Analysis of Shape and Load-Displacement Response of Convertible Car Hoods.

A multidisciplinary project involving civil and mechanical engineering, optical measurement, and material testing. Poster presentation in the House of Commons, "Britain's Younger Engineers", 4th December 2000

University of Warwick Research Team:

Civil Engineering: Dr W.Lewis (project leader), L.W.Choong), S.Shire.
Mechanical Engineering: Dr A.Lucey, Dr C.Shaw, J.Knight.
Optical Engineering: Prof. P.Bryanston-Cross.

Industrial Collaborator: Jaguar Cars, A.Thomas, Dr. M. Richardson.

Project Objectives:

Development of a computer-aided design methodology is required to complement/ eliminate expensive prototyping methods, with the emphasis on:

•Production of an appropriate cutting pattern to avoid differential stressing of fabric, which affects the durability of the hood.

•Prediction of the effect of aerodynamic loading on the shape of hood and stress pattern, particularly for the newly designed hoods.

•Inclusion of:
-tolerances in the frame/ padding manufacture of the composite hood.
-uncertainties associated with material properties.

Double layer ‘composite’ hoods (with padding between the inner and outer layers of fabric).

•Shape is pre-determined by designers. Stress field is found by computation involving iterative methods and making use of non-linear material properties.

•Load-displacement response to aerodynamic loading is found by fluid-structure interaction involving coupling between the structural solver and fluid dynamic simulations.

•Successful experimental work on small-scale models was carried out to test the methodology and involved optical measurement.

•Resultant forces on the supporting structures, i.e. the padding and the hood frame, are provided.

•Work on the cutting pattern completes the progress.

Structural Analysis:

Single layer hoods, **‘rag-tops’.**

•The novel design methodology uses the principle of a minimal surface to calculate the shape.

•The calculated shape is consistent with a constant tension field (as found in natural structures such as soap films) -a desirable feature from the point of view of durability.

•Anisotropic material properties are to be taken into account to provide a cutting pattern for the fabric.

A soap film will naturally form a minimal surface. Such surfaces use a minimum amount of material and have a constant value of surface tension.

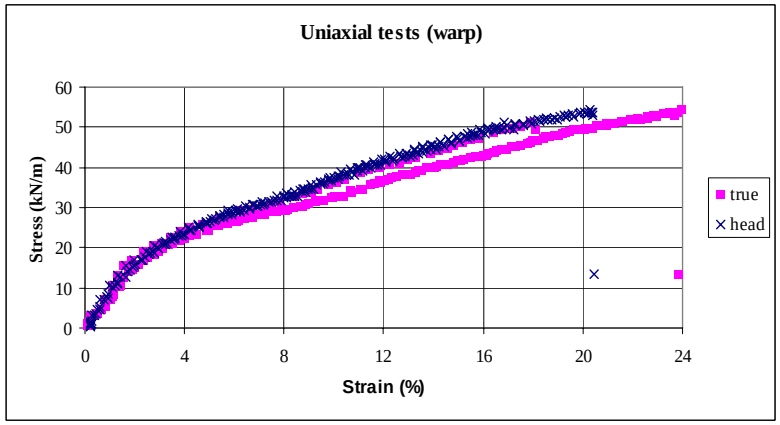
Materials testing:

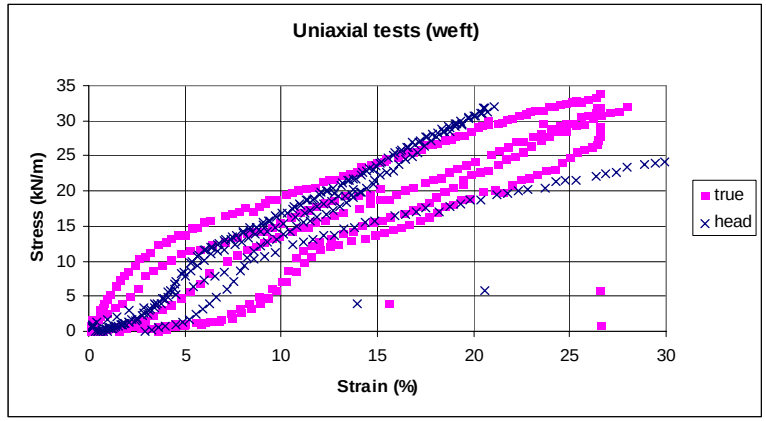
Results are shown for 5 uniaxial tests and 4 biaxial tests in warp and weft directions respectively

