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Fatigue Life Comparison of Modified and Conventional 3 Leg Jacket Offshore Structure

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ABSTRACT

The jacket structure must be adapted to the conditions of the production field to support economic factors. So, the concept of a modular platform for minimal, low-cost facilities is adopted. However, the design differences will affect the performance of the jacket itself, in other words a modular jacket can withstand the same load as a conventional jacket model but has a different structural performance. Therefore, this research discusses the performance comparison, which includes the fatigue life and the natural period, between conventional and modular jacket structures, which in this study are referred to as modified jackets. Conventional jacket as a comparison structure takes the design basis of the modified structure, including the same structural profiles, and environmental loads. In this study, the two jackets will only be modeled on the jacket part and the superstructure will be modeled as a joint load on the three upper ends of the jacket legs. Fatigue life analysis in this study used the full spectral analysis method. By using SACS software, the natural period of modified jacket is 1.756 s and conventional jacket is 1.472 s. While the lowest fatigue life on modified jacket is 44.98 years and conventional jacket is 9125.79 years.

Keywords*: Conventional jacket, modified jacket, natural period, fatigue life*

1. INTRODUCTION

Oil and gas energy is a source of energy that is still widely used today, especially in Indonesia. It is recorded that oil and gas exploration activities in Indonesia have been carried out since 1971 until now in both shallow and deep seas. The sea depth classification is used to determine the type of offshore structure used where the deep sea will use a floating structure while the shallow sea will use a fixed structure.

The fixed structure commonly used in Indonesia is the jacket structure. This structure is suitable with the sea conditions in Indonesia, which are mostly shallow seas. The jacket structure as a whole is divided into two parts, namely the topside and the leg. The design of this structure can be varied according to the needs and environmental conditions in which the structure is built, in the sense that with the same needs and environmental conditions it can have different designs.

Different designs certainly have their own advantages and disadvantages, for example if the structure is slender, the movement of the structure will be significant, the large natural period of a structure with certain environmental conditions can decrease the fatigue life of the structure due to the addition of the dynamic amplification factor. Otherwise, if the structure is large, the structure tends to be stable, which can be seen from the small natural period, the small natural period with certain environmental conditions can increase the fatigue life due to the dynamic amplification factor value is close to 1.

This research will discuss the comparison of fatigue life between the conventional 3 leg jacket structure and the modified 3 leg jacket structure. The research was conducted to determine the effect of the different 3 leg jacket structure configuration on its fatigue life, with the same superstructure load and environmental conditions. The research was carried out with the help of SACS software covering modeling to simulation of loading to obtain the intended results.

2. RESEARCH METHODOLOGY

1. Literature review

Following the quick development in engineering world, the fixed offshore structure cannot be separated from innovations as well, such as a modified configuration that has a comparable strength but with lower price. These new configurations certainly affect the performance of the structure.

In this study, there is a jacket structure that has a configuration with a modular upper leg and a conventional lower leg, which further will be referred as modified 3-leg jacket structure. An analysis was carried out to compare the fatigue life of modified and conventional jacket and determine the natural period and the fatigue life of both 3-leg jacket with the same superstructure load and environmental conditions. [1] in his research analyzed the fatigue life of the same jacket structure and stated that the lowest fatigue life was in the Y-type joint with 121.25 years using the spectral method and 1045.66 years using the spectral method. This research will analyze the fatigue life using the spectral method. There will be an additional structure as a comparison for further development.

2. Data collection

The structural data was obtained from Husky-CNOOC Madura Limited (HCML) given by the lecturer. This structural data will be the object of analysis, which includes static and dynamic strength analysis for fatigue life. This structural data will also be used as a reference for redesigning the jacket to compare the fatigue life of the modified 3 leg jacket structure. The structural model used can be seen in Figure 1.

- Structure type : Wellhead platform
- Location operation : 114° 18 '21.63 "E and 7o 18' 45.70 "S
- Number of decks : 3 (three)
- Number of feet : 3 (three)
- Pile number : 9 pieces of skirt pile OD 64”
- Total elevation : 8 (eight)
- Platform orientation : (-) 135°

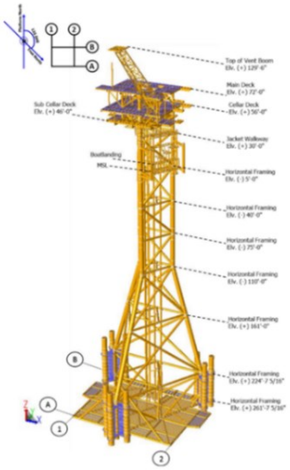


Figure 1 MBH Platform (source: HCML MBH Platform)

The environmental loads in this study were calculated from 16 loading directions, which were 0°, 22,5°, 45°, 67,5°, 90°, 112,5°, 135°, 157,5°, 180°, 202,5°, 225°, 247,5°, 270°, 292,5°, 315°, and 337,5°. The environmental load used for the fatigue analysis is the wave load with a return period of 1 year, indicated by the number of occurrences for each combination of Hs and Tp at every loading direction.

