EFFICIENT TIME SIMULATION REGRESSION PROCEDURE FOR PREDICTING OFFSHORE STRUCTURAL RESPONSES

SAYYID ZAINAL ABIDIN SYED AHMAD

UNIVERSITI TEKNOLOGI MALAYSIA

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SAYYID ZAINAL ABIDIN BIN SYED AHMAD

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DEDICATION

To my beloved family especially walid, ummi and siblings, including my friends for their wits, intelligence and guidance in life

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“*In the name of Allah, the most gracious, the most compassionate and also to our prophet Muhammad s.a.w of Allah peace is upon him*”

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ABSTRACT

The assessment of accurate hydrodynamic loads on structures due to the extreme environmental loadings is the primary concern in the design of offshore platforms. The wind-induced waves are normally the most potential loadings with nonlinear behaviour, contributing to a complicated solution. The conventional Monte Carlo Time Simulation (MCTS) method is required for an accurate analysis of wave loads without offering any approximation error. The MCTS technique is considered a realistic and versatile approach because it can cover all sorts of nonlinearities to evaluate the offshore structural responses. However, this conventional technique is very computationally demanding, as reliable results require a large number of simulations due to unavoidable excessive sampling variability. Past studies showed that an Efficient Time Simulation (ETS) method offered a more effective result without scarifying accuracy. Nevertheless, the ETS method is limited to specific sea state conditions, in which the level of accuracy decreased with the presence of the wave current. Therefore, this study aims to improve the ETS method by taking advantage of their excellent correlation between extreme surface elevation and corresponding structural responses. Hence, an extended version of the ETS method is introduced. A novel model is developed based on regression algorithms and known as an ETS-Regression (ETS-Reg) procedure contributing a simplified method for the direct calculation of the wave-induced loads. Two ETS-Reg models were developed based on different input variables with similar output variables. In model development, the first relationship-based model was developed based on the surface elevation (input) and nonlinear responses (output), defined as the ETS-Reg$_{SE}$ model. The second model was an improved version of the ETS-Reg$_{SE}$ model, the linearised responses (input) with their corresponding nonlinear responses, known as the ETS-Reg$_{LR}$ model. In short-term analysis, these models will be tested by three sea state conditions and three different wave-induced currents. The probability distribution of the 100-year extreme response values from the ETS-Reg models have been compared with corresponding distributions of 100-year response values from the MCTS procedure to examine the accuracy and the efficiency of the developed technique. As a result, for the short-term analysis, the ETS-Reg$_{LR}$ model delivered an excellent accuracy in the range of 93% to 99% in predicting 100-year responses compared with the benchmark value using the MCTS method for all cases of wave conditions. Meanwhile, the ETS-Reg$_{SE}$ model varies between 20% and 96%. Remarkably, the efficiency level achieved by the ETS-Reg$_{LR}$ model was in the range of 43 to 51 times more efficient than the MCTS method in terms of variance ratio of sampling variability, whereas, the ETS-Reg$_{SE}$ model was in the range of 22 to 42 times. The same inference appeared for long-term analysis since both the ETS-Reg models' accuracies were closely matched to the previous short-term analysis. The ETS-Reg$_{LR}$ model's accuracy was 95% to 99%, whereas, 89% to 96% by the ETS-Reg$_{SE}$ model. Overall, the ETS-Reg models can lead to better performance without extensive simulations, which the models require less computationally demanding processes and time. Thus, these innovative models are proposed as an alternative technique for frequency domain in the probabilistic assessment in the oil and gas industry.

ABSTRAK

Penilaian beban hidrodinamik yang tepat pada struktur disebabkan oleh beban persekitaran yang melampau adalah perhatian utama dalam reka bentuk platform luar pesisir. Gelombang yang disebabkan oleh angin merupakan beban yang biasanya paling berpotensi dengan tingkah laku ketaklelurusan, menyumbang kepada penyelesaian yang rumit. Kaedah simulasi masa *Monte Carlo* (MCTS) konvensional diperlukan untuk analisis tepat mengenai beban gelombang tanpa menawarkan ralat penghampiran. Teknik MCTS dianggap sebagai pendekatan yang realistik dan serba boleh kerana ia dapat merangkumi pelbagai jenis ketaklelurusan untuk menilai tindak balas struktur luar pesisir. Walau bagaimanapun, teknik konvensional ini sangat memerlukan pengiraan kerana keputusan yang tepat memerlukan sebilangan jumlah simulasi yang sangat besar kerana kepelbagaian pensampelan berlebihan yang tidak dapat dielakkan. Kajian lepas menunjukkan bahawa kaedah Simulasi Masa Cekap (ETS) menawarkan keputusan yang lebih berkesan tanpa menjelaskan ketepatan. Namun begitu, kaedah ETS terhad pada keadaan laut tertentu di mana aras ketepatannya menurun dengan kehadiran arus gelombang. Oleh itu, kajian ini bertujuan untuk meningkatkan kaedah ETS dengan mengambil kira korelasi yang sangat baik antara ketinggian permukaan air dan tindak balas struktur yang sepadan. Oleh itu, versi lanjutan kaedah ETS diperkenalkan. Model baru dibentuk berdasarkan algoritma regresi dan dikenali sebagai prosedur ETS-Regresi (ETS-Reg) yang menyumbang kaedah yang dipermudah untuk pengiraan terus beban yang disebabkan oleh gelombang. Dua model ETS-Reg dibentuk berdasarkan pemboleh ubah input yang berbeza dengan pemboleh ubah output yang sama. Dalam pembangunan model, perhubungan pertama berasaskan model dibentuk berdasarkan ketinggian permukaan air (input) dan tindak balas tak-lelurus (output), yang dinamakan sebagai model ETS-Reg$_{SE}$. Model kedua adalah versi yang lebih baik dari model ETS-Reg$_{SE}$, tindak balas terlinear (input) dengan tindak balas tak-linear (output) yang sesuai, yang dikenali model ETS-Reg$_{LR}$. Dalam analisis jangka pendek, model-model ini akan diuji dengan tiga keadaan laut dan tiga arus gelombang yang berbeza. Taburan kebarangkalian nilai tindak balas ekstrim 100 tahun dari model ETS-Reg dibandingkan dengan taburan nilai tindak balas 100 tahun yang sepadan dari prosedur MCTS untuk memeriksa ketepatan dan kecekapan teknik yang dibentuk. Hasilnya, untuk analisis jangka pendek, model ETS-Reg$_{LR}$ memberikan ketepatan yang sangat baik dalam lingkungan 93% hingga 99% dalam meramalkan tindak balas 100 tahun berbanding dengan nilai penanda aras menggunakan kaedah MCTS untuk semua kes keadaan gelombang. Sementara itu, model ETS-Reg$_{SE}$ berbeza antara 20% dan 96%. Tahap kecekapan yang dicapai oleh model ETS-Reg$_{LR}$ berada dalam lingkungan 43 hingga 51 kali lebih efisien daripada kaedah MCTS dari segi nisbah varians pemboleh ubah sampel, sedangkan, model ETS-RegSE berada dalam lingkungan 22 hingga 42 kali. Kesimpulan yang sama muncul untuk analisis jangka panjang kerana ketepatan kedua-dua model ETS-Reg sangat berkaitan dengan analisis jangka pendek sebelumnya. Ketepatan model ETS-Reg$_{LR}$ adalah 95% hingga 99%, manakala, 89% hingga 96% oleh model ETS-Reg$_{SE}$. Secara keseluruhannya, model ETS-Reg memberi prestasi yang lebih baik tanpa simulasi tambahan, yang mana model memerlukan pengurangan proses dan masa pengiraan. Oleh itu, model inovatif ini dicadangkan sebagai teknik alternatif untuk frekuensi domain dalam penilaian probabilistik dalam industri minyak dan gas.

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LIST OF ABBREVIATIONS

API	-	American Petroleum Institute
API RP	-	American Petroleum Institute Recommended Practice
BS	-	Base Shear
BV	-	Bureau Veritas
C++	-	C with Classess (Programming Language)
CDF		Cumulative Distribution Function
CPU	-	Central Processing Unit
DFT	-	Discrete Fourier Transform
DNV	-	Det Norske Veritas
DSA	-	Deterministic Spectrum Amplitude
ETS	-	Efficient Time Simulation
ETS-R	-	Efficient Time Simulation Relationship
ETS-Reg	-	Efficient Time Simulation Regression
ETS-Reg$_{SE}$	-	Efficient Time Simulation Regression-based Surface Elevation
ETS-Reg$_{LR}$	-	Efficient Time Simulation Regression-based Linearised Responses
ETS-RTS	-	Efficient Time Simulation-Relationship Time Simulation
ETU	-	Efficient Threshold Up-crossing
EVA	-	Extreme Value Analysis
FFT	-	Fast Fourier Transform
FMNS	-	Finite-Memory Nonlinear System
IDFT	-	Inverse Discrete Fourier Transform
IFFT	-	Inverse Fast Fourier Transform
ITTC	-	International Towing Tank Conference
ISSC	-	International Ship Security Certificate
JONSWAP	-	Joint North Sea Wave Project Spectrum
LRWT	-	Linear Random Wave Theory
MATLAB	-	Matrix Laboratory (Programming Language)
MCTS	-	Monte Carlo Time Simulation

MFMNS	-	Modified Finite-Memory Nonlinear System
MN	-	Mega Newton
MNm	-	Mega Newton meter
MOM	-	Method of Moment
NARX	-	Non-linear Autoregressive with Exogenous Input
NLFD	-	Nonlinear frequency-domain
NSA	-	Non-deterministic Spectrum Amplitude
NWT	-	New Wave theory
OTM	-	Overturning Moment
P-M	-	Pierson Moskowitz
PCT	-	Principal Component Technique
PDF	-	Probability Density Function
POF	-	Probability of Failure
QRA	-	Quantitative Risk Analysis
RTS	-	Relationship Time Simulation
SDOF	-	Single Degree of Freedom
SE	-	Surface Elevation
SFSM	-	Second - Fourth Statistical Moment
SRA	-	Strcutural Reliability Analysis
SST	-	Simple Sampling Technique
SWL	-	Still Water Level
UK	-	United Kingdom

LIST OF SYMBOLS

a,b,c,d - regression model coefficients
A - wave amplitude
A_u and B_u - complex (Fourier series) coefficients of u
A - Phillip’s constant of 0.0081
$\hat{\alpha}$ - factors for the equivalent linear form (drag-induced)
$\bar{\alpha}$ - mode of the extreme value distribution (Gumbel parameters)
$\hat{\beta}$ - factors for the equivalent linear form (inertia-induced)
$\bar{\beta}$ - dispersion coefficients (Gumbel parameters)
cl - celerity
C - damping
C_d - drag coefficient
C_m - inertia coefficient
Δf - frequency interval
Δl - length interval of the structure element
d - water depth
D - diameter of cylindrical structures
E - residual error
ε - random wave phase angle
e - error
$E[e^2]$ - residual error (drag-induced)
$E[e'^2]$ - residual error (inertia-induced)
$\mathrm{EV}_{\mathrm{R100}}$ - 100-year extreme responses
exp - exponent
$\tilde{\eta}$ - sum of sinusoids of sample sea surfaces
η_{ev} - surface elevation extreme value
f - wave frequency
f_p - peak frequency
f^l - function of linear regression model
f^p - function of polynomial regression model
f^c - function of cubic regression model

F - Morison’s force (wave-induced loads)

g - gravitational acceleration of 9.81 m/s^2

gg_i and hh_i - standardised Gaussian random variables

G_f - function of failure

g_{cdf} - Gumbel cumulative distribution function

G_{pdf} - Gumbel probability density function

g_{x_n} - extreme values of cumulative distribution function

$\Gamma_{u,i}$ - *TF* of particle velocity related drag-induced responses

$\Gamma_{\dot{u},i}$ - *TF* of particle acceleration related inertia-induced responses

γ - Euler–Mascheroni constant (≈0.5772)

γ_p - peak enhancement factor

h or H - wave height

Hs - significant wave height

K - stiffness

k - wave number

M - mass

Mz - number of wave cycle during period T (dimensionless)

μ_η - mean of the sea surface elevation

μ_H - mean of the sea wave height

N - total number of simulation records (simulated responses)

NL - numbers of nodal loads

NW - number of wavelet components

N_a - annual average number of sample data

L - load

λ - wavelength

log - logarithm

ln - natural logarithm

lr_{ev} - linearised responses extreme value

ω - angular wave frequency

Π - mathematical constant of 3.142

P - probability distribution

P_η - probability density function of surface elevation

p_{H_s,T_z} - joint occurrence probability density function of H_s and T_z
P_H - probability density function of wave height
p_H - cumulative distribution function of wave height
P_i - probability of occurrence of Group *i*
p_k - equivalent point loads acting on node *k* of wave forces
p_{X_n} - cumulative probability of return periods
$P_{\eta_{ev}}$ - probability surface elevation extreme value
$P_{r_{ev}}$ - probability response extreme value
$P_{r_{max}|h,t}$ - short-term probability distribution by Hsi and Tzj
$P_{LT,r_{max}}(q_n)$ - long-term probability distribution (entire sea states)
q - nodal point displacements
q_n - *n*-th smallest simulated extreme value
r - correlation coefficients / correlation-*r* values
r^2 - determination coefficients / *r*-squared values
R - resistance
$\tilde{R}\ or\ \tilde{R}_{QS}$ - quasi-static offshore structural nonlinear response
$\hat{R}\ or\ \hat{R}_{DYN}$ - dynamic offshore structural nonlinear response
r_{drag} - drag forces
$r_{inertia}$ - inertia forces
$r_{L,drag}$ - linearised drag forces
$r_{L,inertia}$ - linearised inertia forces
r_{ev} - predicted extreme response values
r_{ev}^{l} - predicted extreme responses based on first-order linear
r_{ev}^{p} - predicted extreme responses based on second-order linear
r_{ev}^{c} - predicted extreme responses based on third-order linear
r_{max} - simulated extreme response value
ρ - seawater density
S_η - wave energy spectrum
σ - standard deviation
σ^2 - variance
σ_a - standard deviation to the left
σ_b - standard deviation to the right

σ_η - standard deviation of the sea surface elevation

σ_η^2 - variance of the sea surface elevation

σ_H - standard deviation of the sea wave height

σ_H^2 - variance of the sea wave height

σ_{x_n} - standard deviation of random variables

S_k - flexibility coefficients

SS_{res} - residual sum of squares

SS_{tot} - total sum of squares

t - time

T - wave period

TF - transfer function

$TF_{\tilde{R}_L}$ - transfer function of linearised responses

T_r - specific return periods

T_z - mean zero up-crossing period

u - water particle velocity

$\dot{u}$ - water particle acceleration

U - current velocity

U' - DFT of horizontal water particle velocity

U'' - DFT of horizontal water particle acceleration

W - the total number of sea states

W_{ij} - the number of occurrences of the sea states represented by *Hsi* and *Tzj* in the scatter diagram

x - horizontal direction displacement

x_n - random variable of extreme values

X_0 - mean surface elevation

X_n and X_{-n} - complex Fourier coefficients of $\tilde{\eta}$

X_n^* - complex conjugate of X_n

$\bar{x}$ - stationary random processes (time domain)

$\bar{X}$ - stationary random processes (frequency domain)

$\bar{x}_r$ - amplitude of the r-th complex component

$\bar{X}_k$ - discrete Fourier Transform of k^{th} complex component

y - probability y-axis

z - vertical direction for the seabed

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Crude oil is currently the most abundant energy sources, accounting for an estimated 39 percent of fossil energy, followed by coal and natural gas at 33 and 28 percent, respectively (Ritchie and Roser, 2019). With the arrival of passenger vehicles, aviation, road freight, chemical feedstock, industry, shipping and the extensive use of electricity (buildings/power), oil has become the dominant fuel during the twentieth century (Garside, 2018). Due to high demand, oil and other petroleum commodities have been rapidly rising over the years (Cooper *et al.*, 2018).

High demand has motivated petroleum companies to explore the ocean floor to extract oil and other resources, and to deliver the oil onto land for marketing purpose. Many oil and gas partnerships have made great efforts to take this opportunity to invest in the marine industry (Bennaceur, 2019). To meet this goal, many companies require essential equipment and access to thousands of facilities for the exploration and production of oil and natural gas with a variety of categories and sizes around the world (Laik, 2018).

Offshore oil and gas production has evolved in line with technological progress to remain relevant in different circumstances (Schmidt *et al.*, 2017). The development of oil platforms offers varying capabilities in security, technical, economic and national needs that depend on the depth of the ocean as well (Nouban *et al.*, 2016). The success of a platform and to the success of the entire operation must take into account the most basic offshore drilling in the seabed. Most drilling operations either can be accomplished by a fixed or floating offshore platform (Swamidas and Reddy, 2016).

The main focus of this thesis is on fixed platforms because this is the majority of platforms installed around the world (Goswami *et al.*, 2019). Recently, this kind of fixed offshore structure has played a primary role in oil and gas activity for the past decade (Reddy and Swamidas, 2016). The fixed-based structures account for around 95% of the jacket platforms currently found in different bays, gulf and oceans of the world, a percentage that is growing year by year (Limited, 2017). As reported by O'Connor *et al.* (2007); OECD (2016), more than 9000 offshore platform installations are in service around the world. These installations are employed for drilling, providing water or gas for inoculation into the storage tank for processing crude oil, refining the produced water for dumping into the sea and also serve as staff housing (Bleasdale, 2018).

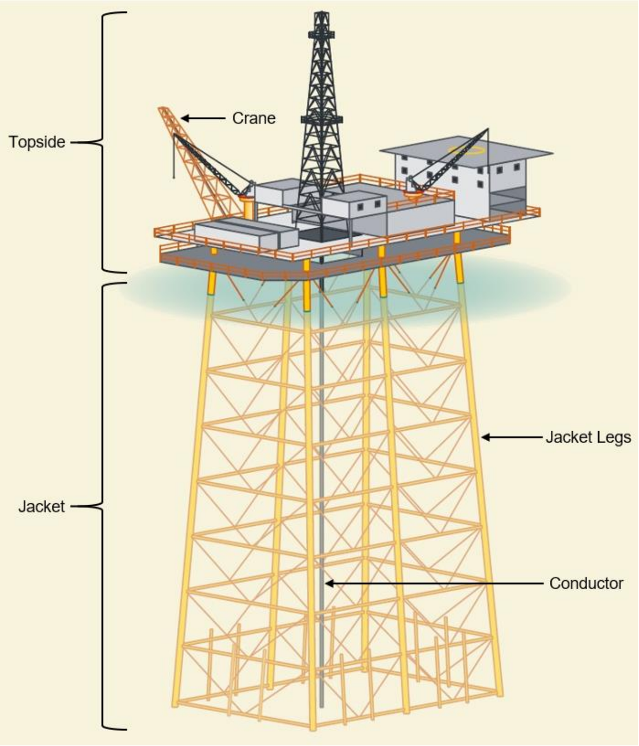

Figure 1.1 Main sections of the jacket offshore platform
Source: (Bücker *et al.*, 2014)

Shallow water fixed offshore structure is very low-cost and more practicable to provide operators and tools on structural platforms (Yu *et al.*, 2015). Under this type, the study would concentrate on piled structures, mainly known as the jacket offshore platforms. "Jackets" refers to fixed steel offshore structures, which are fundamental in support the deck and topsides to ensure the stability of the platforms and piling process (El-Reedy, 2019). They are the most commonly located structure for shallow and intermediate water depths reaching up to 400 metres. Jackets had been designed to assist topside weights about 50000 tonnes, although it is possible to formulate jackets for even larger topside weights as illustrated in Figure 1.1.

