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Re-Assessment and Strengthening Analysis for Life Extension of Offshore Jacket Oil Platform

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ABSTRACT

The concept of 'life extension' is a time or an amount of duty when the installation would normally be considered for retirement, with certain processes and criteria. Life can be extended for a further period without a reduction in margins below safe operating limit. Life of number of existing fixed offshore platforms is exceeding the original design life that need to be maintained in production. Reassessment is possible by taking into account the new information and measurements due to the actual behavior of the platform. This paper present structural performance assessment approach for the offshore fixed platform. Assessment of existing structures for life extension based on static linear analysis for component checks, Non-linear analysis for determining ultimate strength is carried out.
Keywords: Offshore Platform, Assessment, In-Place, Pushover, SACS

I. INTRODUCTION

Jacket structures have been used in petroleum activity for many years. They are the most commonly adopted structure for shallow and intermediate water depths. Improvements in the possible oil recovery from several fields have increased the interest for using these structures well beyond their initial design life. Existing structure used beyond their design life after performed techniques as reconstructions, repairs and inspection. Major concern in this regard is that requirements regarding safety should not be compromised.it should have educational value by presenting a fresh perspective or a synthesis of existing knowledge.

Most of these platforms were originally designed for 25 years in accordance with guidelines set forth as per API RP 2A-Working Stress Method (WSD). A number of these offshore jacket platforms have crossed their design life and many more are approaching it. However, the available oil & gas production profile for the western Indian offshore fields requires these platforms to remain in service up to 2025 / 2030. As per the Oil Industry Safety Directorate (OISD) requirement, these platforms need to be re-assess for 'Fitness for- Purpose' and hence it is imperative to carry out their life extension studies.

Strength assessment is critical issue in offshore jackets. This is mainly due to the inherent constraints present in carrying out engineering work in the offshore atmosphere. It has been further exacerbated by the ageing offshore structures and the necessity of carrying out life extension toward the end of their design service lives. Local and international regulations demand the modification and repair plans when significant changes in the structural integrity are revealed. In this context, strengthening, modification and repair techniques such as welding, member removal/reduction of loading, mechanical clamping and grouted repairs play a vital role.

II. LITERATURE REVIEW

The response of a fixed offshore platform subjected to extreme wind and wave loading (lateral loads) under corrosion condition studied. By Ekkirala Ramana, et al. (2016) the advanced simulation techniques to model corrosion damage and to perform nonlinear pushover analysis is outlined. The location of corrosion perforation and thickness reduction can be identified based on an inspection report. Finite element model of the jacket is developed with a focus on these critical locations. The corrosion perforation can be represented as certain analytical shapes, (elliptical opening at different location and size. The platform capacity under extreme environmental loading is characterized in term of the platform's reserve strength ratio. Thus, a nonlinear pushover analysis is performed to assess the strength of the corroded structure by quantifying the RSR value. The nonlinear pushover analysis is carried out using the general finite element package Abaqus.

This paper Muhammad Al-Farisia and Muhammad Zikrab (2015) presents reassessment of existing offshore platform in the Ardjuna Field, Northwest of Java, Indonesia. The existing platform of B1C was installed in 1975 and owned by PHE ONWJ. The B1C platform is numerically evaluated for service life extension purposes until the next twenty years. The reassessment analyses is in-place analysis, seismic analysis and fatigue analysis. The results indicated that the entire value of unity check for all members fulfill the requirements of API RP 2A - WSD. Analysis of fatigue computation showed that three joints have the fatigue life less than 59 years.

Structural assessment is a key part of the structural integrity management (SIM) process for ensuring the fitness-for-purpose of offshore fixed platforms. This paper Liang Wang, Fraser Munro and Steve Simoni (2010) presents a comprehensive life cycle structural performance assessment approach for the offshore fixed platforms. Non-linear pushover analysis is used to perform the structural assessment, in which the platform capacity is characterized in terms of the platform's reserve strength ratio (RSR). Comparison of the platform RSR and the target RSR specified in the acceptance criteria determine the fitness-for purpose of the platform. A structural reliability methodology is proposed for the development of the regionally specific acceptance criteria.

This paper Offshore and Arctic Engineering OMAE (2013) presents a case study for the structural integrity assessment of an existing 8 legged aging drilling platform located in the Persian Gulf. The platform is now 42 years old and the objective of the study is to check its fit for purpose for a life extension of 25 years beyond 2012. The structural model is based on the best estimates of the existing conditions of the platform.

The paper is divided into three parts. Section 1 is a discussion on the background of the previous assessment study and perspective view on why the case study platform needs to be assess. Section 2 and Section 3 include the finding of the code noncompliance points of the platform based on the recommendations of API RP 2A-2007. Section 4 presents the remedy actions recommended for the fit for purpose of the platform. The structural integrity assessment was carried out based on the best estimates of the existing conditions of the platform data on future equipment on the topside, besides several design assumptions.

