



Modelling of textiles and composites

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We are:

Prof Andrew Long (Head)

Prof Chris Rudd

Prof Nick Warrior

Dr Arthur Jones

Dr Richard Brooks

Dr Mike Clifford

Dr Mike Johnson

Dr Steve Pickering

Dr Colin Scotchford

Dr Gavin Walker

14 post-doctoral fellows

~20 PhD students

3 technical staff

>£1.5million p.a. funding

We study:

Manufacturing processes

Textile composites

Design/performance modelling

Biomedical composites

Recycling/end-of-life



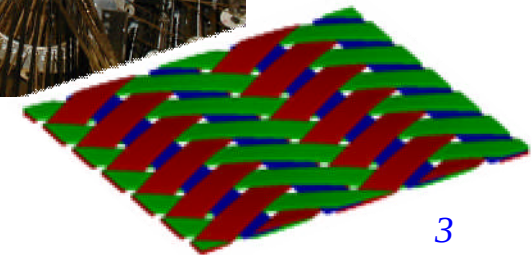
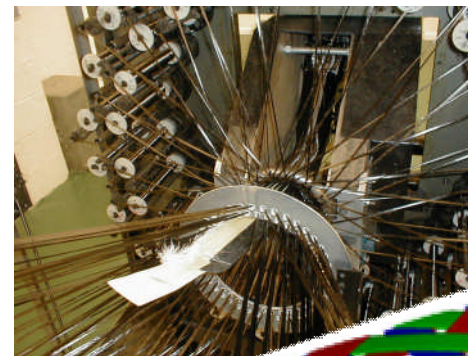
Textile composites

Major awards:

Platform Grant – Processing and Performance of Textile Composites (EPSRC, £445k, 05-09)
High Value Composite Materials from Recycled Carbon Fibre (DTI, £333k, 05-08)
Development of novel anti-slash technical textiles (DTI, £220k, 05-08)
Fatigue, Damping and Impact Properties of Textile Composites (EPSRC, £168k, 06-09)
Simulation of 3D woven fabrics for structural composites (DTI, £189k, 06-09)
Multi-scale integrated modelling for high performance technical textiles (DTI, £318k, 07-10)
Analysis and modelling of advanced preform processing (EPSRC, £495k, 07-10)
Warpage compensation in composite laminate manufacture (DTI, £242k, 07-10)
Carbon Fibre Recycling – Materials and Product Development (Boeing, \$260k, 07-10)
Automated tape placement for wind energy rotor-blades (DTI, £302k, 07-10)

Key partners:

Airbus UK Aston Martin, ACG, BAE Systems, Bentley Motors, Boeing, Bombardier, DeepSea Eng., Dowty Propellers, ESI Software, Ford, Gamesa, Hexcel, JD Wilkie, NaREC, Rolls Royce, Smiths Aerospace, St-Gobain, Tenax, Unilever, Vestas, VT Halmatic



