Application of Performance-Based Seismic Design Method for Existing Onshore Structures

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ABSTRACT

Japan’s Fukushima nuclear power plant was struck by a massive magnitude 9.0 earthquake which triggered a devastating tsunami on the 11th March 2011. In general, the USD (Ultimate Strength Method) for structure design can describe the capacity of elastic, but can not predict the failure mechanism of structure. Therefore, the limit of USD inspires us to study the Performance Base seismic design method and propose a simplified method and compared with a simple and realistic tsunami loading of onshore structure. The tsunami forces used for seismic-resistant design was studied and compared by literature review. Then, the Pushover Analysis Method and Capacity Spectrum Method are combined to develop the guidelines of seismic and tsunami design for onshore structures. After that, a case study of wall pier which support the tsunami protection structure was carried out by the Performance-Based seismic design method with tsunami loading. The results shows that the performance curve in seismic design can be derived and the tsunami force of the onshore structure can be compared which is the key technology of the risk analysis and cost control for onshore structures. This study also shows that we may apply Earthquake Engineering techniques to improve Tsunami Resistant structures.

Key words: onshore structures; Performance-Based seismic design; tsunami force; Capacity Spectral Method; Pushover Analysis Method; performance curve; tsunami protection structure

INTRODUCTION

March 11, 2011, there was a tsunami with 30 m high waves, triggered by a magnitude 9.0 earthquake off the northeast coast of Japan, loss of many human life and many infrastructures were damaged by tsunami. Also damaged Fukushima nuclear power plants and the environment from nuclear pollution aroused our attention for tsunami. Taiwan is located in the complex interface of the Eurasian Plate and the Philippine Sea plate, if the Ryukyu Trench earthquakes, tsunami will have the opportunity to invade Taiwan, especially Taiwan nuclear power plants are concentrated in the northern coast, shown as Fig. 1 and Fig. 2. The 2010 Chile Tsunami is shown for the most part, non-engineered structures, particularly low-rise residential, suffered extensive damage; while engineered structures performed well, experiencing non-structural damage. It may be unrealistic in the Taiwan to construct large tsunami seawalls or breakwaters to protect every coastal community. Yet, we still need to consider tsunami resistant design and evaluation for critical existing onshore structures (ex. nuclear power plant). If the nuclear power plants were affected by the earthquake or tsunami that will have a lot of damage in Taiwan. Especially radioactive contamination is that we cannot face with the threat of tsunami; therefore tsunami engineering became an important issue. Modern tsunami engineering began in the reporting of Dames & Moore (1980). However, up to today, there is no tsunami-resistant design code for onshore structures in Taiwan. Gary (2013) proposed a study about the development of a tsunami building code. ASCE-7 will be included Tsunami force and effects until in 2016. On the other hand, due to the traditional seismic design method cannot predict the failure mechanism and behavior of the structure also cannot control the performance of structure post seismic reaction; therefore the application has been limited. Freeman etc. (1975) developed Pushover Analysis Method, the United States since 1992; Engineers Association of California is trying to develop a set of expectable functional design method of building. Jang etc. (2004) proposed Performance-Based seismic design method is applied to marina structures. Chi etc. (2006) and Sung, etc. (2005, 2008, 2010, 2013) also proposed seismic capacity evaluation methods of bridge, the structural performance of the benchmark. Vijayakuma etc. (2012) using SAP2000 software discussed pushover analysis of existing reinforced concrete framed structures. In this study, we based on Capacity Spectral Method with pushover analysis controlling the process of structure damage to compare with the force of the tsunami. Furthermore, establish a model of real existing tsunami protection structure to obtain its performance curve using nonlinear analysis for SAP 2000. Then, we obtained the performance goals of onshore structure for tsunami resistant and seismic capacity. In this paper, we based on force and deformation controlling the process of structure damage to propose a simplified method approach for comparing tsunami force of onshore structure. The main aim of this research is to analyze structural damage caused by tsunami using the Earthquake Engineering approach of performance-based assessment by structural displacement. This paper also highlights the importance of research on resistant of tsunami to wall pier, discusses the research key points, and presents the countermeasures about the design of tsunami protection structure resistance again tsunami.