ABSTRACT

Offshore platforms exposed to aggressive service and environmental effects would cause their strength and stiffness to deteriorate over an extended period of service. In ice zones, the ice load is the dominant environmental load and may imperil the safety of ageing platforms severely. Based on the measured reaction load time-history data in site, the ice force is simplified as a sequence of randomly occurring pulses with random intensity and duration. The occurrence in time of ice loads is described by a Poisson point process according to the probabilistic characteristics of the ice breaking length and drift velocity of the ice sheet. The base shear force in the ultimate limit state is taken as the global resistance of the structures, and a new corrosion model with a Weibull function expression is employed to study the resistance degradation. Using conditional probability analysis and probability differential equations, a structural deterioration reliability model is developed to calculate probabilities of structural failure for ageing offshore platforms in ice zone. Finally the time-dependent reliability of an ageing platform in Bohai Bay is evaluated for demonstration.

KEY WORDS: ageing platform; time-dependent reliability; ice zone; failure rate; deterioration; degradation function.

INTRODUCTION

At present, many offshore oil platforms are now at or beyond their original design lives, and in their life extension service stage. These offshore structures may be affected by ageing, which may include changes in strength and stiffness beyond the baseline conditions that are assumed in structural design. The ageing effects may cause component or system resistances to degrade and accelerate the risk of structural failure over time. This raises problems about demonstration of the safety and reliability of the structures to remain in service, especially when the platforms are exposed to an aggressive environment, such as ice zone, these problems are more severe. It is necessary to evaluate the safety and reliability of these deteriorating offshore structures. The conventional reliability model of component reliability calculation, i.e., the well known load-strength interference model underlies the hypothesis that the load is static or applied only once to the component during its life time, and the strength degradation is not considered. In other words, it cannot reflect the effect of the load and resistance history on reliability, which is unsuitable for the reliability assessment of ageing platforms (Xu and Chen, 2007; Xu and Chen, 2009). As described above, for these ageing structures, the load and resistance are stochastic processes, and the resistance degrades over time, as shown in Fig.1. In such a situation, the reliability of the structures will decrease with loading history, and a time-dependent reliability assessment is necessary. In the paper, the time-dependent reliability analysis model of ageing platforms in ice zone is proposed, and a demonstration example is given to illustrate how the reliability and failure rate of an ageing platform in Bohai Bay vary with time.

TIME-DEPENDENT RELIABILITY ANALYSIS

Stochastic Ice Load Model

In an ice zone, the ice load is the dominant environmental load (Li and Liu, 2008), and will imperil safety of the platforms and thus will do harm to the normal production, especially for ageing platforms. Depending on the mechanical properties of ice, its thickness, drift velocity, as well as geometry of the structure, three modes of ice failure have been identified: crushing mode, bending mode and buckling mode (Ou and Duan, 1998). Because a well-designed cone can change the ice failure mode from crushing to bending and an ice sheet can fail more easily in the bending mode for its relatively weak bending