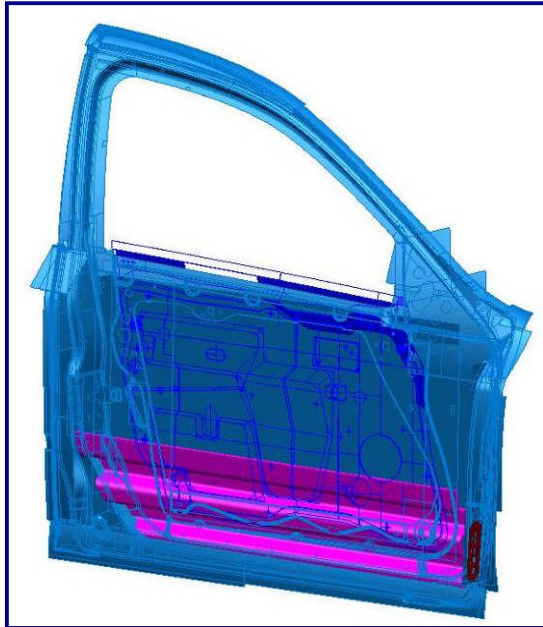
Textile composites



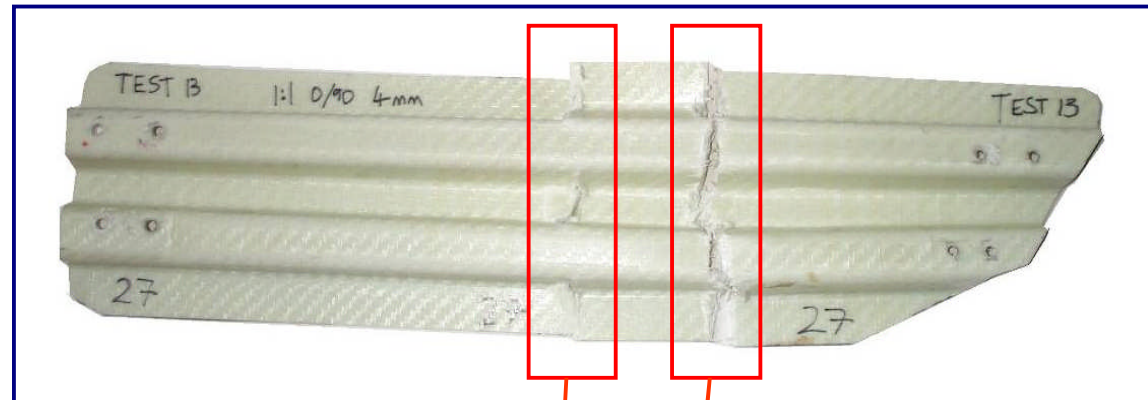
Modelling and Analysis

Structural analysis

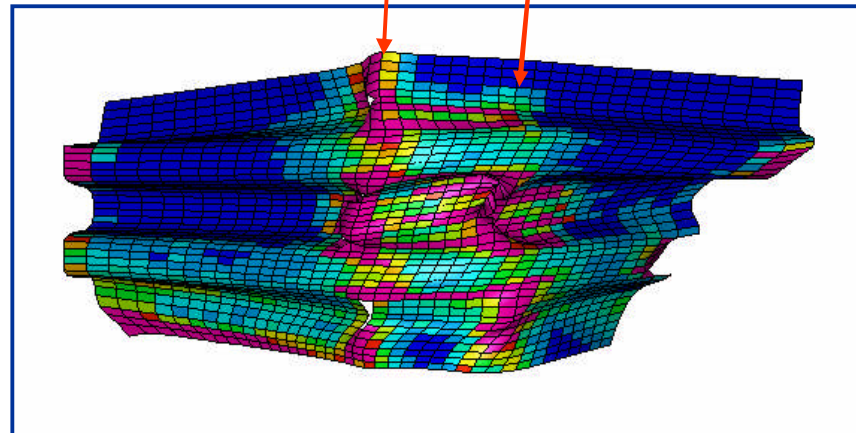
Damage during impact loading



4mm 1:1 Twintex
0/90° Post Failure



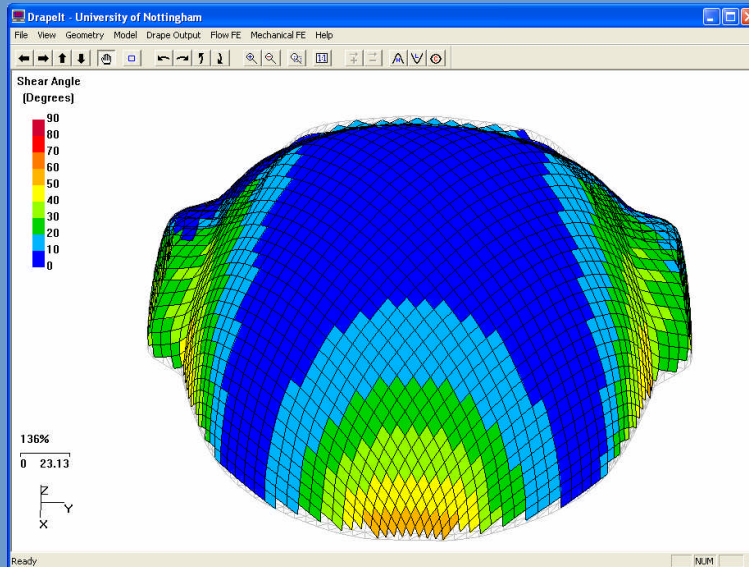
4mm 1:1 Twintex 0/90°
Damage Simulation
Failure Point



