Chapter 1

INTRODUCTION

Inflatable dams are flexible cylindrical structures attached to a rigid base. They were initially developed by N. M. Imbertson in the 1950s with the trade name of “Fabridam” and have been used worldwide extensively ever since (Imbertson, 1960). Since then, over two thousand such dams have been constructed in Japan, the United States, Thailand, and many other countries. A review of published work involving such dams is given in a paper by Hsieh and Plaut (1990), and additional publications include Mika (1981), Wakefield (1987), AbdulRazzak et al. (1988), Ross (1988, 1990), Kahl and Ruell (1989), Bolzon et al. (1990), Nelson (1992), Al-brahim (1994), Economides and Walker (1994), Markus et al. (1994, 1995), Dakshina Moorthy et al. (1995), Higgs (1996), Sehgal (1996), Wu and Plaut (1996), and Tam (1997).

These dams are basically cylindrical tubes, made of rubberized material, and inflated by air, water, or a combination of the two. Their heights range up to 6m and their lengths may reach 150m (but they can be connected in series to form as long a barrier as desired, with concrete piers separating the sections). The material thickness ranges from about 5mm to about 32mm. Present dams have a 30-40 year lifetime, according to manufacturers.

Inflatable dams have been utilized to divert water for irrigation (Tam, 1997) or groundwater recharging (Markus et al. 1994), impound water for recreational purposes, raise the height of existing dams, prevent beach erosion, control water flow for hydroelectric production (Sehgal, 1996), and mitigate flooding by allowing excess water to flow over the deflated dam (Tam, 1997). They have the potential to be used as temporary dikes or levees to protect buildings and metropolitan areas from flood waters.

Although many of these dams are permanently inflated, they have the advantage that they can be deflated and lie flat when not needed, and then inflated in a short period of time when required. They are relatively easy to install, do not corrode, require little maintenance, and have the capability to withstand extreme temperatures.

Early inflatable dams were anchored along two generators. The vibrations of such double-anchor dams were analyzed by Hsieh and Plaut (1990), Dakshina Moorthy et al. (1995), and Wu and Plaut (1996). The dam was filled with water, and external water was impounded on one side. A brief discussion on the earlier work on vibration analysis of inflatable dams can be found in Chapter 2.

Most of the inflatable dams are used for recreational purposes. These dams can also be used for flood control or to protect a critical facility. The dynamic behavior of these dams when impounding hydrostatic or parallel flowing water is investigated here. Most recently-built inflatable dams utilize a single-anchor system and have fins at the ends to facilitate smooth overflow. The dynamic behavior of single-anchor dams with fins has not be studied previously, and hence such a model is used in this investigation.

In a common type of construction, a thick sheet of reinforced rubber is slit into two sheets of half the thickness, except for a strip near one edge. Then the top and bottom sheets at the opposite edge are clamped to the foundation, and the side edges are sealed. Air is pumped between the two sheets, and the upper sheet and part of the lower sheet raise off the foundation. The raised edge that was not slit looks like a fin, as shown in the profile in Figure 1.1.

The inflated dam is modeled as a shell in this study. The finite element method is used to analyze the structure (i.e, the dam), while the boundary element method is used to analyze the fluid-structure interaction. Vibrations of shells in contact with external water have been investigated extensively for other geometrical configurations (e.g., cylindrical and spherical shells). Weingarten et al. (1973), Ross (1990), and Ergin et al. (1992) are a few of those works. Papers utilizing the finite element method for the structure and the boundary element method for the fluid include Giordano and Koopmann (1995) and Hamamoto et al. (1996) and others listed in a paper by Beskos (1997).

The material in this thesis is organized as follows. Chapter 2 involves the review of previous research on inflatable dams. Chapters 3 and 4 deal with the static and dynamic analyses of the single-anchor dam. The conclusions and suggestions for further research are given in Chapter 5. Appendix A discusses the finite element analysis procedures used, in the finite element software ABAQUS, to the model the dam. Appendix B briefly discusses the panel method used to solve the fluid-structure interaction problem. The figures and tables are at the end of each chapter.

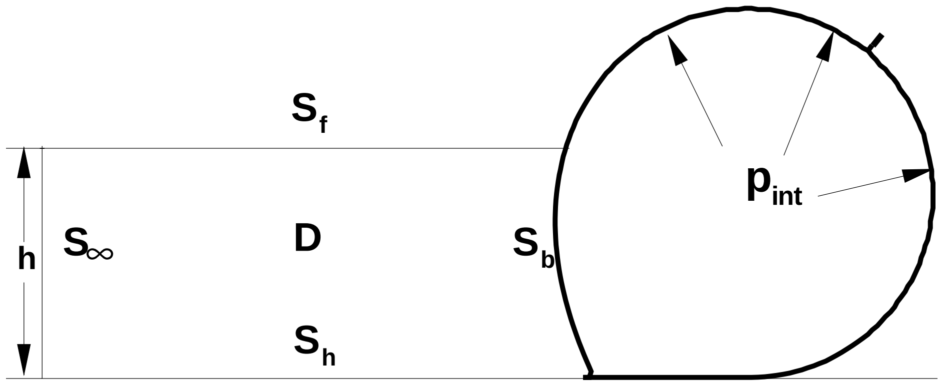

Figure 1.1 Cross section of inflatable dam impounding water.