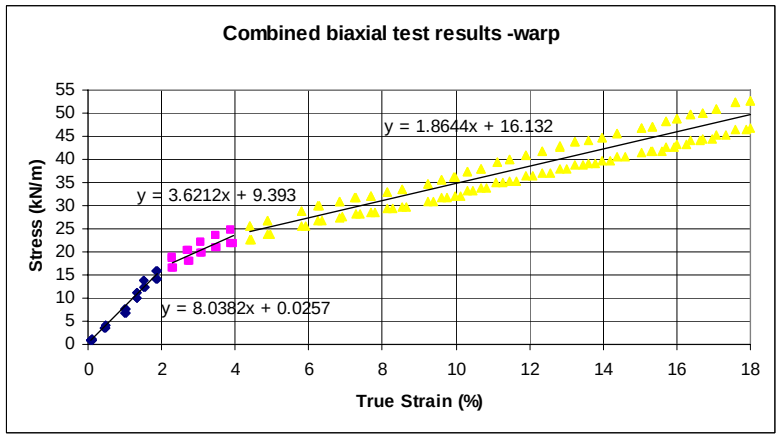
•The graphs show highly anisotropic and non-linear fabric properties which needed to be established from tests.

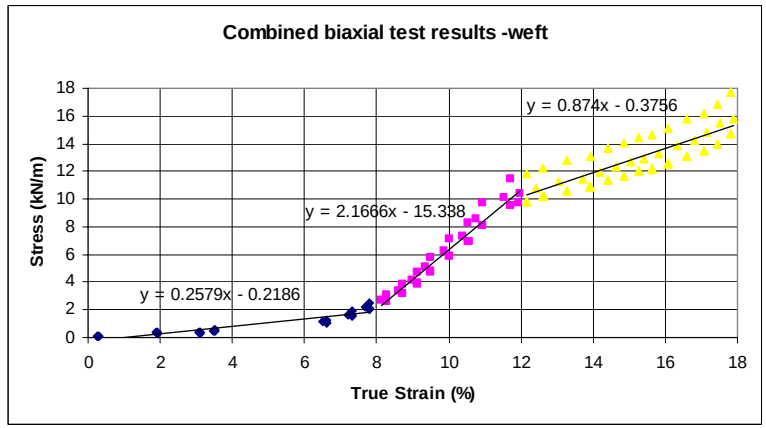
•Properties vary significantly from one sample to another.

•The knowledge of material properties is essential in determining the best cutting pattern for the hood fabric.









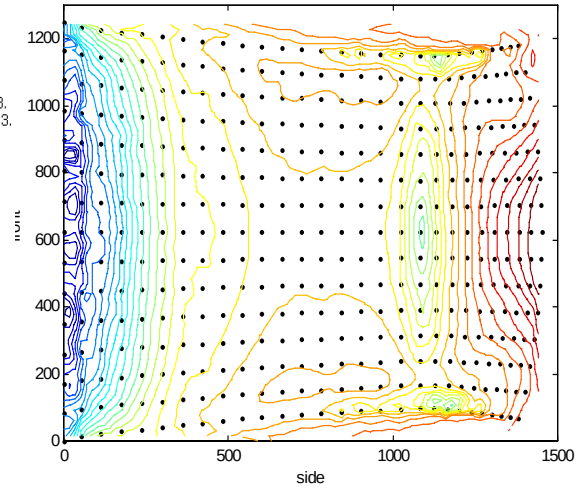
Fluid Dynamics Modelling:

•Predicts aerodynamic loading on the hood.