Offshore platforms positioned in the ocean environments are more vulnerable to hazardous risks compared to onshore oil rig platforms. Some common dangers that can affect the structural integrity are extreme waves, which can exceed 30m or more such as an incident in the northern North Sea, as reported by (Bruserud and Haver, 2019). In this study, the environmental load (e.g. wind-induced wave) is a main consideration in the design of offshore structures. For acceptable structural integrity, offshore structures should be designed with the capability of withstanding extreme wave loads (Henry *et al.*, 2017).

According to Board (2011), the wave loads from an environmental perspective contribute as a dominant load was around 70% affecting the durability of jacket structures. Large waves represent a danger to offshore platforms and marine installations if the design of marine structures is not followed by the right development criteria (Szalewski *et al.*, 2017). Since the harsh environmental loads represent a significant role in leading the design of offshore structures, the precise prediction of environmental wave loads acting on the structure is indispensable.

A study revealed that the risks associated with extreme waves, which have a tremendous effect on offshore structures, have increased in recent years (ATEX, 2016; Slunyaev, 2017). As stated by Demirbilek (2010), a number of platform accidents related to extreme waves had been reported, and this is the lessons learned how the impact of intense waves hits into the platform structures if the design of offshore platform does not follow the predefined guidelines. As demonstrated in Figure 1.2, a massive wave had hit the marine structures such as the Hurricane Lilli in the Gulf of Mexico.

Figure 1.2 EI-322 ‘A’ platform structures damaged by Hurricane Lilli
Source: (DeFranco *et al.*, 2004)

Pursuant to (Cruz and Krausmann, 2008), Hurricane Katrina is another example that caused damage to more than 30 oil platforms and rigs, the closure of nine onshore refineries, and destruction of transport facilities and oil production in the Gulf of Mexico region. The damage could be the occurrence of a particular wave phenomenon, such as an abnormal wave crest. These strange wave phenomena are often referred to as rogue, freak, giant, episodic and extreme waves (Kettle, 2018). The abnormal waves are unexpected and unpredictable phenomena that surface waves immediately reach without warning and can influence (strike) large force.

Incidents of “unprecedented” wave phenomena have occurred in different locations, for example, Model of Ocean Ranger, Draupner oil rig in the North Sea, Jacket platform in the Gulf of Mexico and other offshore platforms related to wave cases (Cavaleri *et al.*, 2017). Such incidents have been highlighted because extreme waves can lead to dominant failures. Figure 1.3 displays an example of the failure mode with an intact structure exposed to a massive wave. An accident on offshore jacket structures reveals that leaning installations with huge deformations are the most expected results as well as a toppled topside and total collapses (Kajuputra *et al.*, 2016).

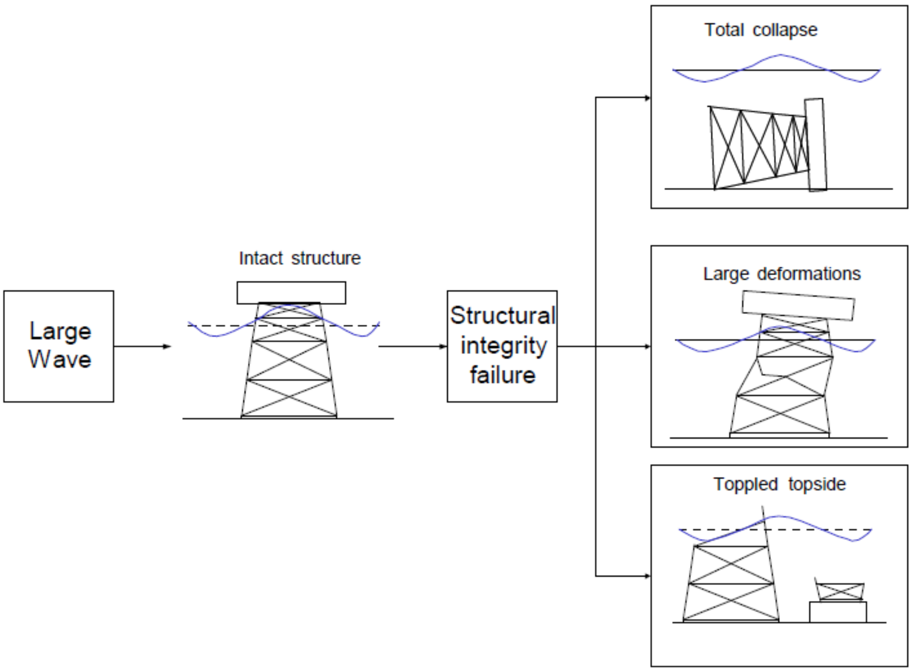

Figure 1.3 Excessive environmental load failure mode
Source: (Ersdal, 2005)

Based on previous accidents, a risk assessment has been carried out on wave-related incidents in order to classify the possible hazards. Hazards can pose a danger to the structural integrity of offshore structures due to insufficient strength of structures (Thapa, 2016). There are two possibilities of risks associated with the inadequate strength, which are fatigue failure (cyclic loading) and first excursion failure (Taylor *et al.*, 2006). Fatigue failure may occur when a response spends too much of its time out of a limit. For instance, degradation of the offshore structure because of fatigue coupled with corrosion might reduce the capability of structures to confront excessive waves and current loadings.

Another mode is the first excursion failure, which arise once the structural responses exceed a designated safety domain for the first time in a certain year (e.g. 50-year or 100-year) (Najafian, 2005; Mohd Zaki *et al.*, 2016b; Mukhlas *et al.*, 2016a; Santo *et al.*, 2016). Hence, structural integrity requires to be sustained by environmental loads during the lifetime of the installation (Nayak and Pandian, 2018). Knowledge of how risky ocean conditions interface with fixed structures is required to assure the safety of employees and avoid property loss (Procedures, 2017). The safety aspect of the offshore structures should be addressed carefully and consciously (Nizamani, 2015).

The main concern in this view is that obligations about safety should not be negotiated. For achieving the safety level, it is essential to emphasise in the design phase and construction of an offshore platform at the initial scope of work (Bea, 1992; Coccon *et al.*, 2017). The design stage of offshore developments is the first step before continuing the next phase of fabrication, installation and operation activities (El-Reedy, 2019). That is why the calculation of the design wave load in the design stage is a crucial task for the construction of offshore structures. The need for design analysis is required in order to guarantee safety in design and operation from extreme wave loads (Sandhya, 2018).

To assure structure design is adequately safe, the initial implementation is to follow the rules and offshore standards. The standards were established by a competent organisation such as the American Petroleum Institute (API), Bureau Veritas (BV), Det Norske Veritas (DNV), International Standards Organization (ISO) etc. (DNV, 1974; BV, 1975; API, 1977; ISO, 2007). Thus, designers should obey all guidelines related to the design and construction of fixed offshore structures. For example, an API RP 2A standard is a well-recognised rule in the offshore fields (Mangiavacchi *et al.*, 2005). This standard is practised for specific perspectives of the offshore structure design around the world.

Referring to API RP 2A manual, the guideline declares that the extreme loads are generated from a combination of wind, wave and current, in which the wave is the most influential load (Goswami *et al.*, 2019). The wave-induced loads acting on offshore platforms are necessary for performing the structural analysis in order to obtain the offshore responses. Thus, offshore structures were designed to meet a standard that would be employed in the context of the level of risk and structural reliability (Onoufriou and Forbes, 2001). Historically, the reliability-based design for offshore structures is practised on the basis of the calculation of the load-induced motion responses (Chandrasekaran, 2017).

Prior to evaluating the data magnitude from these wave load-responses, a statistical and probabilistic description is required (Vanem *et al.*, 2019). Numerical analysis and computational procedures are applied to simulate such wave loads and its corresponding structural responses (Şen, 2018). With the numerical simulation, a Fourier Transform analysis based on the wave spectrum is used (Yu, 2018). In order to determine the design of extreme responses of the structures, the statistical approach via extreme value analysis (EVA) method is used (Coles, 2001). EVA is a conventional approach used to predict the structural response values that have to fit the data into the probability distribution.

EVA has been presented by a number of researchers (Thas *et al.*, 1997; Cooley, 2013; Chaves and Melchers, 2014; Horn and Winterstein, 2018). In brief, the result from the EVA approach is used as design conditions for the offshore structural reliability analysis. Designing the offshore structure is safe when its capability to resist the wave loads exceeds the maximum loads that may be applied once in a given time period (100-year) (Mat Soom *et al.*, 2019). Thus, the wave-induced loads imposed on the marine structures is commonly determined by the 100-year return period (Azman *et al.*, 2017; Mat Soom *et al.*, 2018). Also, calculating wave loading on the structures could be reached using either the deterministic or probabilistic method (Bjerager, 1990; Najafian *et al.*, 1995; Golafshani *et al.*, 2011).

According to Klein *et al.* (2020), the deterministic method is more suitable with the regular waves to forecast structural responses on wave loading. In real life, the ocean surface is always changing in time, which are also considerable uncertainties of the wind-generated random waves (Qiu *et al.*, 2014). Due to the uncertainty perspective (caused by wind, wave and current conditions), the main barrier in applying deterministic approach is about the random nature of the ocean that it does not consider while calculating the nonlinear properties in the design practice (Gao *et al.*, 2016). Due to the nonlinearity excitation, the deterministic-based analytical procedures for assessing irregular waves and its corresponding extreme responses are less accurate (Osborne, 2001; Clauss and Schmittner, 2005; Helder and Bunnik, 2016).

Therefore, the most promising method to estimate random wave-induced forces in the ocean conditions is a probabilistic method (Oumeraci *et al.*, 2001). The probabilistic approach is more consistent because uncertainties are admitted in the calculations (Bruserud and Haver, 2017), which can count random wave-induced loads and responses in the ocean environment. Under the probabilistic method, as stated in (Najafian *et al.*, 1995; Soares, 2012), there are three main approaches; probability, frequency and time domains. Each domain has its own process of evaluating structural responses.

1.2 Problem Statement

In targeting the early design phase, the structural analysis is utilised to determine the extreme structural responses of the structures. The probabilistic approach based on the time-domain simulation has been adopted, which is considered the best method to establish the short-term and long-term probability distribution of extreme offshore structural responses (Cassidy *et al.*, 2003; Abu Husain *et al.*, 2016a; Mohd Zaki *et al.*, 2016d; Mukhlas *et al.*, 2016a). A Monte Carlo Time Simulation (MCTS) method is practised to produce accurate values from the stochastic events of random waves (Norouzi, 2012). The stochastic analysis is feasible to be carried out by a robust MCTS technique, although numerous simulated data must be assessed in order to achieve the desired level of accuracy (Catelani *et al.*, 2014; Chai *et al.*, 2016).

Moreover, time-domain is capable of counting all sorts of nonlinearities without bringing in any approximations (Abu Husain *et al.*, 2016a). Due to its ability, this MCTS method had been applied for evaluation of the extreme responses affected by random excitations (Naess and Gaidai, 2008). It is the most precise, realistic and multifaceted approach for forecasting the statistical features of extreme offshore structural responses opened to irregular wave loads (Metcalfe *et al.*, 2003; Najafian, 2007c; Saha and Naess, 2010; Abu Husain *et al.*, 2016a; Mohd Zaki *et al.*, 2018a; Mukhlas *et al.*, 2018b). At the same time, MCTS method attempted to make less computational cost because it is simple to be applied while maintaining the benefits of conventional tools and computational simulations.

Due to the complex procedure of MCTS (Mukhlas *et al.*, 2016a), the length of the simulations depends on the number of response records varied with the computational time (completed simulations). Likewise, the numerous stages based on each process in wave hydromechanics modelling became more complicated. Also, the impact of nonlinearities will burden the process of calculations in analysing the ocean wave and its corresponding hydrodynamic loadings (Abu Husain *et al.*, 2016a; Mukhlas *et al.*, 2018a). Hence, the MCTS procedure involves a long run of simulations which requires more effort to reduce its sampling variability in order to reach satisfactory results in the calculation.

As shown in Figure 1.4, the sampling variability is very computationally demanding, and this is the main shortcoming of MCTS procedure because the precision required a large number of simulation records (Mohd Zaki *et al.*, 2018a; Abu Husain *et al.*, 2019; Mukhlas *et al.*, 2019). The method was repeated 100 times to display the impact of sampling variability. As observed, it proves that the MCTS method needs a large number of simulations (10,000 records) to reach better accuracy equal to 4 percentage error. It indicates that the sampling variability achieves 95 percent confidence level, which is an acceptable result complied below than 5 percent of the sampling variation (API, 2013). This technique's implementation is very complicated when considering 10,000 simulated records for each stage of the calculation process of schematic wave hydromechanics (Mukhlas, 2020). That is the reason the conventional MCTS method is very time-consuming.

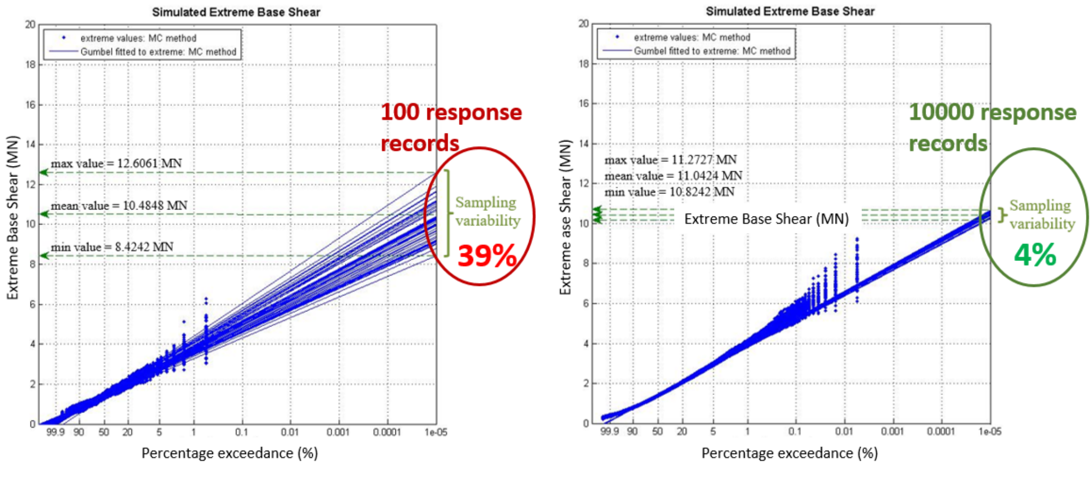

Figure 1.4 Sampling variability of Monte carlo time simulation method

Hence, many studies have been conducted to understand the MCTS method problems and to make an improvement in terms of efficiency, as shown in Figure 1.5. An improved MCTS technique has been extended by many researchers (Najafian and Zaki, 2008; Mohd Zaki *et al.*, 2016b; Mukhlas *et al.*, 2018a). On the other hand, in order to capture this inefficiency, one of the favourable method was studied by (Abu Husain and Najafian, 2011), who presented an Efficient Time Simulation (ETS) method. Currently, the ETS method offers excellent efficiency and has proven in the full-wave investigation to be a very effective method in the development stages for quasi-static responses, dynamic responses and varying sea-state intensity ranging from low to high (Abu Husain *et al.*, 2013b; Johari *et al.*, 2016).

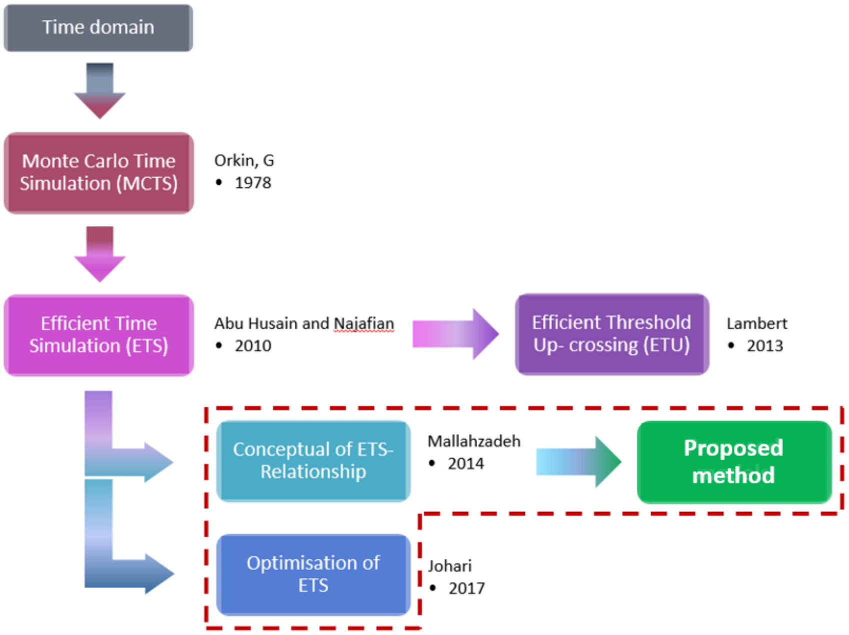

Figure 1.5 Design development of the proposed method and their limitations from previous methods

However, the limitation of the ETS method is that it does not perform well for low sea state (i.e., $Hs = 5$ m), especially the existence of the current effect, which will reduce the level of accuracy. As stated by Abu Husain *et al.* (2013b), this can be seen as the worst relationship between surface elevation and responses is at low *Hs* value. Some researchers put more effort to tackle this issue by introducing several methods such as Efficient Threshold Up-crossing, ETS-Relationship and Optimisation of ETS method. In 2013, Lambert *et al.* (2013) introduced the proficient calculation of probability distribution of the offshore structural responses. The fundamental ETU method was developed based on the information of threshold up-crossings connected with the speed of the ETS method. However, the comprehensive study was made on the aircraft gust loadings.

Mallahzadeh *et al.* (2014a); Mallahzadeh *et al.* (2014b) extended the ETS method with related initiatives of the relationship of input and output considerations. This improved ETS technique was named the ETS-Relationship (ETS-R) method, also known as ETS-Relationship Time Simulation (ETS-RTS) model. A conceptual study was carried out to develop an empirical model by introducing the relationships' extreme values between and surface elevations and responses. This initial investigation was promising, but to date has not dealt with a comprehensive study. Mallahzadeh *et al.* (2013) reviews were limited to a single-legged structure, single high sea state (*Hs* = 15 m) and did not consider certain other wave possibility conditions.

In order to improve this ETS-RTS procedure, Johari (2016) optimises the number of simulation records which will enhance the selection number of groups. Although it makes an enhancement in accuracy and efficiency, it still has the same problems in the low *Hs* value. To this end, referring to Mallahzadeh *et al.* (2013) as a conceptual study, a fully comprehensive examination will be extended in determining the 100-year extreme responses. Applying an advantage of ETS method, the proposed method is developed from the relationship (scattered distribution data) between two variables of extreme surface elevation (input) and its extreme responses (output). Thus, a systematic regression analysis is performed in order to obtain the appropriate model development based on the excellent relationship, which is also known as the ETS-Regression (ETS-Reg) model.

