DEGRADATION LIMIT STATE MODEL FOR STRUCTURAL RELIABILITY SCREENING OF AGEING FIXED OFFSHORE PLATFORMS

NURUL UYUN BINTI AZMAN

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Razak Faculty of Technology and Informatics
Universiti Teknologi Malaysia

JANUARY 2023

DEDICATION

To the loved ones. Thank you.

ACKNOWLEDGEMENT

I wish to express my gratefulness especially to my supervisors Assoc. Prof. Ir. Ts. Dr. Mohd Khairi bin Abu Husain and Assoc. Prof. Ir. Ts. Dr. Noor Irza binti Mohd Zaki for their endless guidance and valuable suggestions to complete this thesis. I am also indebted to my external supervisors, Dr. Ezanizam bin Mat Soom and Dr. Sayyid Zainal Abidin bin Syed Ahmad for knowledge sharing on academic and offshore industry practices. To my family and loved ones, thank you for your countless support and encouragement throughout the journey of my life.

ABSTRACT

Ageing fixed offshore platforms are growing in numbers worldwide. Operators choose to extend the platforms lives beyond the original design to improve economic viability and increase profitability. The structural integrity of these platforms is affected by various degradation factors throughout their service lives. However, a limited number of comprehensive studies have been conducted on the relationship between reserve strength ratio, probability of failure and return period with multiple degradation factors. This study aims to develop a comprehensive regression model of reserve strength ratio, probability of failure and return period by considering marine growth, corrosion and subsidence. Calculating reserve strength ratio, probability of failure, and return period are fairly time consuming. The presence of the proposed model is to provide a quick reference and immediate results of the remaining life of the fixed offshore platform in the occurrence of degradations, thus minimising the usage of industry resources. It is also expected that degradation effects over time will be predicted accurately. The development of the degradation limit state model adopted structural reliability assessment, which has been widely used in the oil and gas industry to determine the probability of failure and return period of offshore structures. The assessment can provide a higher confidence level that is required by regulators and stakeholders. This study includes the effects of wave height at the collapse of the platform caused by wave-in-deck. The wave-in-deck load has been calculated based on the silhouette method introduced by International Organization for Standardization. The degradation limit state models considered have 0 m, 2 m, 4 m, 6 m and 8 m subsidence. Each of them with 0 mm, 3 mm, 6 mm, 9 mm and 12 mm corrosion depth has been studied separately. The model has been developed using both single and linear multi regression method. The proposed models are then validated with a platform of similar configurations. Based on the validation results of single regression method, the lowest accuracy for reserve strength ratio was 94.9 %, while the probability of failure and return period were 56.6 % and 69.7 %, respectively. Despite that, the variations are acceptable since both probability of failure and return period values conform with the standard industry requirements. However, the results for 5 m subsidence shows very low accuracies, hence not recommended to utilise subsidence value that has not been considered in model development. For linear multi regression method, the lowest accuracy for reserve strength ratio has been 92.1 %. However, both probability of failure and return period shows very low accuracies, therefore, not recommended to be utilized by industry. It has been found that although the analysis model used for validation had a similar configuration, the overall platform surfaces were different, which in turn gave different platform responses. This eventually led to differences in the probability of failures and return periods. Careful consideration is expected prior to adopting the proposed model as it is to be used with platforms, which have similar platform configurations, structural member sizing, water depth and metocean data. The accuracy and effectiveness of the proposed model will generally assist operators in the industry in decision-making and more importantly, in outlining the action items for business risk management in which marine growth, corrosion, and subsidence are expected to occur.

ABSTRAK

Bilangan pelantar minyak tetap luar pesisir lebih usia semakin bertambah di seluruh dunia. Pengendali memilih untuk memanjangkan jangka hayat pelantar melebihi usia reka bentuk asal bagi meningkatkan daya maju ekonomi dan keuntungan. Integriti struktur pelantar ini dipengaruhi oleh pelbagai masalah degradasi sepanjang hayat operasi. Walau bagaimanapun, sebilangan kajian komprehensif yang terbatas telah dijalankan mengenai hubung kait antara nisbah kekuatan simpanan, kebarangkalian gagal and tempoh ulangan dengan pelbagai degradasi. Kajian ini bertujuan untuk membangunkan model regresi yang menyeluruh bagi nisbah kekuatan simpanan, kebarangkalian gagal and tempoh ulangan dengan mengambil kira hidupan marin, karatan dan enapan. Mengira nisbah kekuatan simpanan, kebarangkalian gagal dan tempoh ulangan memakan masa yang agak panjang. Kehadiran model yang diusulkan ini dapat menjadi rujukan dan memberikan keputusan yang segera terhadap baki jangka hayat pelantar minyak tetap luar pesisir sekiranya degradasi terjadi, seterusnya mengurangkan penggunaan tenaga kerja industri. Turut dijangkakan bahawa kesan degradasi dari masa ke masa akan dapat diramalkan dengan tepat. Pembangunan model degradasi had keadaan menggunakan penilaian kebolehpercayaan struktur, yang telah banyak digunakan dalam industri minyak dan gas untuk menentukan kebarangkalian gagal dan tempoh ulangan pelantar minyak tetap luar pesisir. Penilaian ini dapat memberikan aras keyakinan yang diperlukan oleh pihak berkuasa dan berkepentingan. Kajian ini juga merangkumi kesan ketinggian ombak ketika platform runtuh disebabkan oleh bebanan hempasan ombak ke dek. Bebanan hempasan ombak ke dek dikira berdasarkan kaedah siluet yang dicadangkan oleh *International Organization for Standardization*. Model degradasi had keadaan ini mengambil kira enapan sebanyak 0 m, 2 m, 4 m, 6 m dan 8m. Setiap model tersebut mempunyai 0 mm, 3 mm, 6 mm, 9 mm dan 12 mm tebal karatan. Model in dibangunkan mengunakan kaedah regresi tunggal dan kaedah lelurus berbilang. Model yang dicadangkan juga telah dibandingkan dengan satu pelantar minyak luar persisir yang mempunyai persamaan konfigurasi. Berdasarkan pengesahan menggunakan kaedah regresi tunggal, nilai ketepatan terendah bagi nisbah kekuatan simpanan adalah 94.9 %, manakala kebarangkalian gagal dan tempoh ulangan, nilainya masing-masing adalah 56.6 % dan 69.7 %. Walau bagaimanapun, perbezaan ini boleh diterima kerana nilai kebarangkalian gagal dan tempoh ulangan memenuhi keperluan piawaian industri. Walau bagaimanapun, keputusan enapan 5 m menunjukkan ketepatan yang sangat rendah, oleh itu tidak digalakkan untuk menggunakan nilai yang tidak diambil kira dalam pembangunan model. Bagi kaedah regresi lelurus berbilang, ketepatan terendah untuk nisbah kekuatan simpanan adalah 92.1 %. Namun begitu, nilai kebarangkalian gagal dan tempoh ulangan menunjukkan ketepatan yang sangat rendah, maka tidak disarankan untuk digunakan oleh industri. Dengan ini didapati bahawa walaupun analisis model yang digunakan untuk validasi mempunyai konfigurasi yang sama, tetapi keseluruhan permukaan pelantar adalah berbeza menyebabkan perbezaan dari segi tindakbalas pelantar. Ini akan menyebabkan perbezaan kebarangkalian gagal dan tempoh ulangan. Pertimbangan yang teliti adalah diperlukan sebelum menggunakan model yang dicadangkan ini kerana ia mestilah digunakan bersama pelantar minyak yang mempunyai persamaan dari segi konfigurasi platform, saiz anggota struktur, kedalaman air dan data meteorologi samudera. Ketepatan dan keberkesanan model degradasi yang diusulkan dalam kajian ini akan membantu pengendali di dalam industri untuk membuat keputusan. Lebih penting, dalam menggariskan item tindakan bagi pengurusan risiko perniagaan sekiranya ada hidupan marin, karatan dan enapan yang dijangka akan berlaku.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ALARP	-	As Low As Reasonably Practical
API	-	American Petroleum Institute
AWS	-	American Welding Society
BOS	-	Bottom of Steel
CAPEX	-	Capital Expenditure
COV	-	Coefficient of Variance
EEMUA	-	Engineering Equipment Material Users Association
GUSA	-	Global Ultimate Strength Assessment
HAT	-	Highest Astronomical Height
HSE	-	Health & Safety Executive
HSSE	-	Health, Safety, Security and Environment
ISO	-	International Organization for Standardization
LAT	-	Lowest Astronomical Height
MSL	-	Mean Sea Level
NCS	-	Norwegian Continental Shelf
NORSOK	-	The Norwegian Shelf's Competitive Position Standard
OPEX	-	Operational Expenditure
PMO	-	Peninsular Malaysia Operation
RBDA	-	Reliability Based Design and Assessment
ROV	-	Remotely Operated Vehicle
SACS	-	Structural Analysis Computer Software
SBO	-	Sabah Operation
SKO	-	Sarawak Operation
SRA	-	Structural Reliability Assessment
TOS	-	Top of Steel
UKCS	-	United Kingdom Continental Shelf
USFOS	-	Ultimate Strength of Offshore Structure

