# CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

For a moored cylindrical breakwater that is modeled as a rigid body made up of flat, quadrilateral panels and filled with air, a three-dimensional analysis was used to find the structure's effectiveness in reducing the amplitude of incident waves as they pass over the structure. For one cylinder, normal and oblique waves were considered for a range of wave frequencies. In addition, two special cases (gaps) were considered for two breakwaters in series and the analysis included both normal and oblique waves at the wet natural frequency of one cylinder.

A boundary integral method was used to solve the integral equations that defined the external fluid flow. The fluid (ocean water) was assumed to be inviscid and incompressible.

First, the structure was analyzed in air to find natural frequencies and mode shapes. It was concluded that given the structure's large net buoyant force in water (which was applied to the structure in air), the mooring lines remain extremely taut during small motion. Hence, massless mooring lines of linear stiffness were deemed adequate for modeling the system's stiffness. The structure was then analyzed in still water to find wet natural frequencies and wet mode shapes. It was found that the presence of water greatly decreased the natural frequencies and also changed both the order of the associated mode shapes and the relative amplitudes making up each mode.

Many conclusions were made about the effectiveness of a moored cylinder of finite length. For the "standard case" breakwater (9.144 m length, 1.52 m radius) considered, it was found that the structure can be effective over a large bandwidth of frequencies for incident wave angles of 0° and 15°. The most effective cases for incident wave angles of 0°, 15°, and 30° were found to be at a wave frequency of 2.05 rad/s, 18.5 rad/s, and 1.25 rad/s, respectively. For all three incident angles considered, the breakwater was found effective in reducing over 50% of the incident wave amplitude in some cases. The only major cause of concern is that seemingly, at large incident angles, the waves can pass around the breakwater and actually become amplified after they are some distance past the structure.

It was found that if two cylinders are used in series, they can very effectively model one longer cylinder if they are placed close enough together (small gap). The analysis also revealed that if the cylinders are placed too far apart, they act independently and the waves can actually pass between the structures. This is not a good result if part of what is being protected is directly behind the gap.

Several topics should still be considered in future research. For the same structure, nonlinear theories for both water waves and mooring lines could be used. With nonlinear motion, large motions are possible and the mooring lines could go slack and provide zero stiffness during these times.

Parametric studies should also be done to find the optimal dimensions of the breakwater and mooring lines so that the most practical structure can be used. The breakwater can be partially filled with water so that the sloshing of this water can actually dissipate some of the energy in the incident waves. Finally, the structure should be considered as a flexible body to see if these new degrees of freedom could help create waves that would tend to cancel out the incident waves.