p–ISSN: 2723 - 6609 e-ISSN: 2745-5254
Vol. 4, No. 11 November 2023 http://jist.publikasiindonesia.id/

Case Study of Strength and Calculation of Remaining Service Life on Rig Equipment Using PT XYZ's Finite Element Analysis

Satya Wicaksana[1], Deni Ferdian[2*], Johny W. Soedarsono[3], Mirza Mahendra[4]
University of Indonesia Depok, Indonesia[1,2], Ministry of Energy and Mineral Resources DKI Jakarta, 12910, Indonesia[3]
Email : satya.wic@gmail.com[1], deni@metal.ui.ac.id[2], johny.ws@gmail.com[3], mirzamahendra@gmail.com[4]

*Correspondence

ABSTRACT

Indonesia is a country that has a variety of natural resources, one of which is oil and gas. In the process of drilling for petroleum, one of the equipment used is a Rig. Age factors can affect the performance of the rig system. Where a structure is depleted beyond ten per cent, then the contribution must be the element undergoing repair or replacement of the defective. The Depletion structure must be repaired. Before operating with new materials, return to the initial condition. Therefore, Regulation Number 32 of 2021, Safety Inspection of Installations and Equipment in Oil and Gas Business Activities, sets the remaining life limit for equipment service. The research method used in this paper refers to the strength of the Rig Tower member, which is calculated using applicable formulas and standards. The final step is a simulation performed using FAE MSC Nastran software. In the calculation, the loading cases of API Spec 4F are used, namely: 1. Max. Rated static hook load of 90.7 tnf (889,463.2 N) with 6 lines, 2. Wind speed of 60 knots with pipe setback. The calculation results can be concluded that the structure of PT XYZ's Rig tower is strong enough against the Maximum Static Hook Load of 889,463.2 N (6 lines), wind load of 60 Knots with pipe setback, rig up load and can last for 30.39 (thirty-thirty-nine hundredths) of years for fatigue, 24 (twenty-four) years for environmental corrosion (Upper Mast) and 20.56 (twenty-fifty-six hundredths) of a year for abrasion corrosion (Lower Mast).

Keywords: rig; finite element analysis (fea); remaining life.

Introduction

Indonesia is a country that has a variety of natural resources, one of which is oil and gas (Anshar, 2017). In the process of drilling for petroleum, one of the equipment used is a Rig. A rig is a set of equipment used for underground drilling to obtain gas, petroleum, and various other underground minerals (Ulfah. Nurul, 2014). The existence of towers made of steel used to raise and lower well tubular pipes is the main characteristic of rigs. This rig is usually used in oil and gas and geothermal operations because it is able to operate at high pressure (Aji, Subagio, Hariyadi, & Weningtyas, 2015). Natural gas and oil drilling rigs can be used to determine the geological properties of reservoirs as well as to create holes that allow the extraction of natural gas or oil content from reservoirs (Minister of Education and Culture, 2013). In oil and gas exploration and exploitation operations, safety is very important because it relates to asset safety, environmental safety, and human resource safety (Rozie, 2020). Age factors can affect the performance of the rig system. Where a structure is depleted beyond ten per cent, then the contribution must be the element undergoing repair or replacement of the defective (Bethoven, 2023). The Depletion structure must be repaired. Before operating with new materials returns to the initial condition (Chen, 2016), and systems that have been improved must be proven feasible. Operations by performing calculations carried out technically (Santika, 2017). Therefore, Regulation Number 32 of 2021, Safety Inspection of Installations and Equipment in Oil and Gas Business Activities, sets the remaining life limit for equipment service. All equipment that has exceeded the operating design life limit (if known) or shows symptoms of ageing that can interfere with the integrity of the equipment must evaluate the remaining service life (Suhendar, 2021).

Research Methods

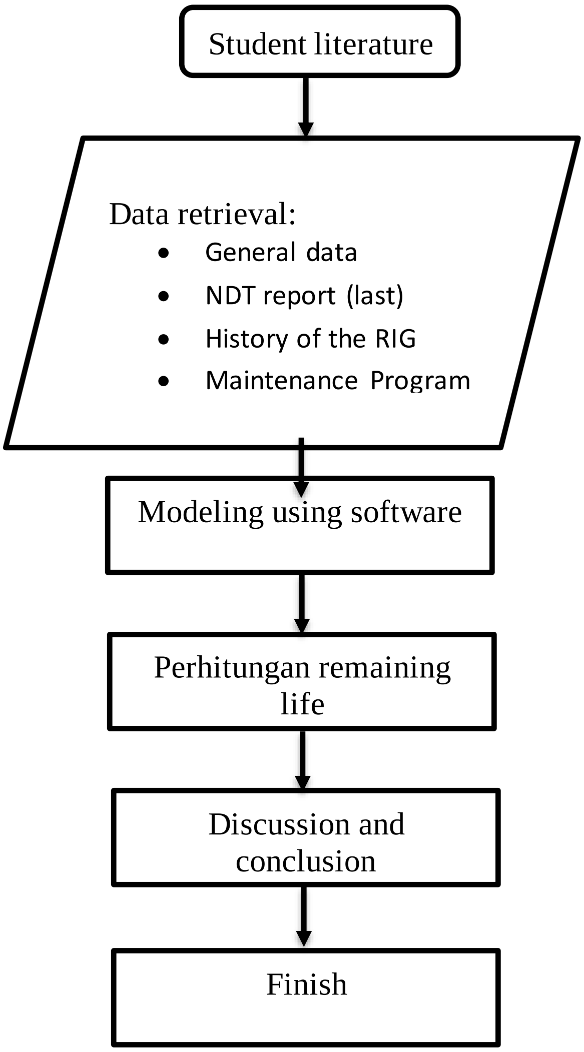

Figure 1

The research method used in this paper refers to the strength of the Rig Tower member, which is calculated using applicable formulas and standards. The final step is a simulation performed using FAE MSC Nastran software. This method is used to evaluate the greatest load that occurs during the construction of the Rig tower to determine the deflection that occurs in the frame structure of the Rig tower bar; this paper presents data from manual calculations and FEA simulation results (Mayudha, 2022). As mentioned above, for calculation and Remaining life Assessment used FEA software MSC/ NASTRAN 4.5 and Patran Nastran 2007 for 3D structures using a choice of AISC ASD-89 calculation modules as recommended by API Spec 4F, section 8 and Design Specification. In calculations used, loading cases from API Spec 4F are:

a. Max. Rated static hook load of 90.7 tnf (889,463.2 N) with 6 lines
b. Wind speed of 60 knots with pipe setback

It uses a static load of 90.7 tnf (889,463.2 N). The placement of the load above on the structure of the boom is as in Figure 3.3 and Figure 3.4, where for the Hook load, the load acting on the boom is the Hook load plus the weight of the travelling block and the forces due to deadline and draw work which are each 1/6 x (Hook load + weight of the travelling block).

The calculation results produced by the software are as follows:

Pressure Clearance (AISC, 1989)

a. Tension Member
b. Compression Member
c. Combined Stresses

Results and Discussion

Calculations are performed on several "Combined Load Cases" (CLCs), where each CLC can consist of one or more Load Cases (Arsita, Saputro, & Susanto, 2021). For booms, there are 3 CLCs each. Each CLC is calculated separately and produces its STRESS RATIO (SR) for each part of the structure (Irawan, Subagio, Hariyadi, & Gerardo, 2017). The highest SR value of each part obtained from the three CLCs is then displayed in the form of the Maximum STRESS RATIO Distribution for the tower, as shown in Figures 1, 2, and 3.

Pembebanan Hook Load (N)	Tegangan Optimum (N/m²)	Deformasi (m)	Keterangan
889,463.2	5.502E+3	0.248	Upper mast
Wind Load (Knots)			
60 (dengan pipe set back)	3.544E+7	0.00323	Upper mast
Rig Up Load	2597E+7	0.00334	Upper mast

Figure 1

The value of the optimum working voltage of compression on the critical beam

Figure 1 details the voltage results of the maximum hook load, wind load and rig-up load. According to AISC, a construction is defined as strong if the SR value of the combined loading of its parts does not exceed the value of one in Figure 5 (Nurhayati & Oktavia, 2022). It can be seen that none of the parts of the tower are red, i.e. the part of the structure that has an SR value greater than 1.

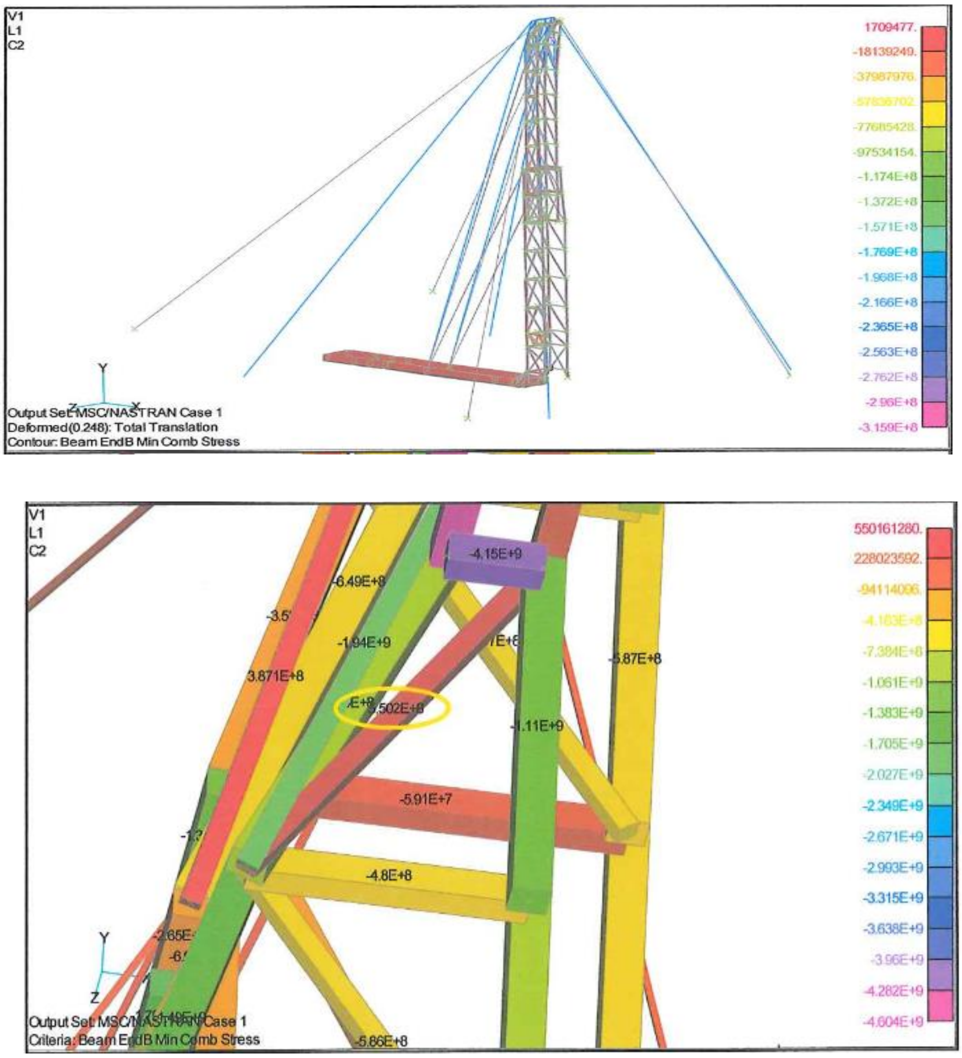

Figure 2 FEA Static Hook Load 90.7 tnf (889,463.2 N) voltage results the maximum is 5.502E+3 N/m², and the deformation is 0.248 m

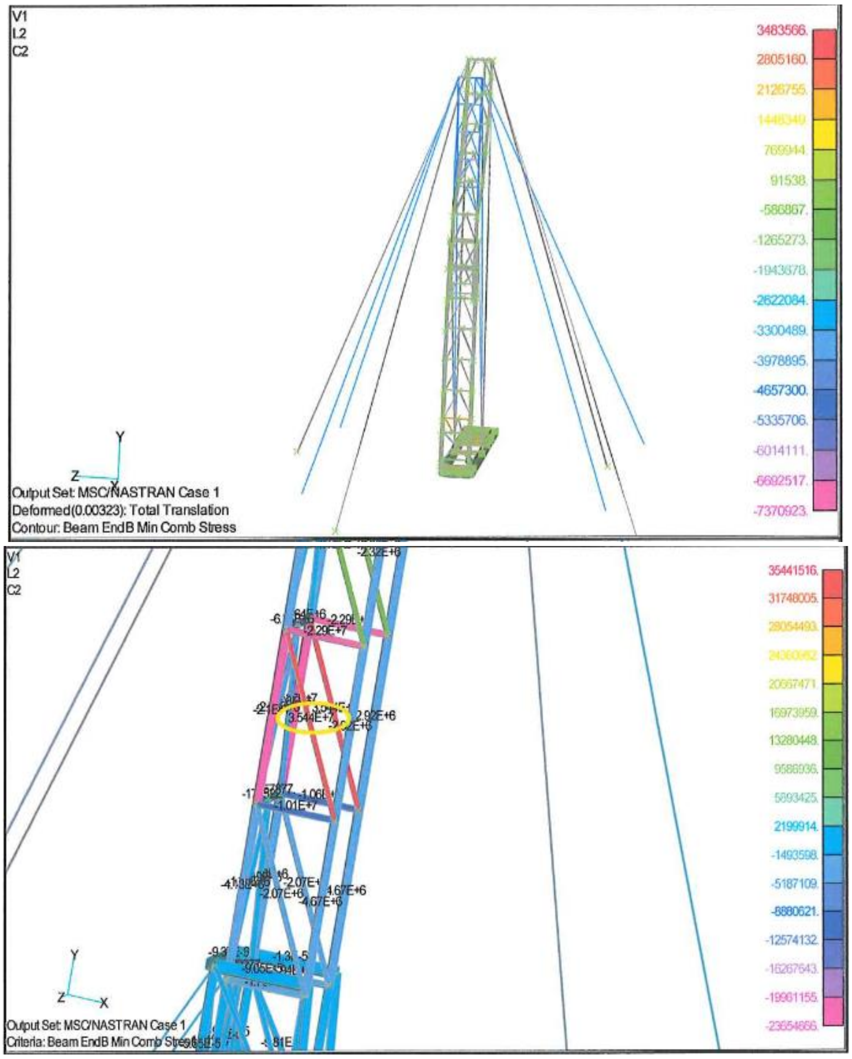

Figure 3 FEA Wind load result of 60 knots (73.63 x 10-6 Kgf/m² distributed load) with pipe setback maximum voltage at lower mast is 3.544E+7 N/m² and deformation is 0.00323 m.

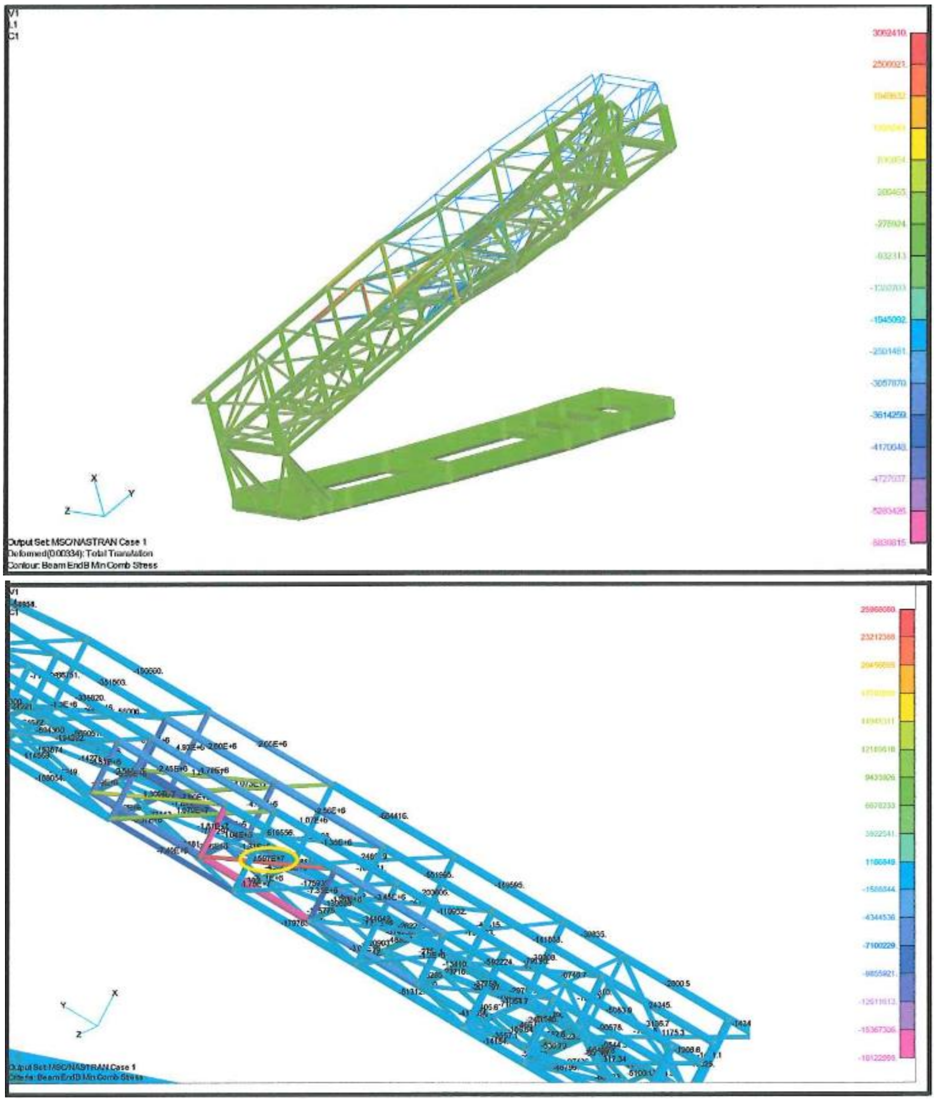

Figure 4 FEA results in the maximum voltage when the rig up is 2597E+7 N/m², and the deformation is 0.00334 m.

The calculation of remaining life is calculated based on the cycle load approach and the actual thickness and corrosion rate that occurs. Here is the calculation of the remaining life (Sari, 2014). Based on the Rig History report, the average rig works for 8.07 hours in one day, then in one year, 8.07x3600x365 = 10,603,980 seconds. The frequency on the Rig is 0.0256 Hz then:

$$\text{Cycles (T)} = \frac{Sec.}{f}$$

$$Sec. = Cycles\ (T)\ x\ f$$

$$Sec. = 10^{10.10}\ x\ 25.6\ x\ 10^{-3} = 25.6\ x\ 10^{7.10}$$

$$\text{Remaining Life} = \frac{25.6\ x\ 10^{7.10}}{10.60398\ x\ 10^{6}} = 30.39\ Tahun$$

Account for remaining life By environmental corrosion (Fontana, 1986).

$$F = \frac{Max.\ Static\ Hook\ Load}{4}$$

$$d_i = \sqrt{(d_o)^2 - \frac{Fx4}{\sigma x \pi}}$$

$$t_{req} = d_o - d_i$$

F = 222,365.8 N
σ_y = 345 Mpa = 345 N/mm²
For the safety factor, the voltage used
σ = 220 Mpa = 220 N/mm²
t_{req} = 7.56 mm
$t_{abr(2017)}$ = 7.78 mm
$t_{act(2017)}$ = 7.80 mm
(Now) = 8.08 mm
Length of operation = 28 Tahun

Corrosion rate Upper Mast results in environmental corrosion be: (Fontana, 1986)

$$C_{r.ec} = \left(\frac{t_{new} - t_{act}}{Years}\right)$$

$$C_{r.ec} = 0.01 mm/Tahun$$

Remaining Life of Upper Mast results in environmental corrosion be: (Fontana, 1986)

$$RL_{ec} = \left(\frac{t_{act} - t_{req}}{C_{r.ec}}\right)$$

$$RL_{ec} = 24\ Tahun$$

Corrosion rate Lower Mast result abrasion corrosion be: (Fontana, 1986)

$$C_{r.ac} = \left(\frac{t_{new} - t_{abr}}{years}\right)$$

$$C_{r.ac} = 0.0107\ mm/Tahun$$

Remaining Life Lower Mast result abrasion corrosion be: (Fontana, 1986)

$$RL_{ac} = \left(\frac{t_{abr} - t_{req}}{C_{r.ac}}\right)$$

$$RL_{ac} = 20.56\ Tahun$$

Conclusion

From the calculation results shown in Figures 4.1, 4.2, 4.3 and Table 4.1, it can be concluded that the structure of PT XYZ's Rig tower is strong enough to the Maximum Static Hook Load of 889,463.2 N (6 lines), wind load of 60 Knots with pipe setback, rig up load and can last for 30.39 (thirty-thirty-nine hundredths) of years for fatigue, 24 (twenty-four) years for environmental corrosion (Upper Mast) and 20.56 (twenty-fifty-six hundredths) years for abrasion corrosion (Lower Mast).