LIST OF SYMBOLS

A	-	environment constant
A_w	-	projected area of the wave-in-deck
C_d	-	drag coefficient
C_m	-	inertia coefficient
D_L	-	gravity load
$E_{collapse}$	-	base shear at the collapse of platform / ultimate capacity
E_{RP}	-	base shear corresponding to return period
$E_{topsides}$	-	wave-in-deck load
E_0	-	environment constant
E_{100}	-	base shear of 100-year return period
$f(x_i)$	-	approximate value to the model function
H_{max}	-	maximum wave height
h_{RSR}	-	maximum wave height at collapse of the platform
h_{100}	-	100-year wave height
L	-	load
$\bar{L}$	-	mean load
L_D	-	design load
n	-	total number of dependent variables
P_E	-	probability density function
P_f	-	probability of failure / failure probability
P_R	-	probability density resistance
POF	-	probability of failure
p	-	total number of coefficients
R	-	resistance
R^2	-	coefficient of determination
${R_{adj}}^2$	-	adjusted coefficient of determination
$\bar{R}$	-	mean resistance
R_i	-	characteristic resistance
R_{mean}	-	mean member capacity or mean member resistance

$\bar{R}_{mean}$	-	mean distribution of structural strength
RP	-	return period
RSR	-	reserve strength ratio
RSS	-	residual sum of squares
S	-	strength
S_{ult}	-	ultimate strength
S_x	-	strength in X-direction
S_y	-	strength in Y-direction
T_{ass}	-	associated period
TSS	-	total sum of squares
U_c	-	current speed in-line with the wave from metocean data
U_w	-	fluid velocity corresponding to crest height
x	-	subsidence depth
x_1	-	independent variable representing subsidence depth
x_2	-	independent variable representing corrosion depth
y	-	dependent variable representing either reserve strength ratio or probability of failure or return period
$\bar{y}$	-	mean value of either reserve strength ratio or probability of failure or return period
α	-	constant from metocean data
α_1	-	intercept
α_2	-	coefficient of linear term
α_3	-	coefficient of quadratic term
α_4	-	coefficient of cubic term
α_5	-	coefficient of quartic term
α_{cb}	-	current blockage factor
α_L	-	constant of linearity
α_{wk}	-	wave kinematic factor from metocean data
β_0	-	intercept
β_1	-	coefficient for subsidence depth
β_2	-	coefficient for corrosion depth
γ_D	-	gravity load factor
γ_E	-	environmental load factor from metocean data

δ	-	displacement
ϕ_i	-	resistance factor
ρ_w	-	density of seawater
σ_R	-	standard deviation of the distribution of structural strength

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Anglo-Saxon Petroleum Company, owned by Royal Dutch Shell, discovered the first commercial oil well in Malaysia in 1910. It was located at onshore field in Miri, Sarawak (Seong and Hong, 1995; Sorkhabi, 2010). The discovery marked the starting point of petroleum industry in Malaysia. Over the years, exploration was extended to offshore location which brought West Lutong oilfield in Sarawak as the first offshore oilfield which started operating in 1968 (Abdul Rahim and Liwan, 2012). In 2000, there were more than 300 offshore platforms in Malaysia operated by PETRONAS Peninsular Malaysia Operation (PMO), Sarawak Operation (SKO) and Sabah Operation (SBO) (Wan Abdullah Zawawi et al., 2012). According to Ng et al. (2019), more than 50 % of platforms in Malaysia operate for more than 25 years as shown in Figure 1.1. The oldest platform owned by PETRONAS is already in operation for 50 years (Ng et al., 2019).

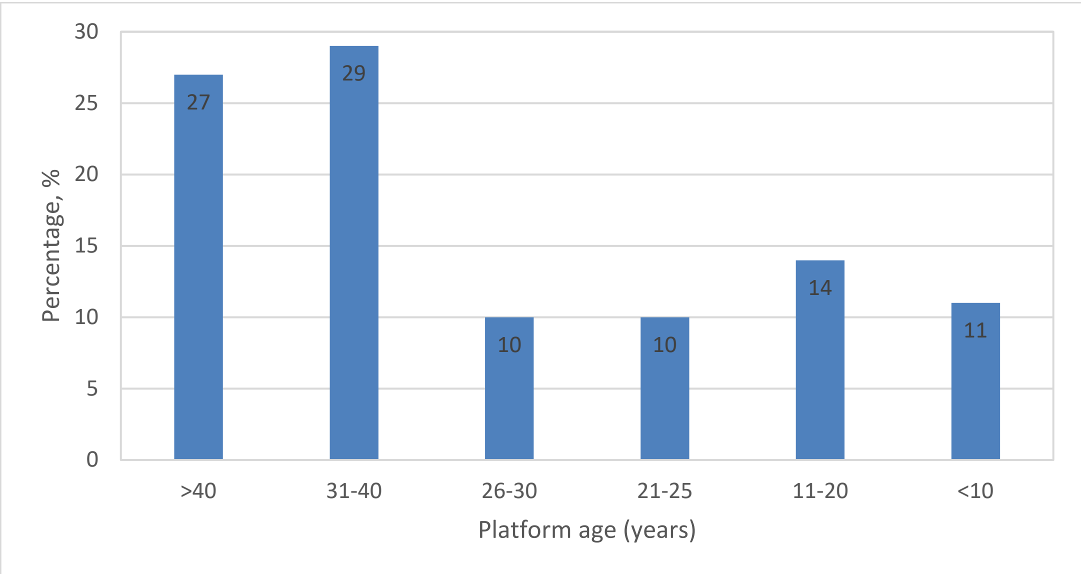

Figure 1.1 PETRONAS platform age distribution (Ng et al., 2019)

Ageing platforms are either decommissioned or go through a series of structural integrity assessment for life extension. Structural integrity assessment is crucial to ensure offshore platforms are able to operate safely and avoid structural failure. There are two factors that may affect the structural integrity of offshore platforms. They are excessive load and insufficient strength (Ayob et al., 2014; Kajuputra et al., 2016). The excessive load may come from environmental load, operational load, and accidental load. Whereas insufficient strength may cause by error in design, fabrication, installation, operation, and degradation. Degradation is critical in ensuring the integrity of platforms as the operators opt to extend their platform service life beyond the original design life (Shanker, 2018).

The structural integrity of ageing platform affected by various degradation factor throughout its service life. For example, they are corrosion, marine growth, weld crack, scour, subsidence, and damaged structural member due to boat impact (Ng et al., 2019; McLean et al., 2019; Dehghani and Aslani, 2019). Degraded offshore structure will reduce the structural integrity over time (Gholami et al., 2018). Hence, it is crucial to consider degradation in the structural integrity assessment to ensure the result represents actual condition at site. This study considers degradation, which are marine growth, corrosion, and subsidence in structural reliability assessment (SRA).