Inplace analysis were calculated from wave loads presented through the summary of Hs and Tp and the current loads is shown by velocities of every 10% water depth with a return period of 1 year for operating conditions and 100 years for storm conditions.

3. Modified Jacket Modeling

Modeling the structure of the modified 3 leg jacket using SACS software based on the structural data that has been obtained. This structural modeling will later become the initial fatigue life data which will be analyzed before redesigning the jacket section.

4. Conventional Jacket Modeling

This jacket model is used as a comparison to the modified jacket. At this stage, the modeling does not change the size of the members, only changing the configuration of the jacket leg and bracing to limit the design so that the comparison is equal.

5. Inplace Analysis with SACS Software

Inplace analysis is applied to both jacket models. Only the conventional jacket configuration will be changed if the analysis results fail. This stage simulates the state of the structure when it is operating with all dead loads, live loads and working environmental loads. The flow of work at this stage can be seen in table 1.

Table 1 Inplace analysis workflow

SACS	Analysis Type	Result
Inplace	*Basic Static Analysis*	Static strength

The inplace analysis stage requires a model file (*sacinp*.) as the object of analysis which contains the jacket model as well as dead and live loads, seastate (*seainp*.) as environmental loads including waves, currents, and combined loads that have been factored for operating conditions and storm conditions, and joint can (*jcninp*.) as input list of selected joints to be analyzed. The output of this analysis is a static power in the form of a common solution file (*saccsf*.) Which can be seen in the postvue database (psvdb) file, this file shows the color of each member which indicates the unity check.

6. *Tubular Joint*

Tubular joint as the main support on the jacket platform, will experience forces generated from all directions, both from the wave and from the topside load above it, [2] in his journal classifies the types of forces acting on a tubular joint as shown in Figure 2.

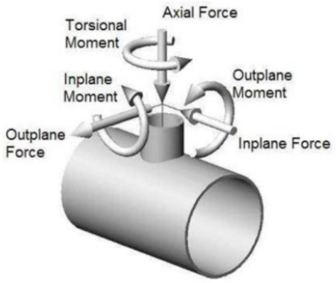


Figure 2 Force and load on the tubular joint [2]

7. Natural Periods and Frequencies

The natural period is the time it takes for a structure to perform one frequency of movement, while the natural frequency is the number of oscillations the structure performs per second. In the fatigue analysis, it is necessary to know the natural period of the structure to obtain the dynamic factor of the structure which is also related to the dynamic amplification factor, a factor of wave load enlargement that occurs due to the resonance of the structure's natural period with the wave period. The natural frequency equation for the structure according to [3] is shown in equation 2.1.

$$\omega_n = \sqrt{\frac{k}{m}} \qquad (2.1)$$

By applying the natural period equation as shown in equation (2.2).

$$T_n = \frac{1}{\omega_n} \qquad (2.2)$$

By substituting equation (2.1) to equation (2.2), it is found that the natural period equation is as shown in equation (2.3).

$$T_n = 2\pi\sqrt{\frac{m}{k}} \qquad (2.3)$$

8. Fatigue Analysis with Full Spectral Method

[4] suggested that the fatigue life analysis is carried out in a spectral analysis method, if the natural period of the structure is < 3 seconds, then the fatigue analysis may use the deterministic analysis method. However, in this study the full spectral method was used. This method uses a spectrum of waves and a structural response due to the waves hitting them. In spectral analysis, the random response of a structure can also be represented in the form of a response spectrum by correlating the response of the structure in the regular wave and wave spectrum. [5] suggested at least the use of the 8 RAO directions that were reviewed, but in this study 16 RAO directions were used, which were 0°, 22.5°, 45°, 67.5°. , 90°, 112.5°, 135°, 157.5°, 180°, 202.5°, 225°, 247.5°, 270°, 292.5°, 315°, and 337.5°. In Figure 2.3, we can see the scenario for calculating fatigue life using the full spectral analysis method.

