CHAPTER 7

CABLE NETS AND FABRIC STRUCTURES

7.1 Introduction

This chapter is something of a digression from the other chapters of this text which are concerned strictly with the analysis of specific types of structures. Here the concern is with how cable nets and fabric structures are designed. This in turn raises the question of how shape is to be determined which in turn returns to the question of the application of some methods of nonlinear analysis. But no new analysis topics are introduced in this chapter.

In the material which follows there will not always be a clear distinction made between cable nets and fabric structures. Obviously, they are physically quite similar but the matter goes deeper than this. The most simple model of a piece of fabric is one with fibers running in two directions (a cable net). Arguments against this model usually revolve around the fact that a cable net can not transmit shear. The counter argument is of course that fabric is not good at transmitting shear anyway and that the cable net model of fabric is physically intuitive and simple. The simple cable net also does not model to warp/woof load interchange found in a piece of fabric when originally straight fibers become deformed under biaxial load (Stubbs and Fluss, 1979).

The design of cable nets and fabric structures can be described in terms of three events: shape finding, analysis, and patterning. In the process of shape finding, the designer specifies a set of parameters and then computes other parameters finally resolving the details of the shape of the structure. Under analysis, loads are applied to a structure whose shape is known and the response to these loads computed. Patterning is concerned with how a curved surface is to be formed from rolls of fabric.

This chapter is first concerned with the process of finding the details of the shape of a structure and later with how a structure is to be patterned. It is argued that methods of analysis have already been discussed in earlier chapters. Finally, only occasional references will be provided below as part of the text. The more ambitious reader may wish to consult the excellent book of Leonard (1988) on tension structures.
7.2 Basic Methods of Shape Finding

The process of shape finding can be thought of roughly in terms of stretching fabric over a frame of arbitrary shape. (For example, in the skylight problem of Figure 7.1, the geometry is fixed along both crossed arches and the base.) Clearly the fabric must follow the frame at the boundaries and certain tensions can be specified on these boundaries. But just as clearly, the locations of the fabric points within the frame must be determined from the equations of equilibrium and in some cases the material parameters. Finding the locations of these internal points is the process of shape finding.

In the early days (Frei Otto, 1973) and in the absence of the computer, physical models were commonly used in the design of fabric structures and cable nets. It is now conventional wisdom that small scale models are not sufficiently accurate either for the prediction of forces or the patterning of the fabric. In the following some computer based approaches which have been used to find shape are discussed.

![Figure 7.1 Skylight example: crossed circular arches on structural frame.](image)

7.2.1 Deformed Shape

If you need to find a shape which is in equilibrium, this can be done by applying loads to, for example, a stretched elastic sheet and then using the deformed sheet or a scaled version of it as the shape. There is nothing wrong with doing so but care is required since loads applied to a sheet may introduce stress concentrations which may not be desired in the structure under design. The basic reference to this method is Argyris, et al. (1964).

Any computer program for nonlinear structural analysis can be used to achieve shape in this manner but it does not appear common to do so. Pertinent to this is the fact that the fabrics now commonly used in permanent structures can not tolerate large strains without tearing.