Structural reliability assessment (SRA) is not new to oil and gas industries as it has been applied to offshore structure since 1960s (Cornell, 1995). According to Szalewski (2019), structural reliability assessment can provide confidence level required by regulators and stakeholders. It is achieved by maintaining the target safety level beyond the original design life. One of structural reliability assessment component is pushover analysis (Tromans and van de Graaf, 1992; Ayob et al., 2014; Mat Soom et al., 2018), which has been performed to generate the reserve strength ratio. Subsequently, reserve strength ratio is utilised to determine annual probability of failure and return period of platform. Both probability of failure and return period of platform are important for the operator to justify the risk to their assets.

Bow-tie diagram is widely adopted in risk analysis. In order to present the background of problem of existing ageing structure, bow-tie diagram has been utilised as shown in Figure 1.2. It comprises of fault trees and event trees, which are connected to hazardous event or top event (Lu et al., 2015; Vileiniskis and Remenyte-Prescott, 2017). The fault tree is divided into hazard and threat, while event tree is consequences of hazardous event. Bow-tie diagram is one of Health, Safety, Security and Environment (HSSE) tool support for as Low as Reasonably Practicable (ALARP) (Valeur, 2014).

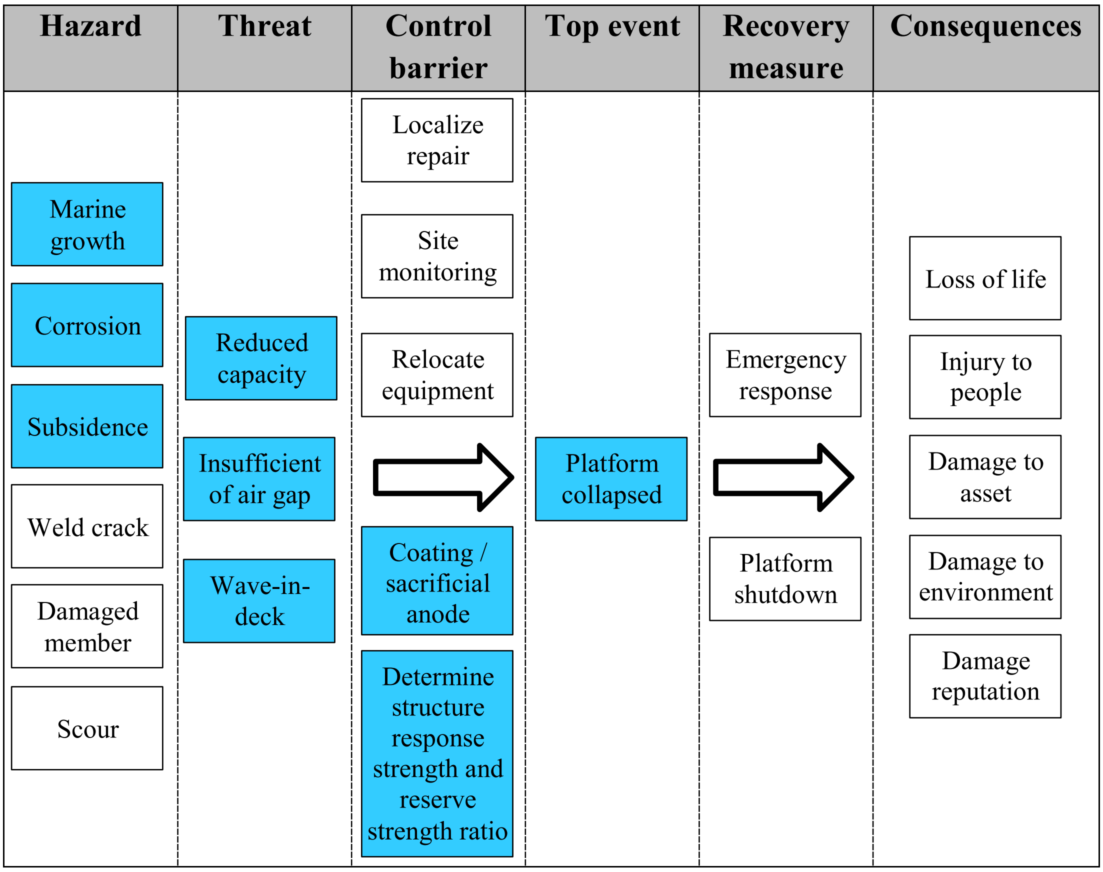

Figure 1.2 Bowtie of existing jacket structure with degradation

Based on Figure 1.2, the problem is triggered by platform degradation such as corrosion, subsidence, marine growth, weld crack, damaged member, and scour (Ng et al., 2019; McLean et al., 2019; Dehghani and Aslani, 2019). This will lead to reduction of platform carrying capacity and insufficient of air gap with a possibility of wave-in-deck. Depending on the type of degradation, control barrier that may be introduced are localized repair, site monitoring, relocation of equipment, coating, or sacrificial anode. Operator may also choose to determine the structure response and reserve strength ratio to ensure the strength of structure is sufficient. Ineffective or failure of control barrier may cause hazardous event or top event which is platform collapse.

As a recovery measure, emergency response will be activated, and platform will be shut down as soon as possible to contain leak from live piping or wells. Consequences of platform collapse can be loss of life, injury to people, damage to assets and damage to environment (Azman et al., 2019). This study focused on three degradation issues which are marine growth, corrosion and subsidence and associated threat, control barrier and top event as shaded in blue in Figure 1.2.

1.2 Problem Statement

Ageing platforms are growing in numbers worldwide. To improve economic viability and increase profitability, operators choose to extend the platform life beyond the original design life (Aeran et al., 2017; Animah and Shafiee, 2018). Life extension also reduces both capital expenditure (CAPEX) and operational expenditure (OPEX) of an offshore platform (Shafiee and Animah, 2017). Structural reliability assessment has been widely adopted in oil and gas industry and has been utilised by operator to quantify whether ageing platform life can be extended, as studied by Mat Soom et al. (2016) and Copello et al. (2017).

However, structural reliability assessment is complex and time-consuming. The conventional procedure explained by Tromans and van de Graaf (1992) and Mat Soom et al. (2019) comprises of data collection, structural modelling, and preparation, hindcast study, pushover analysis and calculation of probability of failure and return period. It is estimated that engineer requires two (2) months to complete per cycle of structural reliability assessment for specific magnitude of degradation per platform with industrial manhours of approximately 280 manhours (total manhours from principle and senior engineer). Thus, by utilising the proposed model, an engineer is able to save time as the reserve strength ratio, probability of failure and return period have been calculated depending on degradation level. This study will help industry to determine the results even before the actual degradation occur hence will save a significant time and minimise the use of resources as the resources may contribute to better field economics.

Based on the review performed on structural reliability assessment, majority of the author did not clearly specify whether degradation has been included as part of their structural reliability assessment. Even if the author considered degradation, only single factor was highlighted as part of their study. However, there are chances that several degradation factors may occur at the same time. It is also an industry requirement to consider degradation such as marine growth and corrosion depth as during design and assessment of fixed offshore platform. Furthermore, the author concentrated on specific value of degradation, whereas this study considered multiple degradation magnitude so that industry will be able to choose a correct model once survey data is available.

It is also noted that limited study has been conducted on the relationship between reserve strength ratio, probability of failure and return period, and degradation faced by fixed offshore structures. This study considered constant marine growth, corrosion, and subsidence to determine the impact of degradation to structural reliability assessment by developing a comprehensive degradation limit state model. Corrosion was applied in the splash zone area by reducing the structural member thickness. Subsidence effects, which include reduction of air gap and wave-in-deck were considered in the proposed model as the effects of wave-in-deck load are excluded during reserve strength ratio determination.