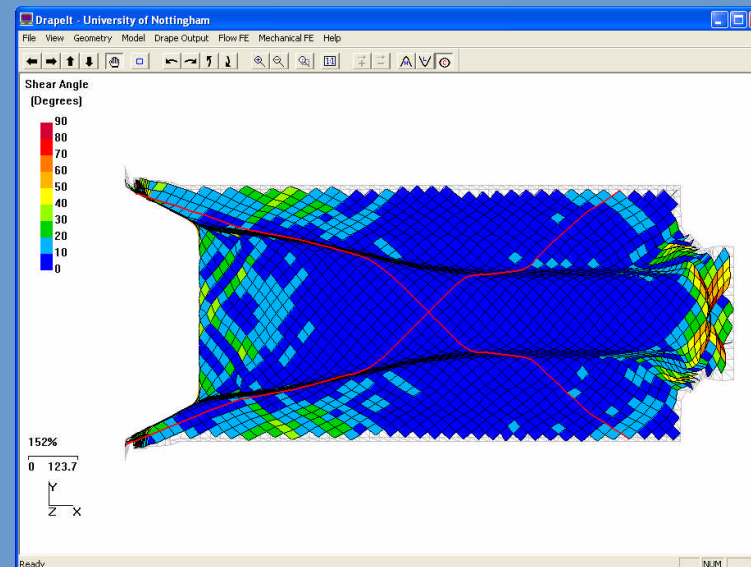
Process modelling

Draping simulation

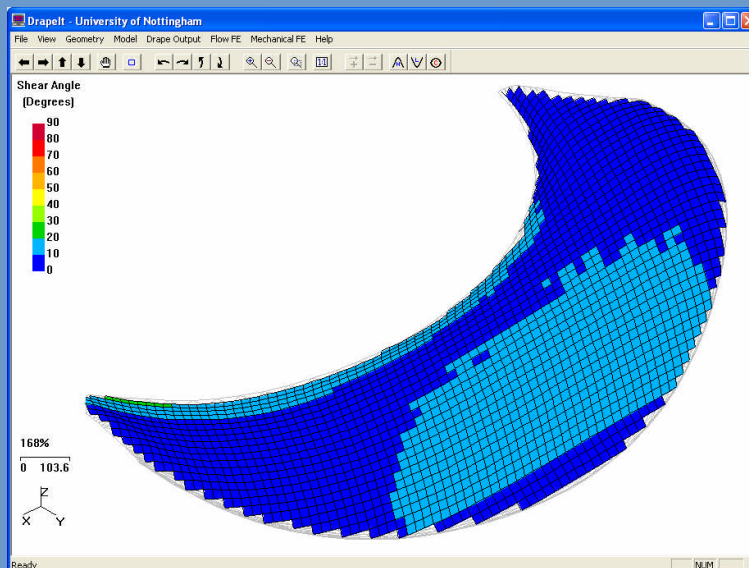
Pilot's
helmet



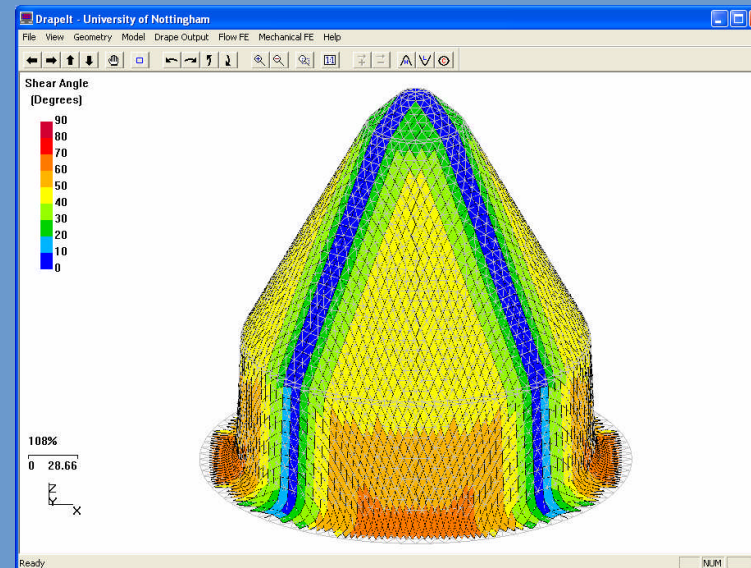
Transmission
tunnel



Marine
propeller

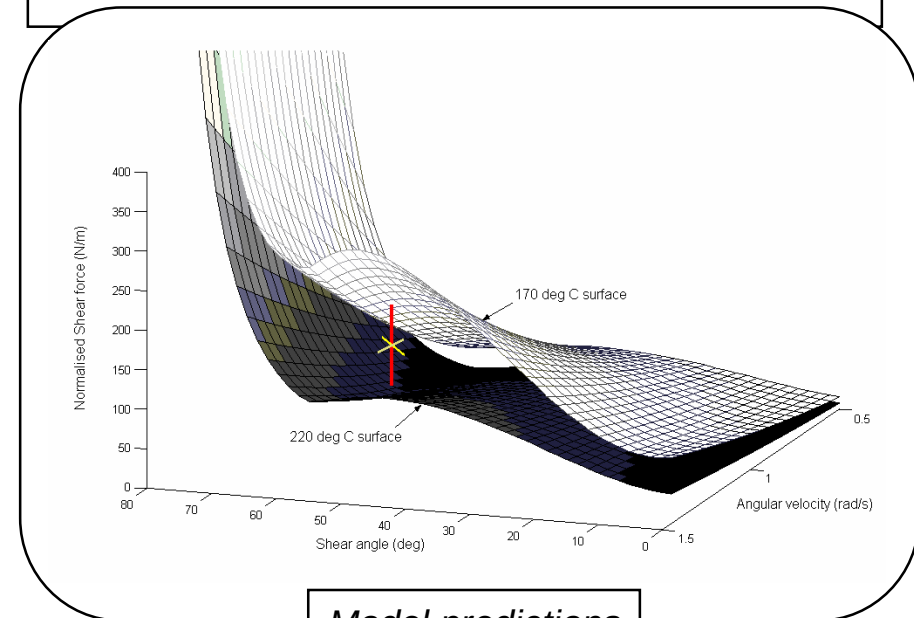
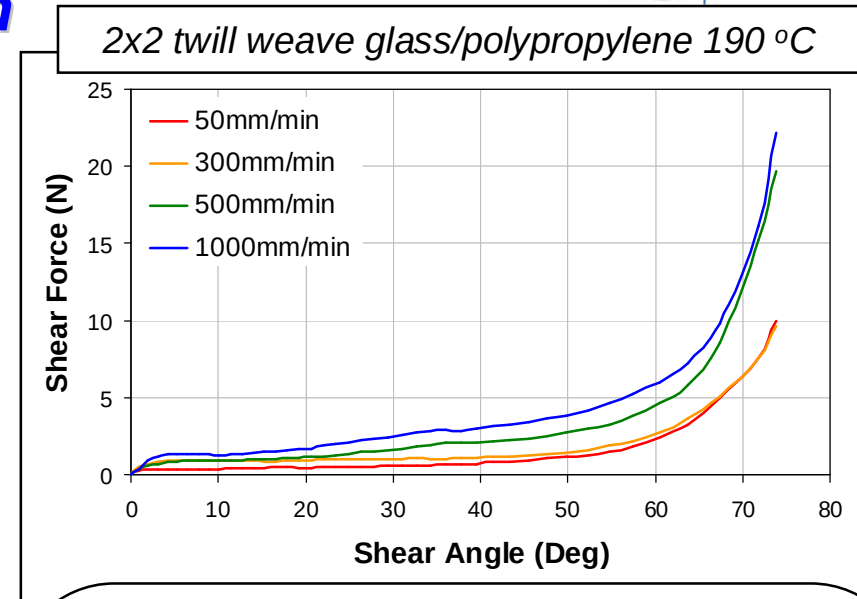
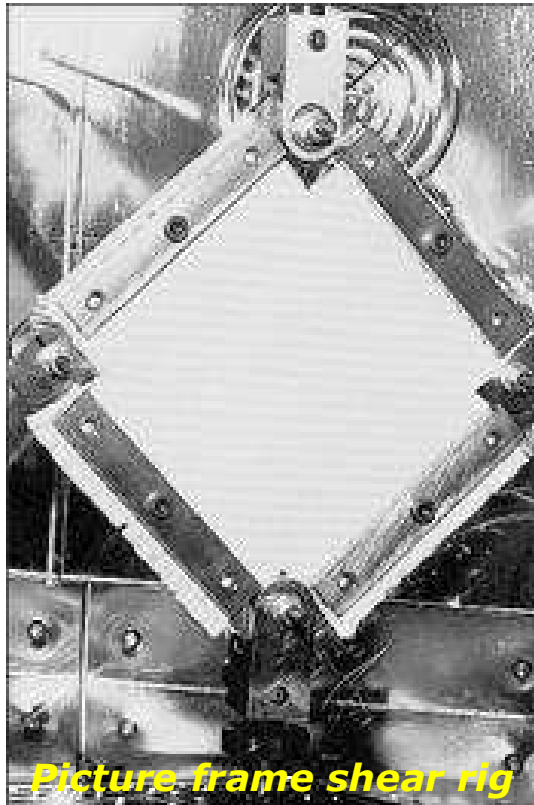
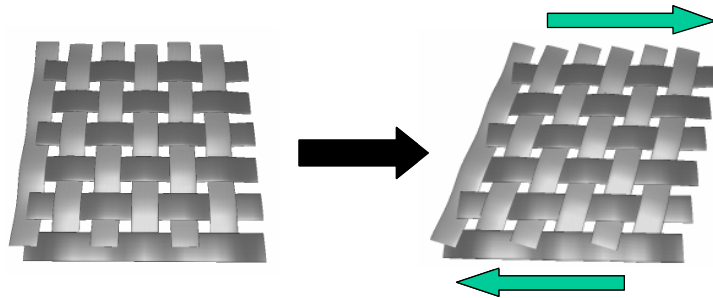


Jet engine
nose cone



Process modelling

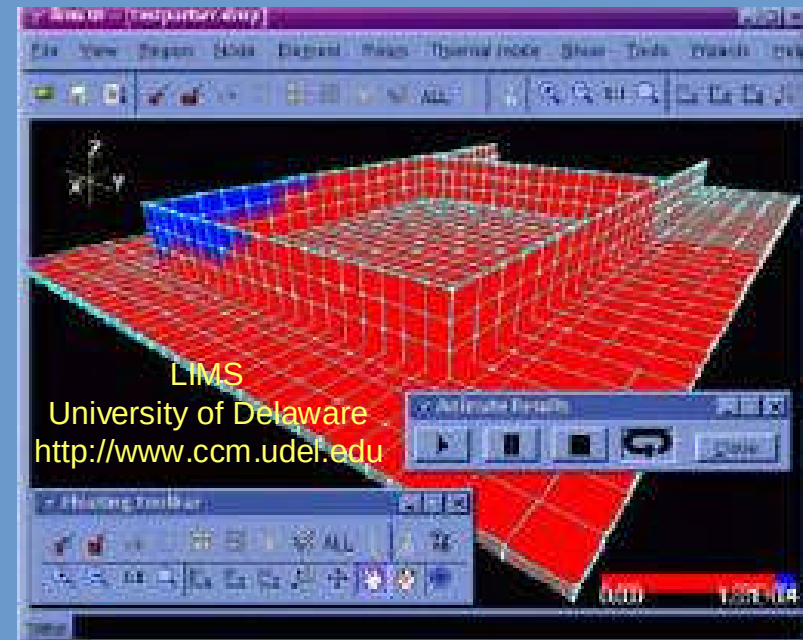
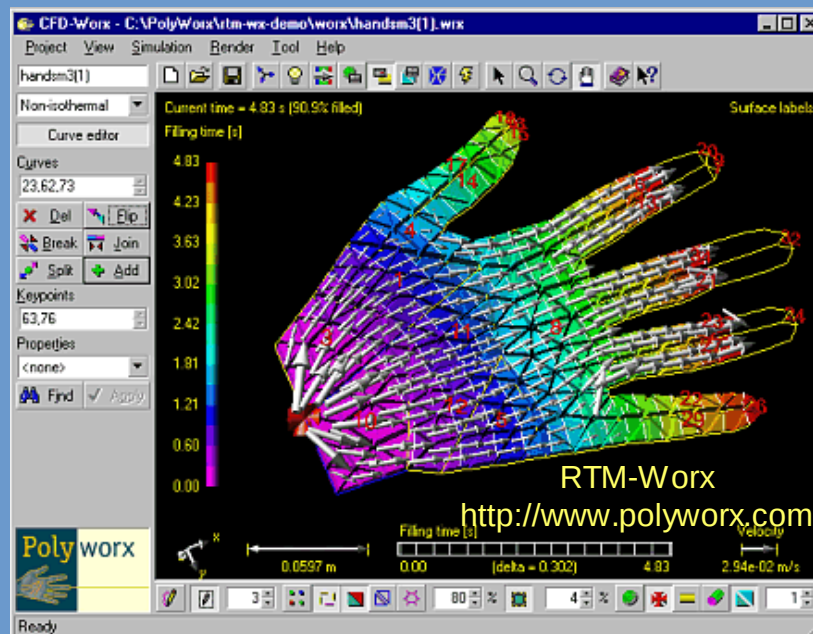
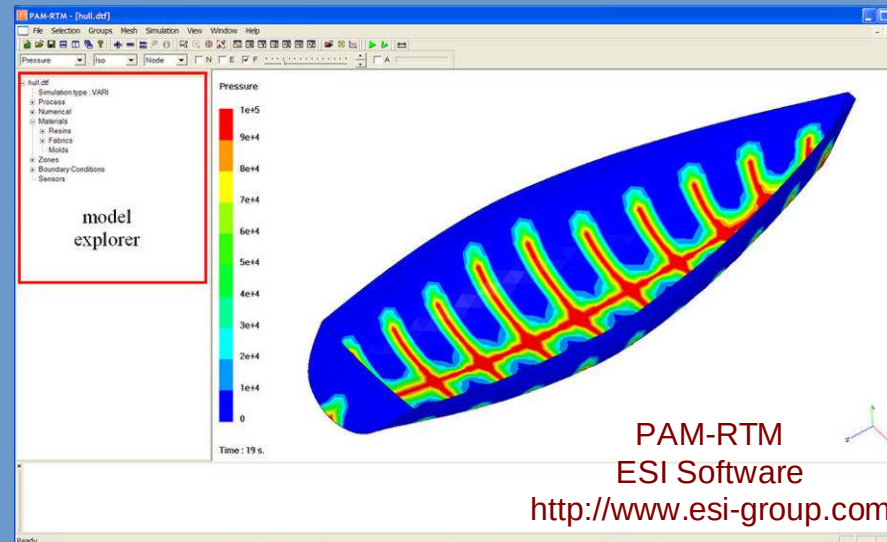
Formability characterisation



