
J. Tinsley Oden


D. R. J. Owen


Pierre Arnaud Raviart


Robert L. Taylor

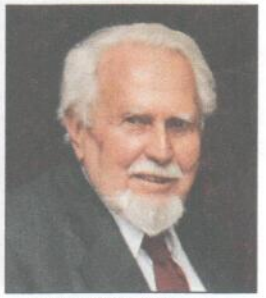
Olgierd C. Zienkiewicz

Figure 1.7 (*continued*)

Early publications in the engineering literature describing what is now known as the finite element method were Argyris and Kelsey, 1960, which is a collection of articles by those authors dating from 1954 and 1955, and Turner *et al.*, 1956. The term "finite elements" was coined by Clough, 1960. However, the first finite element, the linear triangle, can be traced all the way back to Courant, 1943. It is perhaps the simplest element and is still widely used today. It is interesting to note that the engineering finite element literature was unaware of this reference until sometime in the late 1960s by which time the essential features of the finite element method were well established. The linear tetrahedron appeared in Gallagher *et al.*, 1962. Through the use of triangular and tetrahedral coordinates (*i.e.*, barycentric coordinates) and the Pascal triangle and tetrahedron, it became a simple matter to generate C^0-continuous finite elements for straight-edged triangles and flat-surfaced tetrahedra. The bilinear quadrilateral was developed by Taig, 1961, and it presaged the development of ***isoparametric elements*** (Irons, 1966; Zienkiewicz and Cheung, 1968), perhaps the most important concept in the history of element technology.

The idea of isoparametric elements immediately generalized elements which could be developed on a regular parent domain, such as a square, or a cube, to an element which could take on a smoothly curved shape in physical space. Furthermore, it was applicable to any element topology, including triangles, tetrahedra, etc. An essential feature was that the spaces so constructed satisfied basic mathematical convergence criteria, as well as physical attributes in problems of mechanics, namely, the ability to represent all affine motions (*i.e.*, rigid translations and rotations, uniform stretchings and shearings) exactly. Curved quadrilateral and