The model would be tested for the real structures. In this study, the examination will also be considered according to different sea state conditions, a four-legged structure platform, quasi-static jacket platforms, wave structures of nonlinearities kinematics loading, intermittent (cyclic) loading and the effect of current wave propagation. The improvement of the relationship between extreme values would also be conducted. As a result, a new method is likely to solve the complicated issue, particularly for the low *Hs* alongside the current impact.

Also, the proposed method is expected to be more efficient than MCTS and ETS methods because of simplifying another complicated calculation procedure without sacrificing accuracy. As a regression model preferred, there is no need to run extensive simulations or to pass through several processes of calculations. The models would be a great technique to calculate the responses while at the same time, raising its efficiency.

1.3 Aims and Research Objectives

The study aim is to develop an efficient procedure for evaluating the 100-year fixed offshore structure responses using Efficient Time Simulation (ETS) method by taking advantage of their excellent correlation between extreme values of surface elevation and linearised responses (input) with their equivalent extreme values of nonlinear response (output).

The study objectives can be further detailed as follows:

1. To investigate the hydrodynamical relationships between extreme values of surface elevation and linearised responses with their corresponding nonlinear responses.
2. To develop a regression model for the prediction of extreme responses by the utilisation of relationships.
3. To validate the accuracy and efficiency of the regression models for both short-term and long-term probability distribution in predicting extreme offshore responses.

1.4 Scope of the Study

This study will focus on the four-legged fixed offshore platform without internal bracings for a water depth (*d*) up to 110 m. The application of numerical simulation analysis based on the mathematical models is preferred to simulate ocean wave hydrodynamic into the real world with the aid of computer ability. The linear random wave theory (LRWT) is used to simulate the water kinematics in hydrodynamic wave loadings. The forecast for structural responses has been extensively used based on probabilistic modelling due to its ability to calculate the random nature of loading. The probabilistic-based time domain was selected to evaluate 100-year extreme responses in short-term and long-term probability distribution. The derivation of the probability distribution of extreme structural responses are based on the API RP 2A standard (API, 2014).

This study only considered the system structure in quasi-static responses. Two primary responses would be counted, namely; base shear (BS) and overturning moment (OTM) of structural responses, which relies on three hydrodynamic components; drag-induced, inertia-induced and total responses. Ensuring the platform complies with standards, the structure was tested under various wave conditions, including without and with the presence of currents; $U = 0$ m/s, +0.9 m/s and −0.9 m/s, respectively. For a short-term analysis, it considers a single sea state characteristic in the calculation. The three cases of sea states are taken into account accordant with low, mid and high significant wave heights; $Hs = 5$ m, 10 m and 15 m associated with its zero up-crossing wave period; $Tz = 7.94$ sec, 11.23 sec and 13.75 sec, respectively. All terms related to low, mid and high *Hs* are also known as the low, mid and high sea state, which considers the category of sea state intensity.

By completing the short-term analysis on fulfilling a good agreement, the study continues with a long-term analysis that considers the entire sea states based on the scatter diagram alongside their wave frequency of occurrences. These input wave parameters (*Hs*, *Tz* and *d*) are used to find the extreme values that correspond to irregular wave analysis that correlate strongly to the structural responses (design responses) for any specific year of return periods.

1.5 Significance of the Study

This study's primary finding is to provide a simple technique for derivation of the probability distribution of extreme structural responses with reference to a specified period. Applying the relationship-based model development, the proposed model not only reduces the computational demand (time-cost), but it proved to be at least equivalent to the MCTS method used in the probability distribution of extreme responses. The offered regression model delivers a simplified approach to the numerical procedure. There is no need to pass through several calculation stages, and it does not need extensive simulations. For example, this simple model is expected to be an effective technique to determine design responses. As observed, there is too much calculation effort needed in completing the whole process for the long-term analysis.

On the other side, the frequency domain is widely applied in estimating the 100-year extreme responses. In industry practice, the calculation based on the frequency domain is preferred because of its efficiency. However, the frequency-based approach always yields inconsistent results. This inconsistency is related to the issue of underprediction or overprediction values. That is why the presence of the regression model based on the time domain are suggested to be more reliable and competent. By using this simplified model, the sustainable and competitive choice for analysing the fixed offshore structures in the oil and gas sector can be provided. Apart from the application, the potential of model development is a generic model that could be applied in any random discipline related to excitation forces (e.g. waves, vibration, wind turbine, aircraft, renewable energy equipment).

1.6 Thesis Overview

This thesis consists of five chapters. The content of each chapter is briefly described below.

Chapter 1 includes the subject of the specific issue generally addressed; following the current problems faced in ocean engineering and the inspiration of the newest approach on how to solve it. Once the problem statement is identified, the proposed method comes up with the new solution, which is to fulfil the limitation from previous studies that had been done up to now. The chapter concludes with the aims and objectives, the scope of the study and the significance of the study. In summary, this chapter accustoms the reader to what is the focused path in this study.

Chapter 2 deals with the reliability analysis in offshore structures in compliance with the rules and regulations. The study finding is related to the safety practices that will be utilised in the design phase and analysis process in order to sustain the structural integrity imposed by the wave loadings. Details of the probabilistic modelling have been discussed comprehensively, either in the probability, frequency and time domains from the previous research achievement. The most relevant parts will be reviewed on the fundamental of ocean wave hydromechanics and the offshore structural assessment. Under the probabilistic analysis, this study will narrowly focus on the new method used in predicting the structural responses in the research gap.

Chapter 3 involves three main simulation procedures in calculating the structural responses. An MCTS method is used for benchmark purpose; meanwhile, an ETS method is a predecessor method, which is used for a proposed model of ETS-Reg model. Due to the limitation on specific (certain) wave conditions, the improvisation of ETS-Reg model is also introduced. Eventually, the proposed method becomes an alternative approach in deriving the short-term and long-term probability distribution for the offshore structures. Each procedure is provided as a comprehensive workflow.

Chapter 4 provides two forms of analysis, namely the short-term and the long-term response analysis. In this chapter, the proposed model would be compared and validated with the benchmark method of MCTS. By initially focusing on the short-term, the model is assessed in relation to low, medium and high sea state and its corresponding current impact. This initial analysis is to identify the performance of

ETS-Reg model regarding observation of accuracy level and efficiency. Having produced a satisfactory result, the study performed a long-term analysis for the cases of without and with current imposed, in which the prediction would be conducted based on Met-Ocean data (entire wave distribution diagram). Besides, for a more detailed analysis, both analyses were examined on the separate hydrodynamic basis, which is drag-induced, inertia-induced and total responses.

Chapter 5, which is the final chapter, explains the accomplishment of the study objectives, and summarises the conclusions that are made throughout this study. A claim of contribution, whether in academic and practical aspects correlated to the theoretical and knowledge, and how this proposed model could compose an impact in the offshore oil and gas industry also are mentioned and further study recommendations are noted. The published conference paper proceedings and award achievements are also recorded.

REFERENCES

Aarland, Y. (2015). *Time-Domain Simulation of Marine Structures in Irregular Seas.* Master Thesis, Norwegian University of Science and Technology.

Abdel Raheem, S. E. (2016). Nonlinear behaviour of steel fixed offshore platform under environmental loads. *Ships and Offshore Structures,* 11(1), 1-15.

Abdelradi, M. E. (1984). *Hydrodynamic Loading and Design Aspects of Offshore Jacket Platforms.* PhD Thesis, University of Glasgow.

Abhishek, A., Metrikine, A. V., Male, P. v. d., and Dalen, K. N. v. (2018). *Reduction of Fatigue Computational Time for Offshore Wind Turbine Jacket Foundations: Investigation of Lumping Methods for Correlated Wind-Wave Data and Frequency-Domain Approach.* Master Thesis, Delft University of Technology.

Abu Husain, M. K., and Najafian, G. (2010). An Efficient Monte Carlo Simulation Technique for Derivation of the Probability Distribution of the Extreme Values of Offshore Structural Response. *Proceedings of the 29th International Conference on Ocean, Offshore and Arctic Engineering*, June 6–11 2010. Shanghai, China, 369-375.

Abu Husain, M. K., and Najafian, G. (2011). Efficient Derivation of the Probability Distribution of the Extreme Values of Offshore Structural Response Taking Advantage of Its Correlation With Extreme Values of Linear Response. *Proceedings of the International Conference on Offshore Mechanics and Arctic Engineering*, 19–24 June 2011. Rotterdam, The Netherlands, 335-346.

Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2013a). Derivation of the Probability Distribution of Extreme Values of Offshore Structural Response by Efficient Time Simulation Method. *Open Civil Engineering Journal,* 7, 1.

Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2013b). *Prediction of Extreme Offshore Structural Response: An Efficient Time Simulation Approach* (1st ed.). Saarbrucken, Germany: LAP LAMBERT Academic.

Abu Husain, M. K., Mohd Zaki, N. I., Johari, M. B., and Najafian, G. (2016a). Extreme Response Prediction for Fixed Offshore Structures by Monte Carlo Time Simulation Technique. *Proceedings of the 35th International Conference on*

Ocean, Offshore and Arctic Engineering, June 19–24, 2016. Busan, South Korea, V003T002A037 (007 pages).

Abu Husain, M. K., Mohd Zaki, N. I., Mallahzadeh, H., and Najafian, G. (2016b). Short-Term Probability Distribution of the Extreme Values of Offshore Structural Response by an Efficient Time Simulation Technique. *Ships and Offshore Structures*, 11(3), 286-299.

Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2016c). The Effect of Different Methods of Simulating Wave Induced Water Particle Kinematics on the 100-Year Responses. *Proceedings of the Twelfth ISOPE Pacific/Asia Offshore Mechanics Symposium*, 4–7 October 2016. Gold Coast, Australia.

Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2016d). Various Methods of Simulating Wave Kinematics on the Structural Members of the 100-year Responses. *Journal of Mechanical Engineering and Sciences,* 11(4), 18.

Abu Husain, M., Mohd Zaki, N., and Najafian, G. (2017). Prediction of Offshore Structural Response Extreme Values by Three Different Approaches of Efficient Time Simulation Technique. *Ships and Offshore Structures,* 12(2), 290-301.

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.

Agamloh, E. B., Wallace, A. K., and Von Jouanne, A. (2008). Application of Fluid–Structure Interaction Simulation of an Ocean Wave Energy Extraction Device. *Renewable Energy,* 33(4), 748-757.

Aggarwal, A., Alagan Chella, M., Kamath, A., Bihs, H., and Arnsten, Ø. A. (2016a). Numerical Simulation of Irregular Wave Forces On a Horizontal Cylinder. *Proceedings of the 35th international conference on ocean, offshore and arctic engineering,* 19–24 June 2016. Busan, South Korea, V002T008A017.

Aggarwal, A., Chella, M. A., Kamath, A., Bihs, H., and Arntsen, Ø. A. (2016b). Irregular Wave Forces On a Large Vertical Circular Cylinder. *Energy Procedia,* 94, 504-516.

Aggarwal, A., Alagan Chella, M., Bihs, H., Pakozdi, C., Berthelsen, P. A., and Arntsen, Ø. A. (2017). CFD Based Study of Steep Irregular Waves for Extreme Wave Spectra. *International Journal of Offshore and Polar Engineering,* 1, 1-8.

Aggarwal, A., Bihs, H., Shirinov, S., and Myrhaug, D. (2019). Estimation of Breaking Wave Properties and Their Interaction with A Jacket Structure. *Journal of Fluids and Structures,* 91, 102722.

Airy, G. B. (1952). *Tides and Waves*. London: JJ Griffin.

Akkerman, I., Meyer, M., and Eikelder, M. t. (2019). Isogeometric Analysis of Water Waves Using Linear Potential Theory. *Ocean Engineering,* 201.

Akoglu, H. (2018). User's Guide to Correlation Coefficients. *Turkish journal of emergency medicine,* 18(3), 91-93.

Al-Mashan, N., Jradi, A., Aldasthi, H., and Neelamani, S. (2019). The Extreme Waves in Kuwaiti Territorial Waters Using Measured Data. *Ocean Engineering,* 190, 106421.

Alessi, L., Correia, J. A., and Fantuzzi, N. (2019). Initial Design Phase and Tender Designs of a Jacket Structure Converted into A Retrofitted Offshore Wind Turbine. *Energies,* 12(4), 659.

Ameryoun, H., Schoefs, F., Barillé, L., and Thomas, Y. (2019). Stochastic Modeling of Forces on Jacket-Type Offshore Structures Colonized by Marine Growth. *Journal of Marine Science and Engineering,* 7(5), 158.

Andersson, A., Nilsson, B., and Biro, T. (2016). Fourier Methods for Harmonic Scalar Waves in General Waveguides. *Journal of Engineering Mathematics,* 98(1), 21-38.

API. (1977). *API Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms*. Washington, USA: American Petroleum Institute.

API. (1985). Manual of Petroleum Measurement Standards, Chapter 13, Statistical Aspects of Measuring and Sampling, Part 1. In *Statistical Concepts and Procedures in Measurement* (2rd ed.). Washington: API Publications.

API. (1993a). *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Load And Resistance Factor Design*. Washington, USA: American Petroleum Institute.

API. (1993b). *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design*. Washington, USA: American Petroleum Institute.

API. (2013). *Carbon Content, Sampling, and Calculation* (1st ed.). Washington, USA: American Petroleum Institute.

API. (2014). *API Recommended Practice 2A-WSD Planning, Designing, and Constructing Fixed Offshore Platforms–Working Stress Design*. Washington, USA: American Petroleum Institute.

Arena, F., and Romolo, A. (2005). Random Forces On a Slender Vertical Cylinder Given by High Sea Waves Interacting with A Current. *International Journal of Offshore and Polar Engineering,* 15(01).

Arnold, J. C., and Milton, J. S. (2003). Introduction to Probability and Statistics: New York: McGraw-Hill.

ATEX. (2016). Oil and Gas Accidents. *L awyers & Settlements.com* Retrieved 2019 September 2, from https://www.lawyersandsettlements.com/lawsuit/oil-and-gas-accidents.html#.WD1iQbWkqaM

Aydin, D. (2016). Estimation of The Lower and Upper Quantiles of Gumbel Distribution: An Application to Wind Speed Data. *Applied Ecology and Environmental Research,* 16(1), 1-15.

Ayyub, B. M., and McCuen, R. H. (2016). *Probability, Statistics, and Reliability for Engineers and Scientists*: CRC press.

Azman, N., Abu Husain, M., Mohd Zaki, N., and Mat Soom, E. (2017). The Effect of Wave In-Deck in Conventional Pushover Analysis. *Proceedings of the VII International Conference on Computational Methods in Marine Engineering,* 15-17 June 2017. Nantes, Frances, 15-17.

Baarholm, G. S., Haver, S., and Økland, O. D. (2010). Combining Contours of Significant Wave Height and Peak Period with Platform Response Distributions for Predicting Design Response. *Marine Structures,* 23(2), 147-163.

Babinsky, H., and Harvey, J. K. (2011). *Shock Wave-Boundary-Layer Interactions* (Vol. 32). New York, USA: Cambridge University Press.

Bai, Y., and Jin, W.-L. (2016). *Marine Structural Design* (2nd ed.): Elsevier Science.

Baldock, T., and Swan, C. (1996). Extreme Waves in Shallow and Intermediate Water Depths. *Coastal Engineering,* 27(1-2), 21-46.

Banfi, D., Raby, A., and Simmonds, D. (2019). Dynamic Loads Arising from Broken Wave Impacts On a Cylindrical Turbine Substructure in Shallow Waters. *13th EWTEC Conference,* 1-6 September 2019. Napoli, Italy.

Baquet, A., Kim, J., and Huang, Z. J. (2017). Numerical Modeling Using CFD and Potential Wave Theory for Three-Hour Nonlinear Irregular Wave Simulations.

Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering, 25–30 June 2017. Trondheim, Norway.

Bar-Avi, P. (2017). *Nonlinear Dynamics of Compliant Offshore Structures*: Routledge.

Bateman, W. J., Swan, C., and Taylor, P. H. (2001). On The Efficient Numerical Simulation of Directionally Spread Surface Water Waves. *Journal of Computational Physics,* 174(1), 277-305.

Bea, R. G. (1992). Structural Reliability: Design and Requalification of Offshore Platforms. *Reliability of Offshore Operations, Proc., Int. Workshop, Building and Fire Research Laboratory,* 1-3 April 1992. Berkeley, USA, 41-67.

Bendat, J. S. (1990). *Nonlinear System Analysis and Identification from Random Data*: Wiley-Interscience.

Bennaceur, K. (2019). How the Oil and Gas Industry Is Contributing to Sustainability. *Journal of Petroleum Technology,* 71(03), 38-39.

Benstock, D., and Cegla, F. (2017). Extreme Value Analysis (EVA) of Inspection Data and Its Uncertainties. *NDT & E International,* 87, 68-77.

Bewick, V., Cheek, L., and Ball, J. (2003). Statistics Review 7: Correlation and Regression. *Critical care (London, England),* 7(6), 451-459.

Bitner-Gregersen, E. M., Ewans, K. C., and Johnson, M. C. (2014). Some Uncertainties Associated with Wind and Wave Description and Their Importance for Engineering Applications. *Ocean Engineering,* 86, 11-25.

Bitner-Gregersen, E. M. (2017). Wind and Wave Climate in Open Sea and Coastal Waters. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering*, 25-30 June 2017. Trondheim, Norway.

Bitner-Gregersen, E. M., Dong, S., Fu, T., Ma, N., Maisondieu, C., Miyake, R., et al. (2016). Sea State Conditions for Marine Structures' Analysis and Model Tests. *Ocean Engineering,* 119, 309-322.

Bitner-Gregersen, E. M. (2018). Comparison of Wind and Wave Climate in Open Sea and Coastal Waters. *Ocean Engineering,* 170, 199-208.

Bjerager, P. (1990). On Computation Methods for Structural Reliability Analysis. *Structural Safety,* 9(2), 79-96.

Björkqvist, J.-V., Pettersson, H., and Kahma, K. K. (2019). The Wave Spectrum in Archipelagos. *Ocean Science,* 15(6), 1469-1487.

Bleasdale, M. (2018). Structures for Offshore Installations: United States Patent Application 15/673,516.

Board, T. R. (2011). *Structural Integrity of Offshore Wind Turbines: Oversight of Design, Fabrication, and Installation - Special Report 305*. Washington, DC: The National Academies Press.

Bonnefoy, F., Ducrozet, G., Le Touzé, D., and Ferrant, P. (2010). Time Domain Simulation of Nonlinear Water Waves Using Spectral Methods. In *Advances in Numerical Simulation of Nonlinear Water Waves* (pp. 129-164): World Scientific.

Borgman, L. E. (1967). Spectral Analysis of Ocean Wave Forces On Piling (Coastal Engineering Conference in Santa Barbara, California, October 1965). *Journal of The Waterways and Harbors Division,* 93(2), 129-156.

Bouyssy, V., and Rackwitz, R. (1997). Polynomial Approximation of Morison Wave Loading. *Journal of Offshore Mechanics and Arctic Engineering,* 119(1), 30-36.

