**STRENGTH OF MATERIALS**

To think clearly about materials from a mechanical point of view, it is vital to distinguish between stress, strain, strength, stiffness, and toughness.

Stress is defined as load per unit area, measured in meganewtons per square metre.

Strain is the ratio of the change of length to the original length of a material under stress.

For a given material, the ratio of stress to strain is known as Young's modulus of elasticity. This measures its stiffness, or resistance to bending. This is not the same as the strength of a material, which is the stress needed to break it.

An elastic material under stress contains strain energy, calculated per unit of volume by halving the product of the stress and the strain.

The resilience of a material or structure is the amount of strain energy it can hold without being permanently damaged.

The toughness or fracture energy of a material is the amount of energy (not stress) required to break a given cross-section of it. This is not the same as the tensile strength.

The main variables behind fractures of tensed materials are the fracture energy, the strain energy available, and the size and shape of the worst crack in the material. The energy needed to fracture wrought iron may be a million times greater than that needed to break an equal cross-section of glass, even though the respective tensile strengths are fairly similar.

"It is the relative importance of the need for strength and for stiffness which really lies at the root of the question of the cost and [efficiency](http://www.nous.org.uk/efficiency.html) of structures." [Gordon](http://www.nous.org.uk/Gordon2.html) (1978, p.133)