Model predictions

Process modelling

Liquid composite moulding



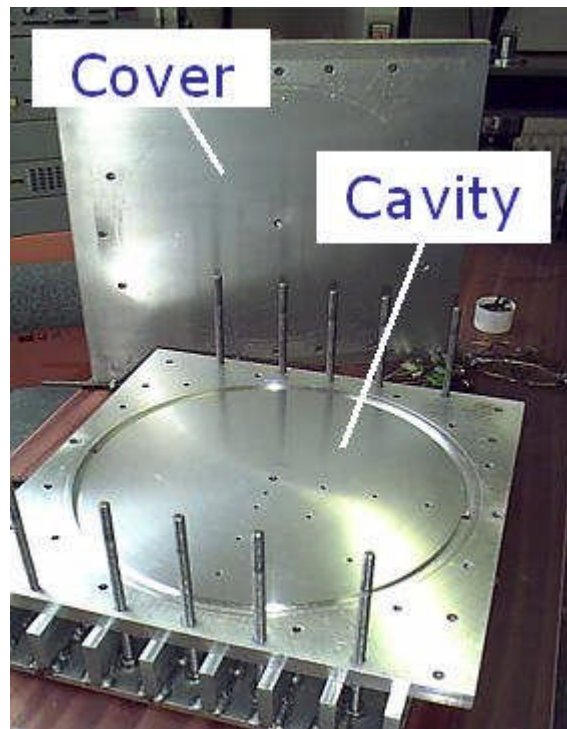
Process modelling

Liquid composite moulding

Flow simulation for liquid composite moulding – Darcy's Law:

$$\vec{u} = -\frac{1}{\mu}[K]\nabla P$$

In-plane K

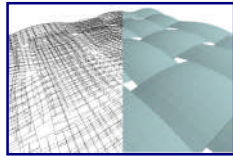


Through-thickness K



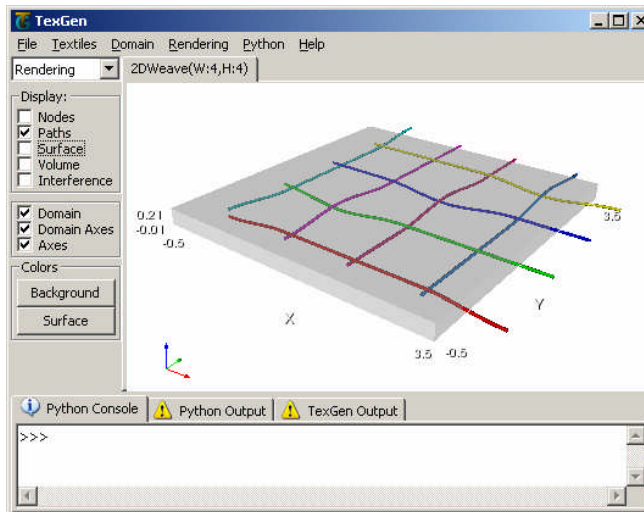


Textile Modelling

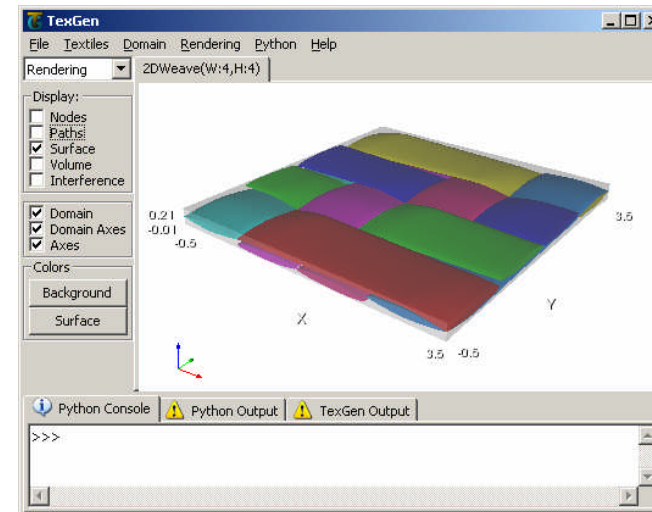


Textile composites

TexGen - textile modelling



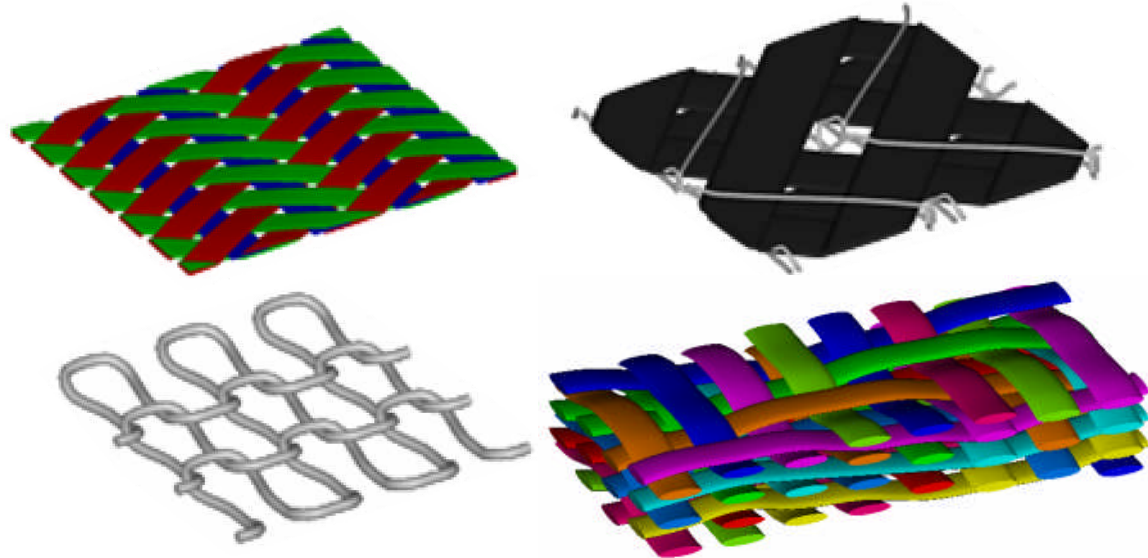
Interlacing pattern (splines)



