

Coping with tension and stress at work – we all have to do it but for Wanda Lewis of the School of Engineering it is at the heart of her research interests. She studies ‘tension structures’ which go with the flow and properties of the building materials rather than forcing them to assume a shape against their ‘will’.

engineering under tension

Wanda’s work involves a ‘form finding’ process where the material is permitted to relax to its minimum energy shape. Consider a soap film suspended between a curved boundary made of thread, or cable, attached to several poles of different height. Such a surface assumes a shape where all the tensions are minimised (see below – top).

Minimising energy

‘I believe that nature’s design principles cannot be matched by conventional engineering design,’ says Dr Lewis. ‘When you minimise the energy in a structure you optimise other desirable qualities like strength to weight ratio.’

You needn’t look far to see this minimal energy approach. Trees grow into a structure that follows a minimal energy form and are able to withstand the varying loads imposed upon them by wind and snow. When their wounds heal, they follow a minimal energy form such that the healed wound has a minimum surface area and is as strong as the surrounding material. You can also use these principles when designing structures with non-living materials.

Gaudi’s inspiration

Picture if you can, climbing a tall ladder in a school gymnasium and drawing a circle on the ceiling of a certain diameter. Then hang chains of varying, or equal length at some intervals around it, with both ends of the chain on a perimeter of the circle. Attach small loads at mid-point of each chain, stand back and wait until the chains come completely to rest. They then assume their new minimal energy shape. It is this shape that inspired Gaudi when he designed the spires of the magnificent cathedral in Barcelona (turn the picture, bottom right, upside down and see if it makes any sense!).

Membranes

Rather than chains, it is how membranes take their

minimum energy shape that interests Dr Lewis. She develops computer models to predict their shape and behaviour under loads from wind or water (see below – left). It is one thing to understand the mathematics of an ideal tension material like soap film, but it is much more challenging to understand how different fabrics and other materials behave. Once we are able to predict how they behave, we will be able to design tension membranes for lightweight roofs for sporting stadia and other applications. A big challenge is the cutting pattern to use for these designs. How to reduce a 3-D form to a bolt of material on a 2-D cutting table is very demanding if the resulting tension structure is to have no wrinkles or develop tears. This opens up opportunities for creating lightweight, visually attractive roof structures and even hoods for convertible cars.

