# Nonlinear modelling for Offshore Robustness. A sensitivity study.

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## Summary

The assessment of existing offshore steel jacket structures for use beyond their initial life requires a proper design of an inspection plan aimed to constantly check-up the structural elements (both members and joints). There is consequently a need to define a set of indicators that, possibly combined with a continuous dynamic monitoring system, provides a reasonable measure of structural robustness and damage tolerance. To investigate these aspects the paper proposes to develop non-linear static pushover analyses to assess the system reserve strength: damages, or deteriorations, of primary and secondary structural components are assumed to evaluate their effects on the robustness of the structure and to evaluate the possibility to employ a structural monitoring system as a check-up of the integrity of the structural elements.

**Keywords**: Offshore steel jacket platform; Non-linear structural analysis, Static pushover analysis; Structural robustness; Inspection planning.

## 1. Introduction

Offshore steel jacket structures have been commonly used for oil (or gas) extraction in shallow and moderate water depth for decades, and a plethora of steel jacket platforms are still operational even if they reach the limits of their design service lives. Even if rather large reconstructions, repairs and inspections have to be executed, the use of existing installations beyond their design lives (due to, for instance, the extended oil reservoir estimates) is in various cases economically preferable. The assessment of such structures for use beyond their initial life requires a proper design of an inspection plan aimed to constantly check-up the structural elements (both members and joints). In principle, proper safety evaluation of an existing structure can be ensured by requiring compliance with the actual recommendations, even if how to perform such safety compliance with regards to life extension of existing structures is an open issue. Moreover, assessing additional fatigue life for a structure that has reached its original fatigue design life is not possible only using design regulations, even if no cracks have been detected. It is therefore of importance to develop a scheme which presents a minimum of work to be done in order to ensure proper future safety of a structure beyond its original design life. In this context the inspections, and the subsequent (if necessary) possible repairs, are so viewed as a safety barrier to prevent corrosion failure, fatigue failure, etc. in members and joints (and, of course, to repair them if they have occurred). The amount of inspections, their frequency and their typology (i.e. the proper selection of the elements and/or joints to check-up) is a critical issue (since, for instance, it may not be feasible to inspect all critical components), and inspection planning was for the last decade, and still is, based mainly on probabilistic analysis (Risk Based Inspection, RBI) [1] [2].

The paper aims to deepening these aspects analyzing the robustness of such structures in order to identify a set of indicators that provides a reasonable measure of structural robustness and damage tolerance. Consequently the paper aim to identify methods for evaluating the safety of a structure beyond its design life, taking into account that for a robust and damage tolerant structure the proper structural safety is not restricted by the occurrence of single (members and/or joints) component failures. In this context, robust and damage tolerant means that the structure has an acceptable probability of failure due to extreme loading in intact condition or with a single member or joint failure. The tasks that the paper approaches are then: a) Evaluate indicators for robustness and damage tolerance able to control if a wave overloading is acceptable in intact condition and with one member failed. The damage tolerance and robustness of the jacket structure is evaluated by means of pushover analyses, and indicators are evaluated; b) Evaluate the possibility to employ a

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