Analysis on Dynamic Response of Wharf with Arched Longitudinal Beams under Ship Abnormal Berthing

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ABSTRACT

A new type of wharf structure with arched longitudinal beams has been proposed to adapt to open sea deep-water area. This study focuses on dynamic response characteristics of the structure when vessels’ abnormally berthing and impacting on the wharf, with the method of dynamic time history curve, which is different from static calculation in previous studies. The results show that the boundary locations of arch beam and top chord should be strengthened in the early stage of the construction. If abnormally berthing happens, the influence on piles is significant unless piles can meet the requirement of wharf’s dead-weight. The present results will provide guidelines in design and construction of the deep-water wharf.

KEY WORDS: Wharf with arched longitudinal beams; abnormal berthing; impact force; finite element; dynamic response.

INTRODUCTION

In recent years, a trend of large tonnage vessels is increasing in port engineering. During the past 10 years, container ships have developed rapidly, and the world's major shipping groups are scrambling to build super-large container ships. By the end of 2017, container ships carrying 21,413 TEU have been put into operation (Gong and Cao, 2018). In China, most coastlines with excellent natural conditions and suitable for port construction have been developed and utilized after decades of rapid development (Mi, 2013). In order to alleviate the problem of insufficient port handling capacity, the construction of deep-water wharf is in urgent needed. China has a short age in the construction of deepwater wharf, however a lot of experience has been accumulated in the design and construction in recent years (Zhao, 2012). A new type of wharf with arched longitudinal beams was proposed (Zhai, Lu and Zhang, 2008), which can make full use of arch’s overhead crossing and reinforced concrete compression resistance, improve the interval between transversal bents greatly, and decrease underwater construction quantity.

Previous studies on the new structure mainly focused on the static analysis while ignored the structural response under the complex dynamic loads. Abnormal berthing accidents often occur due to large-scale ships, frequent berthing operations, management loopholes and some other factors (Xu, 2018). In this study, the dynamic response characteristics of wharf with arched longitudinal beams are analyzed when vessels’ abnormally berthing and impacting. The results will provide guidelines in design and construction of the deep-water wharf.

PARAMETERS OF THE WHARF STRUCTURE

Brief Introduction of Wharf with Arched Longitudinal Beams

The prefabricated reinforced concrete arched longitudinal beams consist of arch beams, top chords, web members, tie-rods and hanger rods. The longitudinal beam is laid on the pile pier. The prefabricated crosswise horizontal braces which are laid on longitudinal beam’s brackets are set among longitudinal beams. They form beam grillages with longitudinal beams. The laminated slabs are laid on crosswise horizontal braces. Pile pier and transversal beam are cast-in-situ, and the transversal beam is set on the same elevation with arched longitudinal beam. The laminated slabs have casting bay and wearing carpet on them. Longitudinal beams, transversal beams, crosswise horizontal braces and slabs are integrally jointed, and they form an integral superstructure of good integrity and rigidity with pile piers on cast-in-situ technology. Tie-rod is set at the bottom of arch beam to bear arch’s thrust force. Loads acting on wharf with arched longitudinal beam transfer to piles through pile pier. The foundation piles are all vertical large diameter steel pipe piles, and the number of piles should be determined based on pile’s bearing capacity. Pile pier and transversal beam are cast-in-situ, and pier is in solid considered to the construction of intersection location of arched longitudinal beam and pier. Figure 1 shows the sketch of wharf with arched longitudinal beams.