Optimization Analysis of Pile Protection Devices for Qiantang River Bridge

Jin Pan1, Weiguo Wu2
(1) Key Laboratory of High Speed Ship Engineering(Wuhan University of Technology),Ministry of Education
Wuhan, Hubei Province, China
Mingcai Xu2
(2) Unit of Marine Technology and Engineering, Instituto Superior Tecnico, Technical University of Lisbon
Lisbon, Portugal

ABSTRACT
According to the Qiantang River Bridge project, the pile structures are adopted to be the protection device of bridge piers. Because the pile structure is not contact to the bridge pier, the design method of impact force control is no longer applicable. Therefore, this paper studies on the large deformation characteristics of piles, takes the interaction between the piles and soil into account by “m” method and determines the form and dimension of pile structures by the DOE method. Then some useful conclusions are achieved.

KEY WORDS: Ship, pile structure, impact, ANSYS, Sensitivity analysis;

INTRODUCTION
The collisions between ships and bridge piers are very dangerous. But during the life of the bridges, such accidents maybe happen. So it’s necessary to consider the possibility in the design process. There are some methods to figure out this problem associated with ship/bridge(or bridge protection device) collisions, including simple formulae, simplified analytical approach, simplified FEM, nonlinear FEM simulation, experiments and so on(ISSC,2006).

Among these methods, the simple formulae method can estimate the collision force very quickly, but they can only be used in some hypothesis case, otherwise the errors maybe happen. So the simple formulae method is commonly used at the primary design phase. The experiment method can simulate the real collision process, but the high fee and long period prevent it from becoming a general way to study the collision problems. In comparison, nonlinear FEM simulation method can analyze a collision accident involving high non-linearity, contact, friction and rupture accurately with relatively low cost, so it has became the main method of recent studies(Liu and Gu,2000,2003; Hu, et al,2005; Wang, et al,2008; Pan, et al,2005a,2005b; Li and Wang,2006; He,et al,2008).

According to the Qiantang River Bridge project, the pile structures are adopted as protection devices of bridge piers. So it is very important to choose the appropriate parameters of pile protection devices, such as the number, the radius, the depth under soil of pile and so on. In this paper, nonlinear FEM method is used to simulation the collision between the ship and protection devices. In addition, according to the criterions(JTJ254-98,1998), the ‘m’ method is used to consider the interaction between the piles and soil. The design and simulation of pile protection device will be carried out in the following steps: Firstly, the impact force is calculated by the criterion formula. Secondly, the DOE method of ANSYS DesignXplore is used to optimize the pier protection device. Then the final dimension and form is determined by transient analysis results and some useful conclusions were achieved.

The Design Criterion of Protection Devices
According to the navigable waterways criterion, the weight of ship is 1000t. The design impact velocity of ship is determined by the normal speed in the channel of river, the distance between the center of channel of river and bridge pier, the length of ship and so on. When the ship is far way to bridge pier enough, the design impact speed of ship is supposed to the speed of water. When the ship is near bridge pier, the design impact speed of ship is supposed to the normal velocity of ship. The water velocity of Qitang River is 2.99 meter per second. The max velocity of ship allowed to pass is 5m/s. So the design impact velocity of ship is 5m/s.

The Design and Static Analysis of Pile Protection Devices
The FEM Model

Fig.1 The FEM model of fence pile

The protection device structure is made of B mild steel with yield stress of 235MPa. The initial principal dimensions of box girders are set as follows:

H=1m; W=1.6m; T=0.018m

here, H, W,T are the height ,Width and plate thickness of the box girder, respectively.