1.3 Aims and Research Objectives

The aim of the study is to develop a comprehensive regression limit state model of reserve strength ratio, probability of failure and return period by considering degradation in the structural reliability assessment of ageing fixed offshore platforms. The proposed model is expected to provide an immediate result in order to determine whether there is a need to perform a comprehensive structural reassessment.

To achieve these aims, three objectives are set as follows:

i) To investigate the primary degradation factors for comprehensive ageing fixed offshore platforms model development.

ii) To develop a comprehensive degradation limit state model of reserve strength ratio, probability of failure and return period for ageing fixed offshore platforms.

iii) To validate the proposed degradation limit state model by conducting a comprehensive parametric study.

1.4 Scopes of the Study

This study focused on 4-legged fixed offshore jacket structures. Three degradation factors were considered in structural reliability assessment. They are marine growth, corrosion, and subsidence. Marine growth is considered constant throughout the analysis. The thickness was based water fixed offshore platform located at East Malaysian water. The value was adopted by industry, which was based on the actual survey. Corrosion was considered up to 12 mm at the splash zone area, while subsidence is considered up to 8 m. Both corrosion and subsidence values were chosen based on the predicted value at platform location. Reliability Based Design and Assessment as explained by Mat Soom et al. (2016) was utilised to calculate the probability of failure and return period of the platform. The target probability of failure and return period were based on International Organization for Standardization (ISO, 2007).

Existing analysis model were used and verified using Structural Analysis Computer Software (SACS). The software is widely used in the industry especially for the fixed jacket offshore structure. It is capable to perform linear static analysis and built-in with several code checks such as International Organization for Standardization (ISO), American Petroleum Institute (API) and Norwegian Shelf's Competitive Position Standard (NORSOK). Ultimate Strength for Offshore Structures

(USFOS) computer programme was utilised to determine the reserve strength ratio. The software is widely used by the industry for nonlinear structural analysis. The regression analysis was performed to identify and develop the most comprehensive model for reserve strength ratio, probability of failure and return period of ageing fixed offshore structure. Details of the method were elaborated further in *Chapter 3*.

1.5 Significance of the Study

A comprehensive regression model of probability of failure considering degradation, which are marine growth, corrosion, and subsidence in structural reliability assessment were introduced in this study. The proposed model is efficient and economical in terms of time and the use of resources as engineers do not need to run a full cycle of structural reliability assessment, which is time consuming. What engineers need to do are to find the degradation value to estimate the reserve strength ratio, probability of failure and return period, and compare the results with industry standard which is ISO (2007).

By systematically considers marine growth, corrosion, and subsidence in structural reliability assessment, it is expected that degradation effect will be predicted accurately. Outcomes from this study shall also allow the operator to decide and to outline the action for their business risk management in case where marine growth, corrosion and subsidence is expected to occur. This is important as it involves quality, safety, and cost, especially when the collapse of the platform potentially involves the loss of life, damage to assets and damage to environment.

1.6 Thesis Outline

Chapter 1 describes the introduction of this thesis, which includes general background of oil and gas scenes in Malaysia, brief description of degradation issue and an introduction of structural reliability assessment. This chapter also include detailed problem statement, aims and objectives, scopes, and significance of the study and lastly thesis outline.

Chapter 2 contains the review of literature of this study. It includes platform degradation factors such as marine growth, corrosion, subsidence, weld crack, damaged member and scour and theories behind the study. This chapter explains the approach, principle and procedure of structural reliability assessment. This chapter also provides review on structural reliability assessment, which has been adopted in oil and gas industry and its development.

Chapter 3 explains research methodology in detail including research flowchart and structural model preparation. This chapter also explains the methodology of structural reliability assessment. The development of degradation limit state model is taking into account marine growth, corrosion, and subsidence. These were elaborated in detail, together with numerical example of proposed method. This chapter also provides validation process of the proposed degradation limit state model.

Chapter 4 discusses the structural reliability assessment results from pushover analysis, extreme air gap analysis and regression analysis of the proposed degradation limit state model. This chapter also includes validation of the proposed degradation limit state model by comparing the reserve strength ratio, probability of failure and return period.

Chapter 5 concludes the objective of the study. Apart from that, it also contains the contribution of current study and recommendation for future. List of publications, innovations and intellectual properties are also part of this chapter.

REFERENCES

Abdul Rahim, K. and Liwan, A. (2012). Oil and Gas Trends and Implications in Malaysia. *Energy Policy*, 50(2012), 262-271.

Abu Husain, M. K., Mohd Zaki, N. I. and Najafian, G. (2019). Efficient Time Simulation Method for Predicting the 100-Year Extreme Responses of an Offshore Platform. *Ships and Offshore Structures*, 14(1), 401-409.

Aeran, A., Siriwardane, S. C. and Mikkelsen, O. (2016). Life Extension of Ageing Offshore Structure: Time Dependent Corrosion Degradation and Helath Monitoring. *Proceeding of the Twenty-Sixth (2016) International Ocean and Polar Engineering Conference*. 26 June - 1 July. Rhodes, Greece.

Aeran, A., Siriwardane, S. C., Mikkelsen, O. and Langen, I. (2017). A Framework to Assess Structural Integrity of Ageing Offshore Jacket Structures for Life Extension. *Marine Structures*, 56(2017), 237-259.

Alex, H. and Kim, C. H. (2000). Laboratory Stokes 5th Order Waves and Forces on a Vertical Truncated Cylinder. *Proceedings of the Tenth (2000) International Offshore and Polar Engineering Conference*. 28 May - 2 June.Seattle, USA.

Amdal, J. and Holmas, T. (2016). ISUM for Offshore Frame Structures. *Proceeding of the ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering*. 19-24 June. Busan, South Korea.

American Petroleum Institute (1997). *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design*. Washington: API Publishing Services.

American Petroleum Institute (2000). *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design*. Washington: API Publishing Services.

American Petroleum Institute (2010). *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design*. Washington: API Publishing Services.

American Petroleum Institute (2014). *Structural Integrity Management of Fixed Offshore Structures. API RP 2SIM*. Washington, USA: API Publishing Services.

Animah, I. and Shafiee, M. (2018). Condition Assessment, Remaining Useful Life Prediction and Life Extension Decision Making for Offshore Oil and Gas Assets. *Journal of Loss Prevention in the Process Industries*, 53(2018), 17-28.

Arangio, S. (2012). Reliability Based Approach for Structural Design and Assessment: Performance Criteria and Indicators in Current European Codes and Guidelines. *International Journal Lifecycle Performance Engineering*, 1(1), 64-91.

Arya, C. (2009). *Design of Structural Elements*. New York: Taylor & Francis.

Askheim, N. E. (1980). Critical Parts Regarding Corrosion and Corrosion Protection of Offshore Structures. *European Offshore Petroleum Conference & Exhibition*. 21-24 October. London, England.

Ayob, M. S., Kajuputra, A. E. and Wong, B. S. (2014). Global Ultimate Strength Assessment for Existing Offshore Jacket Structures. *Offshore Technology Conference Asia*. 25-28 March. Kuala Lumpur, Malaysia.

Azman, N. U., Abu Husain, M. K., Mohd Zaki, N. I. and Mat Soom, E. (2017). The Effect of Wave-in-Deck in Conventional Pushover Analysis. *VII International Conference on Computational Methods in Marine Engineering*. 15-17 May. Nantes, France.

Azman, N. U., Abu Husain, M. K., Mohd Zaki, N. I. and Mat Soom, E. (2019). Structural Integrity of Fixed Offshore Platform by Incorporating Wave-in-Deck Load, in Parunov, J. and Guedes Soares, C. (Eds.) *Trends in Analysis and Design of Marine Structures* (pp. 468-476). London: Taylor & Francis Group.