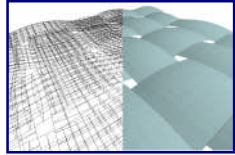
Superimposed tow sections

Key features:

- Interference detection/correction
- In-plane shear, statistical tow paths
- Export to several graphical/data formats
- Automatic specification of material orientations



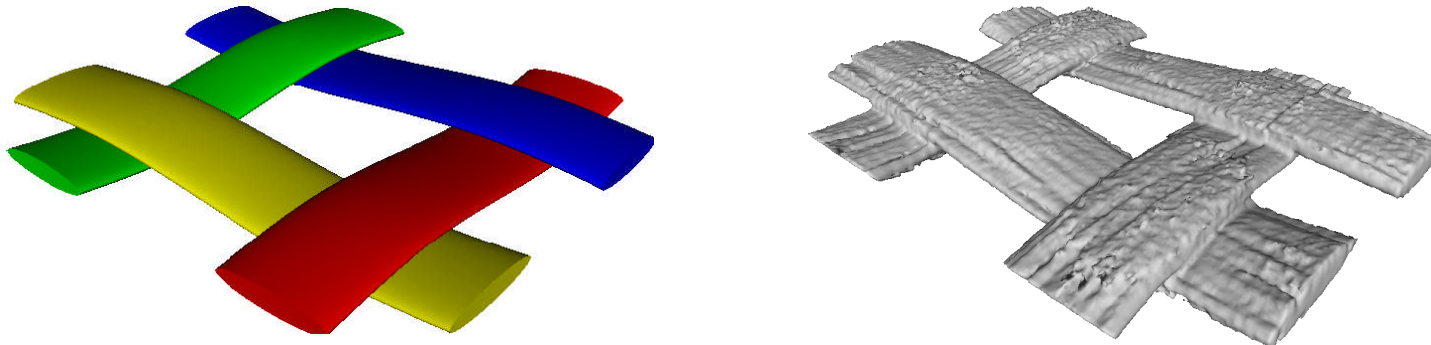
Textile composites



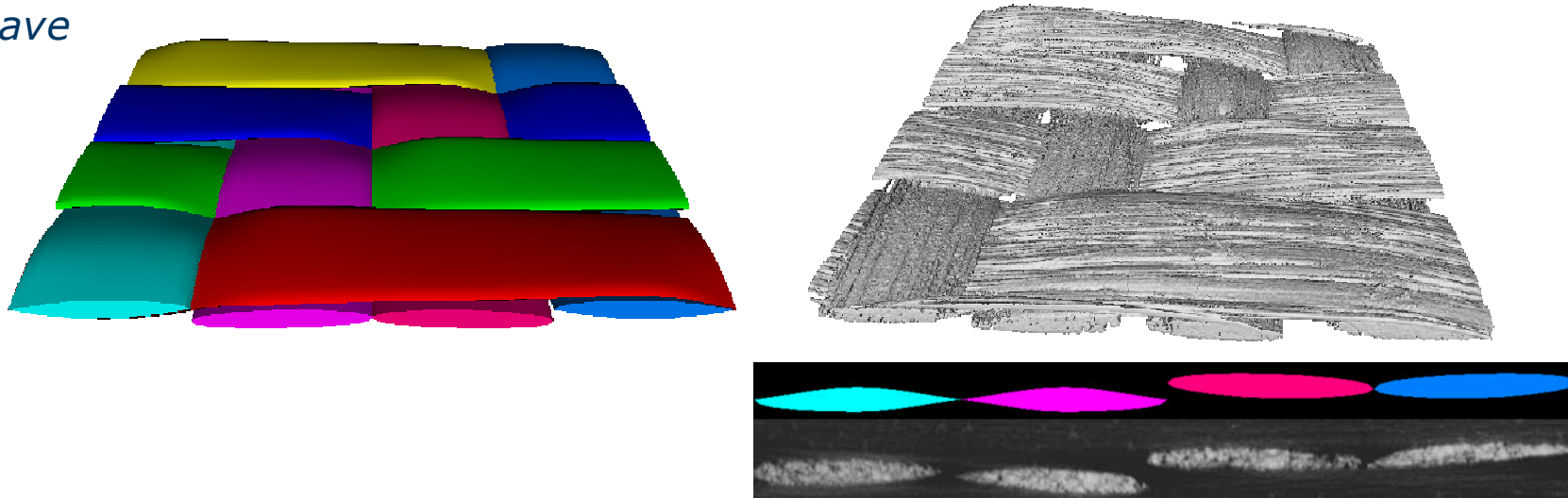
Textile composites

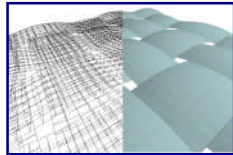
TexGen - textile modelling

TexGen model & micro-CT reconstruction of Chomarat 150TB plain weave



TexGen model & micro-CT reconstruction of Chomarat 800S4-F1 4 harness satin weave





TexGen

Open source – free code!



The University of
Nottingham

Main Page - TexGen - Microsoft Internet Explorer

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Address http://texgen.sourceforge.net/index.php/Main_Page Go

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Main Page

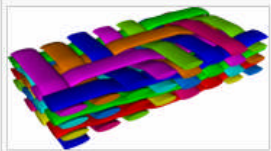
TexGen is open source software licensed under the General Public License developed at the University of Nottingham for modelling the geometry of textile structures. TexGen has been used by the Nottingham team as the basis of models for a variety of properties, including textile mechanics, permeability and composite mechanical behaviour.

A summary of our work involving TexGen can be found on the [TexGen Applications](#) page. Please also visit the [University of Nottingham Textile Composites Research](#) website for more details about our research group.

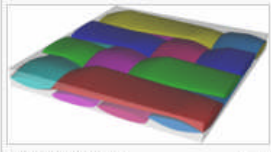
On this website you will find all the information necessary to get started with TexGen by using the sidebar for navigation.

Please leave a message on the [TexGen forum](#) if you find TexGen to be a useful tool. We are very interested to hear about research conducted with TexGen. The [forum](#) is also the place to ask questions, make comments and generally discuss about TexGen with other users.

Specific bug reports, feature requests and patches are always welcome and should be directed to the [sourceforge trackers](#).



