A Review of Failure Modes in Ultimate Strength Assessment for Re-qualification and Life Extension of an Oil Field

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ABSTRACT

During the life-cycle of an offshore structure the ultimate capacity is an important attribute that affects the life expectancy, requalification and life extension of the facility, and can significantly influence the reliability levels and operational costs. This paper provides an overview of ultimate strength assessments and their role in understanding the structural system response and failure modes to extreme loads for requalification and life extension and demonstrating fitness for-purpose of thirteen identified platforms. This paper also discusses the failure modes in ultimate strength of structures taking account of the nonlinear behavior of members, joints and piling foundation.

KEY WORDS: Ultimate Capacity; Failure Modes; Fixed Platform; pushover Analysis; Life Extension.

INTRODUCTION

A large number of the old oil and gas facilities have reached or exceeded their initial design life. With a continued requirement to produce oil or gas, either from the original fields or as a base for neighbouring subsea completions, many of these respective offshore installations are likely to remain operational for a period of time in the foreseeable future. In order to ensure technical and operational integrity of these ageing facilities, the fitness for service of these offshore structures should be maintained (Nezamian and Nicolson, 2011).

The maintenance of structural integrity is a significant consideration in the safety management and life extension of offshore installations. It is recognized that fixed offshore structures are usually redundant and have a number of different load paths such that failure of one member is unlikely to lead to catastrophic structural collapse, provided that adequate redundancy is available. By utilizing this inherent redundancy found in most offshore structures the likelihood of failure of a platform in an extreme event can be determined. During the life-cycle of an offshore structure the ultimate capacity is an important attribute that affects the fitness for service, and can significantly influence the risk levels and operational costs. Therefore, evaluation of the ultimate strength, history of collapse of structures in their intact and damaged conditions is one of the key issues in requalification and life extension of existing facilities based on explicit safety evaluation and collective optimization (Westlake et al, 2006).

Evaluation of the ultimate strength and history of collapse of structures in their intact and damaged conditions is one of the key issues in advanced design techniques based on explicit safety evaluation and collective optimization. The ultimate strength of an offshore structure is evaluated by using non-linear finite analysis of the structural model, where gravity loading is applied as an initial load step, then the metocean design loads for a chosen direction is incrementally applied until the ultimate strength of the structure is reached. The ultimate strength (Pushover) assessment allows all structural members and joints to undergo plastic deformation, carrying load past yield or buckling. When a member has buckled, loads in the member are redistributed within the system until structure collapses (Udea and Rashed, 1991).

During the life cycle of an offshore structure the ultimate capacity of an offshore structure, the ultimate capacity plays an important role in defining the Structural Integrity Management (SIM) Strategy of the structure. Ultimate strength assessment can be used to; optimize the SIM strategy, determine the continuous fitness-for-purpose and to identify if any strengthening, repair or mitigation is required. The configuration of vertical framing of the jacket structure as well as the foundation properties has an effect on the redundancy of the structure. In this study these effects on the ultimate strength of the structure are further investigated (Nezamian at el. 2012 and Stacey and Sharp, 2007).

This paper provides an overview of ultimate strength assessments and their role in understanding the structural system response and failure modes to extreme loads for requalification and life extension of an oil field and for demonstrating fitness for-purpose. An assessment of the structural integrity of thirteen identified platforms under existing conditions was undertaken as these platforms are nearing the end of their design life. This paper also describes an efficient method, the idealized structural system, to evaluate the failure modes in ultimate