ORIGINAL ARTICLE

ANALYSIS OF OFFSHORE JACKET STRUCTURE IN THE SYRIAN COAST BY USING COMPUTER MODELING

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ABSTRACT

Background The efficiency and safe design of marine platforms depend on a complex structure of mutual influence between these facilities and the surrounding environment and the degree of resistance to different loading patterns during the entire investment period. Fixed jacket platforms are huge steel framed structures used for the exploration and extraction of oil and gas from the earth's crust. Jacket type structures are appropriate for relatively shallow water depth. **Objectives**: the objective of this study is to select specific parameters for the elements of a fixed platform (jacket) and conduct an static analysis study to resist these elements for the influence of the basic loads that are subject to it within the environment of the Syrian coast , using the software SACS. **Methods:** the jacket is modeled in SACS finite element program and static analysis is conducted with fixed boundary conditions. Critical conditions are taken into account, which include structure and equipment weight, wind load, hydrodynamic load using Morison equation. **Results:** Linear static analysis is performed for the four legged jacket considering (3) loading directions. The maximum base shear and overturning moment are calculated in normal environmental conditions and stormy. as well as the unit check values, for all member are obtained it**. Conclusions**: the environmental conditions of the Syrian coast are suitable for the construction of jacket offshore, therefore a great importance to support the Syrian national economy.
Keywords: *Unity Check, Jacket, Linear Static Analysis, SACS software*.

1. INTRODUCTION

Offshore platforms are huge steel or concrete structures used for the exploration and extraction of oil and gas from the earth's crust. Offshore structures are designed for installation in the open sea, lakes, gulfs, etc., many kilometers from shorelines. these structures may be made of steel, reinforced concrete or a combination of both [7].

The total number of offshore platform in various bays, gulf and oceans of the world is increasing year by year, most of which are of fixed jacket-type platforms located in 100 ft (32 m) to 650 ft (200 m) depth for oil and gas exploration purposes [8]. The analysis, design and construction of offshore structures compatible with the extreme offshore environmental conditions is a most challenging and creative task. Over the usual conditions and situations met by land-based structures, offshore structures have the added complication of being placed in an ocean environment where hydrodynamic interaction effects and dynamic response become major considerations in their design [6].

The jacket structure typically consists of tubular members of various diameters and wall thicknesses. the air gap between the sea surface and the bottom of the topside structure is made high enough to prevent waves from hitting the topside structure. At the bottom, the jacket is normally outfitted with a temporary foundation which supports the jacket until the permanent foundation is installed. Bracing configurations consist of the vertical, horizontal and diagonal members, who connect jacket legs forming a stiff truss system, transfer the loads acting on the platform to its foundation [4]. The primary function of a jacket structure is to support the weight of the topside structure by transferring the weight to the foundation. The jacket structure is subjected to different environmental loads during their lifetime. These loads are imposed on platforms through natural phenomena such as wind, current, wave, earthquake, snow and earth movement. Among various types of environmental loading, wave forces loading is dominated loads [9]. Offshore structures may be analyzed using static or dynamic analysis methods. Static analysis methods are sufficient for structures, which are rigid enough to neglect the dynamic forces associated with the motion under the time-dependent environmental loadings. On the other hand, structures which are flexible due to their particular form are to be used in deep water must be checked for dynamic loads [2]. The calculation of the wave loads on vertical tubular members is always of major concern to engineers. The analysis of wave effects on offshore structures, such as wave loads and corresponding responses, are of great importance to ocean engineers in the design, and for the operational safety of offshore structures, especially recently when such studies are motivated by the need to build solid marine structures in connection with oil and natural gas productions [3]. The effects of various wave patterns on offshore structure have been investigated by numerous researchers in the past [10, 11].

From the simulations of wave loading and structural analysis on few model tests, it can be concluded that the developed programs are able to reproduce results from the model tests with satisfactory accuracy [5].

The present paper deals the static responses of an four legged jacket platform under the environmental conditions of the Syrian coast, in order to determine the design parameters necessary for the stability of a typical platform at a specific depth by using the computer program SACS. 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.