3d woven fabric



2d woven fabric



Weft knit fabric

texgen

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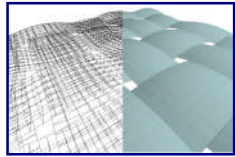
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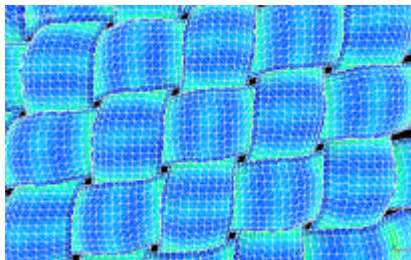
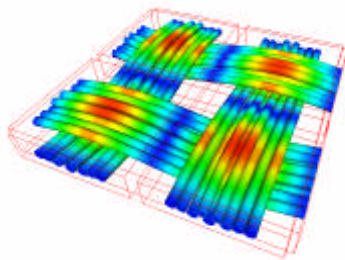
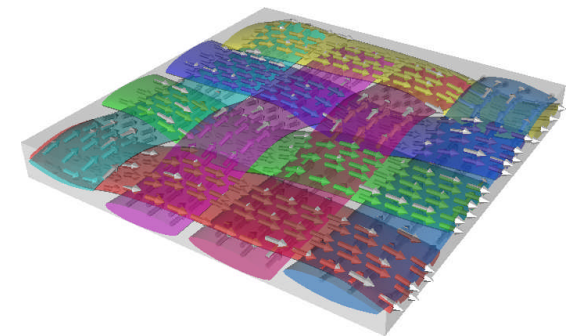
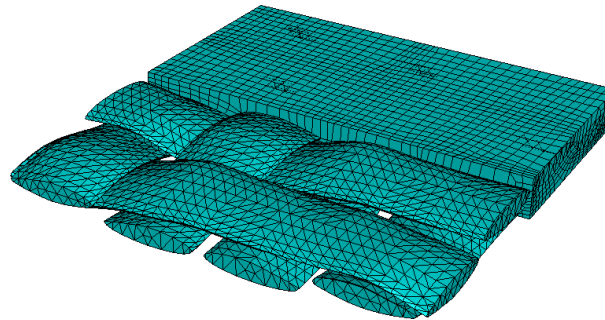
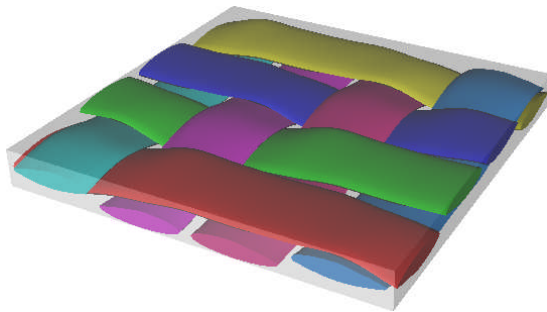
Textile composites

TexGen - textile modelling

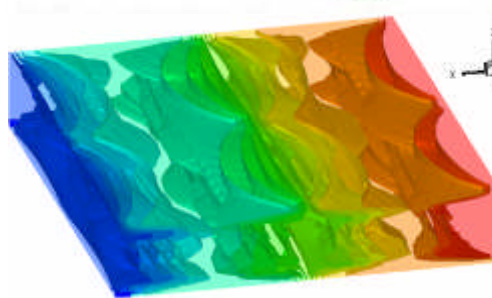
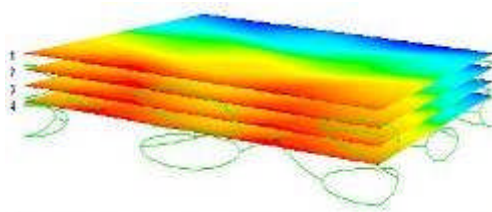
**1. Model created using
TexGen**

**2. Mesh generation
(third party software)**

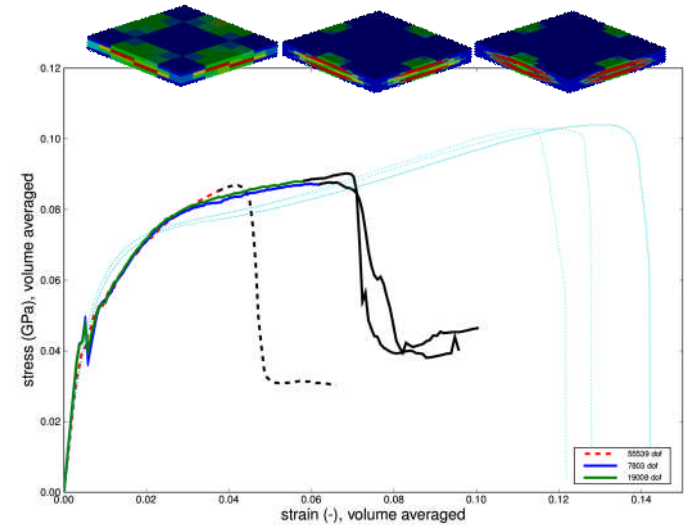
**3. Automatic material
property/ orientation
assignment**



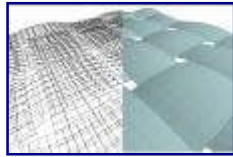
Dry fabric/prepreg compliance



*Resin flow/permeability
Textile composites*

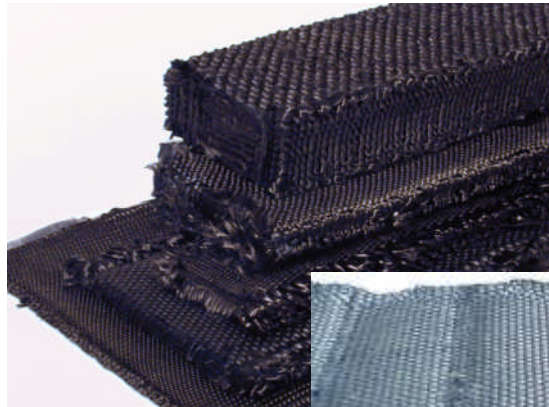


Composite mechanical properties



Textile composites

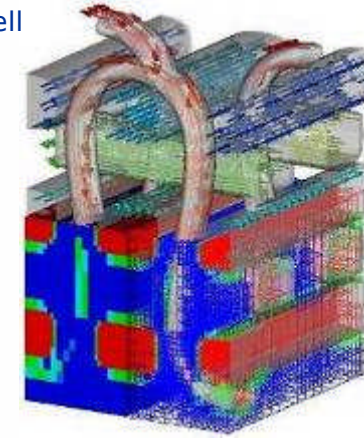
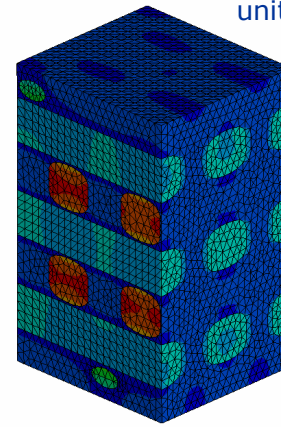
3D woven composites modelling