Stated Samindi M.K. Samarakoon, R.M. Chandima Ratnayake (2015) Structural Integrity Management (SIM) is an on-going process for demonstrating the fitness-for-purpose of an offshore platform over its entire life from installation through to decommissioning. It is an important tool for managing the uncertainties of structural degradation, damage, changes in loading, accidental overloading, and changes in use. Structural assessment is a key element of the overall SIM process. The results from the assessment determine the fitness-for-purpose of the platform and can be used to develop an effective long-term risk-based underwater inspection strategy.

III. ANALYSIS SOFTWARE

SACS (Structural Analysis Computer Systems), a Design and Analysis software for offshore structures and vessels, is used for the modeling and analysis of the jacket. SACS is an integrated suite of finite element based software that supports the analysis, design and fabrication of offshore structures, including oil, gas, and wind farm platforms and topsides.

IV. MODELLING DATA

The structural model of a platform consists of the jacket, topsides, piles, foundation and miscellaneous platform appurtenances, reflecting the platform's as-is condition by accounting for known damage, deterioration and modification based on platform inspection records. The jacket structure is modeled as a space frame, in which tubular beam elements are used to model the jacket structural members. For ungrouted leg-pile annulus, the leg-pile interaction is modeled using 'wishbone' element, which allows only the transfer of lateral forces. The structural data provided in table 1.

Table 1. Required Data

Platform type	Wellhead
Number of leg	4
Water depth	79.5 m
Mud line elevation	-79.5 m
Pile stub elevation	-79.5 m
Horizontal brace level (3)	-50 m
Horizontal brace level (2)	-21 m
Horizontal brace level (1)	2 m
Cellar deck	15.3 m
Main deck	23 m
Bracing x type	28" –outside
	diameter
	0.75"-wall thickness
Conductor	30"-outside diameter
	1"-wall thickness
Wishbone	30"-outside diameter
	1"-wall thickness
Deck leg	30"-outside diameter
	1"- wall thickness
Pile	48.5"- outside diameter
	1.5"- wall thickness

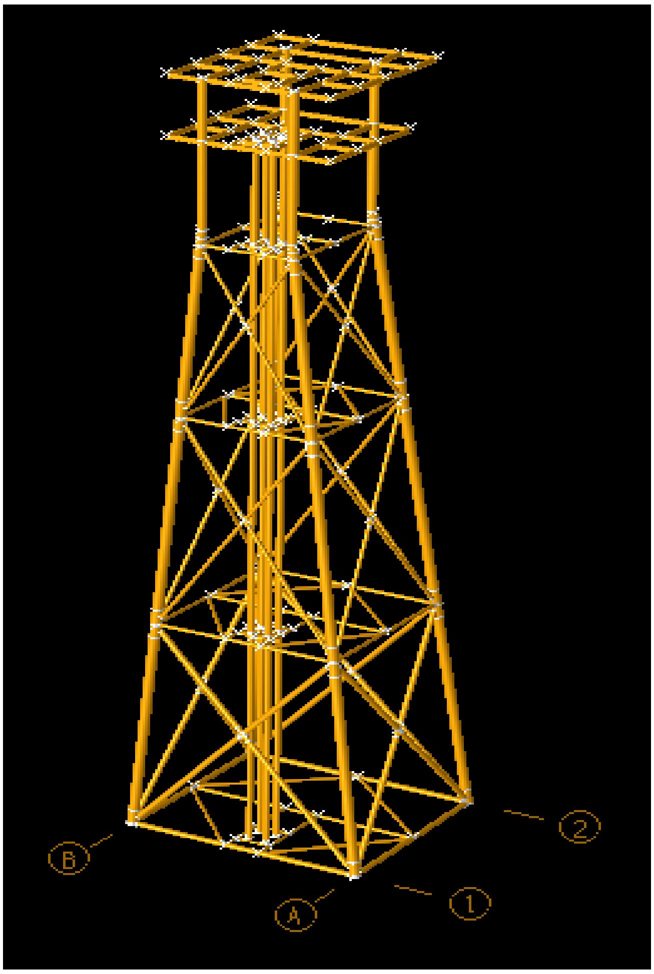

Figure 1. 3D Model in SACS

V. LOAD DATA

1. Permanent Load and Variable Load:

The permanent load includes the mass of the jacket and the topside weight. The topside weight is taken as equivalent load when an equipment box of tonnes is placed at the location of the topside.

2. Environmental Data

The environmental data as shown in table 2 to table 5 is based on a Meta ocean design report of an oil field the hydrodynamic forces, wave and current forces are calculated using Stoke's 5th order theory and Morison equation respectively. The wind force is applied as uniformly distributed on the surface of the topside and the effect of marine growth is accounted.

1. **Marine growth:**

Table 2. Marine Growth

Distance from Mud line(m)	Thickness (cm)	Dry density (T/m^3)
0-60	2.5	1.4
60-79.5	5.0	1.4

2. **Current Load:**

Table 3. Current Profile

Distance from Mud line(m)	Velocity (m/s)	
Bottom	0.514	0.514
Surface	1.029	1.081

3. **Wind:**

Table 4. Wind Data

Velocity at 10m (m/s)	
1 Year	100 Years
25.72	45.17

4. **Wave:**

Table 5. Wave Data

1 Year		100 Years	
Wave Height (m)	Period (sec)	Wave Height(m)	Period (sec)
6.10	12.00	12.19	15.0

3. Environmental load as per direction:

Wind, Wave and Current Load direction for operating and storm condition is 0, 45, 90 degree.