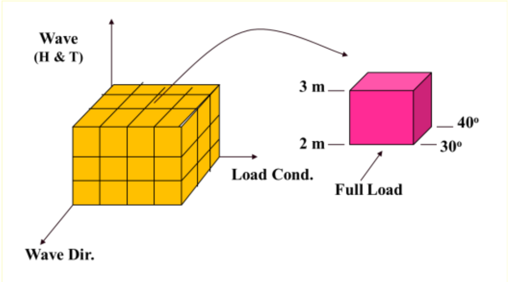


Figure 3 Spectral analysis scenario [6]

a. Hot Spot Stress

This is the stress in the critical area experienced by the joint where the maximum tensile / compressive stress occurs. In general, there are three types of basic stresses that cause hot spots to appear [7]:

1. Type A is caused by axial forces and moments which are the result of the combination of the jacket frame and truss.
2. Type B occured due to the details of the structural joints such as inadequate joint geometry, varying stiffness variations in joints and others.
3. Type C, is caused by the resulting metallurgical factors and welding errors, such as undercuts, porosity, and others.

This stress can be generated using the finite element method assisted by SACS software, but theoretically the hot spot stress has the same equation as in equation 2.4.

$$\sigma_{hs} = \sigma_{nom}\ x\ SCF \qquad (2.4)$$

b. Response Amplitude Operator (RAO)

Also known as transfer function, RAO is a graph that represent structural response due to waves in a certain frequency range or period. In this case, the RAO of the jacket structure can be generated with the help of SACS software with an illustration as shown in Figure 4.

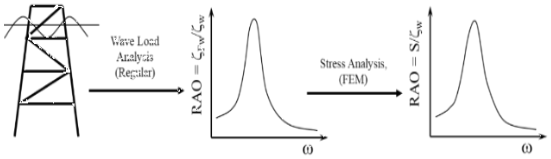


Figure 4 Wave load analysis to obtain RAO and Stress RAO [6]

c. Dynamic Amplification Factor (DAF)

DAF is an amplification factor of the structure's response to a wave period hitting the structure, this is related to the structure's natural period. In the area of the natural period of the structure there will be an enlargement of the structural response caused by the wave period and the natural period of the resonating structure, this makes DAF need to be considered in the structural fatigue analysis so that the resonance effect of the structure is represented. DAF can be calculated using equation 2.5.

$$DAF = \frac{1}{\sqrt{\left\{1-\left(\frac{T_n}{T}\right)^2\right\}^2+\left(2\beta\frac{T_n}{T}\right)^2}} \qquad (2.5)$$

d. Wave Spectrum

The wave spectrum is the result of the random wave recording transformation from the time domain into the frequency domain using Fourier series which is presented in a graph with an abscissa of the wave frequency (ω) and the ordinate in the form of the energy of the wave ($S_\zeta(\omega)$) [8]. The use of wave spectra at this stage is to multiply by the square of the RAO stress to become a stress spectra as shown in Figure 5.

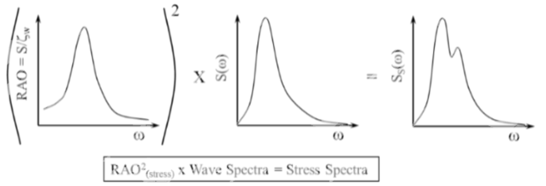


Figure 5 Calculation of Stress Spectra [6]

The wave spectra formulation used in this analysis is the JONSWAP spectra which can be seen in equation 2.6.

$$S_\zeta(\omega) = \alpha g^2\omega^{-5}\exp\{-1.25(\omega/\omega_0)^{-4}\}\gamma^{\exp\left\{-\frac{(\omega/\omega_0)^2}{2\tau\omega_0^2}\right\}} \qquad (2.6)$$

e. Rayleigh Distribution For Short-Run Stress Range Distributions

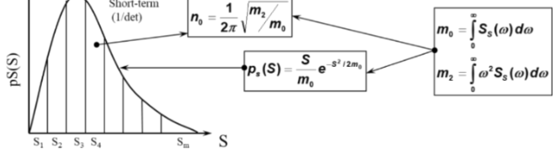


Figure 6 Calculation of the Rayleigh distribution over a short period of time [6]

The Rayleigh distribution is used for short-term stress range calculations as shown in Figure 2.6 using equation 2.7.

$$n_0 = \frac{1}{2\pi}\sqrt{\frac{m_2}{m_0}} \qquad (2.7)$$

Where m_0 and m_2 are the area and moment of area under the stress spectra curve obtained from the transfer function in a short time, respectively. Meanwhile, the probability of the stress range for the short term is expressed by equation 2.8.