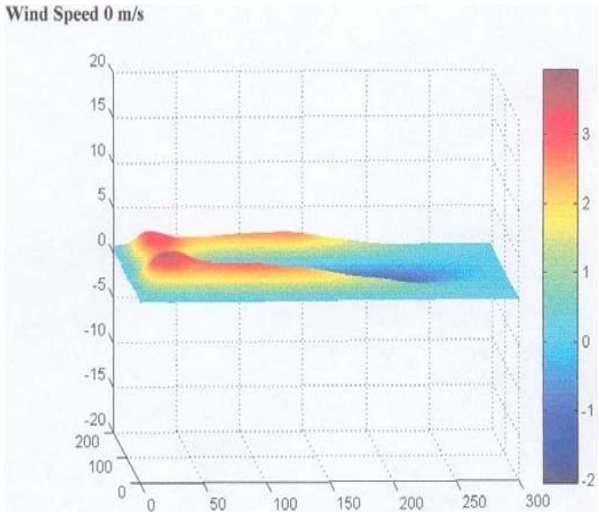
•Pressures generated from 3D modelling are used to determine the forces acting on the hood and displacements.

Initial prediction of pressure field in the centre-line plane for turbulent flow over

the passenger compartment of the car.



Computed contours of pressure over the hood

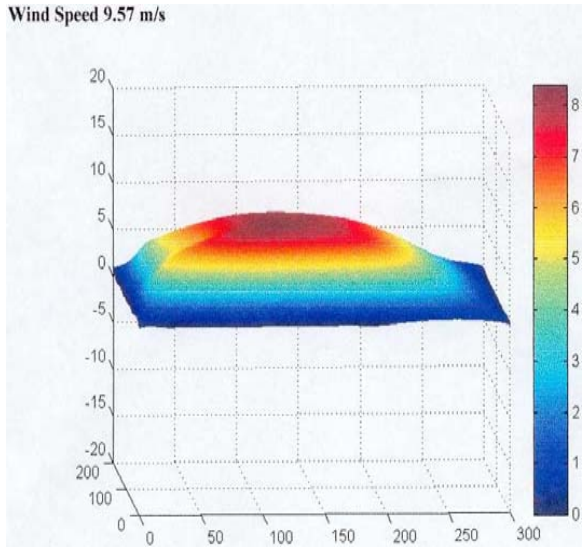


Optical measurement -flat roof model:

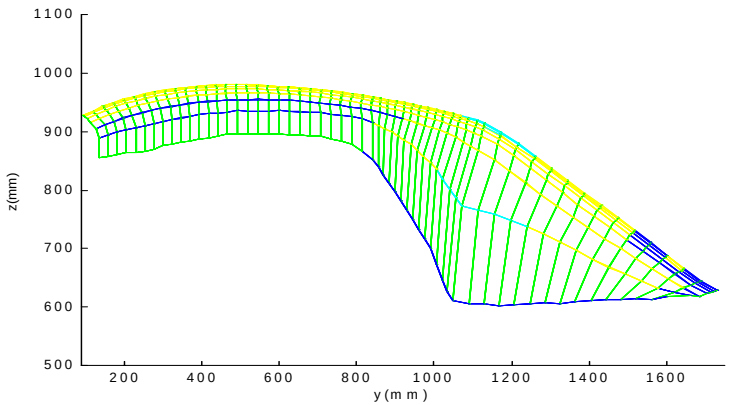
•Used to test the methodology adopted, using a small scale physical model in a wind tunnel.

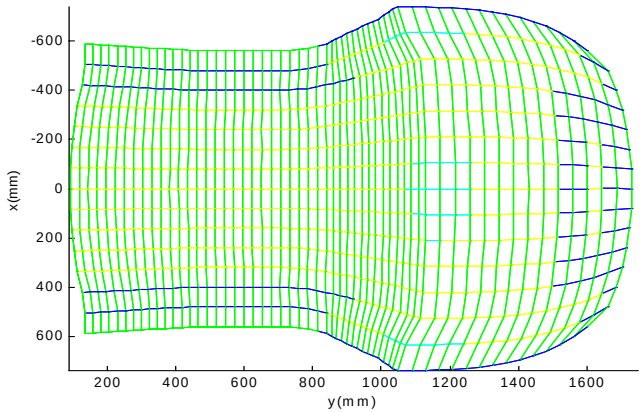
•Measurement of the displacement of the membrane was made at several wind speeds using Infra-red proximity probes.

•Plots show the initial shape of the membrane (with zero pretension), and its deformed shape at a wind speed of 9.57m/s.



Tensions in fabric under wind loading:
warp-weft alignment





Displacement of hood fabric under aerodynamic loading: