

A Damage Detection Algorithm Based on Partial Measurement for Offshore Jacket Platforms

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ABSTRACT

Noting that damage occurrence of offshore jacket platforms is concentrated in two structural regions, a new algorithm to detect damages in a structure using partial measurement of vibration in a target-detecting region is proposed. Employing a numerical model of a typical offshore jacket platform, for which pre- and post-damage modal parameters are available for a few lower modes of vibration, the feasibility of the algorithm is tested. Firstly, the validity of the new algorithm using changes in partial mode shapes and its robustness against identification error of baseline structure are examined by utilizing modal parameters obtained from eigenvalue analysis on the model. Secondly, regarding the simulated dynamic responses of the platform under short-crested waves as ambient vibration measurement, modal parameters are identified by employing an ARMA method, then the new algorithm is applied to locate damages simulated in the structure assisted by the statistical treatment for modal parameters. It is demonstrated that the proposed algorithm in connection with the ARMA modal identification and statistical treatment is feasible and robust against identification error of baseline structure.

KEY WORDS: Damage location; jacket platform; partial measurement; ARMA method; statistical treatment.

INTRODUCTION

The field of health monitoring and damage detection has a great potential for applications in offshore structures (Roesset and Yao 1998). In general, offshore platforms in deep water have to face harsh marine environments, withstanding cyclic waves, severe storms, seaquakes and sea-water corrosion. The occurrence of damage in an offshore structure is inevitable during its lifetime. Therefore, aging structures must be inspected at regular intervals in order to detect the initiation and growth of damages that may lead to catastrophic failure. Currently, divers or Remote Operated Vehicles (ROV) are employed for the purpose of visual inspection and local damage detection. However, the process of inspection and local detection for offshore structures, especially in deep water, is much more difficult than for land structures. The poor visibility and the concealment of damage by marine growth limit the effectiveness of process technically. In addition, the use of divers

and/or ROV is very costly. So it is strongly requested to develop a global technique capable of assessing the health of offshore structures in an automated fashion, providing advance warning of structural damages and minimizing maintenance costs. Also the damage locations are requested to be provided prior to implementing the underwater inspection or local detection.

In response to these requests, a substantial amount of activities related to the global health monitoring and damage detection for offshore platforms have been carried out during the past decades (Nataraja, 1983; Kondo and Hamamoto, 1994; Kim and Stubbs, 1995; Brincker et al., 1995; Mangal et al., 2001; Yang et al., 2003). Among these activities, vibration-based approaches have been widely employed, which detect the changes of structural modal properties. Nataraja (1983) reported on a program designed to monitor three jacket platforms over a two-year period and to demonstrate the feasibility of such a system for structural damage detection. Kim and Stubbs (1995) examined the feasibility of using limited modal information for damage detection in jacket platforms. Mangal et al. (2001) presented an experimental investigation on a laboratory model of a jacket platform for structural monitoring using vibration responses due to impulse and relaxation. Due to the difficulty in implementing free vibration or forced vibration tests for such a huge structural system as an offshore platform, there is a growing interest recently in using ambient vibration measurement for damage detection in offshore structures (Kondo and Hamamoto, 1994; Brincker et al., 1995; Yang et al., 2003). When ambient excitation is considered, a modal identification method only based on the output data should be employed for the vibration-based approach (Alvin, 2003). And it is known that the ambient vibration of an offshore platform is usually excited by waves. Recognizing the wide occurrence of multi-directional irregular waves in real seas, it is important to discuss the feasibility of damage detection for offshore platforms under short-crested waves.

The majority of offshore platforms are jacket-type, steel tubular, space frames. Generally this type of offshore platform consists of hundreds of members and joints. For the jacket-type offshore platform, the most common type of damage is the fatigue crack caused by the oscillatory loads from ocean waves. The other types of damage are usually related to the accidental events (e.g., ship collision and dropped objects). From the experience of underwater inspections (Stacey and Sharp, 1997), it