$$p_s(S) = \frac{S}{m_0}e^{-S^2/2m_0} \qquad (2.8)$$

f. Weibull Distribution For Long-Term Stress Range Distribution

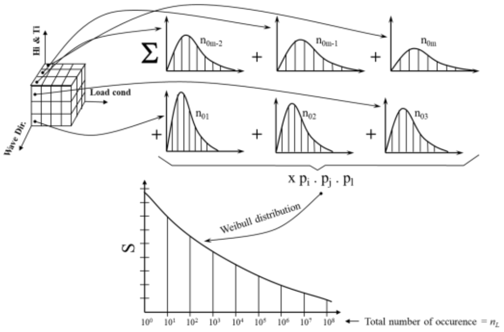


Figure 7 Calculation of the Weibull distribution over a long period of time [6]

Calculating the number of wave cycles in the long term as shown in Figure 2.7 with equation 2.9.

$$n_L = \left(\sum_i\sum_j\sum_k n_0\, x\, p_i p_j p_k\right) x\, T_L \qquad (2.9)$$

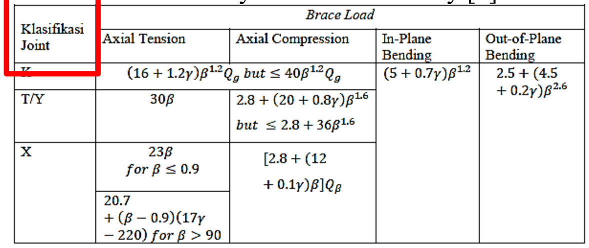
The probability density function for the long-term stress range S, can be calculated using equation 2.10.

$$P_L(S) = \frac{\sum_i\sum_j\sum_k n_0\, x\, p_i p_j p_k\, x\, p_s(S)}{\sum_i\sum_j\sum_k n_0\, x\, p_i p_j p_k} \qquad (2.10)$$

g.*Stress Concentration Factor* (SCF)

Stress concentration factor is a constant obtained by dividing the hot spot stress range with the nominal stress range in the brace. This study used Efthymiou's theory to determine SCF as in table 2.

Table 2 Efthymiou's SCF Theory [9]



Klasifikasi Joint	*Brace Load*			
	Axial Tension	Axial Compression	In-Plane Bending	Out-of-Plane Bending
K	$(16+1.2\gamma)\beta^{1.2}Q_g$ $but \leq 40\beta^{1.2}Q_g$		$(5+0.7\gamma)\beta^{1.2}$	$2.5+(4.5+0.2\gamma)\beta^{2.6}$
T/Y	30β	$2.8+(20+0.8\gamma)\beta^{1.6}$ $but \leq 2.8+36\beta^{1.6}$		
X	23β $for\ \beta \leq 0.9$ $20.7+(\beta-0.9)(17\gamma-220)\ for\ \beta > 90$	$[2.8+(12+0.1\gamma)\beta]Q_\beta$		

Information :
Qβ = 0.3 / β (1-0.833 β) for β> 0.6
Qβ = 1.0 for β ≤ 0.6
Qg = 1 + 0.2 [1 - 2.8g / D] 3 for g / D ≥ 0.05 but ≥ 1.0
Qg = 0.13 + 0.65Φγ0.5 for g / D ≤ -0.05 where,
Φ = tFyb / (TFyc)
Fyb = yield stress brace (or 0.8 of tensile strength if less)
Fyc = yield stress chord

h. SN curve

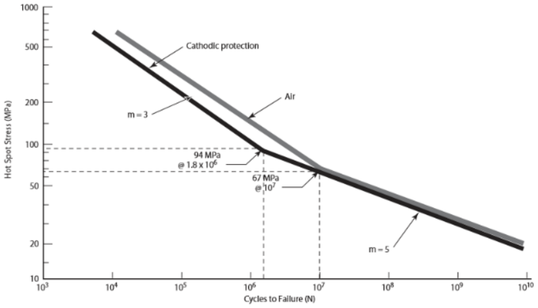


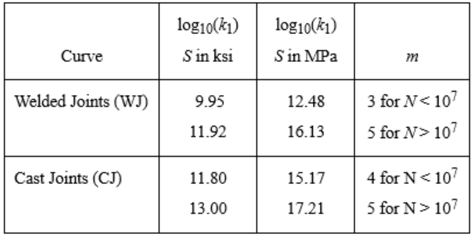
Figure 8 SN curve of tubular joint T = 5/8 in [4]

Theoretically, equation 2.11 can be generated from the SN curve to find the parameter N.

$$\log_{10}(N) = \log_{10}(k_1) - m\log_{10}(S) \qquad (2.11)$$

While the values of k_1 and m can be determined by table 3.