2. MATERIALS AND METHODS

2.1 Study site and data availability:

Environmental data of the platform model for static analysis are based on study conducted by the Institute Kaspmornii proekt, to implement the technical project to expand the port of Lattakia, which is located in the northwestern part of Syrian territory. The wave system was determined in the study area based on the processing of wind data taken from the overall weather maps of the Eastern Mediterranean between 1975 and 1951 (25 years).
Wind speeds at 10m above mean sea level from three main geographical directions with 1 and 100- years return period are shown in table (1).

Table 1: The table presents the wind speeds with 1 and 100- years return period.

Geographical Direction(from)	Wind Velocity (m/s)	
	1-year	**100-years**
south	22	11,0
South-west	26	14,0
North-west	21	10,0

2.2 Data processing:

The values of the significant wave heights and their periods were calculated in the study area Depending on the CEM relationship for wave prediction. The wave height and period of wave with 1 and 100- year return period shown in table (2).

Table 2: The table presents the wave height and period of wave with 1and 100- year return period.

Geographical Direction(from)	wave			
	1-year		**100-year**	
	H_s(m)	**T_s(s)**	**H_s(m)**	**T_s(s)**
south	1.98	6.1	4.4	8.1
South-west	2.4	6.4	6.7	9.94
North-west	1.5	5.3	4.4	8.2

2.3 Environmental loads:

Water force can be classified as forces due to waves and forces due to current. Wind blowing over the ocean’s surface drags water along with it, thus forming current and generating waves. The forces induced by ocean waves on platform are dynamic in nature. However, it is the accepted practice to design shallow water platforms by static approach. As a water depth increases and platforms become flexible, dynamic effect becomes significant [9].

2.4 Waves:

Regular wave theories used for calculation of wave forces on fixed offshore structures are based on the three parameters water depth (d), wave height (h) and wave period (T) as obtained from wave measurements adapted to different statistical models, as The figure1 presents. Wave plus current kinematics (velocity and acceleration fields) are generated using 5th order Stokes wave theory, the forces on individual structural elements are calculated using Morison equation, based on hydrodynamic drag and mass coefficients (Cd , Cm) and particle velocity and acceleration obtained by the 5th order Stokes wave theory. Stokes 5th order wave is defined by providing wave height and period in the input data with the wave type specified as Stokes in the SACS options [7].

2.5 Current loads:

The wave induce an orbital motion in the water in which they travel, and these orbits are closed but experience a slight drift forward to wind surface effects. The current is actually induced by wave. A current in the wave direction tends to stretch the wavelength, typical wind and current profile, as The figure1 presents, is consider in this study [1,6].

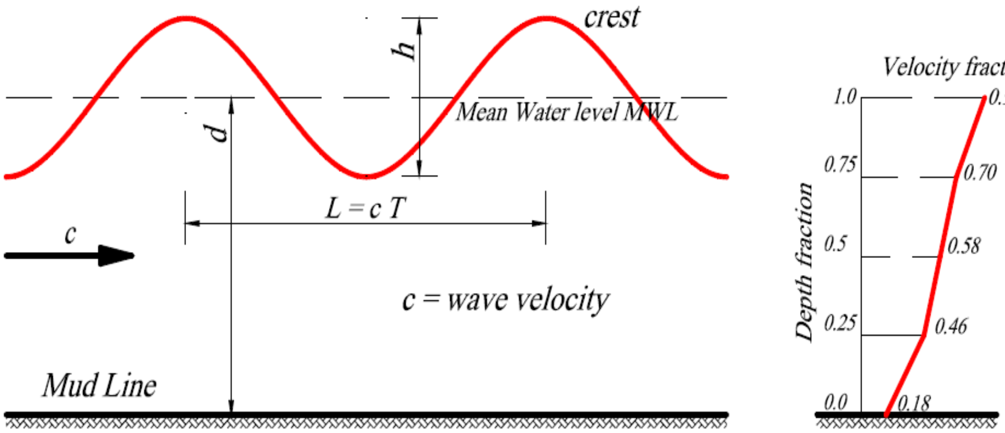

Figure 1: The figure presents the wave coordinate system and typical wind and tidal current profile.