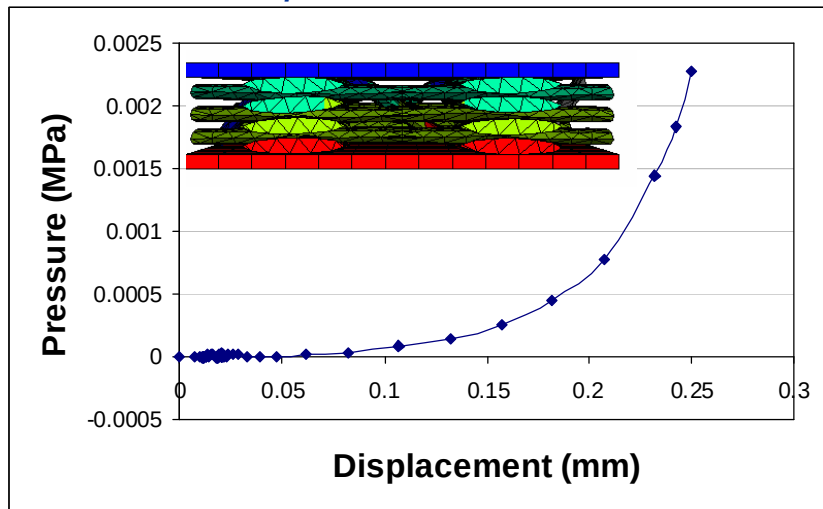
3D woven "thick" & complex shaped carbon preforms
3Tex Inc



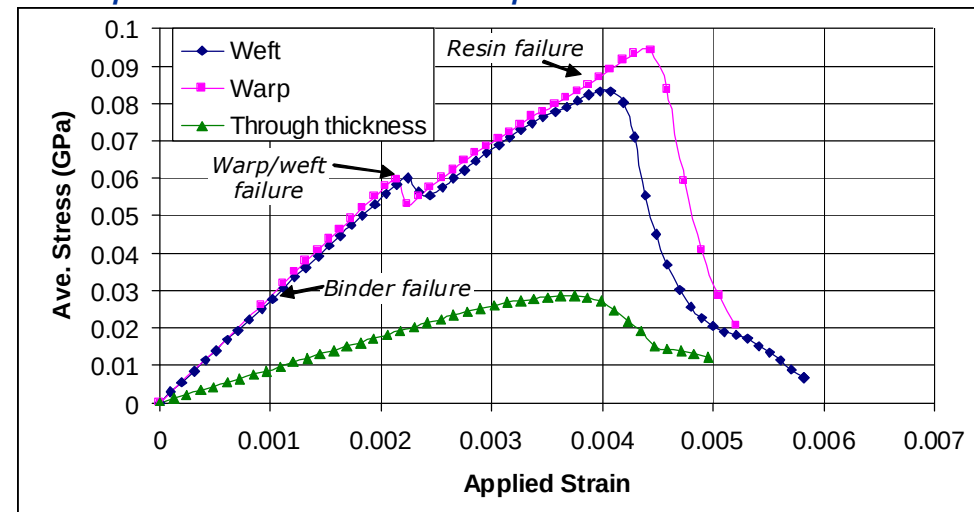
"TexGen" model of orthogonal weave unit cell

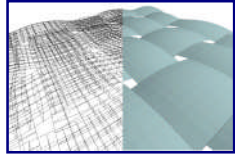


Preform compaction on mould closure



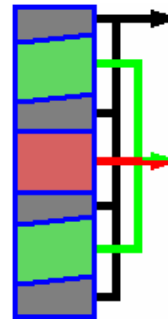
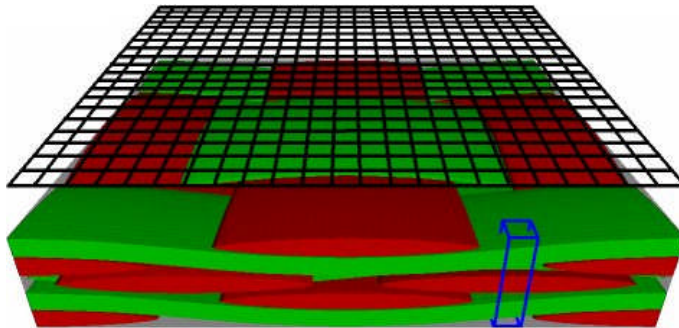
Composite mechanical performance





Textile composites

Permeability modelling – “Grid Average”



$$K_{free} = h_m^2 / 12$$

$$K_{porous}$$

Element permeability:

$$\bar{K}_{ij} = \frac{1}{H} \sum_m h_m K_{ijm}$$

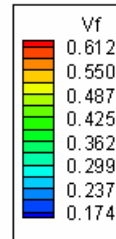
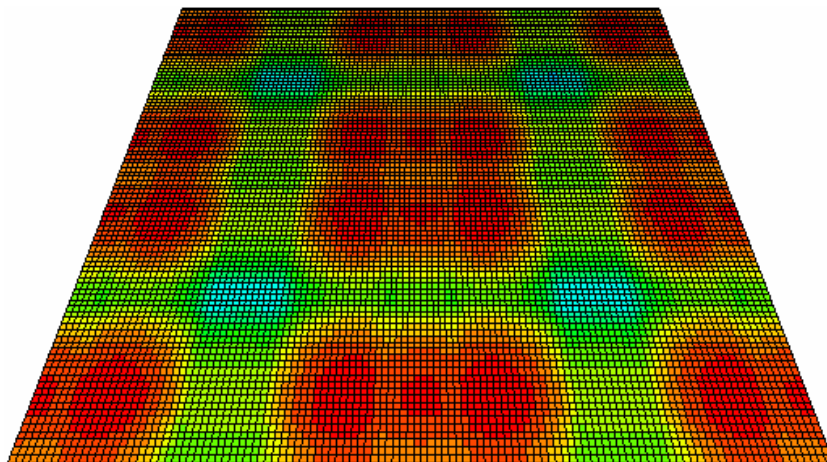
Tow permeabilities – Gebart model:

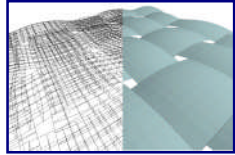
$$k_1 = \frac{8r^2}{c_1} \frac{(1 - V_f)^3}{V_f^2} \quad k_2 = c_2 \left(\sqrt{\frac{V_\infty}{V_f} - 1} \right)^{5/2} r^2$$

Governing equation:

$$\frac{\partial}{\partial x} \left(F_{xx} \frac{\partial P}{\partial x} \right) + \frac{\partial}{\partial x} \left(F_{xy} \frac{\partial P}{\partial y} \right) + \frac{\partial}{\partial y} \left(F_{yx} \frac{\partial P}{\partial x} \right) + \frac{\partial}{\partial y} \left(F_{yy} \frac{\partial P}{\partial y} \right) = 0$$

$$\text{where } F_{ab} = \frac{K_{ab}}{\mu}$$





Textile composites

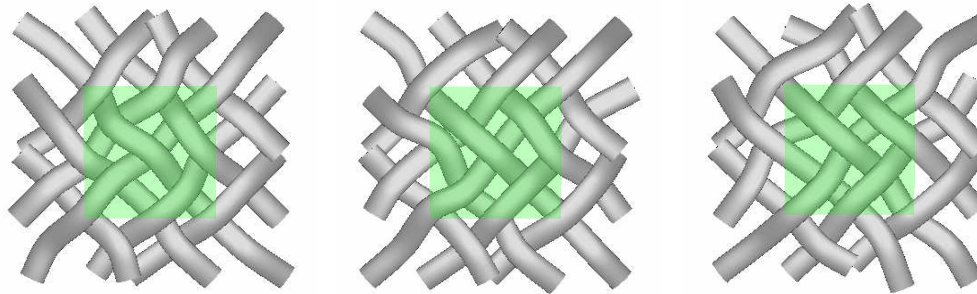
Permeability modelling – “Grid Average”



