

Chapter 1: Introduction

1.1 Overview

The United States Army is considering the development of Large Area Night Maintenance Shelters (LANMaS). These tent-like structures will be used for many purposes including maintenance shelters, aircraft hangars, and medical stations. The LANMaS is to be large, lightweight, easily erected, and durable. One of the possible support structures being considered is the leaning arch. The leaning arch configuration has two arches that are tilted at a specified angle and then attached at the apex as illustrated in Figure 1.1. The leaning arch concept is an inherently stable system, particularly when compared to the alternative of a single arch in a vertical plane. In order to facilitate easy erection the support structure of the LANMaS is to be inflatable. Also, the support structure of the LANMaS is to be lightweight and will most likely be constructed of a thin, woven or braided fabric, with an internal bladder to hold the air within. The behavior of pressurized leaning arches is not fully understood; therefore, a detailed study of their behavior is justified.

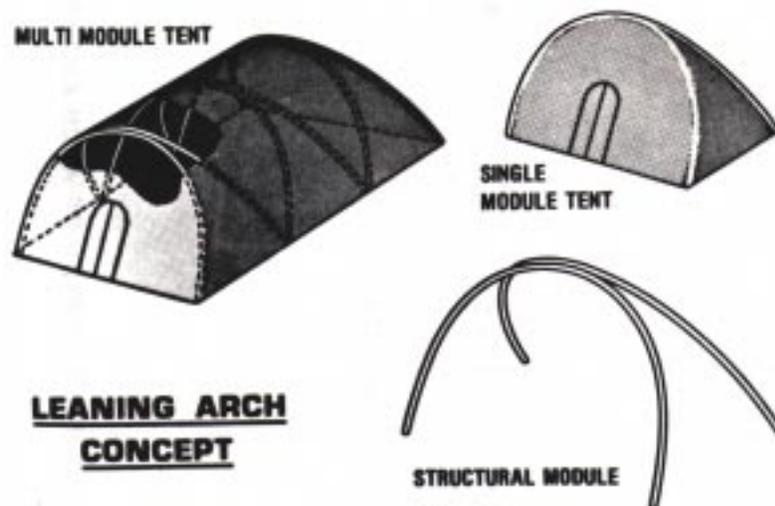


Figure 1.1 The leaning arch concept (Steeves, 1979)

1.2 Scope

This thesis considers a pair of pressurized, leaning arches subjected to a variety of loading conditions that are expected to act on the structure. A three-dimensional structure is considered using the finite element method. A numerical investigation is conducted using the finite element analysis software ABAQUS (Hibbitt, et al., 1995). Since deformation of the cross section is of concern, shell elements are used to model the fabric and bladder as a unit. Shell elements also allow the contact between the arches to be modeled easily. Because of the large deflections that are expected, geometric nonlinearity is taken into account during the analysis. An example of the finite element mesh used for the analysis is depicted in Figure 1.2.

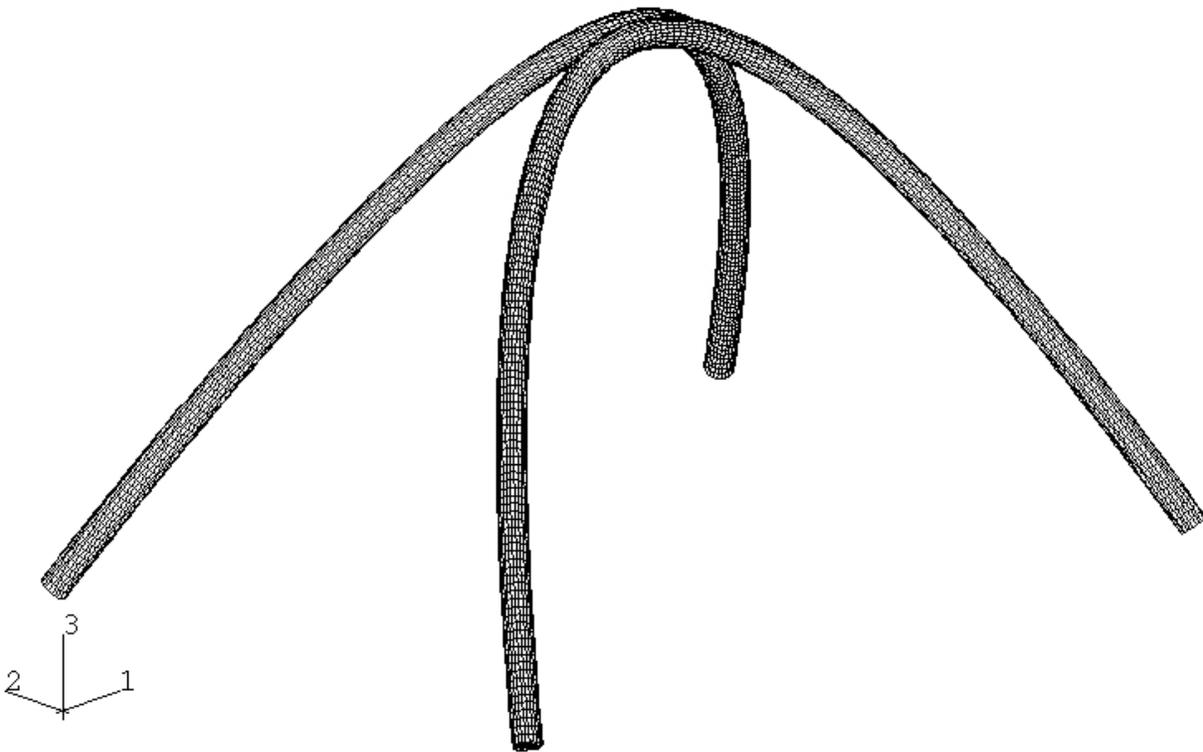


Figure 1.2 Finite element mesh used for analysis

The behavior of circular arches as well as circular leaning arches has been studied in the past. This thesis will consider arches which are parabolic in shape. Various tilt angles, or the angle between the vertical plane and the plane of the arch, are also considered so that the behavior of the structure can be analyzed in various configurations. Also of concern are the boundary conditions on the arches. Two conditions that are modeled in this thesis are fixed and pinned supports; however, it is expected that the actual structure will have some rigidity at the base, but it is not known how much. Therefore, both conditions were modeled so that a deeper understanding of the behavior of the system is achieved.

This thesis is organized in the following manner. First, the assumptions made for the analysis will be explained as well as a description of the analysis techniques and the configurations used for the analysis. Next, a single pressurized arch is considered. Finally, a pair of leaning arches is examined. For each analysis, the load-deflection and load-frequency relationships are determined. Vibration modes, buckling modes, and displaced shapes are presented as well.