2.6 Wind loads:

When a structure is placed in the path of the moving air so that wind is stopped or is deflected from its path, then all or part of the kinetic energy is transformed into the potential energy pressure. Wind forces on any structure therefore result from the differential pressure caused by the obstruction to the free flow of the wind. These forces are functions of the wind velocity, orientation, area, and shape of the structural elements. Wind forces on a structure are a dynamic problem, but for design purposes, it is sufficient to consider these forces as an equivalent static pressure [1].

2.7 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 [7]. Its ability to dynamically iterate designs allows users to perform advanced analysis, comply with offshore design criteria, and visualize complex results. SACS provides reliable beam member code checking and tubular joint code checking capacity ; therefore it is very suitable for topsides structures consisting of plate girders and tubular columns/ braces [4].

2.8 Modeling Data

The jacket platform is four-legged jacket for the purpose of supporting 6960 KN maximum operation weight located in The Syrian Coast, at a water depth of 79.5 m. The total height of the sea platform (102.5m) intended to support the loads of the upper section (main, secondary). The jacket footprint at sea floor is (22.112m × 25.46m) and topside footing dimension is (13.96m x 9.16m) at level (+2). The dimensions of the main section (20mx18m) at level (23) and the secondary section (15 mx18m) at the level (+15.3). The bracing pattern used is (X- pattern). All the members are tubular with outside diameter varying from 320mm to 1230 mm and wall thickness from 12.5mm to 44.5 mm. Computer model of the four legged platform is shown in figure 2.

The steel s420 is used for legs, piles and primary members and steel grade s355 is used for secondary members. The properties of are taken from NS-EN10025-3.

The design loading models depend on permanent loads, variable loads, current and wind loads and wind loads.

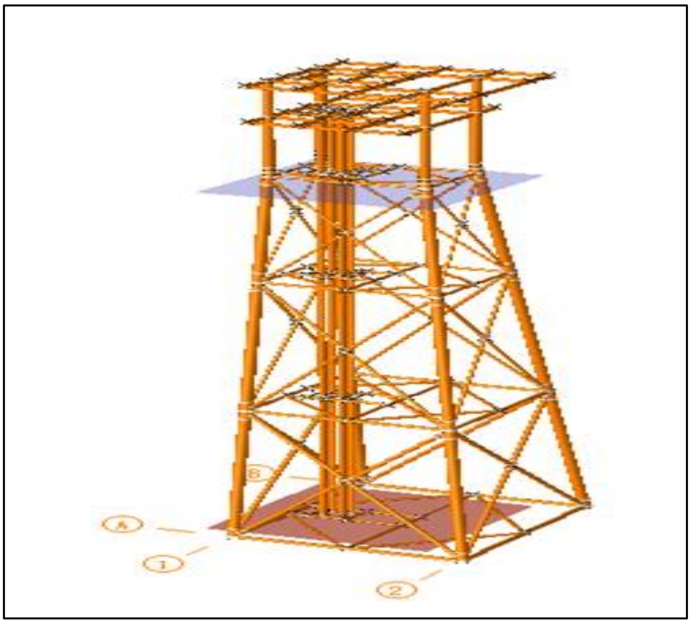

Figure 2: The figure presents the 3D Model in SACS and test.

3. RESULTS AND DISCUSSION

Linear static analysis is performed for the four legged jacket considering 3 loading directions (135, 180 & 45) deg, depending on the dominant trends of wind waves affecting the Syrian coast (southwest, west, northwest). Post, a sub program of SACS vi, is used to calculate element stresses and compare them to allowable stresses. The (APIRP2A-WSD) code is selected to check stresses in the elements [1].

Six load combinations will be added into the model. Three of them are corresponding to operating storms and the other three are corresponding to extreme storms. Load factor 1.1 will be used for environmental loads. Live loads will be included with a 0.75 factor in maximum storm load combinations, in order to check the efficiency of the structure. The maximum base shear and overturning moment for ULS_A (for operational condition) and ULS_B (for extreme condition) analysis are shown in table (2) and table (3).

The stresses and forces (shear forces, axial and bending stresses) to which each element of the platform is subjected, as well as the unit check values, are calculated after the analysis. The result of unit check values for all members are shown in figures (3,4)**.**

Table 2: The table presents the maximum base shear and overturning moment for ULS_A Analysis.