Azman, N. U., Abu Husain, M. K., Mohd Zaki, N. I.. Mat Soom, E., Mukhlas, N. A. and Syed Ahmad, S. Z. A. (2021). Structural Integrity of Fixed Offshore Platforms by Incorporating Wave-in-Deck. Structural Integrity of Fixed Offshore Platforms by Incorporating Wave-in-Deck. *Journal of Marine Science and Engineering*, 2021(9), 1027-1044.

Bhandari, J., Khan, F., Abbassi, R. Garaniya, V. and Ojeda, R. (2015). Modelling of Pitting Corrosion in Marine and Offshore Steel Structures - A Technical Review. *Journal of Loss Prevention in the Process Industries*, 37(2015), 39-62.

Brant, H. and Mohd Sarif, S. (2013). Life Extension of Offshore Assets: Balancing Safety and Project Economics. *SPE Asia Pacific Oil & Gas Conference and Exhibition*. 22-24 October. Jakarta, Indonesia.

Chakrabarti, P. and Rikhy, A. (1990). Marine Growth Criteria for Offshore Platforms in India. *Proceedings of the First Pacific/Asia Offshore Mechanics Symposium*. 24-28 June. Seoul, Korea.

Chakrabarti, S. K. (2005). *Handbook of Offshore Engineering (Vol. I)*. Illinois: Elsevier.

Chapra, S. C. and Canale, R. P. (2010). *Numerical Method for Engineers (Sixth)*. McGraw-Hill.

Chartterjee, S. and Hadi, A. (2006). *Regression Analsyis by Example*, Fourth Edition. USA: John Wiley and Sons.

Chen, Y., Wu, Y., Bahuguni, A., Gullman-Strand, J., Zhang, Y., Stewart, G. and Lv, X. (2016). Advances in Computational Hydrodynamics Applied to Wave-in-Deck. *Offshore Technology Conference Asia*. 22-25 March. Kuala Lumpur, Malaysia.

Chen, Y., Wu, Y., Bahuguni, A., Gullman-Strand, J., Lv, X., Lou, J. and Ren, W. (2018). Directional Wave-in-Deck Loading on Offshore Structures with Porous and Plated Decks with Supporting I-Beams. *Coastal Engineering*, 137(2018), 79-91.

Chu, B., Lee, S. and Chang, D. (2017). Determination of Design Accidental Fire Load for Offshore Installations Based on Quantitative Risk Assessment with Treatment of Parametric Uncertainty. *Journal of Loss Prevention in the Process Industries*, 45(2017), 160-172.

Compton, K. G. and Craig Jr., H. L. (1970). Cathodic Protection of Offshore Structures. *Offshore Technology Conference*. 22-24 April. Houston, Texas, USA.

Copello, S., Magliano, M. and Manera, A. (2017). Minimum Requirements for Decision Making and Maintenance of Existing Fixed Offshore Structures. *The 13th Offshore Mediterranean Conference and Exhibition*. 29-31 March. Ravenna, Italy.

Cornell, C. A. (1995). Structural Reliability - Some Contributions of Offshore Technology. *Offshore Technology Conference*. 1-4 May. Houston, Texas, USA.

Dehghani, A. and Aslani, F. (2019). A Review on Defects in Steel Offshore Structures and Developed Strengthening Techniques. *Structures*, 20(2019), 635-657.

Det Norsk Veritas (1992). Structural Reliability Analysis of Marine Structures, *Classification Note No. 30.6*. Norway: Det Norsk Veritas.

DNV GL (2014). *USFOS Best Practice - SESAM User Course SE-10*. Oslo: DNV GL.

Dong, W. Moan, T. and Gao, Z. (2012). Fatigue Reliability Analysis of the Jacket Support Structure for Offshore Wind Turbine Considering the Effect of Corrosion and Inspection. *Reliability Engineering and System Safety*, 106(2012), 11-27.

Efthymiou, M. and van de Graaf, J. W. (2011). Reliability and (Re)Assessment of Fixed Steel Structures. *Proceedings of the ASME 2011 30th International Conference on Ocean, Offshore and Arctic Engineering*. 19-24 June. Rotterdam, Netherlands.

Efthymiou, M., van de Graaf, J. W., Tromans, P. S. and Hines, I. M. (1997). Reliability-Based Criteria for Fixed Steel Offshore Platforms. *Journal of Offshore Mechanics and Arctic Engineering*, 119(2), 120-124.

Elsayed, T., El-Shaib, M. and Gbr, K. (2014). Reliability of Fixed Offshore Jacket Platform Against Earthquake Collapse. *Ship and Offshore Structures*, 11(2), 167-181.

El-Reedy, M. A. (2012). *Offshore Structures: Design, Construction and Maintenance*. USA: Gulf Professional Publishing, Elsevier.

Ersdal, G. (2005). Assessment of Existing Offshore Structures for Life Extension. PhD Thesis, University of Stavanger.

Ersdal, G. and Langen, I. (2002). On Assessment of Existing Offshore Structures. *Proceedings of the Twelth (2002) International Offshore and Polar Engineering Conference*. 26-31 May. Kitakyushu, Japan.

Ersdal, G., Sorensen, J. D. and Langen, I. (2003). Updating of Structural Failure Probability Based on Experienced Wave Loading. *Proceeding of the Thirteenth (2003) International Offshore and Polar Engineering Conference*. 25-30 May. Hawaii, USA.

Fayazi, A. and Aghakouchak, A. (2015). Reliability Based Assessment of Existing Fixed Offshore Platforms Located in the Persian Gulf. *International Journal of Maritime Technology*, 4(2015), 37-50.

Fjeld, S. (1978). Reliability of Offshore Structures. *Journal of Petroleum Tecnology*, 30(10), 1486-1496.

Fraser, R., Manzocchi, M. and Gibson, R. (2015). Pushover Load Factors for Fixed Steel Platforms Sensitive to Topside Load and Wave-in-Deck Load. *Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering*. 31 May-5 June. St. John's, Newfoundland, Canada.

Galbraith, D. and Sharp, J. (2007). Recommendation for Design Life Extension Regulations. *Petroleum Safety Authority, Poseiden Report POS-DK06-134R02*.

Gebara, M. J., Dolan, D., Pawsey, S., Jeanjean, P. and Dahl-Stamnes, K. H. (2000). Assessment of Offshore Platforms Under Subsidence – Part I: Approach. *Journal of Offshore Mechanics and Artic Engineering*, 122(4), 260-266.

Gierlinski J. T., Sears R. J. and Shetty N. K. (1993). Integrity of Fixed Offshore Structures: A Case Study Using ROSAS Software. *Proceedings of the 12th International Conference on Offshore Mechanics and Artic Engineering*. 20-24 June. Glasgow, Scotland

Golafshani, A. A., Ebrahimian, H., Bagheri, V. and Holmas, T. (2011). Assessment of Offshore Platforms under Extreme Waves by Probabilistic Incremental Wave Analysis. *Journal of Constructional Steel Research*, 67(2011), 759-769.

Gholami, H., Asgarian, B. and Gharebaghi, S. A. (2018). Time-Variant Ultimate Reliability Analysis of Jacket Platform Considering a New Probabilistic Corrosion Model for the Persian Gulf. *Journal of Offshore Mechanics and Artic Engineering*, 140(2018), 1-10. doi: 10.1115/1.4040505.

Gholizad, A., Golafshani, A. A. and Akrami, V. (2012). Structural Reliability of Offshore Platforms Considering Fatigue Damage and Different Failure Scenarios. *Ocean Engineering*, 46(2012), 1-8.

Guede, F. (2019). Risk-Based Structural Integrity Management for Offshore Jacket Platforms. *Marine Structures*, 63(2019), 444-461.

Hagen, O., Johannessen, T. B. and Birkness-Berg, J. (2016). Airgap and Wave In Deck Statistic. *Proceeding of the ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering*. 19-24 June. Busan, South Korea.