4. Load Combination

- ✓ OPR1: DL + EQPT + (1.0) LL + MISC + (1.1) P000
- ✓ OPR2: DL+ EQPT + (1.0) LL + MISC + (1.1) P045
- ✓ OPR3: DL+ EQPT + (1.0) LL + MISC + (1.1) P090
- ✓ STM1: DL + EQPT + (0.75) LL + MISC + (1.1) S000
- ✓ STM2: DL+ EQPT + (0.75) LL + MISC + (1.1) S045
- ✓ STM3: DL+ EQPT + (0.75) LL + MISC + (1.1) S090

VI. METHODOLOGY

The procedure for reassessment of offshore platform for this study refers to the standard API RP2A-WSD2 and AISC-ASD.

1. **In-place analysis:**

In-place analysis performed by considering loading conditions for Water Case, operating Condition and extreme Condition. Still Water condition cases combines maximum load operation without taking into account the environmental load, while operational conditions using extreme environmental loads with return period 1 year, and for extreme conditions using extreme environmental loads with return period of 100 years. Design and strength of structures are expressed in Unity Checks (UC) as the ratio between the actual stresses that occurs on the member of structure with allowable stress. The UC criteria for each member in the structure should be less than 1.0.

2. **Pushover Analysis:**

The platform ultimate strength is generally determined from a static pushover analysis, in which environmental loads are applied progressively until the platform collapses. Platform failure is generally defined as formation of a limiting mechanism in the platform structure or foundation. As the load is progressively increased during the pushover analysis, non-linear events such as member buckling and yielding, joint plasticity, and pile pullout or plunging are monitored, which is used to detect the formation of a limiting mechanism in the structure or foundation.

During a pushover analysis, the loadings are generally applied in two steps. The first step consists of the platform's dead weight and topsides loads. In the second step, the lateral environmental load is ramped up progressively until platform failure is reached. The ramping of the environmental load should be consistent with the rate of increase in wave load with increasing return period and account for the point at which wave inundation of the topsides occurs.

VII. RESULTS AND DISCUSSION

Static analysis is performed for the four-legged jacket considering 3 loading directions, 4 in direction 0, 45, 90 deg. Post, a sub program of SACS, is used to calculate element stresses and compare them to allowable stresses. The NORSOK-N003 code is selected to check stresses in the elements. The base shear and moment for operational condition and for extreme condition the comparison. Unity check has been performed and found that the ratio of actual stress to allowable stress is less than unity for all members. In-place analysis are shown in Table 6. The entire values of UC members on operational conditions and storm condition are under 1 (UC<1).

Results from the pushover analysis shown in Table7 and 8, provided the platform ultimate strength is categories in the form of RSR (reserve strength ration) for extreme and operating condition. It shows structural system which led to formation of plastic hinges along the piles and eventually a total failure in the platform.

Figure 2. Collapse Platform.

Table 6. Members stress Unity Check (UC)

Jacket member	1 year			100 year		
Location	Member	Group	UC	Member	Group	UC
Jacket leg	303L-403L	LG3	0.21	301L-401L	LG3	0.33
Vertical brace	104L-104X	BR2	0.23	201L-103X	BR2	0.23
Horizontal member	1104-103L	H11	0.80	1104-103L	H11	0.60
Pile above mud line	103P-203P	PL1	0.46	104P-204P	PL1	0.68
Topside member	1 year			100 year		
location	Member	Group	UC	Member	Group	UC
Main deck	8103-802L	W01	1.94	8103-802L	W01	1.45
Cellar deck	802L-804L	W02	1.69	802L-804L	W02	1.49
Main deck leg	701L-801L	Dl7	0.34	701L-801L	Dl7	0.25
Cellar deck leg	604L-704L	Dl6	0.22	604L-704L	Dl6	0.22

s

Table 7. Operating Condition

DIRECTION (deg)	DESIGN BASE SHEAR (KN)	BASE SHEAR (KN)	RSR
0	8761	10193.76	1.16
45	8781	10843.05	1.23
90	8863	13478.48	1.52

Table 8. Storm Condition

DIRECTION (deg)	DESSIGN BASE SHEAR (KN)	BASE SHEAR (KN)	RSR
0	9133.61	20075.36	2.19
45	9073	15449.33	1.70
90	9092	13695.50	1.5

VIII. CONCLUSION

In the static analysis typical jacket in modelled in SACS. It is analysed for environmental and operating conditions for the all load combinations given in DNV code and Unity check has been performed. Failure members is fousnd at the cellar deck and main deck both. However, the jacket safe in this analysis so if the retrofitting techniques is design for the failure member so the platform can be used for production. Non-linear pushover analysis is used to perform the structural assessment in which the platform capacity is characterized in terms of the platform's reserve strength ratio (RSR). From the analysis can also be used to determine the criticality of components apply inspection and repair schemes for life extension.

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