Bozzi, S., Giassi, M., Miquel, A. M., Antonini, A., Bizzozero, F., Gruosso, G., et al. (2017). Wave Energy Farm Design in Real Wave Climates: The Italian Offshore. *Energy,* 122, 378-389.

Brede, M., Karow, N., and Grundmann, S. (2018,). Ground Water Discharge and Turbulent Transport in Oceanic Bottom Boundary Layers in A Flow Channel. *Proceedings of the 20th EGU General Assembly*, 4-13 April 2018. Vienna, Austria, 5971.

Brekhovskikh, L. M., and Lysanov, Y. P. (2004). *Fundamentals of Ocean Acoustics* (3rd ed.). New York: Acoustical Society of America.

Bretschneider, C. L., and Company, N. E. S. (1965). *Generation of Waves by Wind: State of the Art*: National Engineering Science Company.

Bruserud, K., and Haver, S. (2017). Uncertainties in Current Measurements in The Northern North Sea. *Journal of Atmospheric and Oceanic Technology,* 34(4), 855-876.

Bruserud, K., and Haver, S. (2019). Waves and Associated Currents–Experiences from 5 Years Metocean Measurements in The Northern North Sea. *Marine Structures,* 63, 429-443.

Bücker, C., Jenisch, U., Lutter, S., Matz-Lück, N., Messner, J., Petersen, S., et al. (2014). Chapter 1 Oil and gas from the sea. *WOR 3 Marine Resources – Opportunities and Risks* Retrieved 2020 April 4, from https://worldoceanreview.com/.../WOR3_en_chapter_1

Bulgakov, K., Kuzmin, V., and Shilov, D. (2018). Evaluation of Extreme Wave Probability On the Basis of Long-Term Data Analysis. *Ocean Science,* 14(5), 1321-1327.

Burrows, R. (1977). Quasi-Static Response of Offshore Structures Using Probabilistic Methods. *Applied Mathematical Modelling,* 1(6), 325-332.

Burrows, R. (1979). Probabilistic Description of the Response of Offshore Structures to Random Wave Loading. *Shaw TL, editor. Mechanics of wave induced forces on cylinders,* 577-595.

Burrows, R. (1982). *Wave Loading on Offshore Structures: A Probabilistic Approach.* PhD Thesis, University of Liverpool.

Burrows, R. (1983). Expected Value Analysis for The Quasi-Static Response of Offshore Structures. *Applied Mathematical Modelling,* 7(5), 317-328.

Buscemi, N., and Marjanishvili, S. (2005, 20-24 April 2005). SDOF Model for Progressive Collapse Analysis. *Proceedings of the Structures Congress 2005: Metropolis and Beyond*, New York, USA, 1-12.

BV. (1975). *Rules and Regulations for The Construction and Classification of Offshore Platforms*: Bureau Veritas.

Campos, R., Soares, C. G., Alves, J., Parente, C., and Guimaraes, L. (2019). Regional Long-Term Extreme Wave Analysis Using Hindcast Data from The South Atlantic Ocean. *Ocean Engineering,* 179, 202-212.

Cao, D., Yat-Man, E. L., Jian, W., and Huang, Z. (2017). An Experimental Study of Wave Run Up: Cylinder Fixed in Waves Versus Cylinder Surging in Still Water. *International Journal of Engineering and Technology,* 9(2), 124.

Carassale, L., and Kareem, A. (2009). Modeling Nonlinear Systems by Volterra Series. *Journal of Engineering Mechanics,* 136(6), 801-818.

Care, F. R. A. M., Subagio, B. S., and Rahman, H. (2018). Porous Concrete Basic Property Criteria as Rigid Pavement Base Layer in Indonesia. *MATEC Web of Conferences*, 13-14 August 2018. Kuala Lumpur, Malaysia., 02008.

Casas-Prat, M., and Holthuijsen, L. H. (2010). Short-Term Statistics of Waves Observed in Deep Water. *Journal of Geophysical Research: Oceans,* 115(C9).

Cassidy, M., Houlsby, G., and Eatock Taylor, R. (2003). Probabilistic Models Applicable to The Short-Term Extreme Response Analysis of Jack-Up Platforms. *J. Offshore Mech. Arct. Eng.,* 125(4), 249-263.

Cassidy, M., Taylor, R. E., and Houlsby, G. (2001). Analysis of Jack-Up Units Using a Constrained Newwave Methodology. *Applied Ocean Research,* 23(4), 221-234.

Cassidy, M., Taylor, P., Taylor, R. E., and Houlsby, G. (2002). Evaluation of Long-Term Extreme Response Statistics of Jack-Up Platforms. *Ocean Engineering,* 29(13), 1603-1631.

Catelani, M., Ciani, L., Rossin, S., and Venzi, M. (2014). Failure Rates Sensitivity Analysis Using Monte Carlo Simulation. *Proceedings of the 13th IMEKO TC10 Workshop on Technical Diagnostics-'Advanced measurement tools in technical diagnostics for systems' reliability and safety*, 26- 7 June 2014. Warsaw, Poland, 195-200.

Cavaleri, L., Benetazzo, A., Barbariol, F., Bidlot, J.-R., and Janssen, P. (2017). The Draupner Event: The Large Wave and The Emerging View. *Bulletin of the American Meteorological Society,* 98(4), 729-735.

Chai, W., Naess, A., Leira, B. J., and Bulian, G. (2016). Efficient Monte Carlo Simulation and Grim Effective Wave Model for Predicting the Extreme Response of a Vessel Rolling in Random Head Seas. *Ocean Engineering,* 123, 191-203.

Chakrabarti, S. K. (1994). *Offshore Structure Modeling* (Vol. 9): World Scientific.

Chakrabarti, S. (2005). *Handbook of Offshore Engineering (2-volume set)*: Elsevier.

Chalikov, D., and Babanin, A. V. (2016). Comparison of Linear and Nonlinear Extreme Wave Statistics. *Acta Oceanologica Sinica,* 35(5), 99-105.

Chandrasekaran, S. (2015). *Dynamic Analysis and Design of Offshore Structures* (Vol. 5): Springer, New Delhi.

Chandrasekaran, S. (2017). *Offshore Structural Engineering: Reliability and Risk Assessment*: CRC Press.

Chandrasekaran, S. (2018). Environmental forces. In *Dynamic Analysis and Design of Offshore Structures* (pp. 63-125): Springer.

Chandrasekaran, S., and Nagavinothini, R. (2020). *Offshore Compliant Platforms: Analysis, Design, and Experimental Studies*: John Wiley & Sons.

Chapra, S. C., and Canale, R. P. (2010). *Numerical Methods for Engineers*: Boston: McGraw-Hill Higher Education.

Chapra, C., and Canale, R. (2013). *Numerical Methods for Engineers.* (6th ed.). Kyobo Book Centre, Seoul: McGraw Hill.

Chaves, I. A., and Melchers, R. E. (2014). Extreme Value Analysis for Assessing Structural Reliability of Welded Offshore Steel Structures. *Structural Safety,* 50, 9-15.

Chella, M. A., Bihs, H., Myrhaug, D., and Arntsen, Ø. A. (2017). Computation of Wave Impact Pressures and Kinematics During Plunging Breaking Wave Interaction with a Vertical Cylinder Using CFD Modelling. *Proceedings of the 36th Int. Conf. on Offshore Mechanics and Arctic Engineering,* June 25–30, 2017. Trondheim, Norway.

Chen, L., Zang, J., Hillis, A. J., Morgan, G. C., and Plummer, A. R. (2014). Numerical Investigation of Wave–Structure Interaction Using OpenFOAM. *Ocean Engineering,* 88, 91-109.

Chen, J., and Gilbert, R. B. (2017). Offshore Pile System Model Biases and Reliability. *Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards,* 11(1), 55-69.

Chen, Y., and Zhang, D. (2017). Response-Based Analysis for Tension Leg Platform. *Journal of Marine Science and Application,* 16(1), 87-92.

Choi, H. J., Lee, S. J., Jo, H. J., Lee, G. N., and Jung, K. H. (2018). Comparison Study of Experiments and Predictions of Wave Kinematics for Rogue Wave. *Brodogradnja: Teorija i praksa brodogradnje i pomorske tehnike,* 69(1), 15-38.

Chuang, W.-L., Chang, K.-A., and Mercier, R. (2018). Kinematics and Dynamics of Green Water On a Fixed Platform in A Large Wave Basin in Focusing Wave and Random Wave Conditions. *Experiments in Fluids,* 59(6), 100.

Chung, J. S. (2017). Morison Equation in Practice and Its Validity. *Proceedings of the 27th International Ocean and Polar Engineering Conference,* 25-30 June 2017. San Francisco, California, USA.

Chung, J. S. (2018). Morison Equation in Practice and Hydrodynamic Validity. *International Journal of Offshore and Polar Engineering,* 28(01), 11-18.

Clauss, G., and Schmittner, C. E. (2005). Experimental Optimization of Extreme Wave Sequences for The Deterministic Analysis of Wave/Structure Interaction. *Proceedings of the 24th International Conference on Offshore Mechanics and Arctic Engineering,* 12–17 June 2005. Halkidiki, Greece, 61-67.

Coccon, M. N., Song, J., Ok, S.-Y., and Galvanetto, U. (2017). A New Approach to System Reliability Analysis of Offshore Structures Using Dominant Failure

Modes Identified by Selective Searching Technique. *KSCE Journal of Civil Engineering,* 21(6), 2360-2372.

Coe, R. G., Michelen, C., Eckert-Gallup, A., and Sallaberry, C. (2018). Full Long-Term Design Response Analysis of a Wave Energy Converter. *Renewable energy,* 116, 356-366.

Cohen, J. (1992). A Power Primer. *Psychological bulletin,* 112(1), 155.

Coles, S. (2001). *An introduction to statistical modeling of extreme values* (1st ed.). London: Springer.

Connor, J. J., and Faraji, S. (2016). *Fundamentals of Structural Engineering* (2nd ed.): Springer.

Constantin, A., and Villari, G. (2008). Particle Trajectories in Linear Water Waves. *Journal of Mathematical Fluid Mechanics,* 10(1), 1-18.

Cooley, D. (2013). *Return Periods and Return Levels Under Climate Change*. Dordrecht: Springer Netherlands.

Cooper, A., Johnson, C., and Hudson, D. (2018). Now Near 100 Million Bpd, When Will Oil Demand Peak? *Discover Thomson Reuters* Retrieved 2020 March 23, from https://www.reuters.com/article/us-oil-demand-peak/now-near-100-million-bpd-when-will-oil-demand-peak-idUSKCN1M01TC

Cooray, K. (2010). Generalized Gumbel Distribution. *Journal of Applied Statistics,* 37(1), 171-179.

Craik, A. D. D. (2004). The Origins of Water Wave Theory. *Annual Review of Fluid Mechanics,* 36(1), 1-28.

Cremona, C. (2012). *Structural Performance: Probability-based Assessment*: John Wiley & Sons.

Cruz, A. M., and Krausmann, E. (2008). Damage to Offshore Oil and Gas Facilities Following Hurricanes Katrina and Rita: An Overview. *Journal of Loss Prevention in the Process Industries,* 21(6), 620-626.

Czujko, J., Bayatfar, A., Smith, M., Xu, M., Wang, D., Lützen, M., et al. (2018). Committee III. 1: Ultimate Strength. *Proceedings of the 20th International Ship and Offshore Structures Congress (ISSC 2018),* 9–14 September 2018. Liege, Belgium and Amsterdam, The Netherlands, 381-390.

Davenport, A. G. (1983). The Relationship of Reliability to Wind Loading. *Journal of Wind Engineering and Industrial Aerodynamics,* 13(1), 3-27.

De Serio, F., and Mossa, M. (2016). Assessment of Classical and Approximated Models Estimating Regular Waves Kinematics. *Ocean Engineering,* 126, 176-186.

Dean, R. G., and Dalrymple, R. A. (1991). *Water Wave Mechanics for Engineers and Scientists* (Vol. 2): World Scientific Publishing Company.

Dean, R. G., and Dalrymple, R. A. (2004). *Coastal processes with engineering applications*: Cambridge University Press.

DeFranco, S. J., Fitzhugh, J. T., Locke, H. A., apos, Connor, P. E., Straub, T. J., et al. (2004). *Eugene Island 322 'A' Drilling Platform Decommissioning After Hurricane Lilli*. Paper presented at the Offshore Technology Conference. from

Demirbilek, Z. (2010). Hurricane Katrina and Ocean Engineering lessons learned. *Ocean Engineering,* 37(1), 1-3.

Deng, Y., Yang, J., Zhao, W., Li, X., and Xiao, L. (2016). Freak Wave Forces On a Vertical Cylinder. *Coastal Engineering,* 114, 9-18.

Dimitrov, N. (2016). Comparative Analysis of Methods for Modelling the Short-Term Probability Distribution of Extreme Wind Turbine Loads. *Wind Energy,* 19(4), 717-737.

Ding, W., and Pang, L. (2016). Structural Fatigue Assessment of Offshore Platform Considering the Effect of Nonlinear Drag Force. *Proceedings of the 35th International Conference on Ocean, Offshore and Arctic Engineering*, 18-24 June 2016. Busan, Korea.

Discusser, O., Fukasawa, T., Discussers, F., Boon, B., Zakky, A., Constantinescu, A., et al. (2020). Quasi-Static Response. *Proceedings of the 20th International Ship and Offshore Structures Congress (ISSC 2018) Volume 3: Discussions*, 9-13 September 2018. Liège, Belgium and Amsterdam, The Netherlands, 31.

DNV. (1974). *Rules for The Design, Construction and Inspection of Fixed Offshore Structures*: Det Norske Veritas.

Donelan, M., and Pierson, W. J. (1983). The Sampling Variability of Estimates of Spectra of Wind-Generated Gravity Waves. *Journal of Geophysical Research: Oceans,* 88(C7), 4381-4392.

Dyke, P. (2007). *Modeling Coastal and Offshore Processes*: Imperial College Press.

Dymarski, P., Ciba, E., and Marcinkowski, T. (2016). Effective Method for Determining Environmental Loads On Supporting Structures for Offshore Wind Turbines. *Polish Maritime Research,* 23(1), 52-60.

Edwards, S. J., Collette, M., and Troesch, A. (2019). Wind and Wave Environments that Lead to Extreme Loads on Offshore Structures. *Proceedings of the OCEANS 2019-Marseille*, 1-6.

Efthymiou, M., and Graham, C. (1990). Environmental Loading on Fixed Offshore Platforms. *Environmental Forces on Offshore Structures and Their Predictions: Proceedings of an international conference*, 28-29 November 1990. London, UK.

El-Reedy, M. (2014). *Marine Structural Design Calculations*: Butterworth-Heinemann.

El-Reedy, M. A. (2019). *Offshore Structures: Design, Construction and Maintenance*: Gulf Professional Publishing.

El Kaddah, N. (1983). *Water Wave-Structure Interaction for Small Amplitude Structural Oscillations.* PhD Thesis, City University London.

Elsafty, H., and Lynett, P. (2018). Bottom Boundary Layer Forced by Finite Amplitude Long and Short Surface Waves Motions. *Ocean Modelling,* 124, 48-60.

Emmanouil, G., Galanis, G., Kalogeri, C., Zodiatis, G., and Kallos, G. (2016). 10-Year High Resolution Study of Wind, Sea Waves and Wave Energy Assessment in The Greek Offshore Areas. *Renewable Energy,* 90, 399-419.

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

Ertekin, R. C., and Rodenbusch, G. (2016). Wave, Current and Wind Loads. In *Springer Handbook of Ocean Engineering* (pp. 787-818): Springer.

Ewans, K., and Jonathan, P. (2014). Evaluating Environmental Joint Extremes for The Offshore Industry Using the Conditional Extremes Model. *Journal of Marine Systems,* 130, 124-130.

Ewans, K., and Jonathan, P. (2020). Extreme Conditions. *Ocean Wave Dynamics*, 271.

Faltinsen, O. M. (1990). *Sea Loads On Ships and Offshore Structures* (Vol. 1). New York: Cambridge University Press.

Faulkner, D., Cowling, M., and Incecik, A. (1991). *Integrity of Offshore Structures*: CRC Press.

Fedele, F., Brennan, J., De León, S. P., Dudley, J., and Dias, F. (2016). Real World Ocean Rogue Waves Explained Without the Modulational Instability. *Scientific reports,* 6, 27715.

Fernandez, L., Onorato, M., Monbaliu, J., and Toffoli, A. (2016). Occurrence of Extreme Waves in Finite Water Depth. In *Extreme Ocean Waves* (pp. 45-62): Springer.

Filip, G. P., Xu, W., and Maki, K. J. (2018). Prediction of Extreme Wave Slamming Loads on a Fixed Platform. *Proceedings of the 37th International Conference on Ocean, Offshore and Arctic Engineering*, 17–22 June 2018. Madrid, Spain.

Fjeld, S. (1978). Reliability of Offshore Structures. *Journal of Petroleum Technology,* 30(10), 1,486-481,496.

Flügge, F.-J. (2017). *Realtime GPGPU FFT Ocean Water Simulation* (1st ed.). Harburg: Universitätsbibliothek der Technischen Universität Hamburg.

Folley, M. (2017). The Wave Energy Resource. In A. Pecher and J. P. Kofoed (Eds.), *Handbook of Ocean Wave Energy* (pp. 43-79). Cham: Springer International Publishing.

Fréchot, J. (2006). Realistic Simulation of Ocean Surface Using Wave Spectra. *Proceedings of the First International Conference on Computer Graphics Theory and Applications (GRAPP 2006),* 25-28 February 2006. Setúbal, Portugal, 76--83.

Gaidai, O., Cheng, Y., Xu, X., and Su, Y. (2018). Long-Term Offshore Bohai Bay Jacket Strength Assessment Based On Satellite Wave Data. *Ships and Offshore Structures,* 13(6), 657-665.

Gao, N., Yang, J., Zhao, W., and Li, X. (2016). Numerical Simulation of Deterministic Freak Wave Sequences and Wave-Structure Interaction. *Ships and Offshore Structures,* 11(8), 802-817.

Garside, M. (2018). Distribution of Global Oil Demand from 2017 to 2050. *Oil demand shares by sector* Retrieved 2020 January 3, from https://www.statista.com

Gaspar, B., Naess, A., Leira, B. J., and Soares, C. G. (2014). System Reliability Analysis by Monte Carlo Based Method and Finite Element Structural Models. *Journal of offshore mechanics and Arctic engineering,* 136(3).

Gavrilyuk, S., Kalisch, H., and Khorsand, Z. (2015). A Kinematic Conservation Law in Free Surface Flow. *Nonlinearity,* 28(6), 1805.

Ghezelbashan, A., and D'Mello, C. (2017). Wave Loading on a Flexible Offshore Structure. *Proceedings of the 27th International Ocean and Polar Engineering Conference,* 25-30 June 2017. San Francisco, California, USA.

Glisic, A., and Ferraz, G. T. (2017). Stochastic Variables in Modelling of the Wave Loads on Offshore Wind Turbine Structures.

Goda, Y. (1990). Distribution of Sea State Parameters and Data Fitting. *Handbook of coastal and ocean engineering,* 1, 371-408.

Goda, Y. (1992). Uncertainty of Design Parameters From Viewpoint of Extreme Statistics. *Journal of Offshore Mechanics and Arctic Engineering,* 114(2), 76-82.

Goda, Y. (2004). Spread Parameter of Extreme Wave Height Distribution for Performance-Based Design of Maritime Structures. *Journal of waterway, port, coastal, and ocean engineering,* 130(1), 29-38.

Goda, Y. (2010). *Random Seas And Design Of Maritime Structures* (3rd ed.). Singapore, Singapore: World Scientific Publishing Co Pte Ltd.

Gogtay, N., and Thatte, U. (2017). Principles of Correlation Analysis. *Journal of the Association of Physicians of India,* 65(3), 78-81.

Golafshani, A., Bagheri, V., Ebrahimian, H., and Holmas, T. (2011). Incremental Wave Analysis and Its Application to Performance-Based Assessment of Jacket Platforms. *Journal of Constructional Steel Research,* 67(10), 1649-1657.

Goryunova, M., Kuleshova, L., and Khakimova, A. (2017). Application of Signal Analysis for Diagnostics. *International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM)*, 16-9 May 2017. Petersburg, Russia, 1-5.

Goswami, B., Sharma, V., Sharma, G. S., Prasad, S., and Pathak, T. K. (2019). Design Analysis of Offshore Petroleum Platforms. *International Journal of Landscape Planning and Architecture,* 5(2), 9-16.

Goswami, B., Sharma, V., Sharma, G. S., Prasad, S., and Pathak, T. K. (2020). Offshore Structures Toward Speculative Forms of Loading. *Journal of Offshore Structure and Technology,* 7(1), 25-31.

Grigoriu, M., and Alibe, B. (1986). Response of Offshore Structures to Random Waves. *Journal of engineering mechanics,* 112(8), 729-744.

Gudmestad, O. T., and Moe, G. (1996). Hydrodynamic Coefficients for Calculation of Hydrodynamic Loads On Offshore Truss Structures. *Marine Structures,* 9(8), 745-758.

Guha, A., Somayajula, A., and Falzarano, J. (2016). Time Domain Simulation of Large Amplitude Motions in Shallow Water. *Proceedings of the 21st SNAME Offshore Symposium, Society of Naval Architects and Marine Engineers, Houston, TX*, 16 February 2016. Houston, Texas, 1-20.

Gumbel, E. J. (1958). Statistics of Extremes, Columbia Univ. *Press, New York*, 201.

Guo, Y., Xiao, L., Kou, Y., and Zhao, G. (2017). A Method to Measure Wave Impact Force and Its Validation. *Proceedings of the 27th International Ocean and Polar Engineering Conference*, 25-30 June 2017. San Francisco, California, USA.

Ha, Y.-J., Kim, K.-H., Nam, B. W., and Hong, S. Y. (2018). Experimental Study of Wave Impact Loads on Circular Cylinder by Breaking Waves. *Proceedings of the 28th International Ocean and Polar Engineering Conference*, 10-15 June 2018. Sapporo, Japan.

Hagen, Ø., Håøy Grue, I., Birknes-Berg, J., Lian, G., and Bruserud, K. (2017). Analysis of Short-Term and Long-Term Wave Statistics by Time Domain Simulations Statistics. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering*, 25-30 June 2017. Trondheim, Norway.

Hagen, Ø., Birknes-Berg, J., Grue, I. H., Lian, G., Bruserud, K., and Vestbøstad, T. (2018). Long-Term Area Statistics for Maximum Crest Height Under a Fixed Platform Deck. *Proceedings of the 37th International Conference on Ocean, Offshore and Arctic Engineering*, 17–22 June 2018. Madrid, Spain.

Hallowell, S. T., Arwade, S. R., Johlas, H., Lomonaco, P., and Myers, A. (2019). Quantification of Predicted Wave Forces From Distant Elevation Measurements. *Proceedings of the 38th International Conference on Offshore Mechanics and Arctic Engineering*, 9-14 June 2019. Glasgow, Scotland, V003T002A006.

Han, C., Ma, Y., Qu, X., and Qin, P. (2017). A Hybrid Time-Frequency Domain Method for Evaluation of Fatigue Damage in Offshore Structures. *Proceedings of the 27th International Ocean and Polar Engineering Conference*, 25-30 June 2017. San Francisco, California, USA.

Hansen, H. F., and Kofoed-Hansen, H. (2017). An Engineering-Model for Extreme Wave-Induced Loads On Monopile Foundations. *Proceedings of the 36th*

International Conference on Ocean, Offshore and Arctic Engineering, 25-30 June 2017. Trondheim, Norway, V03BT02A014.

Hansen, H. F., Randell, D., Zeeberg, A. R., and Jonathan, P. (2020). Directional–Seasonal Extreme Value Analysis of North Sea Storm Conditions. *Ocean Engineering*, 195, 106665.

Haritos, N. (2007). Introduction to The Analysis and Design of Offshore Structures–An Overview. *Electronic Journal of Structural Engineering*, 7(Special Issue: Loading on Structures), 55-65.

Harris, R. (2001). The Accuracy of Design Values Predicted from Extreme Value Analysis. *Journal of Wind Engineering and Industrial Aerodynamics*, 89(2), 153-164.

Hasselmann, K., P. Barnett, T., Bouws, E., Carlson, H., E. Cartwright, D., Enke, K., et al. (1973). *Measurements of Wind-Wave Growth and Swell Decay During the Joint North Sea Wave Project (JONSWAP)* (Vol. 8).

Haver, S., and Winterstein, S. (1990). The Effects of a Joint Description of Environmental Data On Design Loads and Reliability. *Proceedings of the 9th International Conference Offshore Mechanics & Arctic Engineering*, 18-23 Feb 1990. Houston, USA, 7-15.

Haver, S. K., Edvardsen, K., and Lian, G. (2017). Uncertainties in Wave Loads On Slender Pile Structures Due to Uncertainties in Modelling Waves and Associated Kinematics. *Proceedings of the 27th International Ocean and Polar Engineering Conference*, 25-30 June 2017. San Francisco, California, USA.

Haver, S. (2019). Airgap and Safety: Metocean Induced Uncertainties Affecting Airgap Assessments. *Marine Structures*, 63, 406-428.

He, R., Li, X., Chen, G., Wang, Y., Jiang, S., and Zhi, C. (2018). A Quantitative Risk Analysis Model Considering Uncertain Information. *Process Safety and Environmental Protection*, 118, 361-370.

Hedges, T. S., Anastasiou, K., and Gabriel, D. (1985). Interaction of Random Waves and Currents. *Journal of Waterway, Port, Coastal, And Ocean Engineering*, 111(2), 275-288.

Helder, J. A., and Bunnik, T. (2016). Deterministic Breaking Wave Simulation for Offshore Applications. *Proceedings of the SNAME 21st Offshore Symposium*, 16 February 2016. Houston, Texas, USA.

Henry, Z., Jusoh, I., and Ayob, A. (2017). Structural Integrity Analysis of Fixed Offshore Jacket Structures. *Jurnal Mekanikal,* 40(2).

Herbich, J. B. (1998). *Developments in Offshore Engineering: Wave Phenomena and Offshore Topics*: Elsevier.

Hicks, C. (2011). Chapter 8 Waves and Water Dynamics: Pearson Education, Inc.

Hiles, C. E., Robertson, B., and Buckham, B. J. (2019). Extreme wave statistical methods and implications for coastal analyses. *Estuarine, Coastal and Shelf Science,* 223, 50-60.

Holmes, P., Tickell, R., and Burrows, R. (1978). Prediction of Long-Term Wave Loading On Offshore Structures. *UK: Report Department of Energy*, 7823-7824.

Holthuijsen, L. H. (2010). *Waves in Oceanic and Coastal Waters*: Cambridge university press.

Horn, J.-T. (2018). *Statistical and Modelling Uncertainties in The Design of Offshore Wind Turbines.* PhD Thesis, Norwegian University of Science and Technology.

Horn, J.-T., and Winterstein, S. R. (2018). Extreme Response Estimation of Offshore Wind Turbines with an Extended Contour-Line Method. *Journal of Physics: Conference Series,* 1104(1), 012031.

Hørte, T., and Sigurdsson, G. (2017). On The Application of Structural Reliability Analysis. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering*, 25-30 June 2017. Trondheim, Norway.

Housseine, C. O., Monroy, C., Bigot, F., and Neuilly-sur-Seine, F. (2015a). A New Linearization Method for Vectorial Morison Equation. *Proceedings of the 30th International Workshop on Water Waves and Floating Bodies*, 12-15 April 2015. Bristol, UK, 12-15.

Housseine, C. O., Monroy, C., and de Hauteclocque, G. (2015b). Stochastic Linearization of the Morison Equation Applied to an Offshore Wind Turbine. *Proceedings of the 34th International Conference on Ocean, Offshore and Arctic Engineering*, 31 May - 5 June 2015. St. John's, Newfoundland, Canada.

Huang, N. E., Chen, D. T., Tung, C.-C., and Smith, J. R. (1972). Interactions Between Steady Won-Uniform Currents and Gravity Waves with Applications for Current Measurements. *Journal of Physical Oceanography,* 2(4), 420-431.

Hübler, C. J. (2019). *Efficient Probabilistic Analysis of Offshore Wind Turbines Based on Time-Domain Simulations.* PhD Dissertation, Leibniz Universität Hannover.

Hudspeth, R., Nath, J. H., and Sollitt, C. K. (2018). Digital to Analog Wavemaker Simulations. *Physical Modelling in Coastal Engineering: Proceedings of an International Conference, Newark, Delaware, August 1981*, 3-6 June 1985. Newark, USA, 81.

Huebler, C. (2019). *Efficient probabilistic analysis of offshore wind turbines based on time-domain simulations.* University of Hanover.

Hwang, P. A., Fan, Y., Ocampo-Torres, F. J., and García-Nava, H. (2017). Ocean surface wave spectra inside tropical cyclones. *Journal of Physical Oceanography,* 47(10), 2393-2417.

IEC, I. (2009). 61400-3, Wind Turbines-Part 3: Design Requirements for Offshore Wind Turbines. *International Electrotechnical Commission, Geneva*.

Inglis, R., Pijfers, J., and Vugts, J. (1985). A Unified Probabilistic Approach to Predicting the Response of Offshore Structures, Including The Extreme Response. *Proceedings of the 4th International Conference on Behaviour of Offshore Structures*, 1-5 July 1985. Zuid-Holland, The Netherlands, 95-110.

Irschik, K., Sparboom, U., and Oumeraci, H. (2003). Breaking Wave Characteristics for The Loading of a Slender Pile. In *Coastal Engineering 2002: Solving Coastal Conundrums* (pp. 1341-1352): World Scientific.

ISO. (2007). Petroleum and Natural Gas Industries-Fixed Steel Offshore Structuress, ISO 19902. *International Organization for Standardization*.

Isobe, M., and Horikawa, K. (1982). Study On Water Particle Velocities of Shoaling and Breaking Waves. *Coastal Engineering in Japan,* 25(1), 109-123.

Janssen, P. A. (2008). Progress in Ocean Wave Forecasting. *Journal of Computational Physics*, 227(7), 3572-3594.

Jefferys, E. (1984). Simulation of Wave Power Devices. *Applied Ocean Research,* 6(1), 31-39.

Jefferys, E. R., and Patel, M. H. (1982). Dynamic Analysis Models of Tension Leg Platforms. *Journal of Energy Resources Technology*, 104(3), 217–223.

Jensen, J. J. (2011). Extreme Value Predictions using Monte Carlo Simulations with Artificially Increased Load Spectrum. *Probabilistic Engineering Mechanics,* 26(2), 399-404.

Jeschke, S., Skřivan, T., Müller-Fischer, M., Chentanez, N., Macklin, M., and Wojtan, C. (2018). Water Surface Wavelets. *ACM Transactions on Graphics (TOG),* 37(4), 1-13.

Jia, J. (2017). Offshore Structures Versus Land-Based Structures. In *Modern Earthquake Engineering* (pp. 73-106): Springer.

Jiang, Z., Hu, W., Dong, W., Gao, Z., and Ren, Z. (2017). Structural reliability analysis of wind turbines: A review. *Energies,* 10(12), 2099.

Jin, S., Wu, Y., and Jia, P. (2017). *Research On Waves Simulation of The Virtual Sea Battled-Field*. Paper presented at the Chinese Conference on Image and Graphics Technologies.

Johannessen, K. (2010). *Stochastic Analysis of Workover Risers.* Master Thesis, Norwegian University of Science and Technology.

Johannessen, T. B., Lande, Ø., and Hagen, Ø. (2017). On The Distribution of Wave Impact Loads on Offshore Structures. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering*, 25-30 June 2017. Trondheim, Norway.

Johari, M. B. (2016). *Optimisation Of Efficient Time Simulation Method For The Prediction Of Extreme Offshore Structural Response.* Master Thesis, Universiti Teknologi Malaysia.

Johari, M. B., Abu Husain, M. K., and Mohd Zaki, N. I. (2016). Estimation of Offshore Structural Response by Efficient Time Simulation. *Proceedings of the International Conference on Ocean, Mechanical & Aerospace-Scientists & Engineer,* 7-8 November 2016. Kuala Terengganu, Malaysia.

Jurado, A. M. P., Borg, M., and Bredmose, H. (2018). An Efficient Frequency-Domain Model for Quick Load Analysis of Floating Offshore Wind Turbines. *Wind Energy Science,* 3(2), 693-712.

K. Ochi, M. (2005). *Ocean Waves: The Stochastic Approach* (Vol. 6): Cambridge University Press.

Kaihatu, J. M. (2009). Application of a Nonlinear Frequency Domain Wave–Current Interaction Model to Shallow Water Recurrence Effects in Random Waves. *Ocean Modelling,* 26(3-4), 190-205.

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. *Proceedings of the Offshore Technology Conference Asia*.

Kanegaonkar, H. B., and Haldar, A. (1987). Non-Gaussian Response of Offshore Platforms: Dynamic. *Journal of Structural Engineering,* 113(9), 1882-1898.

Kang, H., and Kim, M. (2017). Time-Domain Hydroelastic Analysis with Efficient Load Estimation for Random Waves. *International Journal of Naval Architecture and Ocean Engineering,* 9(3), 266-281.

Karadeniz, H. (2001). Uncertainty Modeling in The Fatigue Reliability Calculation of Offshore Structures. *Reliability Engineering & System Safety,* 74(3), 323-335.

Karadeniz, H., Saka, M. P., and Togan, V. (2013). Water Wave Theories and Wave Loads. In *Stochastic Analysis of Offshore Steel Structures* (pp. 177-252): Springer.

Kareem, A., Hsieh, C., and Tognarelli, M. (1998). Frequency-Domain Analysis of Offshore Platform in Non-Gaussian Seas. *Journal of Engineering Mechanics,* 124(6), 668-683.

Kareem, A., and Kijewski, T. (2002). Time-Frequency Analysis of Wind Effects On Structures. *Journal of Wind Engineering and Industrial Aerodynamics,* 90(12-15), 1435-1452.

Karow, N., Kandler, L., Brede, M., and Grundmann, S. (2020). Turbulent Transport of Discharged Ground Water in Oceanic Bottom Boundary Layers in A Water Channel Experiment. *Ocean Science Discussions*, 1-20.

Katz, R. W. (2010). Statistics of Extremes in Climate Change. *Climatic change,* 100(1), 71-76.

Kennedy, A. (2019). Fundamentals of Water Waves. *Encyclopedia of Water: Science, Technology, and Society*, 1-7.

Kettle, A. J. (2018). The North Sea surge of 31 October–1 November 2006 during Storm Britta. *Advances in Geosciences*, 45, 273-279.

Khan, K., Rahman, M. A., Islam, M. N., Akter, M., and Islam, M. S. (2018). Wave Climate Study for Ocean Power Extraction. *Int J Adv Res Innov Ideas Educ,* 4(6), 83-93.

Kharade, A., and Kapadiya, S. (2014). Offshore Engineering: An Overview of Types and Loadings On Structures. *International Journal of Structural and Civil Engineering Research*, 1-13.

Kim, Y. (2015). Prediction of The Dynamic Response of a Slender Marine Structure Under an Irregular Ocean Wave Using The NARX-Based Quadratic Volterra Series. *Applied Ocean Research,* 49, 42-56.

Kim, Y., Kim, K.-H., Kim, J.-H., Kim, T., Seo, M.-G., and Kim, Y. (2011). Time-Domain Analysis of Nonlinear Motion Responses and Structural Loads On Ships and Offshore Structures: Development of WISH Programs. *International Journal of Naval Architecture and Ocean Engineering,* 3(1), 37-52.

Kim, H.-J., Lee, K., and Jang, B.-S. (2018). A Linearization Coefficient for Morison Force Considering the Intermittent Effect Due to Free Surface Fluctuation. *Ocean Engineering,* 159, 139-149.

Kirchsteiger, C. (1999). On The Use of Probabilistic and Deterministic Methods in Risk Analysis. *Journal of Loss Prevention in the Process Industries,* 12(5), 399-419.

Kirkwood, B. R., and Sterne, J. A. (2010). *Essential Medical Statistics*: John Wiley & Sons.

Kitaigorodsky, S. (1961). On The Possibility of Theoretical Calculation of Vertical Temperature Profile in Upper Layer of the Sea. *Bull. Acad. Sci. USSR Geophys. Ser,* 3, 313-318.

Klein, M., Dudek, M., Clauss, G. F., Ehlers, S., Behrendt, J., Hoffmann, N., et al. (2020). On the Deterministic Prediction of Water Waves. *Fluids,* 5(1), 9.

Kokorina, A., and Slunyaev, A. (2019). Lifetimes of rogue wave events in direct numerical simulations of deep-water irregular sea waves. *Fluids,* 4(2), 70.

Koliopulos, P. (1988). Quasi-Static and Dynamic Response Statistics of Linear SDOF Systems Under Morison-Type Wave Forces. *Engineering Structures,* 10(1), 24-36.

Kolios, A., and Brennan, F. (2009). Reliability Based Design of Novel Offshore Structures. *Proceedings of the 3rd International Conference on Integrity, Chengdu, China*, 20-24 July 2009. Porto, Portugal.

Köllisch, N., Behrendt, J., Klein, M., and Hoffmann, N. (2018). Nonlinear Real Time Prediction of Ocean Surface Waves. *Ocean Engineering,* 157, 387-400.

Krishna, H. (2017). *Digital signal processing algorithms: number theory, convolution, fast Fourier transforms, and applications*: Routledge.

Krishnamoorthy, K. (2016). *Handbook of Statistical Distributions with Applications*: Chapman and Hall/CRC.

Kristoffersen, M., Børvik, T., Langseth, M., and Hopperstad, O. S. (2016). Dynamic Versus Quasi-Static Loading of X65 Offshore Steel Pipes. *The European Physical Journal Special Topics,* 225(2), 325-334.

Kühn, M. J. (2001). *Dynamics and Design Optimisation of Offshore Wind Energy Conversion Systems*: DUWIND, Delft University Wind Energy Research Institute.

