10 Viscoelasticity

The Linear Elastic Solid has been the main material model analysed in this book thus far. It has a long history and is still the most widely used model in applications today.

Viscoelasticity is the study of materials which have a **time-dependence**. Vicat, a French engineer from the Department of Road Construction, noticed in the 1830's that bridge-cables continued to elongate over time even though under constant load, a viscoelastic phenomenon known as **creep**. Many other investigators, such as Weber and Boltzmann, studied viscoelasticity throughout the nineteenth century, but the real driving force for its study came later – the increased demand for power and the associated demand for materials which would stand up to temperatures and pressures that went beyond previous experience. By then it had been recognised that significant creep occurred in metals at high temperatures. The theory developed further with the emergence of synthetic polymer plastics, which exhibit strong viscoelastic properties. The study of viscoelasticity is also important in Biomechanics, since many biomaterials respond viscoelastically, for example, heart tissue, muscle tissue and cartilage.

Viscoelastic materials are defined in section 10.1 and some everyday viscoelastic materials and phenomena are discussed in section 10.2. The basic mechanical models of viscoelasticity, the Maxwell and Kelvin models, are introduced in section 10.3, as is the general differential equation form of the linear viscoelastic law. The hereditary integral form of the constitutive equation is discussed in section 10.4 and it is shown how the Laplace transform can be used to solve linear viscoelastic problems in section 10.5. In section 10.6, dynamic loading, impact and vibrations of viscoelastic materials are considered. Finally, in the last section, temperature effects are briefly discussed, including the important concept of thermorheologically simple materials.