Properties used to define materials

Selecting the correct material to use in a structure requires an understanding of a materials suitability for different purposes. This involves considering the properties of a material which describe how it behaves under certain types of loading. The main properties that a structural engineer must consider include:

Strength
Strength is the ability of a material to withstand an applied loading without deforming. The greater the loading it can resist, the greater the strength of the material. This strength can be classified further as compressive, tensile or shear. A material can have a high tensile strength whilst also having a low compressive strength, for example mild steel. The reverse can also be true, such as with concrete, which is strong in compression but weak in tension. For this reason, concrete beams are often reinforced with mild steel bars to increase the tensile strength of the beam.

Elasticity
Elasticity is the ability of a material to return to its original form after an applied loading has been removed. A material will deform elastically as the applied loading is increased until its elastic limit is reached. The greater the value of this elastic limit, the greater the elasticity of the material. This behavior is important as most engineering applications require materials to act within their elastic limit. For example, a crane cable must be able to lift a load without being extended beyond its elastic limit as this would result in permanent damage of the cable and eventually lead to failure.

Plasticity
Plasticity is the ability of a material to remain deformed after an applied loading has been removed. Plastic deformation occurs when the applied loading has caused the material to exceed the elastic limit. This behavior is utilised in the ‘crumple zone’ at the extreme front and rear of a car which is designed to plasticly deform in the event of a collision to help absorb the impact.

Ductility
Ductility is the ability of a material to plastically deform under tensile loading without fracturing. The greater the loading sustained during plastic deformation before failure occurs, the greater the ductility of the material. This behaviour plays an important role in the safety of structures in the event of an accident or overloading by allowing it to deform rather than suddenly fail. For example, if a cable made from a ductile material on a suspension bridge was overloaded and began to plastically deform, it would be permanently stretched but would still retain some of its strength preventing the structure from failing.

Brittleness
Brittleness is the ability of a material to fail without any plastic deformation under an applied loading.

Malleability
Malleability is the ability of a material to plastically deform under compressive loading without fracturing. The greater the loading sustained during plastic deformation before failure occurs, the greater the ductility of the material.