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Dynamic behavior of an innovative replaceable pier structure under lateral impact loadings

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1 Abstract

In order to improve the repair efficiency of bridge piers subjected to vehicle and ship collisions, an innovative replaceable pier structure based on flange connection and PBL shear connector was proposed. The finite element model of the replaceable pier and the traditional pier were developed and then validated through experimental test results. The behavior of replaceable pier and connection joint under lateral impact loading was studied based on numerical simulations. Compared with the traditional pier, it shows that the ability of new replaceable pier to resist impact loading is more favorable, and the connection component of new replaceable pier is repeatable.

Keywords: replaceable pier; flange connection; PBL shear connector; impact loading; numerical simulation.

2 Introduction

In recent years, the damage of the bridge caused by the collision of vehicles and ships has frequently occurred, resulting in serious casualties and significant property loss [1, 2]. For bridges vulnerable to impact damage, the current design methods are mainly divided into anti-collision design of piers considering impact force [3-5] and anti-collision design of protective structures [6-8]. However, the impact load is of great uncertainty, and the bridge designed by collision avoidance may still suffer from impact damage [1]. Many scholars have studied different repair methods for damaged piers [9-14]. But for the impact damage of serious damage degree, the repair efficiency of current repair methods is limited. And research on methods for repairing by quick replacement of piers is rarely seen.

In this paper, an innovative replaceable pier was proposed and its performance under horizontal impact load was studied by numerical simulations. Firstly, the structure of the replaceable pier was introduced, and specimens of the replaceable pier and the traditional pier were designed for comparison. Then, the finite element model (FEM) of two kinds of piers were established using LS-DYNA software, and the rationality of the numerical simulation was verified by the impact test. Finally, the impact behavior of replaceable pier and the dynamic behavior of its joint under impact load were studied by numerical simulations.

3 Design of the replaceable pier

3.1 Overall configuration

The overall configuration of the replaceable pier is shown in Figure 1. The upper connection component and the lower connection component are connected by high-strength bolts. The replaceable function of the replaceable pier is guaranteed by the detachability of the high-strength bolts and the repeatability of the lower connection component. Considering the

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