Kurian, V., Tuhaijan, S., and Ng, C. (2016). Effects of Current Coexisting with Random Wave on Offshore Spar Platforms. In *Engineering Challenges for Sustainable Future* (Vol. 39, pp. 39-43): ROUTLEDGE in association with GSE Research.

Kvingedal, B., Bruserud, K., and Nygaard, E. (2018). Individual Wave Height and Wave Crest Distributions Based On Field Measurements from The Northern North Sea. *Ocean Dynamics,* 68(12), 1727-1738.

Laik, S. (2018). *Offshore Petroleum Drilling and Production* (1st ed.). Boca Raton: CRC Press.

Lambert, L. A., Najafian, G., Cooper, J. E., Abu Husain, M. K., and Mohd Zaki, N. I. (2013). Efficient Estimation of Offshore Structural Response Based on Threshold Upcrossing Rates. *Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering,* 9–14 June 2013. Nantes, France, 9-14.

Lambert, L. (2015). *Efficient Probabilistic Structural Response Prediction for Aircraft Turbulence and Offshore Wave Loading.* PhD Thesis, University of Liverpool.

Le Mehaute, B. (2013). *An Introduction to Hydrodynamics and Water Waves*: Springer Science & Business Media.

Li, J., Pan, S., Chen, Y., Fan, Y.-M., and Pan, Y. (2018). Numerical Estimation of Extreme Waves and Surges Over the Northwest Pacific Ocean. *Ocean Engineering,* 153, 225-241.

Li, P., Zhu, Q., Zhou, C., Li, L., and Li, H. (2017). Metocean Design Criteria Considerations in South China Sea by Adopting Multivariate Extreme Value Theory. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering,* 25-30 June 2017. Trondheim, Norway.

Li, X.-M., Quek, S.-T., and Koh, C.-G. (1995). Stochastic Response of Offshore Platforms by Statistical Cubicization. *Journal of Engineering Mechanics,* 121(10), 1056-1068.

Li, X., Chen, G., and Zhu, H. (2016). Quantitative Risk Analysis On Leakage Failure of Submarine Oil and Gas Pipelines Using Bayesian Network. *Process Safety and Environmental Protection,* 103, 163-173.

Liang, X.-f., Yang, J.-m., Jun, L., Xiao, L.-f., and Xin, L. (2010). Numerical Simulation of Irregular Wave-Simulating Irregular Wave Train. *Journal of Hydrodynamics, Ser. B,* 22(4), 537-545.

Lim, D., Kim, Y., and Park, B. (2016). Comparison between Quasi-Static Analysis and Dynamic Simulation for the Motions and Mooring Tensions of Floating Offshore Platforms. *Proceedings of the Offshore Technology Conference Asia*.

Lim, D.-H., and Kim, Y. (2019). Probabilistic Analysis of Air Gap of Tension-Leg Platforms by A Nonlinear Stochastic Approach. *Ocean Engineering,* 177, 49-59.

Limited, I. S. (2017). *Fixed Platforms Market Report to 2017*. (T. E. Analysts o. Document Number)

Lin, C.-K., Hsu, S.-Y., and Lin, J.-G. (2019a). FFT Phase Shift of Water Wave Analysis. *Journal of Marine Science and Technology,* 27(6), 513-522.

Lin, L., Ang, A. H., Fan, W., and Xia, D. (2019b). A Probability-Based Analysis of Wind Speed Distribution and Related Structural Response in Southeast China. *Structure and Infrastructure Engineering,* 15(1), 14-26.

Lin, P. (2008). *Numerical modeling of water waves*: CRC Press.

Lindgren, G. (2019). Gaussian Integrals and Rice Series in Crossing Distributions—to Compute the Distribution of Maxima and Other Features of Gaussian Processes. *Statistical Science,* 34(1), 100-128.

Liu, G., Chen, B., Wang, L., Zhang, S., Zhang, K., and Lei, X. (2019a). Wave Height Statistical Characteristic Analysis. *Journal of Oceanology and Limnology,* 37(2), 448-460.

Liu, G., Gao, Z., Chen, B., Fu, H., Jiang, S., Wang, L., et al. (2019b). Extreme values of storm surge elevation in Hangzhou Bayy. *Ships and Offshore Structures*, 1-12.

Liu, K., Chen, Q., and Kaihatu, J. M. (2016). Modeling Wind Effects on Shallow Water Waves. *Journal of Waterway, Port, Coastal, and Ocean Engineering,* 142(1), 04015012.

Longuet-Higgins, M. S. (1980). On The Distribution of the Heights of Sea Waves: Some Effects of Nonlinearity and Finite Band Width. *Journal of Geophysical Research: Oceans,* 85(C3), 1519-1523.

Lotsberg, I., Sigurdsson, G., Fjeldstad, A., and Moan, T. (2016). Probabilistic Methods for Planning of Inspection for Fatigue Cracks in Offshore Structures. *Marine Structures,* 46, 167-192.

Low, B. (2017). Insights from Reliability-Based Design to Complement Load And Resistance Factor Design Approach. *Journal of Geotechnical and Geoenvironmental Engineering,* 143(11), 04017089.

Ma, C., Zhu, Y., He, J., Zhang, C., Wan, D., Yang, C., et al. (2018). Nonlinear Corrections of Linear Potential-Flow Theory of Ship Waves. *European Journal of Mechanics-B/Fluids,* 67, 1-14.

Machado, U. E. (2002). *Statistical Analysis of Non-Gaussian Environmental Loads and Responses.* Master Thesis, Lund University.

Mackay, E. (2017). *Return Periods of Extreme Loads on Wave Energy Converters*.

Madhuri, J., Kumar, S., and Srinivasan, R. (2016). Methods of Estimating Wave Parameters Using Frequency Domain Analysis Algorithm. *International Conference on Computation of Power, Energy Information and Commuincation (ICCPEIC),* 20-21 April 2016. Chennai, India, 20-24.

Mahdavi, A. (2018). Robust Correlation Coefficient Goodness-Of-Fit Test for The Gumbel Distribution. *Journal of Biostatistics and Epidemiology,* 4(1), 30-35.

Malayjerdi, E., and Tabeshpour, M. R. (2016). Frequency Domain Analysis of Froude-Krylov and Diffraction Forces on TLP. *Ocean Syst Eng,* 6(3), 233-244.

Mallahzadeh, H., Wang, Y., Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2013). Efficient Derivation of the Probability Distribution of Extreme Responses Due to Random Wave Loading from The Probability Distribution of Extreme Surface Elevations. *Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering*, 9–14 June 2013. Nantes, France.

Mallahzadeh, H., Najafian, G., Husain, M., and Zaki, N. M. (2014a). Derivation of Probability Distribution of Extreme Offshore Structural Response due to Combined Wave and Current Loading from the Probability Distribution of Extreme Surface Elevations. *Proceedings of the 7th International ASRANet Conference,* 18-20 August 2014. Glasgow, UK.

Mallahzadeh, H., Wang, Y., Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2014b). Accurate Estimation of The 100-Year Responses from The Probability Distribution of Extreme Surface Elevations. *Proceedings of the 33rd International Conference on Ocean, Offshore and Arctic Engineering,* 8-13 June 2014. San Francisco, California, USA, 8-13.

Mangiavacchi, A., Rodenbusch, G., Radford, A., and Wisch, D. (2005). API Offshore Structure Standards: RP 2A and Much More. *Proceedings of the Offshore Technology Conference*.

Margaretha, H. (2005). *Mathematical Modelling of Wave-Current Interaction in A Hydrodynamic Laboratory Basin.* PhD Thesis, University of Twente.

Massel, S. R. (2001). Wavelet Analysis for Processing of Ocean Surface Wave Records. *Ocean Engineering,* 28(8), 957-987.

Massel, S. R. (2017). *Ocean Surface Waves: Their Physics and Prediction* (Vol. 45): World scientific.

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. *Proceedings of the 35th International Conference on Ocean, Offshore and Arctic Engineering*, 19-24 June 2016. Busan, South Korea, V003T002A044-V003T002A044.

Mat Soom, E. (2018). *Efficient Load Coefficient Method for Structural Reliability Assessment of Ageing Offshore Platforms.* PhD Thesis, Universiti Teknologi Malaysia.

Mat Soom, E., Husain, M. K. A., Zaki, N. I. M., Nor, M. N. K. M., and Najafian, G. (2018). Lifetime Extension of Ageing Offshore Structures by Global Ultimate Strength Assessment (GUSA). *Malaysian Journal of Civil Engineering,* 30(1).

Mat Soom, E., Khairi, M., Irza, N., and Nurul Uyun, A. (2019). Structural Reliability Analysis for Fixed Offshore Platforms. *Jurutera*.

Mazas, F. (2019). Extreme Events: A Framework for Assessing Natural Hazards. *Natural Hazards,* 98(3), 823-848.

McCormick, M. E. (2009). *Ocean Engineering Mechanics: With Applications*: Cambridge University Press.

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

Mendes, A., Kolodziej, J., and Correia, H. (2003). Numerical Modelling of Wave-Current Loading On Offshore Jacket Structures. *WIT Transactions on The Built Environment,* 71.

Menéndez, M., Méndez, F. J., Losada, I. J., and Graham, N. E. (2008). Variability of Extreme Wave Heights in The Northeast Pacific Ocean Based On Buoy Measurements. *Geophysical Research Letters*, 35(22).

Mérigaud, A., and Ringwood, J. V. (2017a). Free-Surface Time-Series Generation for Wave Energy Applications. *IEEE Journal of Oceanic Engineering,* 43(1), 19-35.

Mérigaud, A., and Ringwood, J. V. (2017b). A Nonlinear Frequency-Domain Approach for Numerical Simulation of Wave Energy Converters. *IEEE Transactions on Sustainable Energy,* 9(1), 86-94.

Metcalfe, A., Najafian, G., Burrows, R., and Tickell, R. (2003). Prediction of Extreme Forces and Moments for an Offshore Structure. *EMAC 2003 Proceedings : Proceedings of the Sixth Engineering Mathematics and Applications Conference*, 9-11 July 2003. Sydney, Australia, 147-152.

Mirzadeh, J., Kimiaei, M., and Cassidy, M. J. (2015). A Framework to Efficiently Calculate the Probability of Failure of Dynamically Sensitive Structures in A Random Sea. *Ocean Engineering*, 110, 215-226.

Mirzadeh, J., Kimiaei, M., and Cassidy, M. J. (2016). Effects of Irregular Nonlinear Ocean Waves on the Dynamic Performance of an Example Jack-Up Structure During an Extreme Event. *Marine Structures,* 49, 148-162.

Moan, T. (2005). *Safety of Offshore Structures*. National University of Singaporeo. Document Number)

Moan, T., Zheng, X. Y., and Quek, S. T. (2007). Frequency-Domain Analysis of Non-Linear Wave Effects On Offshore Platform Responses. *International Journal of Non-Linear Mechanics,* 42(3), 555-565.

Moan, T., and Zheng, X. Y. (2009). Quasi-Static Response of Fixed Offshore Platforms to Morison-Type Wave Loadings. *Journal of engineering mechanics,* 135(10), 1057-1068.

Moan, T. (2018). Life Cycle Structural Integrity Management of Offshore Structures. *Structure and Infrastructure Engineering,* 14(7), 911-927.

Mockutė, A., Marino, E., Lugni, C., and Borri, C. (2017). Comparison of Hydrodynamic Loading Models for Vertical Cylinders in Nonlinear Waves. *Procedia Engineering*, 199, 3224-3229.

Moghimi, S., Gayer, G., Günther, H., and Shafieefar, M. (2005). Application of Third Generation Shallow Water Wave Models in A Tidal Environment. *Ocean Dynamics*, 55(1), 10-27.

Mohammadi, S., Galgoul, N., and Starossek, U. (2016). Comparison of Time Domain and Spectral Fatigue Analyses of an Offshore Jacket Structure. *Proceedings of the 26th International Ocean and Polar Engineering Conference*, 26 June - 2 July 2016. Rhodes, Greece.

Mohd Zaki, N. I., Abu Husain, M. K., Mallahzadeh, H., and Najafian, G. (2013a). Finite-Memory Nonlinear System Modelling of Offshore Structural Response Accounting for Extreme Values Residues *Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering*, 9–14 June 2013. Nantes, France.

Mohd Zaki, N. I., Abu Husain, M. K., Wang, Y., and Najafian, G. (2013b). Short-term distribution of the extreme values of offshore structural response by modified finite-memory nonlinear system modeling. *Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering*, 9-14 June 2013. Nantes, France.

Mohd Zaki, N. I., Abu Husain, M. K., Abdullah Shuhaimy, N., and Najafian, G. (2016a). The Effect of Different Methods of Simulating Water Particle Kinematics on the 100-Year Responses. *Proceedings of the 35th International Conference on Ocean, Offshore and Arctic Engineering*, 19-24 June 2016. Busan, South Korea.

Mohd Zaki, N. I., Abu Husain, M. K., Mukhlas, N. A., and Najafian, G. (2016b). Prediction of Offshore Structural Response Extreme Values by Modified Finite-Memory Nonlinear System Modeling. *Proceedings of the 35th International Conference on Ocean, Offshore and Arctic Engineering*, 19-24 June 2016. Busan, South Korea.

Mohd Zaki, N. I., Abu Husain, M. K., and Najafian, G. (2016c). Extreme Structural Response Values from Various Methods of Simulating Wave Kinematics. *Ships and Offshore Structures*, 11(4), 369-384.

Mohd Zaki, N. I., Abu Husain, M. K., and Najafian, G. (2016d). Prediction of 100-Year Responses of Fixed Offshore Structures Using the Modified Version of Finite Memory Nonlinear System Models. *Proceedings of the Twelfth ISOPE Pacific/Asia Offshore Mechanics Symposium*, 4–7 October 2016. Gold Coast, Australia.

Mohd Zaki, N., Abu Husain, M., and Najafian, G. (2018a). Extreme Structural Responses by Nonlinear System Identification for Fixed Offshore Platforms. *Ships and Offshore Structures,* 13(sup1), 251-263.

Mohd Zaki, N. I., Abu Husain, M. K., and Najafian, G. (2018b). Comparison of Extreme Surface Elevation for Linear and Nonlinear Random Wave Theory for Offshore Structures. *MATEC Web of Conferences*, 01021.

Moon, M.-Y., Kim, H.-S., Lee, K., Park, B., and Choi, K. (2020). Uncertainty Quantification and Statistical Model Validation for an Offshore Jacket Structure Panel Given Limited Test Data and Simulation Model. *Structural and Multidisciplinary Optimization*, 1-14.

Morison, J. R., Johnson, J. W., and Schaaf, S. A. (1950). The Force Exerted by Surface Waves on Piles. *Journal of Petroleum Technology,* 2(05), 149-154.

Morooka, C. K., and Yokoo, I. H. (1997). Numerical Simulation and Spectral Analysis of Irregular Sea Waves. *International Journal of Offshore and Polar Engineering,* 7(03).

Morton, I., and Bowers, J. (1996). Extreme Value Analysis in A Multivariate Offshore Environment. *Applied Ocean Research,* 18(6), 303-317.

Mukherjee, D., and Mahadevan, S. (1995). Reliability-based Structural Design. *Proceedings of the Annual Reliability and Maintainability Symposium*, 16-19 January 1995. Washington, USA, 207-212.

Mukhlas, N. A., Mohd Zaki, N. I., and Abu Husain, M. K. (2016a). Prediction of the 100-year Responses by Advanced MFMNS. *International Conference on Ocean, Mechanical and Aerospace for Scientist and Engineer*, 7–8 November 2016. Kuala Terengganu, Malaysia.

Mukhlas, N. A., Shuhaimy, N. A., Johari, M. B., Soom, E. M., Abu Husain, M. K., and Mohd Zaki, N. I. (2016b). Design and Analysis of Fixed Offshore Structure–An Overview. *Malaysian Journal of Civil Engineering,* 28(3), 503-520.

Mukhlas, N. A. (2017). *Efficient Derivation of Extreme Offshore Structural Response Exposed to Random Wave Load.* Master Thesis, Universiti Teknologi Malaysia.

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

Mukhlas, N. A., Zaki, N. I. M., Husain, M. K. A., and Najafian, G. (2018b). Comparison of Extreme Surface Elevation for Linear and Nonlinear Random Wave Theory for Offshore Structures. *International Conference on Civil, Offshore & Environmental Engineering (ICCOEE),* 13-15 August 2018. Kuala Lumpur, Malaysia, 01021.

Mukhlas, N. A., Mohd Zaki, N. I., Abu Husain, M. K., and Najafian, G. (2019). Efficient Methods for The Prediction of Non-Gaussian Stochastic Response of Offshore Structure. *Trends in the Analysis and Design of Marine Structures: Proceedings of the 7th International Conference on Marine Structures (MARSTRUCT),* 6-8 May 2019. Dubrovnik, Croatia, 93.

Mukhlas, N. A. (2020). *Efficient Derivation of Extreme Non-Gaussian Stochastic Structural Response.* PhD Thesis, Universiti Teknologi Malaysia.

Muraleedharan, G., Lucas, C., Guedes Soares, C., Unnikrishnan Nair, N., and Kurup, P. G. (2012). Modelling Significant Wave Height Distributions with Quantile Functions for Estimation of Extreme Wave Heights. *Ocean Engineering,* 54, 119-131.

Naess, A., Gaidai, O., and Haver, S. (2007). Efficient Estimation of Extreme Response of Drag-Dominated Offshore Structures by Monte Carlo Simulation. *Ocean Engineering,* 34(16), 2188-2197.

Naess, A., and Pisano, A. (1997). Frequency Domain Analysis of Dynamic Response of Drag Dominated Offshore Structures. *Applied ocean research,* 19(5-6), 251-262.

Naess, A., and Gaidai, O. (2008). Monte Carlo Methods for Estimating the Extreme Response of Dynamical Systems. *Journal of Engineering Mechanics,* 134(8), 628-636.

Naess, A., Leira, B., and Batsevych, O. (2009). System Reliability Analysis by Enhanced Monte Carlo Simulation. *Structural safety,* 31(5), 349-355.

Naess, A., and Moan, T. (2013). *Stochastic Dynamics of Marine Structures*: Cambridge University Press.

Najafian, G. (1991). *Local Hydrodynamic Force Coefficients from Field Data and Probabilistic Analysis of Offshore Structures Exposed to Random Wave Loading.* PhD Thesis, University of Liverpool.

Najafian, G., Burrows, R., and Tickell, R. (1995). A Review of the Probabilistic Description of Morison Wave Loading and Response of Fixed Offshore Structures. *Journal of fluids and structures,* 9(6), 585-616.

Najafian, G., Burrows, R., and Tickell, R. (1999). Probabilistic Description of the Response of Offshore Structures to Wave Loading Via Random Sampling Technique. *Proceedings of the Ninth International Offshore and Polar Engineering Conference*, 30 May - 4 June 1999. Brest, France.

Najafian, G., Burrows, R., Tickell, R. G., and Metcalfe, A. V. (2002). Higher-Order Statistical Moments of Wave-Induced Response of Offshore Structures Via Efficient Sampling Techniques. *Proceedings of the Twelfth International Offshore and Polar Engineering Conference*, 26–31 May 2002. Kitakyushu, Japan.

