CHAPTER 1 INTRODUCTION

1.1 Background

With a steadily increasing demand for gas in the urban areas of many countries, the distribution capacity of liquid natural gas (LNG) plants in coastal areas to inland consumers through existing pipelines is expected to reach its limit in the near future. To balance the supply of natural gas with the variations in consumption within an area, such as seasonal fluctuations, short-term adjustment (weekly and daily), and peak winter demand, large agglomerations worldwide are planning to increase the storage capacity of LNG. A Lined Rock Cavern (LRC) system with Compressed Gas Energy Storage (CGES), which could contribute to a more efficient management of local and regional supplies of natural gas (Anderson, 1989) is proposed to enhance the efficiency of the existing infrastructures and reduce the need for large additional investments. Although compressed gas has a lower density than LNG and therefore requires more geometric volume to store the same mass of gas, preliminary cost-benefit assessments indicate that CGES in large rock cavities would be more advantageous than LNG tanks on the ground surface or buried just under the surface (Tengborg, 1989). Additionally, the temperature in the rock caverns can be kept over 0˚C, and environmental aspects favor the rock chamber solution because of the very modest land use compared to the LNG tanks.

The principal idea behind the LRC storage concept is to rely on rock mass to serve as a pressure chamber for containing stored natural gas at maximum pressures approximately between 9 and 20 MPa (Larsson et al., 1989). The concept involves the excavation of relatively large, vertically cylindrical caverns 20–50 m in diameter, 30–115 m in height, with domed roofs and rounded inverts to maximize excavation stability and optimize the deformation of components of the cavern wall (i.e., concrete and steel liners) during operation. The caverns are located at a depth approximately 100–200 m below the ground surface, and lined with approximately 1-m thick reinforced concrete and thin (12–15 mm) carbon steel liners to ensure gas tightness.

According to the principle idea of CGES, rock mass is served as a pressure containing. The increase of maximum operating pressure in caverns may generate unfavorable instability of the storage caverns such as a crack growing in rock mass surrounding the storage cavern. This can lead to the instability of the cavern. It was found in many previous researches that the fracture propagation behaviors had not been understood yet. For this reason, the behaviors of fractures propagation are of interest to be analyzed so as to prevent the severe collapse of the gas storage cavern under high pressure.

1.2 State of Problem

To understand behaviors of the underground structures, study can be conducted by means of either experiment or numerical simulation. However, such gas storage cavern testing under high pressure, especially full scale test is almost impossible at the conceptual design stage because the investment is high. Therefore, numerical study offers a better alternative.

A number of models have been developed based on micromechanical models to simulate the instability of a tunnel or borehole (e.g., Hazard and Young, 2000 and Germanovich and Dyskin, 2000). These have improved the understanding of the mechanisms and consequences of fracture initiation and propagation. Commonly, in mining and other tunneling operations, failure at compressive stress concentrations is of a major concern, and primary tensile fractures are rare because the confining pressure is usually high enough to suppress the tensile stress concentration at the cavity wall. For the problem of caverns under high internal pressure, investigation on failure behavior of rock mass surrounding cavern by using the physical and numerical approaches (Tunsakul et al., 2013) indicated that, for rock mass in their study, the failure mode is governed by the tensile mode. The crack initiation points and fracture propagation strongly depend on the in-situ stress condition.

However, the study was limited on only the artificial rock used in the study which is brittle with low strength. With the diverse properties of in-situ natural rock, more extensive investigation should be done covering all range of possible rock properties. Moreover, wider range of stress, particularly under in-situ condition, should be also further considered.

1.3 Objectives of Study

1. To study the fracture initiation behaviors of rock mass surrounding a high pressure gas storage cavern considering both tensile and shear failure

2. To study the fracture propagation behaviors of rock mass surrounding a high pressure gas storage cavern considering both tensile and shear failure

3. To suggest the idea to distinguish the fracture behaviors of rock mass surrounding a high pressure gas storage cavern for rock engineering.

1.4 Scope and Limitation of Study

1. Cover possible range of rock strength properties and k

2. Effect of the concrete liner and steel liner will not be considered in this study

3. The uplift from groundwater level will not be considered.

4. The natural crack is not considered. This study therefore assumes that the rock is a continuum mechanics