Load Direction(Deg)	**Base Share**	**Overturning Moment**
45	187.973KN	13154.158 KN.M
135	357.994 KN	24991.627KN.M
180	263.994KN	18265.729 KN.M

Table 3: The table presents the maximum base shear and overturning moment for ULS_B analysis.

Load Direction(Deg)	**Base Share**	**Overturning Moment**
45	912.209 KN	63894.941 KN.M
135	1706.071KN	120899.492 KN.M
180	837.998 KN	59707.098 KN.M

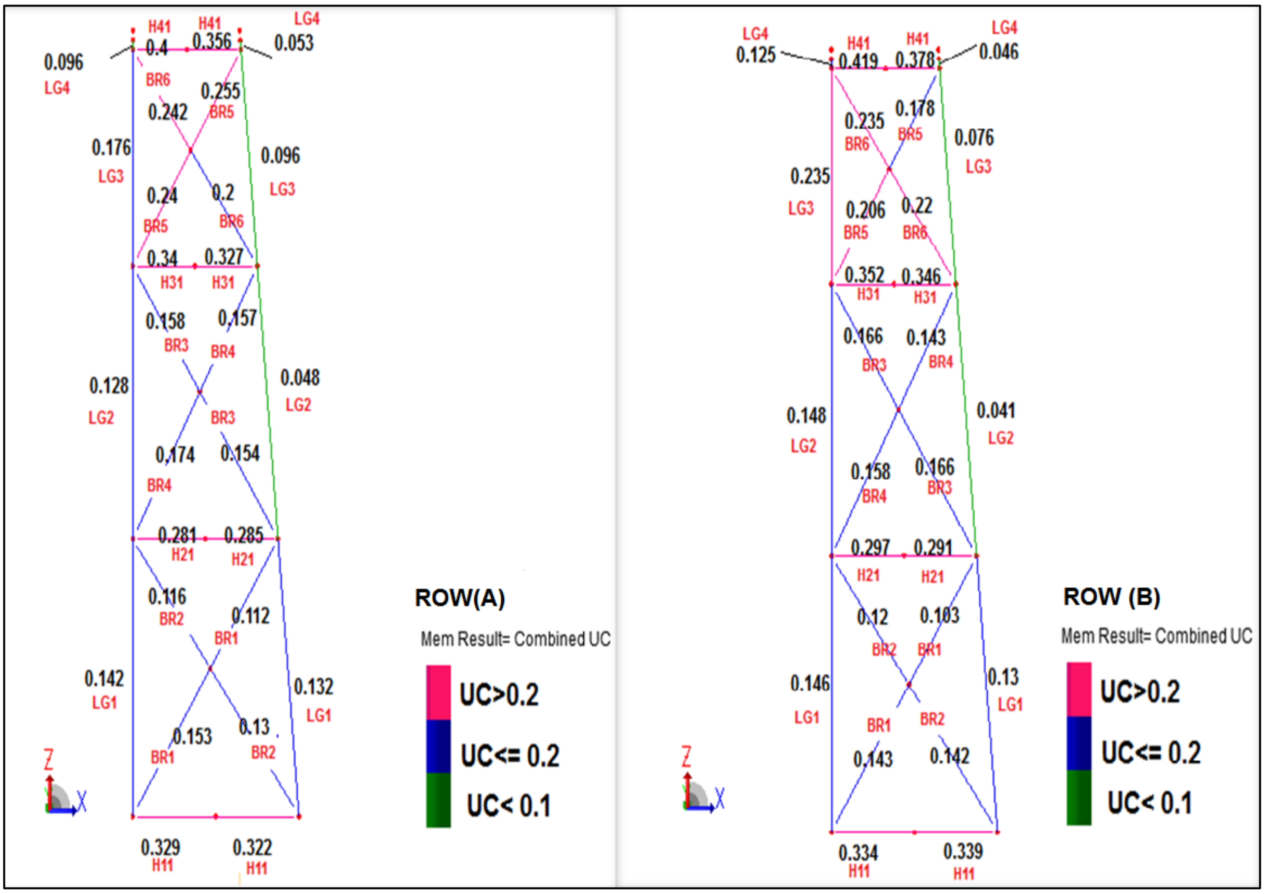

Figure 3: The figure presents the four-legged jacket's member check results, Row (A,B).