Table 3 Log values (k1) and m [4]



Curve	$\log_{10}(k_1)$ S in ksi	$\log_{10}(k_1)$ S in MPa	m
Welded Joints (WJ)	9.95 11.92	12.48 16.13	3 for $N < 10^7$ 5 for $N > 10^7$
Cast Joints (CJ)	11.80 13.00	15.17 17.21	4 for $N < 10^7$ 5 for $N > 10^7$

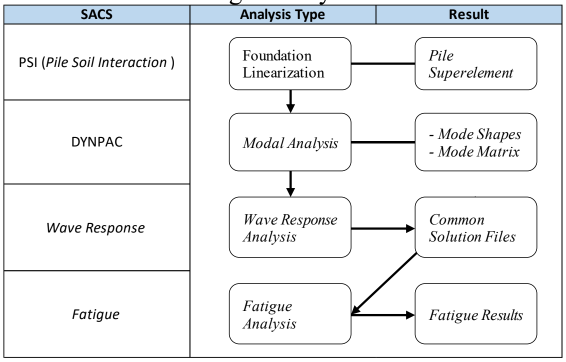
The SN curve selection must be based on the material type and thickness, therefore there is a thickness effect to consider in all SN curves. This equation can be seen in equation 2.12.

$$S = S_o(t_{ref}/t)^{0,25} \qquad (2.12)$$

9. Fatigue Analysis with SACS Software

This stage simulates the use of the full spectral analysis. From this analysis, the fatigue life of each joint will be obtained and it will be known which joint does not meet the requirement. The work flow at this stage can be seen in table 4.

Table 4 Fatigue analysis workflow



a. PSI (Pile Soil Interaction)

From the jacket that has been modeled, it is necessary to do a PSI analysis to get some moving load with the pilehead support. This analysis requires a model file (*sacinp.*) and a soil interaction pile file (*psiinp.*) to be run and produce superelement output (*dynsef.*).

b. DYNPAC

Using *dynsef* files. from previous analysis and models (*sacinp.*) for dynamic analysis (shape mode) to generate dynamic modes (*dynmod.*) and dynamic mass (*dynmas.*). At this stage you can also get the natural period of the structure in dynamic mode 1 which is listed in the *dynlst* file.

c. Wave Response

Insert the *dynmod* file and *dynmas.*, model files (*sacinp.*) and *wvrinp* files. which contains the number of wave steps and the damping factor that will produce a transfer function in the form of a base shear, overturning moment and a common solution file (*saccsf.*).

d. Fatigue

Entering the fatigue input file (*ftginp.*) which contains the planned operational life, safety factor, number of wave events etc. In addition, you need pile superelements, mode shapes, transfer functions, common solution files from wave response analysis, Mode Matrix 30 to include a common solution file (*saccsf.*) For each wave direction and produce a fatigue list (*ftglst.*) File that contains results of detailed fatigue analysis in the form of stress concentration factor, damage, and fatigue life in units of years.

3. RESULTS AND DISCUSSION

1. Modified Jacket Modeling

SACS 5.6 was used to model the modified jacket based on data from the structure owned by Husky-CNOOC Madura Limited (HCML). In this research, the modified 3 leg jacket was modeled only on the leg section, while the topside section was modeled as a joint load on the upper end of the leg, where the working point elevation is located. Modeling results can be seen in Figure 9 below.

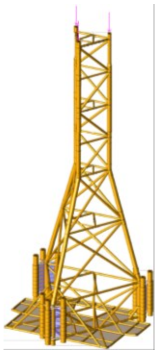


Figure 9 The result of modified jacket modeling

2. Conventional Jacket Modeling

Conventional jacket modeling were based from the modified jacket model, only differs in the slope of the jacket configuration, in form of a straight line from (+) 30' elevation to (-) 261'-7 5/16" for each jacket leg. The type of foundation was also changed to the jacket leg. As a limitation so that the two models could be compared, the conventional jacket design were modeled with the same elevation, material properties, and topside load. Illustration of conventional jacket modeling can be seen in Figures 9 and 10.

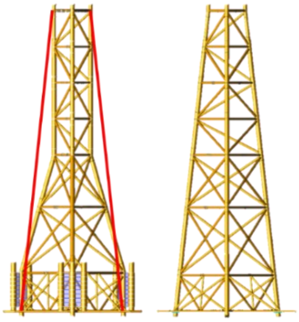


Figure 10 Illustration of a conventional jacket batter

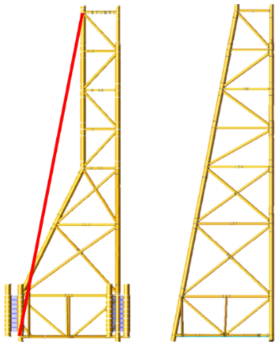


Figure 3.3 Illustration of a conventional jacket batter (continued)

Therefore, the results of conventional jacket modeling can be seen in Figure 11.

