Finite Element Analysis of Cracking Pattern of Large LNG Storage Tank Dome under the Influence of Three Main Failure Factors

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1. Introduction

As the most commonly used pressure vessels to store liquefied natural gas which is an ultra-low temperature liquid, Large-scale concrete LNG storage tank are generally built in peri-urban areas [1]. When cracks run through spherical reinforced concrete tank dome, the gas will easily leak out. Once the natural gas escaped, it will not only cause a direct result of the huge economic losses, but also lead to secondary disasters such as fire, explosion and environmental pollution easily, further caused urban paralysis and even threaten human life.

A large LNG storage tank consists of two parts: the concrete outer tank and inner tank. The inner tank is constructed by the nickel steel [2] [3] [4]. At present, a very large number of LNG storage tanks have been used for a long time, and many spherical reinforced concrete tank domes have generated cracks. For example, in Shenzhen, China, there are four LNG storage tanks. The tank dome generated evenly distributed meridional cracks along the edge of the tank dome. The cracks of the tank dome are shown in Fig 1. And, similar cracks appear on tank dome of two LNG storage tanks in Dalian, China. In addition, the same meridional cracks appeared in two LNG storage tanks in Fujian Province China [5].

In general, excessive inner barometric pressure and thermal load is the main reason for tank dome cracking, therefore they have been considered adequately in the design. But LNG tanks usually built in coastal areas, erosion of chloride ions is very serious, the expand pressures caused by corrosion products also will lead to cracking. So, we will use finite element method to respectively simulate three different cracking pattern of LNG tank dome.

2. Finite Element Models

In this paper, we take the Shenzhen CNPC LNG terminal storage tanks as the research object. The tank’ s volume is 160000m^3, the radius of the spherical tank dome is 82m, the cross-height is 11m and the span is 82m, the thickness of the tank dome is 400mm. The tank dome used the C50 concrete and HRB400 reinforcement whose diameter is 28mm. Concrete cover is 50mm, rebar spacing is 200mm. We respectively established three finite element models to analyze the stress distribution and cracking of LNG tank dome.

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