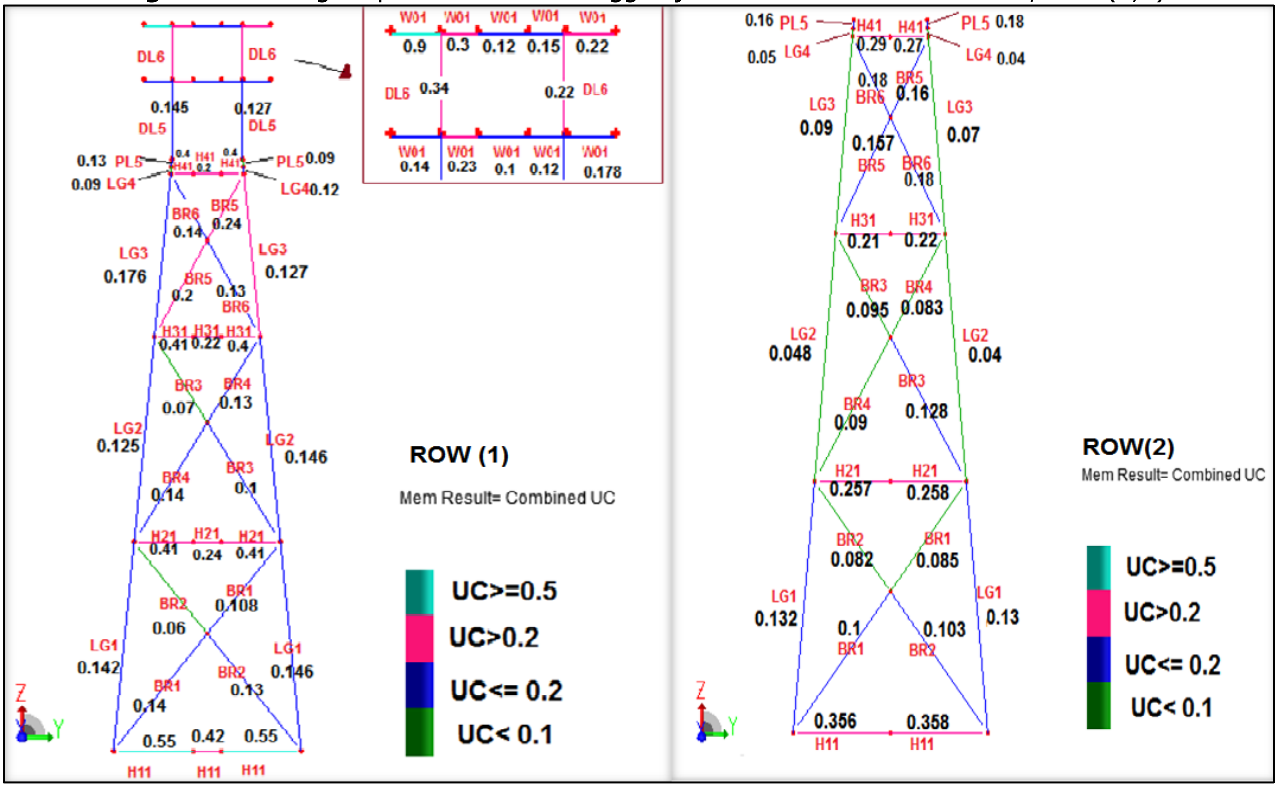

Figure 4: The figure presents the four-legged jacket's member check results, Row (1,2).

The comparison of base shears shows that the maximum base shear occurs in (135°) and the maximum overturning moment in (135°) in both operating and extreme conditions.

Unity check has been performed and found that the ratio of actual stress to allowable stress is less than unity for all members; thus the structure is safe.

5. CONCLUSION

Typical jacket in Syrian coast is modeled in SACS. It is analyzed for environmental and operating conditions for the all load combinations given in APIRP2A-WSD code and the base shear and overturning moments are found. The worst-case occurs while the environmental loads act from the south-west of the structure.
The environmental conditions of the Syrian coast are suitable for the construction of jacket offshore, therefore a great importance to support the Syrian national economy.

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