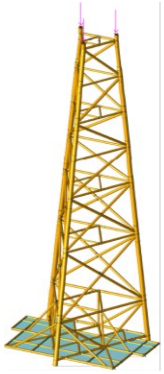


Figure 11 The results of conventional jacket modeling

Furthermore, the elevation of the two jackets was divided into 3 parts, which were top (elevation -5 ', -40', and -75 '), middle (elevation -110' and 161 '), and bottom (224,61' and 261 , 61 ') as shown in Figure 12.

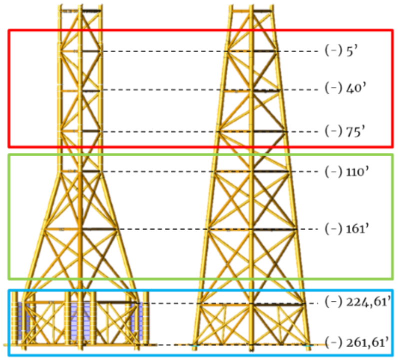


Figure 12 Division of elevation

3. Inplace Analysis

From the inplace analysis that has been carried out on both jacket models, the results are shown in Figure 13.

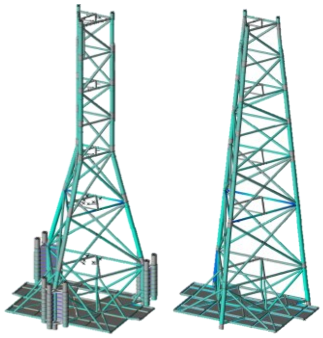


Figure 13 Inplace analysis results of modified and conventional jacket

From the results above, it is noted that the largest UC experienced by modified jacket was 0.225 for member 0055 - 0101. While the largest UC experienced by conventional jackets was 0.285 for members 0070 - 0114. From these results, it can be said that the two jacket models with different legs configuration were qualified because the largest UC checking result was less than 1.

4. Fatigue Analysis

a. Natural Periods and Frequencies

The calculation results of the period and natural frequency using SACS software for the two jacket models are shown in mode 1 in tables 5 and 6.

Table 5 The first 5 mode shape of modified jacket

Modified Jacket				
MODE	**FREQ.(CPS)**	**GEN. MASS**	**EIGENVALUE**	**PERIOD(SECS)**
1	0,570	1,58E+11	7,81E+05	1,756
2	0,576	1,44E+11	7,64E+05	1,737
3	0,951	1,45E+11	2,80E+05	1,052
4	1,652	1,35E+10	9,28E+04	0,605
5	1,675	8,25E+09	9,03E+04	0,597

Table 6 The first 5 modes shape of conventional jacket

Conventional Jacket				
MODE	**FREQ.(CPS)**	**GEN. MASS**	**EIGENVALUE**	**PERIOD (SECS)**
1	0,679	1,71E+11	5,49E+05	1,472
2	0,684	1,68E+11	5,41E+05	1,461
3	1,065	2,23E+11	2,23E+05	0,939
4	1,948	2,23E+11	6,68E+04	0,513
5	1,979	2,75E+11	6,47E+04	0,505

b. Response Amplitude Operator (RAO)

By using the same environmental load, the RAO calculation results for the base shear and overturning moment of the two jacket models showed different results. The results of the modified RAO jacket are shown in Figures 14 and 17.

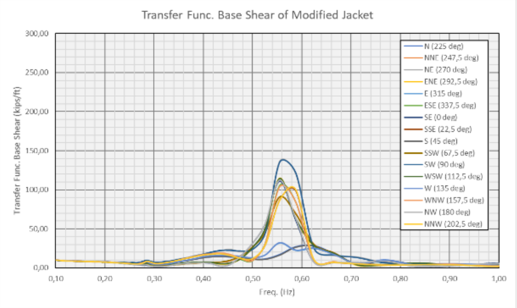


Figure 14 RAO base shear of modified jacket in frequency.

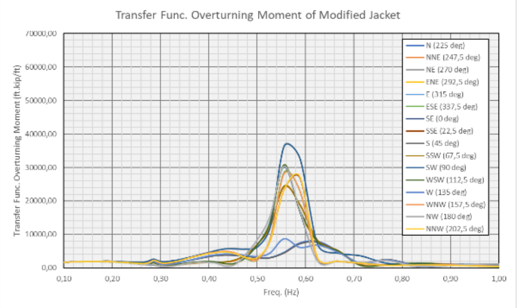


Figure 15 RAO overturning moment of modified jacket in frequency

Meanwhile, the RAO produced by conventional jackets had a greater value as shown in Figures 3.12 and 3.13.

