CHAPTER – 1

Introduction

The essential role of sea ports mainly as a member of supply chains in regional, national, and international scales are due to their unique functionality as intermodal transfer points in transportation networks. The activities of ports including loading and unloading of cargo and raw materials, temporary storage, and intra-port operations are concentrated in a small geographic area and therefore, any interruption in the regular performance of structural and geotechnical components of ports may lead to partial or even full distraction of the commercial activities of the port.

Historical cases of seismic events in sea ports have shown vulnerability of wharves to threatening earthquakes along with Tsunami right from 325 BC Makran Subduction Zone earthquake (North Arabian Sea) to the recent Tohoku (Japan) March 11, 2011 [2]. A classic example to this is 1995 Great Hanshin earthquake Japan, in which damage to the port in Kobe was estimated as 1 trillion yen, taking almost 2 years to repair. The interruption caused by closing of the port was nearly 30 billion yen per month owing to the loss of port related industries and trade [3]. In 2010 Haiti earthquake, the destruction to the main port “Port-au-Prince” along with road blockage due to debris resulted in loss of functionality of berthing facilities, creating difficulties in the relief works [4]. Thus earthquake creates lower probability of occurrence but higher risk to port structures and hence seismic vulnerability assessment of such structures is essential.

1.1 Need for study

Port transportation is one of the most important logistical systems, supporting universal movement of passengers and cargos cost effectively, thereby acting as a backbone for economic growth of country. In addition to playing a vital role in transporting people and cargos globally, ports and jetties play a crucial role in evacuating people and supplying relief materials before, during and after natural disasters when other transportation systems fail. A large numbers of important ports are located in active seismic regions worldwide. Rapid proliferation of international sea trade during last few decades has raised concerns about seismic safety of port structures.
In India, nearly 95% of foreign trade by volume and 70% by value takes place through ports [5]. Around 65% of country’s land is under moderate to very high seismic risk, witnessing several major earthquakes at Bihar (1988), Uttarkashi (1991), Latur (1993), Jabalpur (1997), Chamoli (1999), Bhuj (2001), Sumatra (2004), Kashmir (2005), Nicobar islands (2005), Andaman islands (2009), Sikkim (2011), and Nepal (2015), indicating high frequency of earthquakes. Currently, there is no guideline for earthquake resistant design of port structures. The existing earthquake-resistant design standards IS1893 [6] and IS13920 [7] are proposed for buildings that behave very differently from port structures during earthquakes [8].

So, in the absence of particular seismic design code for jetty structure, it becomes necessary to make vulnerability analysis of structure to understand its behavior and probability of failure (or probability of repair work after seismic hazard) for different intensity earthquake.

A universal engineering practice to reduce seismic risk of port amenities is characteristically based on design or retrofit measures for distinct components articulated in terms of random levels of force and/or displacement. Seismic vulnerability analysis on the other hand provides a framework through which both economic issues and system performance can be taken into account and the performance of the port can be seen as a whole.

1.2 Objectives

The main aim of the research is to perform seismic vulnerability assessment of pile supported wharf using fragility analysis. It also includes

- Evaluation of seismic performance of a pile supported wharf using performance based design.

- Constructing site specific spectra for the selected site, for three levels of earthquake motions and comparing it to the default spectra provided by IS1893.

- Determining fragility functions and deriving fragility curves for a pile supported wharf for different levels of earthquake motions, for some important port sites in Gujarat.
The output of the research supports hazard extenuation efforts for port structures, achieved through seismic vulnerability assessment of wharves. To accomplish the goals, enhanced numerical wharf models are generated followed by the derivation of fragility curves.

1.3 Scope of work

Allied research tasks that would be accomplished as a part of this research are:

- Generating 3D model of pile supported wharf in SAP2000, analyzing it for various forces acting on it as per IS4651 [9] and designing it for given load combinations as per IS4651 [10].
- Performing nonlinear static pushover analysis on the structure to obtain the capacity curve of the wharf and identifying damage states as per PIANC.
- Constructing site specific spectra for three levels of earthquake motions, with reference to IBC [11] and ASCE [12]; and comparing it to the default spectra provided by IS1893 [6].
- Evaluation of seismic performance of the wharf using Capacity Spectrum Method (CSM) with reference to ATC40 and linear Time History Analysis. Owing to time constraint and inaccessibility to high speed computer, nonlinear Time History Analysis has not been considered in the scope of this study. However, preliminary analysis using simplified methods are also done to verify the results.
- Determining fragility functions and deriving fragility curves for the selected wharf for various intensity level of earthquake, for some important port sites in Gujarat.
- Validation of the research by implementing the methodology adopted for fragility analysis for pile supported wharf, to an existing building that has already confronted a seismic event.