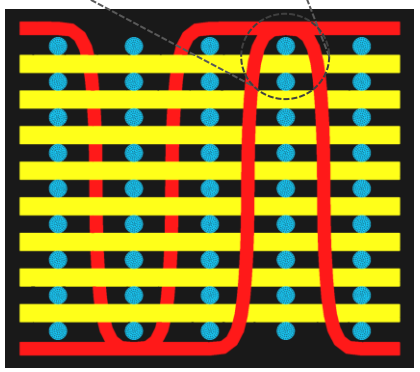


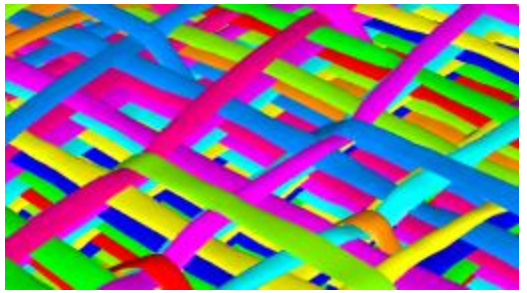
LS-DYNA beam model



LS-DYNA deformed model





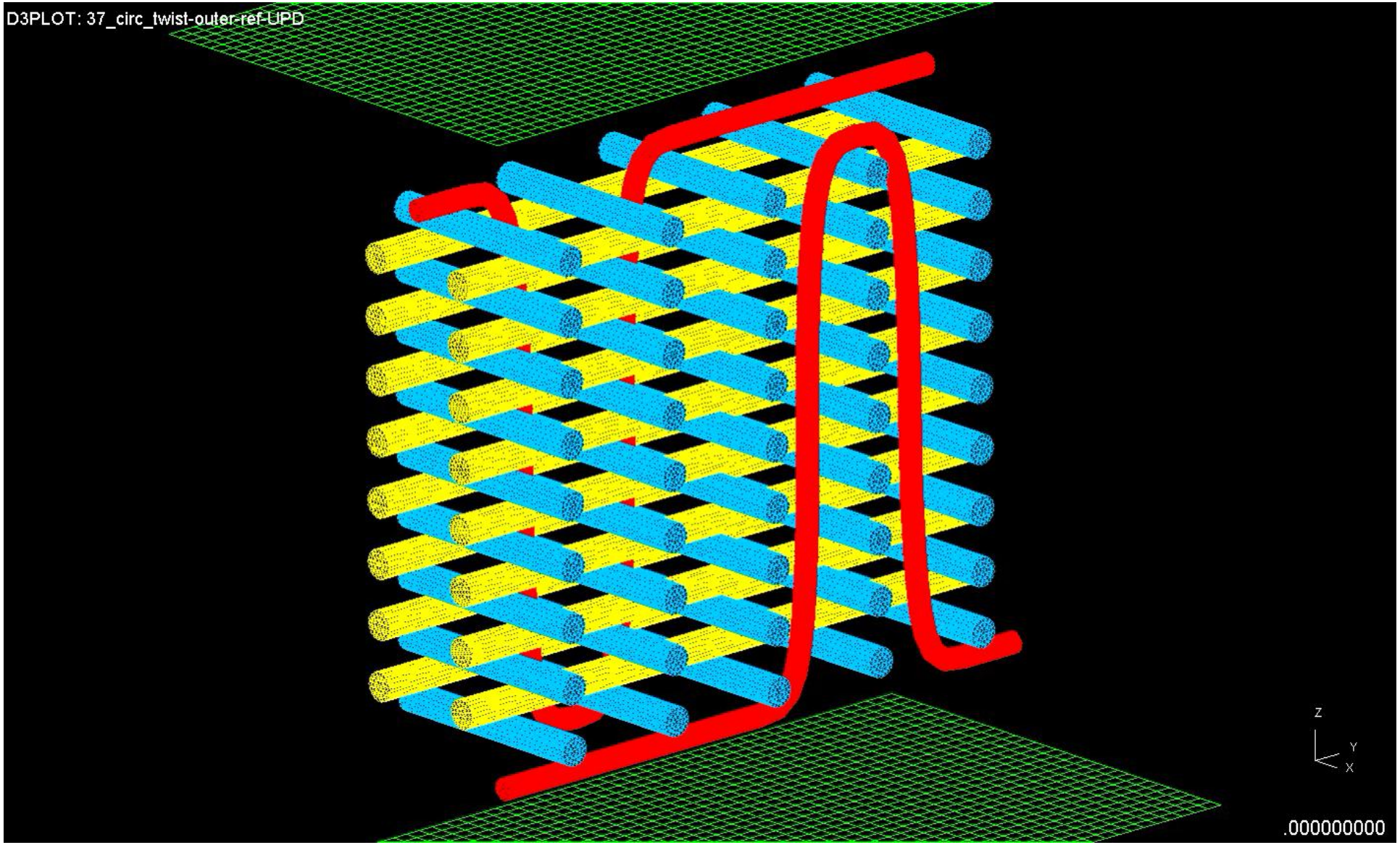


Realistic TexGen model

Stiffness / failure analysis

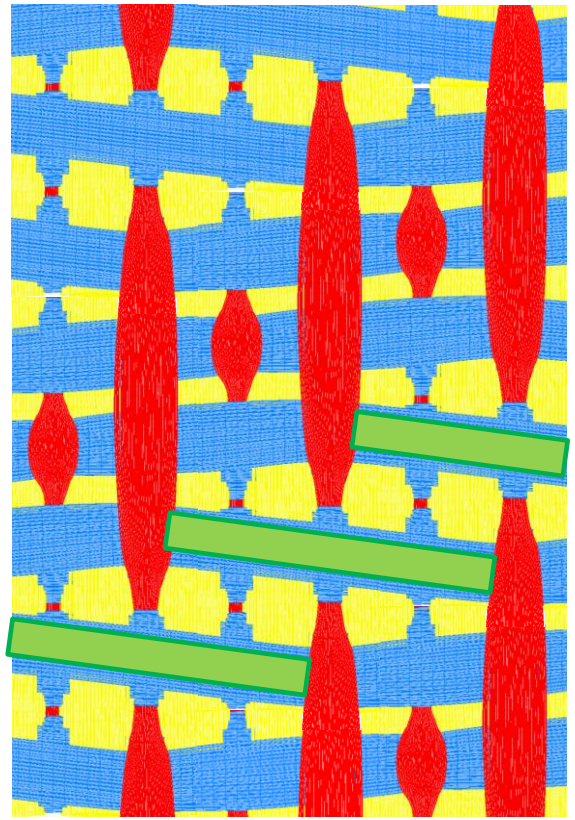
[4] *TexGen; Textile geometry pre-processor*, University of Nottingham

# Results: Video

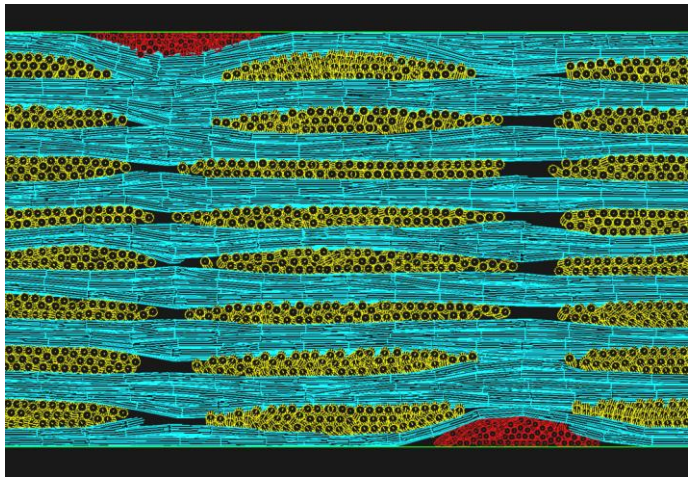


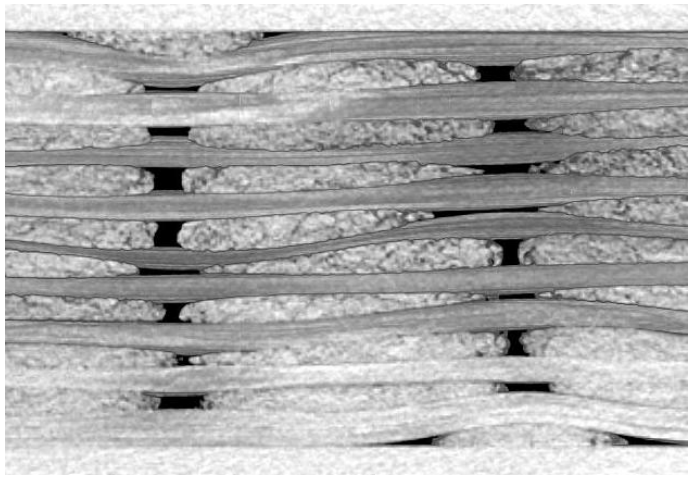
# Results: Experimental Validation

Top surface of fabric:



Cross-section through fabric:



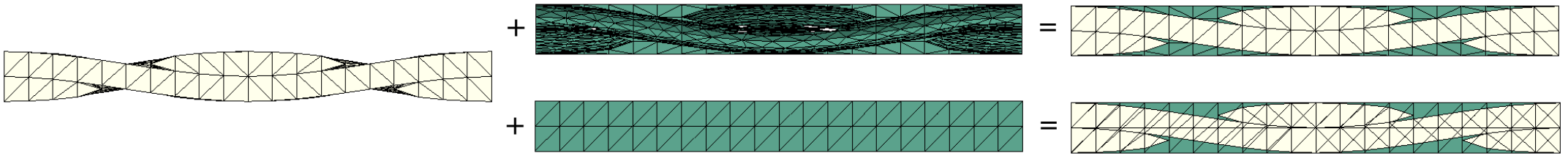


[5] *CT scans carried out at μ–VIS*, University of Southampton

# Stiffness Modelling: Review

- **Standard FE:**
  - Tow and matrix domains modelled explicitly
  - Need fine mesh to model degenerated resin pockets

- **Domain Superposition Technique (DST), 3DSIMCOMS:**
  - Superimposed matrix and tow meshes with coupling technique to ensure continuity of deformation
  - Altered material properties for tows
    - $[D]_{\text{modelled tows}} = [D]_{\text{tows}} - [D]_{\text{matrix}}$
  - Advantages:
    - Simple meshing of matrix volume
    - Can tolerate some yarn interpenetration

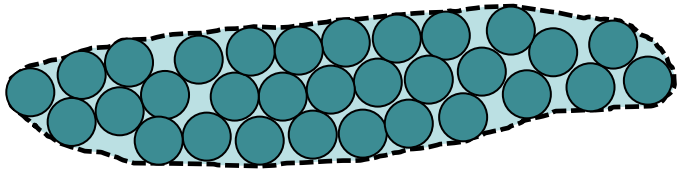



➢ Initial study using Abaqus and ANSYS suggested discrepancies between standard FE and DST in certain scenarios

# Conclusions and Future Work

- Development of deformation models
- Model results validated against detailed CT scan data
- Preliminary study on DST

- Future work:
  - Parametric study
  - Validation against angle interlock 3D weave
  - Conversion back into TexGen
  - Revisit mechanical performance modelling:
    - DST and other methods



# END

- **Any questions?**

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