Najafian, G. (2005). Comparison of '100-year'response Values from the Design Wave Technique with those from the Time-Domain Probabilistic Technique. *Proceedings of the Fifteenth International Offshore and Polar Engineering Conference*, 19–24 June 2005. Seoul, Korea.

Najafian, G. (2007a). Application of System Identification Techniques in Efficient Modelling of Offshore Structural Response. Part I: Model Development. *Applied Ocean Research,* 29(1-2), 1-16.

Najafian, G. (2007b). Application of System Identification Techniques in Efficient Modelling of Offshore Structural Response. Part II: Model Validation. *Applied Ocean Research,* 29(1-2), 17-36.

Najafian, G. (2007c). Comparison of Three Probability Models for Offshore Structural Response Due to Morison Wave Loading. *Fluid Structure Interaction and Moving Boundary Problems IV,* 37.

Najafian, G. (2007d). Derivation of Statistical Properties of Wave-Induced Offshore Structural Response by Principal Component Technique. *Ocean engineering,* 34(7), 987-999.

Najafian, G., and Mohd Zaki, N. I. (2008). Finite-Memory Nonlinear Modeling of Offshore Structures. *Proceedings of the 27th International Conference on Offshore Mechanics and Arctic Engineering*, 15–20 June 2008. Estoril, Portugal, 743-752.

Najafian, G., Mohd Zaki, N. I., and Aqel, G. (2009). Simulation of water particle kinematics in the near surface zone. *Proceedings of the 28th International Conference on Ocean, Offshore and Arctic Engineering*, 31 May - 5 June 2009. Honolulu, Hawaii, USA, 157-162.

Najafian, G., and Zaki, N. (2008). Finite-Memory Nonlinear System Modelling of Offshore Structures. *Proceedings of the 27th International Conference on Offshore Mechanics and Arctic Engineering*, 15–20 June 2008. Estoril, Portugal, 743-752.

Nallayarasu, S. (1981). *Offshore Structures - Analisys and Design.* PhD Thesis, Indian institute of Technology Madras.

Nava-Viveros, I., and Heredia-Zavoni, E. (2018, 13-14 October 2016). Assessment of Statistical Parameter Uncertainty in The Reliability Analysis of Jacket Platforms. *Ocean Engineering*, Hong Kong, 370-379.

Nayak, A., and Pandian, G. A. M. (2018). Parametric Study of Fixed Jacket Platform Under Varying Jacket Configuration and Environmental Loads. *International Journal of Pure and Applied Mathematics*, 119(15), 445-453.

Nelson, B., Lin, T.-Y., Quéméner, Y., Huang, H., and Chien, C. (2016). Extreme Typhoon Loads Effect on the Structural Response of an Offshore Wind Turbine. *Proceedings of 7th PAAMES and AMEC2016*, 13-14 October 2016. Hong Kong, 1-7.

Nielsen, U. D. (2018). Deriving The Absolute Wave Spectrum from an Encountered Distribution of Wave Energy Spectral Densities. *Ocean Engineering*, 165, 194-208.

Nikolaidis, E., Mourelatos, Z. P., and Pandey, V. (2011). *Design Decisions Under Uncertainty With Limited Information: Structures and Infrastructures Book Series, Vol. 7*: CRC Press.

Niroomandi, A., Ma, G., Ye, X., Lou, S., and Xue, P. (2018). Extreme Value Analysis of Wave Climate in Chesapeake Bay. *Ocean Engineering*, 159, 22-36.

Nizamani, Z. (2015). *Environmental Load Factors and System Strength Evaluation of Offshore Jacket Platforms* (Vol. 4): Springer.

Njoku, T. N., and Ephraim, M. E. (2019). Structural Performance Assessment of Fixed Platforms Located Offshore Nigeria. *World Journal of Innovative Research,* 6(6), 87-93.

Noorzaei, J., Bahrom, S. I., Jaafar, M. S., Thanoon, W. A. M., and Mohammad, S. (2005). Simulation of Wave and Current Forces on Template Offshore Structures. *Suranaree J Sci Technol,* 12(3), 193-210.

Nørgaard, J. H., Andersen, T. L., and Knudsen, J. E. (2017). Wave Height Distribution for Nonlinear Swell Waves in Deep an Depth-Limited Wave Conditions. *Coastal Dynamics 2017 : Proceedings of Coastal Dynamics 2017*, 12-17 June 2017. Helsingør, Denmark, 377-388.

Norouzi, M. (2012). *An efficient method to assess reliability under dynamic stochastic loads.* PhD Dissertation, University of Toledo.

Norouzi, M., and Nikolaidis, E. (2012). Efficient Estimation of First Excursion Failure of Dynamic Systems by Probabilistic Re-analysis. *Proceedings of the 12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and 14th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference*, 17-19 September 2012. Indianapolis, Indiana, 5664.

Nouban, F., French, R., and Sadeghi, K. (2016). General Guidance for Planning, Design and Construction of Offshore Platforms. *Academic Research International,* 7(5), 37-44.

O'Connor, P., America, B., Bucknell, J., Corp, M. S., Lalani, M., and Ltd., M. E. (2007). Chapter 14 – Offshore and Subsea Facilities. In *Petroleum engineering handbook* (Vol. Volume III – Facilities and Construction Engineering, pp. 525-564): Richardson, TX: Society of Petroleum Engineers.

OECD. (2016). *Development Co-operation Report*.

Okada, H., and Murotsu, Y. (1990). A Study On The Probabilistic Analysis Of The Quasi-Static Strength And The Natural Frequencies Of Slender Offshore Structures. *Proceedings of the First ISOPE Pacific/Asia Offshore Mechanics Symposium,* 24–28 June 1990. Seoul, Korea.

Olagnon, M., Prevosto, M., and Joubert, P. (1988). Nonlinear Spectral Computation of the Dynamic Response of a Single Cylinder. *Journal of Offshore Mechanics and Arctic Engineering,* 110(3), 278-281.

Onoufriou, T., and Forbes, V. (2001). Developments in Structural System Reliability Assessments of Fixed Steel Offshore Platforms. *Reliability Engineering & System Safety*, 71(2), 189-199.

Orkin, G. L., Folck, R. L., and Startzman, R. A. (1978, 12–14 April 1978). Monte Carlo Simulation of Offshore Terminal Operations. *SPE California Regional Meeting*, San Francisco, California.

Osborne, A. R. (2001). The Random and Deterministic Dynamics of ‘Rogue Waves’ in Unidirectional, Deep-Water Wave Trains. *Marine structures*, 14(3), 275-293.

Oumeraci, H., Kortenhaus, A., Allsop, W., de Groot, M., Crouch, R., Vrijling, H., et al. (2001). *Probabilistic Design Tools for Vertical Breakwaters*: CRC Press.

Papoulis, A., and Pillai, S. U. (1991). *Probability, random variables, and stochastic processes*: International Edition.

Papoulis, A., and Pillai, S. U. (2002). *Probability, random variables, and stochastic processes*: Tata McGraw-Hill Education.

Park, S. B., Shin, S. Y., Shin, D. G., Jung, K. H., Choi, Y. H., Lee, J., et al. (2020). Extreme Value Analysis of Metocean Data for Barents Sea. *Journal of Ocean Engineering and Technology,* 34(1), 26-36.

Patel, M. H. (2013). *Dynamics of Offshore Structures*: Butterworth-Heinemann.

Pereyra, B., Wendt, F., Robertson, A., and Jonkman, J. (2017). *Assessment of First- and Second-Order Wave-Excitation Load Models for Cylindrical Substructures*: National Renewable Energy Lab.(NREL), Golden, CO (United States)o. Document Number)

Perrie, W., Tang, C., Hu, Y., and DeTracy, B. (2003). The Impact of Waves On Surface Currents. *Journal of Physical Oceanography,* 33(10), 2126-2140.

Petrauskas, C., Heideman, J. C., and Berek, E. P. (1993). *Extreme Wave-Force Calculation Procedure for 20th Edition of API-RP-2A*. Offshore Technology Conference.

Phillips, O. M. (1958). The Equilibrium Range in The Spectrum of Wind-Generated Waves. *Journal of Fluid Mechanics,* 4(4), 426-434.

Pierson Jr., W. J., and Moskowitz, L. (1964). A Proposed Spectral Form for Fully Developed Wind Seas Based On the Similarity Theory of S. A. Kitaigorodskii. *Journal of Geophysical Research,* 69(24), 5181-5190.

Plant, W. J. (2009). The Ocean Wave Height Variance Spectrum: Wavenumber Peak Versus Frequency Peak. *Journal of Physical Oceanography,* 39(9), 2382-2383.

Platzer, F., Saillard, M., and Fabbro, V. (2019). Two-Dimensional Spectra of Radar Returns from Sea: 1. Theoretical and Numerical Study of the Group Line. *Journal of Geophysical Research: Oceans,* 124(12), 8767-8776.

Pook, L. P. (2019). Review of The Mathematical Background to The Development of Realistic Load Histories for Fatigue Testing Relevant to Tubular Structures in The North Sea. *Fatigue & Fracture of Engineering Materials & Structures,* 42(9), 1889-1911.

Pors, A., Ding, F., Chen, Y., Radko, I. P., and Bozhevolnyi, S. I. (2016). Random-Phase Metasurfaces at Optical Wavelengths. *Scientific Reports,* 6, 28448.

Powers, D., and Xie, Y. (2008). *Statistical Methods for Categorical Data Analysis*: Emerald Group Publishing.

Price, R. (1958). A Useful Theorem for Nonlinear Devices Having Gaussian Inputs. *IRE Transactions on Information Theory,* 4(2), 69-72.

Procedures, I. A. o. O. a. G. (2017). Safety Performance in 2017: Fewer Fatalities Than Ever. *International Association of Oil and Gas Producers* Retrieved 2018 May 10, from https://www.iogp.org/blog/oil-and-gas-safety/fewer-fatalities-in-2017/

Qiu, W., Junior, J. S., Lee, D., Lie, H., Magarovskii, V., Mikami, T., et al. (2014). Uncertainties Related to Predictions of Loads and Responses for Ocean and Offshore Structures. *Ocean Engineering,* 86, 58-67.

Raheem, S. E. A. (2013). Nonlinear Response of Fixed Jacket Offshore Platform Under Structural and Wave Loads. *Coupled Syst. Mech,* 2, 111-126.

Rajan, A., Kuang, Y. C., Ooi, M. P.-L., and Demidenko, S. N. (2019). Measurement Uncertainty Evaluation: Could It Help to Improve Engineering Design? *IEEE Instrumentation & Measurement Magazine,* 22(2), 27-32.

Reddy, D., and Swamidas, A. (2016). *Essentials of Offshore Structures: Framed and Gravity Platforms*: CRC press.

Regev, O., Umurhan, O. M., and Yecko, P. A. (2016). Linear and Nonlinear Incompressible Waves. In *Modern Fluid Dynamics for Physics and Astrophysics* (pp. 161-239): Springer.

Reid, S., and Naess, A. (2017). Influence on Structural Reliability of Uncertain Extreme Value Estimates. *Proceedings of the 36th International Conference* *on Ocean, Offshore and Arctic Engineering*, 25–30 June 2017. Trondheim, Norway, V009T012A037.

Reikard, G. (2017). Wave Energy Forecasting. In *Renewable Energy Forecasting* (pp. 199-217): Elsevier.

Reza, T. M., Mani, F. D., Ali, D. D. M., Saied, M., and Saied, S. M. (2017). Response Spectrum Method for Extreme Wave Loading with Higher Order Components of Drag Force. *Journal of Marine Science and Application*, 16(1), 27-32.

Rice, S. O. (1944). Mathematical Analysis of Random Noise, *Bell System Technical Journal*, 23(3), 282-332.

Rice, S. O. (1945). Mathematical Analysis of Random Noise, *Bell System Technical Journal*, 24(1), 46-156.

Ritchie, H., and Roser, M. (2019). Fossil Fuels. *Our World in Data* Retrieved 2019 November 15, from https://ourworldindata.org/fossil-fuels

Rodenbusch, G., and Forristall, G. (1986, 5–8 May 1986). An Empirical Model for Random Directional Wave Kinematics Near the Free Surface. *Proceedings of the Offshore Technology Conference*, Houston, Texas.

Rodriguez, G., Clarindo, G., and Guedes Soares, C. (2018). Robust Estimation and Representation of Climatic Wave Spectrum. *Progress in Maritime Technology and Engineering-Proceedings of the 4th International Conference on Maritime Technology and Engineering (MARTECH)*, 6-8 May 2019. Dubrovnik, Croatia.

Romolo, A., Malara, G., Laface, V., and Arena, F. (2016). Space–Time Long-Term Statistics of Ocean Storms. *Probabilistic Engineering Mechanics*, 44, 150-162.

Ross, E., Astrup, O. C., Bitner-Gregersen, E., Bunn, N., Feld, G., Gouldby, B., et al. (2020). On Environmental Contours for Marine and Coastal Design. *Ocean Engineering*, 195, 106194.

Roy, S., Ghosh, V., Dey, S., Vimmadi, S., and Banik, A. (2017). A Coupled Analysis of Motion and Structural Responses for an Offshore Spar Platform in Irregular Waves. *Ships and Offshore Structures*, 12(sup1), S296-S304.

Rueda, A., Camus, P., Méndez, F. J., Tomás, A., and Luceño, A. (2016). An Extreme Value Model for Maximum Wave Heights Based On Weather Types. *Journal of Geophysical Research: Oceans*, 121(2), 1262-1273.

Ruggiero, P., Komar, P. D., and Allan, J. C. (2010). Increasing Wave Heights and Extreme Value Projections: The Wave Climate of The US Pacific Northwest. *Coastal Engineering,* 57(5), 539-552.

Rusu, E., and Venugopal, V. (2019). *Offshore Renewable Energy: Ocean Waves, Tides and Offshore Wind*: MDPI.

Rychlik, I., Johannesson, P., and Leadbetter, M. R. (1997). Modelling and Statistical Analysis of Ocean-Wave Data Using Transformed Gaussian Processes. *Marine Structures,* 10(1), 13-47.

Ryszard, M. S. (1996). *Ocean Surface Waves: Their Physics and Prediction* (Vol. 11): World Scientific.

Sadeghi, K., and Dilek, H. (2019). An Introduction to the Design of Offshore Structures. *Academic Research International,* 10, 19-27.

Sagaut, P., and Cambon, C. (2018). The Essentials of Linear and Nonlinear Theories and Models. In *Homogeneous Turbulence Dynamics* (pp. 831-880): Springer.

Sagrilo, L., Naess, A., and Doria, A. (2011). On the Long-Term Response of Marine Structures. *Applied Ocean Research,* 33(3), 208-214.

Saha, N., and Naess, A. (2010). Monte–Carlo Based Method for Predicting Extreme Value Statistics of Uncertain Structures. *Journal of engineering mechanics,* 136(12), 1491-1501.

Sakhare, S., and Deo, M. (2009). Derivation of Wave Spectrum Using Data Driven Methods. *Marine Structures,* 22(3), 594-609.

San Tint, A. (2015). *Reliability Analysis of the Final Design of a Fixed Offshore Jacket.* Master Thesis, Asian Institute of Technology.

Sandhya, G. (2018). Analysis of Offshore Jacket Platform. *International Research Journal of Engineering and Technology,* 5(1), 722-729.

Santo, H., Taylor, P. H., and Gibson, R. (2016). Decadal Variability of Extreme Wave Height Representing Storm Severity in The Northeast Atlantic and North Sea Since the Foundation of the Royal Society. *Proceedings. Mathematical, physical, and engineering sciences,* 472(2193), 20160376-20160376.

Sapsis, T. P. (2020). Statistics of Extreme Events in Fluid Flows and Waves. *Annual Review of Fluid Mechanics,* 53.

Sarpkaya, T. (1981). *Mechanics of Wave Forces On Offshore Structures / Turgut Sarpkaya, Michael Isaacson*. New York: Van Nostrand Reinhold Co.

Schmidt, V. A., Crager, B., and Rodenbusch, G. (2017). Historical Development of the Offshore Industry. *Encyclopedia of Maritime and Offshore Engineering,* 1-17.

Schnabl, S., Planinc, I., and Turk, G. (2013). Buckling Loads of Two-Layer Composite Columns with Interlayer Slip and Stochastic Material Properties. *Journal of Engineering Mechanics,* 139, 961-966.

Schöpfer, P. (2016). *Non-linear Wave Impact on Monopile Structures.* Master Dissertation, Norwegian University of Science and Technology.

Schreck, C., Hafner, C., and Wojtan, C. (2019). Fundamental Solutions for Water Wave Animation. *ACM Transactions on Graphics (TOG),* 38(4), 1-14.

Sclavounos, P. D. (2005). Nonlinear Particle Kinematics of Ocean Waves. *Journal of Fluid Mechanics,* 540, 133-142.

Sclavounos, P. D., Zhang, Y., Ma, Y., and Larson, D. F. (2019). Offshore Wind Turbine Nonlinear Wave Loads and Their Statistics. *Journal of Offshore Mechanics and Arctic Engineering,* 141(3), 031904.

Seidel, M. (2014). Wave Induced Fatigue Loads: Insights from Frequency Domain Calculations. *Stahlbau,* 83(8), 535-541.

Şen, Z. (2018). Probability and Statistical Methods. In *Flood Modeling, Prediction and Mitigation* (pp. 245-301): Springer.

Shengchang, W., Dacuo, Z., Peifang, G., and Bohai, C. (2018). Parameters in Wind-Wave Frequency Spectra and Their Bearings On Spectrum Forms and Growth. *Journal of Acta Oceanologica,* 8(1), 15-39.

Shetty, N. (1992). *System Reliability of Fixed Offshore Structures Under Fatigue Deterioration.* PhD Thesis, Imperial College of Science, Technology and Medicine.

Siow, C., Koto, J., Abyn, H., and Khairuddin, N. (2014). Linearized Morison Drag for Improvement Semi-Submersible Heave Response Prediction by Diffraction Potential. *Journal of Ocean, Mechanical and Aerospace Science and Engineering,* 6, 8-16.

Slåke, T. (2016). *Analysis of Jacket Type Fixed Platforms–Effect of Various Mass Modelling Approaches for Topsides on Structural Response.* Master Thesis, University of Stavanger.

Sloan, D. (2020). Understanding Scatter Diagrams and Correlation Analysis [Electronic Version], from https://www.isixsigma.com/toolstemplates/graphical-analysis-charts/understanding-scatter-diagrams-and-correlation-analysis/

Slunyaev, A. (2017). Predicting Rogue Waves. *Moscow University Physics Bulletin,* 72(3), 236-249.

Smit, P., Janssen, T., and Herbers, T. (2017). Nonlinear Wave Kinematics Near the Ocean Surface. *Journal of Physical Oceanography,* 47(7), 1657-1673.

Smith, R. L. (1986). Extreme Value Theory Based On the R Largest Annual Events. *Journal of Hydrology,* 86(1-2), 27-43.

Smith, H. D. (2017). *Numerical Integration of Signals Using the Fast Fourier Transform.* Master Thesis, Texas A&M University-Central Texas.

Smolik, M., Skala, V., and Majdisova, Z. (2018). A New Simple, Fast and Robust Total Least Square Error Computation in E2: Experimental Comparison. In *International Conference on Advanced Engineering Theory and Applications* (pp. 325-334): Springer.