Bibliography

Aji, Akhmad Haris Fahruddin, Subagio, Bambang Sugeng, Hariyadi, Eri Susanto, & Weningtyas, Widyarini. (2015). Evaluasi Struktural Perkerasan Lentur Menggunakan Metode AASHTO 1993 dan Metode Bina Marga 2013 Studi Kasus: Jalan Nasional Losari-Cirebon. *Jurnal Teknik Sipil ITB*, *22*(2), 147–164.

Anshar, Anshar. (2017). Penguasaan Negara Atas Migas Sebagai Wujud Kedaulatan Atas Sumberdaya Alam Dalam Perspektif Hukum Internasional Kontemporer. *Jurnal IUS Kajian Hukum Dan Keadilan*, *5*(2), 163–176.

Arsita, Savira Ayu, Saputro, Guntur Eko, & Susanto, Susanto. (2021). Perkembangan kebijakan energi nasional dan energi baru terbarukan Indonesia. *Jurnal Syntax Transformation*, *2*(12), 1779–1788.

Bethoven, Muhamad Aqila. (2023). *Analisis Pengendalian Risiko Keselamatan dan Kesehatan Kerja (K3) Pada Proyek Jalan Tol Solo-jogja-nyia Kulon Progo Dengan Metode Risk Assesment Berdasarkan As/nzs 4360: 2004*. Universitas Islam Indonesia.

Chen, J. Z. (2016). Inspection Techniques for Tubulars Used in Oilfield. *Materials Evaluation*, *74*(10), 1362–1370.

Irawan, S., Subagio, B., Hariyadi, E., & Gerardo, Faisal. (2017). Evaluasi Struktural Perkerasan Kaku Menggunakan Metoda AASHTO 1993 dan Metoda AUSTROADS 2011 Studi Kasus: Jalan Cakung-Cilincing. *Jurnal Teknik Sipil*, *24*(2), 173–182.

MAYUDHA, MARTIN. (2022). *Analisis Kinerja Supply Chain Pada Proses Pengiriman Barang Pt. Xyz Menggunakan Scor Model 12.0*.

Nurhayati, Dwi Astuti Wahyu, & Oktavia, Novi Tri. (2022). Pemanfaatan Sumber Daya Alam Pesisir Pantai Selatan Sebagai Penunjang Pembangunan Pariwisata Pantai Gemah. *NAWASENA: Jurnal Ilmiah Pariwisata*, *1*(3), 56–70.

Rozie, Amam Fachrur. (2020). Remaining Life Assessment dan Kasus Laju Korosi Pada LPG Storage Tank Kapasitas 50 Ton. *JTTM: Jurnal Terapan Teknik Mesin*, *1*(2), 96–106. https://doi.org/10.37373/msn.v1i2.26

Santika, Putu Mahayana. (2017). Perhitungan Teknis Perbaikan Menara Atas (Upper Mast) Rig# 77. *JTM-ITI (Jurnal Teknik Mesin ITI)*, *1*(2), 40–45. https://doi.org/10.31543/jtm.v1i2.22

Sari, Dian Novita. (2014). Analisa Beban Kendaraan Terhadap Derajat Kerusakan Jalan dan Umur Sisa (Studi Kasus: PPT. Senawar jaya Sumatera Selatan). *Jurnal Teknik Sipil Dan Lingkungan*, *2*(4), 615–620.

Suhendar, Atep. (2021). Pengaruh Persepsi tentang Perubahan Struktur Organisasi terhadap Kinerja Pegawai pada Direktorat Jenderal EBTKE Kementerian ESDM.

Journal of Education, Humaniora and Social Sciences (JEHSS), *4*(1), 546–552.