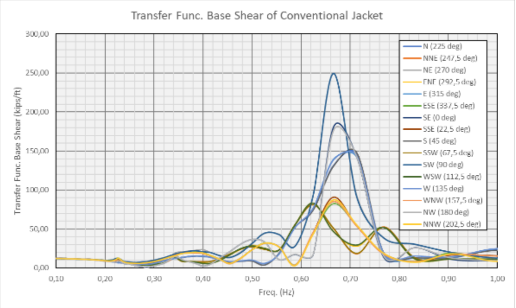


Figure 16 RAO base shear of conventional jacket in frequency.

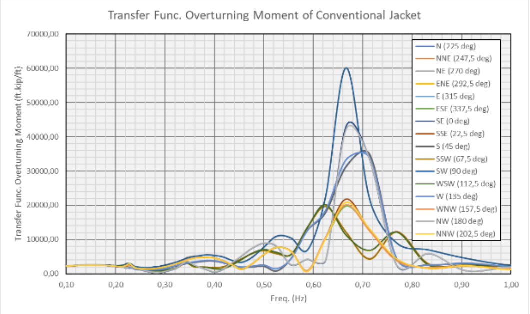


Figure 17 RAO overturning moment of conventional jacket in frequency

c. Dynamic Amplification Factor (DAF)

By applying a structure damping factor of 2%, the DAF calculation results of the two jacket models can be seen in table 7.

Table 7 DAF calculation results

Wave Direction		Tp (s)	DAF Conventional Jacket			DAF Modified Jacket		
			$\{1-(T_n/T)^2\}^2$	$(2\beta T_n/T)^2$	DAF	$\{1-(T_n/T)^2\}^2$	$(2\beta T_n/T)^2$	DAF
N	225	3,31	0,6436	0,0003	1,246	0,5163	0,0005	1,391
NNE	247,5	3,25	0,6318	0,0003	1,258	0,5014	0,0005	1,412
NE	270	3,23	0,6278	0,0003	1,262	0,4962	0,0005	1,419
ENE	292,5	3,53	0,6825	0,0003	1,210	0,5663	0,0004	1,328
E	315	5,84	0,8770	0,0001	1,068	0,8274	0,0001	1,099
ESE	337,5	5,20	0,8462	0,0001	1,087	0,7849	0,0002	1,129
SE	0	3,28	0,6378	0,0003	1,252	0,5089	0,0005	1,401
SSE	22,5	3,17	0,6152	0,0003	1,275	0,4805	0,0005	1,442
S	45	3,07	0,5931	0,0004	1,298	0,4527	0,0005	1,485
SSW	67,5	2,97	0,5691	0,0004	1,325	0,4231	0,0006	1,536
SW	90	2,98	0,5715	0,0004	1,322	0,4261	0,0006	1,531
WSW	112,5	3,48	0,6742	0,0003	1,218	0,5556	0,0004	1,341
W	135	5,31	0,8522	0,0001	1,083	0,7932	0,0002	1,123
WNW	157,5	6,54	0,9012	0,0001	1,053	0,8610	0,0001	1,078
NW	180	4,70	0,8134	0,0002	1,109	0,7403	0,0002	1,162
NNW	202,5	3,25	0,6318	0,0003	1,258	0,5014	0,0005	1,412

d. Fatigue Life

The fatigue life analysis was only concentrated on the main joints that connect the main members such as jacket leg and bracing.

Table 8 Top section joints fatigue life

Top						
Row/Elevation (from MSL)	Conventional Jacket			Modified Jacket		
	Joint	Member	Fatigue Life (years)	Joint	Member	Fatigue Life (years)
(-) 5'	0078	0061-0078	31533,32	0012	0001-0012	36033,51
	0091	0078-0091	150529,8	0006	0195-0006	1302607
	0061	0067-0061	9125,79	0009	0013-0009	13229,9
(-) 40'	0067	0105-0067	983051,7	0010	0100-0010	261460000
	0107	0105-0107	infinite	0098	0207-0098	infinite
	0092	0093-0092	15593,67	0007	0008-0007	9886,43
	0105	0107-0105	infinite	0100	0010-0100	infinite
	0106	0105-0106	infinite	0099	0208-0099	infinite
	0079	0080-0079	11138,05	0013	0014-0013	11367,81
(-) 75'	0068	0069-0068	15539,58	0011	0005-0011	13843,78
	0093	0080-0093	2236095	0008	0215-0008	306370000
	0080	0079-0080	35491,34	0014	0013-0014	10953,7

Table 9 Middle section joints fatigue life.

