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# Fatigue Design of Offshore Floating Structures

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## ABSTRACT

A novel fatigue analysis procedure is introduced for offshore floating structures. It is based on separation of hydrodynamic load and structural stress responses, effective fatigue load concept and response interpolation. The actual fatigue analysis is simplified to a spreadsheet calculation with a few directional fatigue effective load cases.

With the present approach fatigue damage estimates are calculated at early stage of the project. Detailed information is produced on load and stress responses of structural details for design development. A limited effort is needed for updating the fatigue life estimates as the design and stress and load analyses become more accurate.

KEY WORDS: Fatigue analysis; floating offshore structures

## INTRODUCTION

Floating offshore structures are being utilized in remote offshore areas where they need to keep position regardless of weather conditions. An example is the spar design for which the number of installations is about to reach 10 at the Gulf of Mexico. The service life of these structures is typically at least 20 years. With high safety factor of 10 the design life for safety critical details becomes 200 years. High safety factors are necessary, as repairs would be very costly if at all possible.

Design of welded steel structures for offshore are affected by demands for structural efficiency, faster production time and cost effectiveness, which are not allowed to compromise the high safety requirement. In today's offshore structures high strength steels are used, which mainly helps in meeting the strength requirements with smaller scantlings and less weight. The fatigue strength of welded joints is close to being independent of steel strength. Similarly, optimization of designs typically results in smaller scantlings. Both the high steel strength and the design optimization will increase the nominal stress levels. As a consequence the relative importance of fatigue as a design driver has been increased.

An important milestone for any oilfield development is the time spent up to the first oil. In order to minimize this time span projects are scheduled based on the steel mill, yard and transport capacities and the time for the necessary on-site installations. Structural design is done, to large extent, concurrently with the fabrication. Offshore structures are in practice prototypes designed specifically for certain field. Each structure has to be analyzed and designed independently even though similar details are often used. This is especially true for the spar and truss spar structures, which are relatively new designs with short history.

The design process is always a challenge. The main dimensions might be chosen relatively early but often the decisions, which are important for the structural design, are delayed. Typically a large number of major design changes tend to come up in the middle of the structural design process or simply after the design is complete. Often the significance of a certain design change for strength or fatigue becomes clear only after costly and time consuming analyses.

A typical approach in structural design process is first to estimate the extreme loading conditions and check the strength against them. Fatigue is more complex to assess and consequently the fatigue analysis is made afterwards. This has been acceptable approach as fatigue analysis has typically resulted to local detail changes at the most. With the present designs this is not anymore true. Fatigue has become equally important design driver with strength. The nominal stress levels, acceptable for strength, may need to be lowered due to fatigue. Such changes may result in excessive costs, if done at a late stage. It has become clear that fatigue design tools should be applied already when first design checks are made.

The present paper introduces a fatigue analysis procedure developed for truss spar structures. Such procedures become partly design specific but certain features of the procedure are directly applicable for other floating offshore structures as well.

## FATIGUE ANALYSIS PROCEDURE

Fatigue analysis needs to include estimation of local cyclic stress history at all potentially critical structural details. It is not dictated by a single extreme loading condition, but the cumulative effect of all