Hansen, K. and Gudmestad, O. T. (2001). Reassessment of Jacket Type of Platforms Subject to Wave-in-Deck Forces: Current Practice and Future Development. *Proceedings of the Eleventh (2001) International Offshore and Polar Engineering Conference*. June 17-22. Stavenger, Norway.

Heaf, N. J. (1979). The Effect of Marine Growth on the Performance of Fixed Offshore Platforms in the North Sea. *Offshore Technology Conference*. 30 April - 3 May. Houston, Texas, USA.

Health & Safety Executive, HSE (1998). *Offshore Technology Report - OTO 97 073, Review of Wave in Deck Load Assessment Procedure*. Sheffield, HSE.

Hedborg, C. E. (1974). Corrosion in the Offshore Environment. *Offshore Technology Conference*. Dallas, Texas, USA. 6-8 May.

Henry, P., Nedrebo, E. L. and Myrhaug, D. (2016). Visualisation of the Effect of Different Types of Marine Growth on Cylinders. Wake Structure in Low Re Steady Flows. *Ocean Engineering*, 115(2016), 182-188.

Henry, Z., Jusoh, I. and Ayob, A. (2017). Structural Integrity Analysis of Fixed Offshore Jacket Structures. *Jurnal Mekanikal*, 40(2017), 23-36.

International Organization for Standardization (2001). Petroleum and Natural Gas Industries – Design of Fixed Steel Jacket, Draft E.

nternational Organization for Standardization (2007). Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures. ISO 19902: 2007. Switzerland: HIS.

Iwanowski, B., Grigorian, H. and Scherf, I. (2002). Subsidence of the Ekofisk Platforms: Wave in Deck Impact Study. Various Wave Models and Computational Method. *Proceedings of the OMEA'02 21st International Conference on Offshore Mechanics and Artic Engineering*. 23-28 June. Oslo, Norway.

Jha, K. A., Kiciman, O. K., Gebara, M. J., Stahl, B. and Dahl-Stamnes, K. H. (2000). Assessment of Offshore Platforms Under Subsidence – Part II: Analysis and Results. *Journal of Offshore Mechanics and Artic Engineering*, 122(4), 267-273.

Jin, W., Song, J. Gong, S. and Lu, Y. (2005). Evaluation of Damage to Offshore Platform Structures Due to Collision of Large Barge. *Engineering Structures*, 27(2005), 1317-1326.

Kajuputra, A. E., Shiiun, W. B. and Shamsuddin, M. A. (2016). The Importance of SIMS in Structural Integrity Review and Life Extension Requirement for Existing Fixed Offshore Structure. *Offshore Technology Conference Asia*. 22-25 March. Kuala Lumpur, Malaysia.

Kang, B. J., Kim, J. H. and Kim, Y. (2016). Engineering Criticality Analysis on an Offshore Structure using the First and Second-Order Reliability Method. *International Journal of Naval Architecture and Ocean Engineering*, 8(2016), 577-588.

Kaplan, P., Murray, J. and Yu, W. C. (1995). Theoretical Analysis of Wave Impact Forces on Platform Deck Structures. *Proceedings of the 14th International Conference on Offshore Mechanics and Artic Engineering*. 18-22 June. Copenhagen, Denmark.

Kurian, V. J., Voon, M. C., Wahab, M. M. A and Liew, M. S. (2014). System Reliability Assessment of Existing Jacket Platform in Malaysian Waters. *Research Journal of Applied Sciences, Engineering and Technology*, 8(23), 2305-2314.

Libot, M. A. (2012). Wave-in-Deck Loading. *Proceeding of the 1st Civil and Environmental Engineering Student Conference*. 25-26 June. Imperial College London, United Kingdom.

Lopez-Ortega, A., Bayon, R. and Arana, J. L. (2018). Evaluation of Protective Coatings for Offshore Applications. Corrosion and Tribocorrosion Behaviour in Synthetic Seawater. *Surface and Coating Technology*, 349(2018), 1083-1097.

Lu, L., Liang, W., Zhang, L., Zhang, H., Lu, Z. and Shan, J. (2015). A Comprehensive Risk Evaluation Method for Natural Gas Pipelines by Combining a Risk Matrix with a Bow-Tie Model. *Journal of Natural Gas Science and Engineering*, 25(2015), 124-133.

Ma, L., Wang, L., Guo, Z., Jiang, H. and Gao, Y. (2018). Time Development of Scour Around Pile Groups in Tidal Currents. *Ocean Engineering*, 163(2018), 400-418.

Marley, M., Etterdal, B. and Grigorian, H. (2001). Structural Reliability Assessment of Ekofisk Jackets Under Extreme Loading. *Offshore Technology Conference*. April 30 - May 3. Houston, Texas, USA.

Mat Soom, E., Abu Husain, M. K., Mohd Zaki, N. I., Mohd Nor, M. N. K., Ayob, M. S. and Najafian, G. (2015). Global Ultimate Strength Assessment (GUSA) for Lifetime Extension of Ageing Offshore Structures. *Proceedings of the Twenty-Fifth International Ocean and Polar Engineering Conference on Civil, Offshore and Environmental Engineering*. 21-26 June. Hawaii, USA.

Mat Soom, E., Abu Husain, M. K., Mohd Zaki, N. I., Azman, N. U. and Najafian, G. (2016). Reliability-Based Design and Assessment for Lifetime Extension of Ageing Offshore Structures. *Proceeding of the ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering*. 19-24 June. Busan, South Korea.

Mat Soom, E., Abu Husain, M. K., Mohd Zaki, N. I. Mohd Nor, M. N. K. and Azman, N. U. (2017a). Reliability System for Fixed Offshore Structures in Malaysian Water. *International Conference on Advanced Technology*. 10 October. Kuala Lumpur, Malaysia.

Mat Soom, E., Abu Husain, M. K., Mohd Zaki, N. I. Azman, N. U. and Najafian, G. (2017b). Comparison Methods for Derivation of the Failure Probability of Fixed Offshore Structures. *International Conference on Ships and Offshore Structures*. 11-13 September. Shenzhen, China.

Mat Soom, E., Abu Husain, M. K., Mohd Zaki, N. I., Mohd Nor, M. N. K. and Najafian, G. (2018). Lifetime Extension of Aeging Offshore Structures by Global Ultimate Strength Assessment (GUSA). *Malayisan Journal of Civil Engineering*, 30(1), 152-171.

McLean, D. L., Taylor, M. D., Giraldo Ospina, A. and Partrige, J.C. (2019). An Assessment of Fish and Marine Growth Associated with an Oil and Gas Platform Jacket using an Augmented Remotely Operated Vehicle. *Continental Shelf Research*, 179(2019), 66-84.

Melchers, R. E. (2002). Effect of Temperature on Marine Immersion Corrosion of Carbon Steels. *Corrosion*, 58(9), 769-782.

Melchers, R. E. (2005). The Effect of Corrosion on the Structural Reliability of Steel Offshore Structures. *Corrosion Science*. 47(2005), 2391-2410.

Melchers, R. E. (2012). Modelling and Prediction of Long-Term Corrosion of Steel in Marine Environments. *International Journal of Offshore and Polar Engineering*, 20(4), 257-263.

Melchers, R. E. and Beck, A. T. (2018). *Structural Reliability Analysis and Prediction*. New Jersey: John Wiley & Sons.

Melchers, R. E. and Jeffrey, R. J. (2004). Influence of Water Velocity on Marine Immersion Corrosion of Mild Steel. *Corrosion*, 60(1), 84-94.

Melchers, R. E. and Jeffrey, R. J. (2008). Probabilistic Model for Steel Corrosion Loss and Pitting of Marine Infrastructure. *Reliability Engineering and System Safety*, 93(2008), 423-432.

Moan, T. (2005). Reliability-Based Management of Inspection, Maintenance and Repair of Offshore Structures. *Structure and Infrastructure Engineering*, 1(1), 33-62.

Moan, T. (2009). Development of Accidental Collapse Limit State Criteria for Offshore Structures. *Structural Safety*, 31(2009), 124-135.

Moan, T., Hovde, G. O. Blanker, A. M. (1993). Reliability-Based Fatigue Design Criteria for Offshore Structures Considering the Effect of Inspection and Repair. *Offshore Technology Conference*. 3-6 May. Houston, Texas, USA.

Mortazavi, M. and Bea, R. G. (1996). A Simplified Structural Reliability Analysis Procedure for Use in Assessment and Requalifications of Template-Type Offshore Platforms. *Proceeding of the Sixth (1996) International Offshore and Polar Engineering Conference*. 26-31 May. Los Angeles, USA.

Moses, F. (1981). Reliability Based Design of Offshore Structures. *Annual Meeting Papers, Division of Production*. 5-8 April. San Francisco, California.

Moses, F. and Stahl, B. (1979). Reliability Analysis Format for Offshore Structures. *Journal of Petroleum Technology*, 31(03), 347-354.

Moulas, D., Shafiee, M. and Mehmanparast, A. (2017). Damage Analysis of Ship Collisions with Offshore Wind Turbine Foundations. *Ocean Engineering*, 143(2017), 149-162.

MSL Engineering Limited (2000). Joint Industry Project - Rationalization and Optimization of Underwater Inspection Planning Consistent with API RP2A Section 14. *Report No. CH104R006*.

Mukhlas, N. A., Mohd Zaki, N. I., Abu Husain, M. K. and Najafian, G. (2018). Efficient Derivation of Extreme Offshore Structure Response Exposed to Random Wave Loads. *Ship and Offshore Structures*, 13(7), 719-733.

Nagel, N. B. (2001). Compaction and Subsidence Issues Within the Petroleum Industry: From Wilmington to Ekofisk and Beyond. *Physics and Chemistry of the Earth, Part A: Solid Earth and Geodesy*, 26(1-2), 3-14.

Ng, S. M., Khan, R., Isnadi, B., Lee, L. A. and Saminal, S. N. (2019). A Holistic Approach to Life Extension of Fixed Offshore Platforms in Malaysian Waters.

International Petroleum Technology Conference. 26-28 March. Beijing, China.

Nezamian, A. and Nezamian, M. (2014). A Review of Failure Modes in Ultimate Strength Assessment for Re-qualification and Life Extension of an Oil Field. *Proceedings of the Twenty-fourth (2014) International Ocean and Polar Engineering Conference*. 15-20 June. Busan, Korea.

Norwegian Marine Technology Research Institute, MARINTEK (1999). *USFOS User Manual*. Norway: Marintek.

Norwegian Marine Technology Research Institute, MARINTEK (2001). *USFOS Getting Started*. Norway: Marintek.

Paik, J. K. and Kim, D. K. (1990). Damage Characteristics of Offshore Tubular Members. *Proceeding of the First Pacific/Asia Offshore Mechanics Symposium*. 24-28 June. Seoul, Korea.

Paik, J. K. and Kim, D. K. (2012). Advanced Method for the Development of an Empirical Model to Predict Time-Dependent Corrosion Wastage. *Corrosion Science*, 63(2012), 51-58.

Paulson, D. S. (2007). *Handbook of Regression and Modelling - Application for the Clinical and Pharmaceutical Industries*. Boca Raton: Chapman & Hall/CRC.

Qin, S. and Cui, W. (2003). Effect of Corrosion Models on the Time-Dependent Reliability of Steel Plated Elements. *Marine Structures*, 16(2003), 15-34.

Raval, H. (2016). Advanced Structural Reassessment of Fixed and Floating Offshore Structures. *Abu Dhabi International Petroleun Exhibition and Conference*. 7-10 November. Abu Dhabi, UAE.

Rawlings, J. O., Pantula, S. G. and Dickey, D. A. (1998). *Applied Regression Analysis: A Research Tool, Second Edition.* New York: Springer.

Restivo, A. and Brune, M. (2016). Removing Marine Growth Using an ROV with Cavitation Technology. *Offshore Technology Conference*. 2-5 May. Houston, Texas, USA.

Rutten, J.G, van Gelder, P. H. A. J. M., Ewans, K. C. and Efthymiou, M. (2004). Uncertainties in Extreme Value Analysis and Their Effect on Load Factors. Proceedings of the OMAE04 23rd International Conference on Offshore Mechanics and Arctic Engineering. 20-25 June. Vancouver, British Columbia, Canada

Sari, A., Ramana, E., Nguyen, H., Arablouei, A. and Azimov, U. (2016). Structural Corrosion Modelling for Strength Assessment of Fixed Offshore Platforms for Life Extension Study. *Offshore Technology Conference Asia*. 22-25 March. Kuala Lumpur, Malaysia.

Schneider, J. (1997). *Introduction to Safety and Reliability of Structures*. Zurich: IABSE-AIPC-IVBH.

Schoefs, F. and Boukinda, M. (2004). Modelling of Marine Growth Effect on Offshore Structures Loading Using Kinematics Fiels of Water Particle. *Proceedings of the Fourteenth (2004) International Offshore and Polar Engineering Conference*. 23-28 May. Toulon, France.

Seong, C. K. and Hong, T. Y. (1995). A Review of Offshore Oilfields Development in Malaysia. *SPE Oil and Gas India Conference*. 20-22 March. Kuala Lumpur, Malaysia.

Shabakhty, N., van Gelder, P. and Boonstra, H. (2002). Reliability Analysis of Jack-Up Platforms Based on Fatigue Degradation. *Proceeding of OMEA'02 21st International Conference on Offshore Mechanics and Artic Engineering*. June 23-28. Oslo, Norway.

Shafiee, M. and Animah, I. (2017). Life Extension Decision Making of Safety Critical Systems: An Overview. *Journal of Loss Prevention in the Process Industries*, 47(2017), 174-188.

Shanker, V. (2018). Integrity and Life Extension Assessment of Fixed Offshore Platforms. *Abu Dhabi International Petroleun Exhibition and Conference*. 12-15 November. Abu Dhabi, UAE.

Sharp, J. V., Stacey, A. and Birkinshaw, M. (1995). Review of Data for Structural Damage to Offshore Installations. *Offshore Structures - Hazards, Safety and Engineering: Fourth International Conference and Exhibition, Conference Proceedings*. 12-13 December. London, United Kingdom.

Singh, D., Panneerselvam, N. and Kumar, D. (2015). Reliability Analysis of Strength of Offshore Jackets in Indian Western Offshore. *SPE Oil and Gas India Conference and Exhibition*. 24-26 November. Mumbai, India.

Smith, A. G., Smith, T. E. and Monshaugen, T. (1988). Ekofisk Subsidence: Conceptual and Design Considerations Along the Road to Jacking. *Offshore Technology Conference*. 2-5 May. Houston, Texas, USA.

Smit, M. Bowey, C. and Willaims L. (2002). In Situ Protection of Splash Zone - 30 Years On. *Corrosion/2002 Annual Conference and Exhibition*. 7-11 April. Denver, USA.

Sorkhabi, R. (2010). Miri 1910: The Centenary of oil Discovery in Sarawak. *Geoexpro*, 7(2), 44-49.

Speight, J. G. (2015). Chapter 8 - Corrosion, in Speight, J. G. (Ed.) *Subsea and Deepwater Oil and Gas Science and Technology*. USA: Gulf Professional Publishing, Elsevier, pp. 213-256.

Stacey, A., Birkinshaw, M. and Sharp, J. V. (2008). Life Extension Issues for Ageing Offshore Installations. *Proceeding of OMEA2008 27th International Conference on Offshore Mechanics and Artic Engineering*. 15-20 June. Estoril, Portugal.

Stansberg, C. T., Baarhom, R., Berget, K. and Phadke, A. C. (2010). Prediction of Wave Impact in Extreme Weather. *Offshore Technology Conference*. 3-6 May. Houston, Texas, USA.

Szalewski, P., Malinowski, G. and Lu, J. Y. (2019). Demonstrating Target Safety Level for Life Extension of Offshore Structures. *Proceedings of the 24th Offshore Symposium*. 20 February. Houston, Texas, USA.

Tomlinson, M. and Woodward, J. (2007). *Pile Design and Construction Practice*. 5th Edition. London: CRC Press.

Tromans, P. S. and van de Graaf, J. W. (1992). A Substantiate Risk Assessment of a Jacket Structure. *Offshore Technology Conference*. 4-7 May. Houston, Texas, USA.

Tryaputra, M. R. (2014). *F23 Subsidence Pre-FEED Structural Assessment Premises.* F23 Subsidence Project. Technip Consultant Sdn. Bhd.

Valeur, J. R. (2014). Integrated HSE ALARP Assessment – Reducing HSE Risk and Impacts in Same Processes. *SPE Middle East Health, Safety, Environment & Sustainable Development Conference and Exhibition*. 22-24 September. Doha, Qatar.

Van de Graaf, J. W., Tromans, P. S., Vanderschuren, L. and Jukui, B. H. (1996.) Failure Probability of a Jack-up Under Environmental Loading in Central North Sea. *Marine Structures*, 9(1996), 3-24.

Vileiniskis, M. and Remenyte-Prescott, R. (2017). Quantitative Risk Prognostics Framework Based on Petri Net and Bow-Tie Models. *Reliability Engineering and System Safety*, 165(2017), 62-73.

Wan Abdullah Zawawi, N. A., Liew, M. S. and Na, K. L (2012). Decomissioning of Offshore Platform: A Sustainable Framework. *2012 IEEE Colloquium on Humanities, Science & Engineering Research*. 3-4 December. Kota Kinabalu, Sabah, Malaysia.

Wan Abdul Majid, W. M., Haji Hashim, A. R. and Embong, M. (1998). Determination of Structural Reserve Strength Ratio (RSR) of an Existing Offshore Structure. *Proceedings of Eighth (1998) International Offshore and Polar Engineering Conference*. 24-29 May. Montreal, Canada.

Wan Alwi, S. M. Y., Abu Husain, M. K. and Mohd Zaki, N. I. (2019). Marine Growth Inspection for Jacket Structures by Behaviour and Sensitivity Analysis, in Parunov, J. and Guedes Soares, C. (Eds.) *Trends in Analysis and Design of Marine Structures* (pp. 586-593). London: Taylor & Francis Group.

Whitehouse, R. J. S., Sutherland, J. and Harris, J. M. (2010). Evaluating Scour at Marine Gravity Foundations. *Proceeding of the ICE - Maritime Engineering*. 164(4), 143-157.

Wintle, J. and Sharp, J. (2008). Requirement for Life Extension of Ageing Offshore Production Installation. *Petroleum Safety Authority*, TWI report 17554/1/08.

Yu, Z. and Amdahl, J. (2018). A Review of Structural Responses and Design of Offshore Tubular Structures Subjected to Ship Impacts. *Ocean Engineering*, 154(2018), 177-203.

Zaman, M. M., Abdulraheem, A. and Roegiers, J. (1995). Reservoir Compaction and Surface Subsidence in the North Sea Ekofisk Field. In Chilingarian, G. V., Donaldson, E. C. and Yen, T. F. (Ed.). *Subsidence Due to Fluid Withdrawal. Development in Petroleum Science*, 41(1995), 373-423.

Zhang, Y. and Jin, W. (2010). Reliability Evaluating of a Jacket Platform Example. *Proceedings of the Twentieth (2010) International Offshore and Polar Engineering Conference*. 20-25 June. Beijing, China.

Zve, E. S., Loukogeorgaki, E. and Angelides, D. C. (2015). Effect of Zoning Corrosion on the Life-Time Structural Reliability of Jacket Offshore Structure. *Proceeding of the Twenty-Fifth (2015) International Ocean and Polar Engineering Conference*. 21-26 June. Hawaii, USA.

LIST OF PUBLICATIONS

Journal with Impact Factor

1. **Azman, N. U.**, Husain, M.K.A., Zaki, N. I.M., Soom, E.M., Mukhlas, N. A., & Ahmad, S.Z.A.S. (2021). Structural Integrity of Fixed Offshore Platforms by Incorporating Wave-in-Deck. *Journal of Marine Science and Engineering*, 2021(9), 1027-1044. **(Q2, IF:2.458)**

2. Ahmad, S.Z.A.S, Husain, M.K.A., Zaki, N. I.M., Mukhlas, N. A., Soom, E.M., **Azman, N. U.**, & Najafian, G. (2021). Offshore Structural Reliability Assessment by Probabilistic Procedure – A Review. *Journal of Marine Science and Engineering*, 2021(9), 998-1022. **(Q2, IF:2.458)**

Indexed Journal

1. Soom, E.M., Husain, M.K.A., Zaki, N. I.M., and **Azman, N. U.** (2020). A Reliable Approach for Fixed Offshore Structures Probability of Failure Determination. *International Journal of Advanced Research in Engineering and Technology (IJARET)*,11(5), 469-475. **(Indexed by SCOPUS)**

Indexed Conference Proceedings

1. Zulkifli, M.A.R., Husain, M.K.A., Zaki, N.I.M., Jaafar, A.B., Mukhlas, N.A., Ahmad, S.Z.A.S., Soom, E.M., & **Azman, N. U.** (2021). Environmental Impacts of Utilization of Ageing Fixed Offshore Platform for Ocean Thermal Energy Conversion. Proceedings of the 9th Conference on Emerging Energy and Process Technology 2021 (CONCEPT 2021). Kuala Lumpur, Malaysia. **(Indexed by SCOPUS)**

2. **Azman, N. U.**, Husain, M.K.A., Zaki, N.I.M. & Soom, E.M. (2019). Structural Integrity of Fixed Offshore Platform by Incorporating Wave-in-Deck Load. *7th International Conference on Marine Structures*. 6-8 May. Dubrovnik, Croatia. **(Indexed by SCOPUS)**

3. Soom, E., Husain, M.K.A., Zaki, N.I.M., & **Azman, N. U.** (2019). Managing Risk for Damaged Offshore Structures. *7th International Conference on Marine Structures*. 6-8 May. Dubrovnik, Croatia. **(Indexed by SCOPUS)**

4. **Azman, N. U.**, Husain, M.K.A, Zaki, N.I.M., & Soom, E.M. (2017). The Effects of Wave-in-Deck in Conventional Pushover Analysis. *VII International Conference on Computational Methods in Marine Engineering. MARINE 2017*. May 15-17. Nantes, France. **(Indexed by SCOPUS)**

5. Soom, E.M., Husain, M. K.A., Zaki, N.I.M., **Azman, N. U.,** & Najafian, G. (2016). Reliability-Based Design and Assessment for Lifetime Extension of Ageing Offshore Structures. *OMAE: Proceeding of the ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering*. June 19-24. Busan, South Korea. **(Indexed by SCOPUS)**

Non-Indexed Conference Proceedings

1. Soom, E.M., Husain, M.K.A., Zaki, N.I.M., **Azman, N. U.**, Zakiyuddin, A., & Najafian, G. (2017). Reliability System for Fixed Offshore Structures in Malaysian Water, Malaysia. *UTM. 1st International Conference on Sustainable Infrastructure and Engineering (UTMRS-ICAT)*.

2. Soom, E.M., Husain, M.K.A., Zaki, N.I.M., **Azman, N. U.**, Zakiyuddin, A. & Najafian, G. (2017). Comparison Methods for Derivation of the Failure Probability of Fixed Offshore Structures. *International Conference on Ships and Offshore Structures*. September 11-13. Shenzhen, China.