Middle						
Row/Elevation (from MSL)	Conventional Jacket			Modified Jacket		
	Joint	Member	Fatigue Life (years)	Joint	Member	Fatigue Life (years)
(-) 110' and X-bracings under it	0069	0070-0069	2001440	0017	0055-0017	677,464
	0113	0111-0113	infinite	0081	0088-0081	infinite
	0094	0080-0094	123072,1	0015	0049-0015	96,1158
	0111	0069-0111	infinite	0079	0088-0079	infinite
	0112	0081-0112	infinite	0082	0089-0082	infinite
	0081	0068-0081	43505,3	0016	0050-0016	101,0301
	0097	0083-0097	279810,6	0056	0015-0056	26037000
	0098	0070-0098	1263107	0060	0015-0060	10869000
	0099	0083-0099	1360852	0066	0050-0066	13010,48
(-) 161' dan X-bracings under it	0070	0071-0070	843017,8	0055	0023-0055	79235,86
	0116	0095-0116	infinite	0101	0049-0101	infinite
	0095	0096-0095	1453852	0049	0101-0049	503315,7
	0114	0070-0114	infinite	0096	0107-0096	infinite
	0115	0083-0115	infinite	0104	0101-0104	infinite
	0083	0081-0083	984899,6	0050	0022-0050	55470,17
	0100	0084-0100	10665000	0068	0049-0068	481450000000
	0101	0095-0101	93268000	0120	0023-0120	1008500000
	0120	0070-0120	10520000	0072	0022-0072	1287954

Table 10 Bottom section joints fatigue life.

Bottom						
Row/Elevation (from MSL)	Conventional Jacket			Modified Jacket		
	Joint	Member	Fatigue Life (years)	Joint	Member	Fatigue Life (years)
(-) 224,61'	0071	0070-0071	4758150	0023	0026-0023	149,6136
	0119	0071-0119	infinite	0051	0052-0051	infinite
	0096	0095-0096	8195252	0018	0224-0018	974,0327
	0117	0071-0117	infinite	0039	0038-0039	infinite
	0118	0084-0118	infinite	0045	0025-0045	infinite
	0084	0083-0084	946588,7	0022	0025-0022	44,98
(-) 261,61'	0010	0071-0010	16481000	0029	0226-0029	infinite
	0032	0125-0032	infinite	0052	0165-0052	infinite
	0011	0096-0011	1822043	0027	0246-0027	infinite
	0012	0123-0012	infinite	0038	0025-0038	infinite
	0031	0084-0031	322020000	0033	0024-0033	infinite
	0009	0084-0009	35093000	0028	0040-0028	infinite

With different results, the fatigue life of the two structures globally can be represented by the lowest fatigue life at the joint of each structure shown in Table 11.

Table 11 Lowest fatigue life of each structure

Lowest Fatigue Life					
Conventional Jacket			Modified Jacket		
Joint	Member	Fatigue Life (years)	Joint	Member	Fatigue Life (years)
0061	0067-0061	9125,79	0022	0025-0022	44,98

While the joint location with the lowest fatigue life in each structural model can be seen in Figure 18.

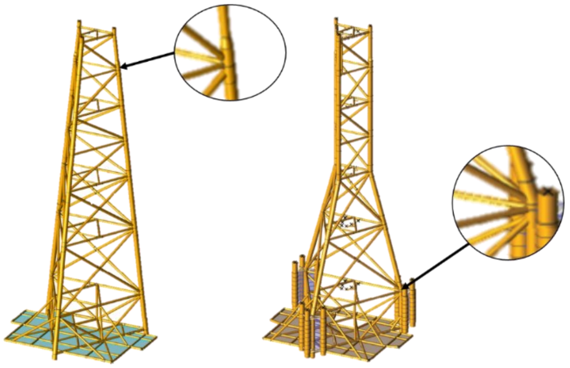


Figure 18 The joint location with the lowest fatigue life

4. CONCLUSION

The conclusions that can be drawn from the results of this study are as follows:

1. The natural period in the modified jacket has a higher value of 1.756 s due to the lower stiffness value of the conventional jacket with a natural period value of 1.472 s.
2. Overall, the joints in the modified jacket at the top at (-) 5 ', (-) 40', and (-) 75' elevations have a higher fatigue life than the joints at the same point on the conventional jacket. This is due to the higher SCF occurs in the joint with the angle of inclination between the chord and brace that is not right angled as in conventional jackets.
3. *Joint* on modified jackets in the middle at elevation (-) 110 'and (-) 161' have lower fatigue life than joints at the same point on conventional jackets. This is due to the higher SCF in the joint with a more extreme tilt angle between the chord and brace on the modified jacket.
4. Based on the structural configuration, conventional jacket has a longer operational life with the lowest fatigue life is 9125.79 years compared to modified jacket with the lowest fatigue life of 44.98 years.

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