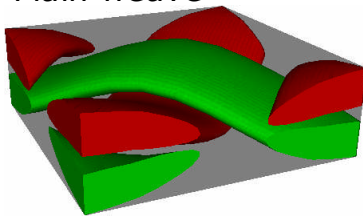
The University of
Nottingham

Monte Carlo method:

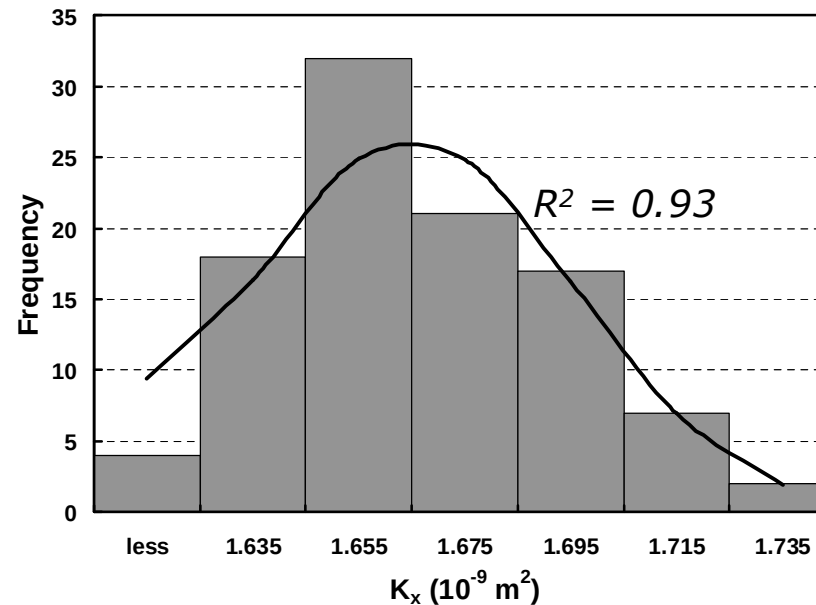
- yarn crossovers displaced “randomly” along global x and y axes
- movement follows a Normal distribution with user-specified standard deviation



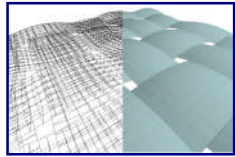
Plain weave



Tow displacement
s.d. = 8.7%



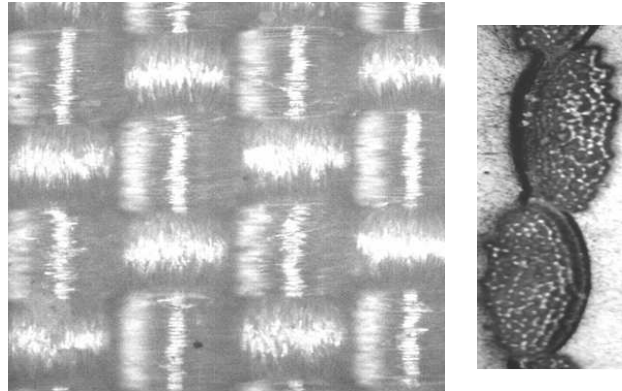
Textile composites



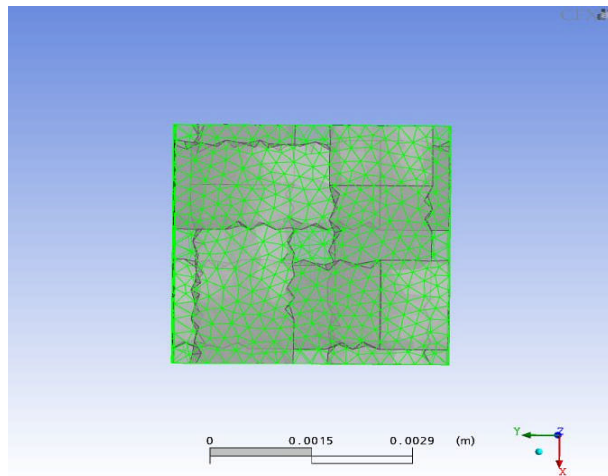
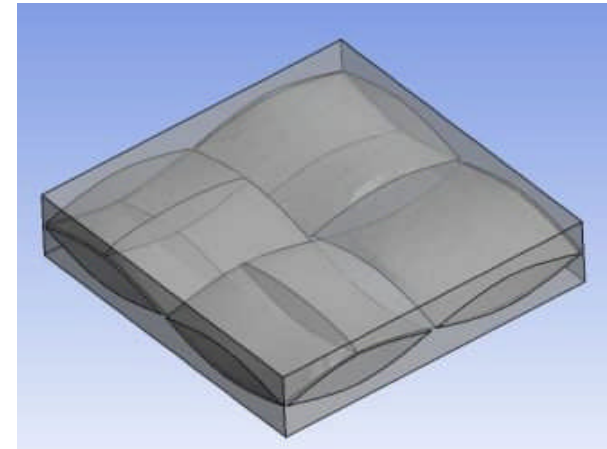
Textile composites

Permeability modelling – CFD

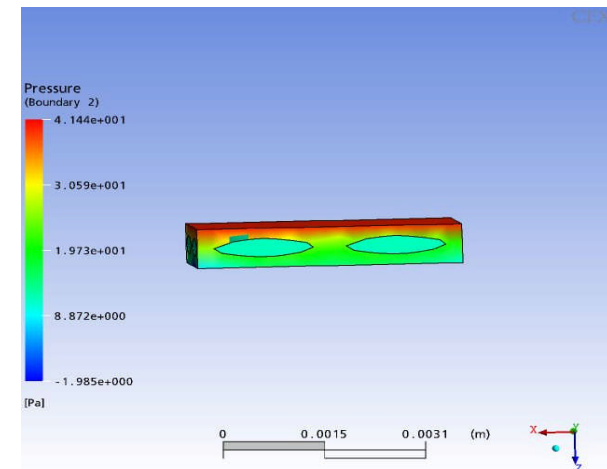
Plain weave nylon 6.6 airbag fabric



Geometric model



Discretised model (CFX)



Pressure field for through-thickness flow

Textiles & Composites - Sponsors/collaborators:

Engineering & Physical Sciences Research Council

Department of Trade & Industry

Advanced Composites Group

BAE Systems

Carr Reinforcements

Dowty Propellers

FEA Ltd

Granta Design

Katholieke Universiteit Leuven

MIRA

QinetiQ Ltd

Saint-Gobain Vetrotex

Toho Tenax

University of Cranfield

University of Manchester

University of Ulster

Airbus UK

Bentley Motors

Deepsea Engineering

ESI Software

Ford Motor Company

Hexcel Composites

Litec

MSC Software

Quadrant Plastics

Sigmatex

University of Bristol

University of Delaware

University of Ottawa

Uvasol

Aston Martin Lagonda

Bombardier Aerospace UK

Department for Transport

Euro-Projects

Formax UK Ltd

JR Technology

LTC Ltd

Pera

Rolls-Royce

Southfield Coachworks

University of Cambridge

University of Loughborough

University of Twente

VT Halmatic

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... Thank You