Soares, C. G. (2012). *Probabilistic Methods for Structural Design* (Vol. 56): Springer Science & Business Media.

Somayajula, A., and Falzarano, J. (2015). Large-Amplitude Time-Domain Simulation Tool for Marine and Offshore Motion Prediction. *Marine Systems & Ocean Technology*, 10(1), 1-17.

Sorensen, R. M. (2005). *Basic Coastal Engineering* (Vol. 10): Springer Science & Business Media.

Soulsby, R., Hamm, L., Klopman, G., Myrhaug, D., Simons, R., and Thomas, G. (1993). Wave-Current Interaction Within and Outside the Bottom Boundary Layer. *Coastal engineering,* 21(1-3), 41-69.

Staneva, J., Alari, V., Breivik, Ø., Bidlot, J.-R., and Mogensen, K. (2017). Effects of Wave-Induced Forcing On a Circulation Model of the North Sea. *Ocean Dynamics,* 67(1), 81-101.

Stansell, P., Wolfram, J., and Linfoot, B. (2004). Improved Joint Probability Distribution for Ocean Wave Heights and Periods. *Journal of fluid Mechanics,* 503, 273-297.

Stewart, G. (2017). Reassessment of Fixed Offshore Structures. *Encyclopedia of maritime and offshore engineering*, 1-17.

Stewart, G., and Manzocchi, M. (2018). Recent Developments in Probabilistic Pushover Models for The Reliability Re-Assessment of Fixed Offshore Structures. *Safety and Reliability*, 38(1-2), 3-31.

Stoker, J. J. (2011). *Water Waves: The Mathematical Theory with Applications* (Vol. 36): John Wiley & Sons.

Suen, Y., Xiao, S., Hao, S., Zhao, X., Xiong, Y., and Liu, S. (2016). Time-Frequency Representation Measurement Based On Temporal Fourier Transformation. *Optics Communications,* 376, 86-91.

Sumer, B. M. (2006). *Hydrodynamics Around Cylindrical Structures* (Vol. 26): World scientific.

Sundararajan, C. R. (2012). *Probabilistic Structural Mechanics Handbook: Theory and Industrial Applications*: Springer Science & Business Media.

Sura, P., and Gille, S. T. (2010). Stochastic Dynamics of Sea Surface Height Variability. *Journal of Physical Oceanography,* 40(7), 1582-1596.

Suyuthi, A., and Haver, S. K. (2009). Extreme Loads Due to Wave Breaking Against Platform Column. *Proceedings of the Nineteenth International Offshore and Polar Engineering Conference*, 21-26 July 2009. Osaka, Japan.

Swamidas, A. S., and Reddy, D. V. (2016). Offshore Platforms. In *Springer Handbook of Ocean Engineering* (pp. 745-754): Springer.

Syed Ahmad, S. Z. A., Abu Husain, M. K., Mohd Zaki, N. I., Mohd, M. H., and Najafian, G. (2018a). Comparison of Various Spectral Models for 100-Year Extreme Values of Offshore Structural. *Proceedings of the 11th International Conference on Marine Technology (MARTEC)*, 13-14 August 2018. Kuala Lumpur, Malaysia, 316-328.

Syed Ahmad, S. Z. A., Abu Husain, M. K., Mohd Zaki, N. I., Mohd, M. H., and Najafian, G. (2018b). Comparison of Various Spectral Models for the Prediction of the 100-Year Design Wave Height. *International Conference on Civil, Offshore & Environmental Engineering (ICCOEE)*, 13-15 August 2018. Kuala Lumpur, Malaysia, 01020.

Syed Ahmad, S. Z. A., Abu Husain, M. K., Mohd Zaki, N. I., Mohd, M. H., and Najafian, G. (2019). Offshore Responses Using an Efficient Time Simulation Regression Procedure. *Trends in the Analysis and Design of Marine Structures: Proceedings of the 7th International Conference on Marine Structures (MARSTRUCT),* 6-8 May 2019. Dubrovnik, Croatia, 12.

Szalewski, P., Lu, J. Y., and Johannessen, T. B. (2017). Horizontal Wave Impact Loads for Column-Stabilized Units Operating in Harsh Environment. *Proceedings of the Offshore Technology Conference*.

Taboada, J. V., and Lemu, H. G. (2016). Analysis of Wave Energy Sources in the North Atlantic Waters in View of Design Challenges. *Proceedings of the 35th International Conference on Ocean, Offshore and Arctic Engineering*, 19-24 June 2016. Busan, South Korea.

Taghipour, R., Perez, T., and Moan, T. (2008). Hybrid Frequency–Time Domain Models for Dynamic Response Analysis of Marine Structures. *Ocean Engineering,* 35(7), 685-705.

Taheri, A., and Shahsavari, E. (2019). Time History Dynamic Analysis of a New Constructed Offshore Jacket Platform in Persian Gulf Due to Random Waves. *Journal of Marine Science and Application,* 18(3), 372-379.

Taniguchi, T., and Kawano, K. (2001). Current Effects On Extreme Response Value Statistics of Offshore Structures Subjected to Wave and Current. *Proceedings of the the Eleventh International Offshore and Polar Engineering Conference*, 17-22 June 2001. Stavanger, Norway.

Taylor, P. H., Adcock, T. A., Borthwick, A. G., Walker, D. A., and Yao, Y. (2006). The Nature of the Draupner Giant Wave of 1st January 1995 And The Associated Sea-State, And How to Estimate Directional Spreading from a Eulerian Surface Elevation Time History. *Proceedings of the 9th International Workshop on Wave Hindcasting and Forecasting*, 24-29 September 2006. Victoria, Canada.

Taylor, R. E., and Jefferys, E. (1986). Variability of Hydrodynamic Load Predictions for A Tension Leg Platform. *Ocean Engineering,* 13(5), 449-490.

Terro, M. J., and Abdel-Rohman, M. (2007). Wave Induced Forces in Offshore Structures Using Linear and Nonlinear Forms of Morison's Equation. *Journal of Vibration and Control,* 13(2), 139-157.

Thapa, P. B. (2016). Oil Gas Offshore Safety Case (Risk Assessment). *Newfoundland, Canada*.

Thas, O., Vanrolleghem, P., Kops, B., Van Vooren, L., and Ottoy, J.-P. (1997). Extreme Value Statistics: Potential Benefits in Water Quality Management. *Water science and technology,* 36(5), 133-140.

Thurman, H. V., and Trujillo, A. P. (2005). *Essentials of Oceanography* (7th ed.): Prentice Hall.

Tickell, R. (1977). Continuous Random Wave Loading On Structural Members. *Structural Engineer,* 55(Analytic).

Tickell, R. G., Burrows, R., and Holmes, P. (1976). Long-Term Wave Loading On Offshore Structures. *Proceedings of the Institution of Civil Engineers,* 61(1), 145-162.

Tognarelli, M. A., Zhao, J., Rao, K. B., and Kareem, A. (1997). Equivalent Statistical Quadratization and Cubicization for Nonlinear Systems. *Journal of engineering mechanics,* 123(5), 512-523.

Tong, W. (2010). *Wind Power Generation and Wind Turbine Design*: WIT press.

Tørum, A., and Gudmestad, O. T. (2012). *Water Wave Kinematics* (Vol. 178): Springer Science & Business Media.

Towe, R., Tawn, J., Eastoe, E., and Lamb, R. (2020). Modelling the Clustering of Extreme Events for Short-Term Risk Assessment. *Journal of Agricultural, Biological and Environmental Statistics,* 25(1), 32-53.

Tromans, P. S., Anaturk, A. R., and Hagemeijer, P. (1991). A New Model for The Kinematics of Large Ocean Waves-Application as a Design Wave. *Proceedings of the First International Offshore and Polar Engineering Conference*, 11-16 August 1991. Edinburgh, The United Kingdom.

Trowbridge, J. H., and Lentz, S. J. (2018). The Bottom Boundary Layer. *Annual Review of Marine Science,* 10, 397-420.

Trubat, P., Molins, C., Hufnagel, P., Alarcón, D., and Campos, A. (2018). Application of Morison Equation in Irregular Wave Trains With High Frequency Waves. *Proceedings of the 37th International Conference on Ocean, Offshore and Arctic Engineering*, 17-22 June 2018. Madrid, Spain.

Tu, Y., Cheng, Z., and Muskulus, M. (2018). A Global Slamming Force Model for Offshore Wind Jacket Structures. *Marine Structures,* 60, 201-217.

Twomey, P., and Kroll, M. (2008). How to Use Linear Regression and Correlation in Quantitative Method Comparison Studies. *International journal of clinical practice,* 62(4), 529-538.

United, S., Beach Erosion, B., and Bretschneider, C. L. (1959). *Wave Variability and Wave Spectra for Wind-Generated Gravity Waves*. Washington, D. C.: The Board.

Van Der Tempel, J. (2006). *Design of Support Structures for Offshore Wind Turbines.* PhD Thesis, Delft University of Technology.

van Os, J., Caires, S., and van Gent, M. (2011). Guidelines for Metocean Data Analysis. *Proceedings of the Twenty-first International Offshore and Polar Engineering Conference*, 20-25 June 2010. Beijing, China.

Vanem, E. (2016). Joint Statistical Models for Significant Wave Height and Wave Period in A Changing Climate. *Marine Structures,* 49, 180-205.

Vanem, E. (2017). A Regional Extreme Value Analysis of Ocean Waves in a Changing Climate. *Ocean Engineering,* 144, 277-295.

Vanem, E., Fazeres-Ferradosa, T., Rosa-Santos, P., and Taveira-Pinto, F. (2019). Statistical Description and Modelling of Extreme Ocean Wave Conditions. *Proceedings of the Institution of Civil Engineers-Maritime Engineering,* 172(4), 124-132.

Varela, J. M., and Soares, C. G. (2013). Ring Discretization of the Wave Spectrum for Sea Surface Simulation. *IEEE computer graphics and applications,* 34(2), 58-71.

Veletsos, A. S., and Ventura, C. E. (1985). Dynamic Analysis of Structures by The DFT Method. *Journal of structural engineering,* 111(12), 2625-2642.

Venugopal, V., Varyani, K., and Westlake, P. (2009). Drag and Inertia Coefficients for Horizontally Submerged Rectangular Cylinders in Waves and Currents. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment*, 223(1), 121-136.

Videiro, P. M., and Sagrilo, L. V. S. (2017). Efficient Evaluation of Long-Term Response for Design of Components of Offshore Structures. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering,* 25–30 June 2017. Trondheim, Norway.

Vigsø, M., Brincker, R., and Georgakis, C. T. (2019). Identifying Wave Loads During Random Seas Using Structural Response. *Proceedings of the 29th International Ocean and Polar Engineering Conference*, 16–21 June 2019. Honolulu, Hawaii, USA.

Vikebø, F., Furevik, T., Furnes, G., Kvamstø, N. G., and Reistad, M. (2003). Wave Height Variations in the North Sea and on the Norwegian Continental Shelf, 1881–1999. *Continental Shelf Research,* 23(3-4), 251-263.

Wahl, T., Haigh, I. D., Nicholls, R. J., Arns, A., Dangendorf, S., Hinkel, J., et al. (2017). Understanding Extreme Sea Levels for Broad-Scale Coastal Impact and Adaptation Analysis. *Nature communications,* 8, 16075.

Walker, J. S. (2017). *Fast Fourier Transforms*: CRC press.

Wang, Y., and Xia, Y. (2012). Simulating Mixed Sea State Waves for Marine Design. *Applied Ocean Research,* 37, 33-44.

Wang, Y., Mallahzadeh, H., Abu Husain, M. K., Mohd Zaki, N. I., and Najafian, G. (2013). Probabilistic Modelling of Extreme Offshore Structural Response Due to Random Wave Loading. *Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering*, 9–14 June 2013. Nantes, France, V02BT02A007 (006 pages).

Wang, Y.-g. (2016). Prediction of Short-Term Distributions of Load Extremes of Offshore Wind Turbines. *China Ocean Engineering,* 30(6), 851-866.

Wang, Y., Wei, W., and Xiang, J. (2017). Multipoint Interpolated DFT for Sine Waves in Short Records with DC Components. *Signal Processing,* 131, 161-170.

Wang, Y., Liu, Y., Mao, X., Chi, Y., and Jiang, W. (2019). Long-Term Variation of Storm Surge-Associated Waves in The Bohai Sea. *Journal of Oceanology and Limnology,* 37(6), 1868-1878.

Wei, K., Liu, Q., and Qin, S. (2019). Nonlinear Assessment of Offshore Steel Trestle Subjected to Wave and Current Loads. *Ships and Offshore Structures*, 1-13.

Welc, J., and Esquerdo, P. J. R. (2018). Basics of Regression Models. In *Applied Regression Analysis for Business* (pp. 1-6): Springer.

Whitley, E., and Ball, J. (2002). Statistics Review 2: Samples and Populations. *Critical Care,* 6(2), 143.

Wolfram, J. (1999). On Alternative Approaches to Linearization and Morison's Equation for Wave Forces. *Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences,* 455(1988), 2957-2974.

Wouts, M., van der Graaf, J., and Vrouwenvelder, A. (1988, 16–19 October 1988). Fatigue Reliability Analyses of Fixed Offshore Structures. *European Petroleum Conference*, London, United Kingdom.

Wu, S. C. (1976). The Effects of Current On Dynamic Response of Offshore Platforms. *Offshore Technology Conference*, 2-5 May 1976. Houston, Texas.

Wu, Y., Randell, D., Christou, M., Ewans, K., and Jonathan, P. (2016). On The Distribution of Wave Height in Shallow Water. *Coastal Engineering,* 111, 39-49.

Xia, J., Wang, Z., and Jensen, J. J. (1998). Non-linear wave loads and ship responses by a time-domain strip theory. *Marine structures*, 11(3), 101-123.

Xie, B., Ren, X., Jia, X., and Li, Z. (2019). Research on Ocean Wave Spectrum and Parameter Statistics in the Northern South China Sea. *Proceedings of the Offshore Technology Conference*, 6–9 May 2019. Houston, Texas.

Yamaguchi, A., and Ishihara, T. (2018). Numerical Prediction of Normal and Extreme Waves at Fukushima Offshore Site. *Journal of Physics: Conference Series,* 1037(4), 042022.

Yim, S. C., Osborne, A. R., and Mohtat, A. (2017). Nonlinear Ocean Wave Models and Laboratory Simulation of High Seastates and Rogue Waves. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering*, 25–30 June 2017. Trondheim, Norway.

Young, I. R. (2020). *Wind-Generated Ocean Waves* (1st ed. Vol. 2). Oxford, UK: Elsevier.

Yu, L.-C., King, L.-S., Hoon, A. T.-C., and Yean, P. C.-C. (2015). A Review Study of Oil and Gas Facilities for Fixed and Floating Offshore Platforms. *Research Journal of Applied Sciences, Engineering and Technology,* 10(6), 672-679.

Yu, S. (2018). *Ocean Wave Simulation and Prediction.* Master Thesis, Virginia Polytechnic Institute and State University.

Zakikhani, K., Nasiri, F., and Zayed, T. (2020). A Review of Failure Prediction Models for Oil and Gas Pipelines. *Journal of Pipeline Systems Engineering and Practice*, 11(1), 03119001.

Zeinoddini, M., Golpour, H., Khalili, H., Matin Nikoo, H., and Ahmadi, I. (2017). Sensitivity Analysis of Selected Random Variables of Existing Offshore Jacket Structures in Persian Gulf. *International Journal of Coastal and Offshore Engineering,* 5, 7-16.

Zhang, J., Randall, R., and Spell, C. (1991). On Wave Kinematics Approximate Methods. *Proceedings of the Offshore Technology Conference*.

Zhang, X., Simons, R., and Buldakov, E. (2016). A Numerical Study of Wave-Current Interaction in The Bottom Boundary Layer. *Proceedings of 35th International Conference on Coastal Engineering*, 17-20 November 2016. Antalya, Turkey.

Zhang, J., Benoit, M., Kimmoun, O., Chabchoub, A., and Hsu, H.-C. (2019). Statistics of Extreme Waves in Coastal Waters: Large Scale Experiments and Advanced Numerical Simulations. *Fluids*, 4(2), 99.

Zhao, Y., Dong, S., Jiang, F., and Soares, C. G. (2020). System Reliability Analysis of an Offshore Jacket Platform. *Journal of Ocean University of China,* 19(1), 47-59.

Zheng, X., and Liaw, C. (2004). Response Cumulant Analysis of a Linear Oscillator Driven by Morison Force. *Applied Ocean Research,* 26(3-4), 154-161.

Zheng, X. Y., Moan, T., and Quek, S. T. (2006). Numerical Simulation of Non-Gaussian Wave Elevation and Kinematics Based on Two-Dimensional Fourier Transform. *Proceedings of the 25th International Conference on Offshore Mechanics and Arctic Engineering*, 4–9 June 2006. Hamburg, Germany, 7-16.

Zhou, C., Zheng, J., Zhang, J., and Fu, X. (2017). Study on the Extreme High Water Levels and Wave Heights of Different Return Periods in Laizhou Bay, China. *Proceedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering*, 25–30 June 2017. Trondheim, Norway.

Ziegler, L. S. (2015). *Probabilistic Estimation of Fatigue Loads on Monopile-based Offshore Wind Turbines.* Master Thesis, Norwegian University of Science and Technology.

Ziegler, L., Voormeeren, S., Schafhirt, S., and Muskulus, M. (2016). Design Clustering of Offshore Wind Turbines Using Probabilistic Fatigue Load Estimation. *Renewable Energy,* 91, 425-433.

Zou, K. H., Tuncali, K., and Silverman, S. G. (2003). Correlation and Simple Linear Regression. *Radiology,* 227(3), 617-628.

Appendix A   Structural Data

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%basic_hse_structural_data_2004

%'EXPLANATION :  All the units are metric, except mass and force '
%'which are in terms of tonnes (1000Kg) and KN, respectively.'
%Note that the lower frequency limit must be greater than zero

%basic_hse_structural_data
global global_gravitational_constant global_water_depth global_WLW global_WUW
global global_segment_length global_frequency_interpolation_interval ...
       global_upper_frequency_limit_for_frequency_spectrum_plot

global_upper_frequency_limit_for_frequency_spectrum_plot = 0.50;         %Hz
global_frequency_interpolation_interval                  = 0.005;        %Hz
global_gravitational_constant                            = 9.806;        %m/s^2
global_segment_length                                    = 2^0*1024;
wave_kinematics_factor                                   = 0.95;

gnrlsd_stiffness_2      = [98.60 105.56 1210.25 4446.75 3382.74 3070.13 2510.56 20061.60 2489.89 4728.80];  %MN/m
gnrlsd_stiffness_5      = [23.81 33.86 96.80 1326.71 489.09 813.09 247.26 457.23 369.68 694.73];             %MN/m
gnrlsd_stiffness_8      = [10.02 15.78 29.09 1105.56 77.43 206.18 135.93 179.16 153.46 235.70];              %MN/m

natural_frequency_2     = [0.39571 0.41085 1.4202 2.6819 4.7498 5.2018 10.358 10.5 11.067 11.83];            %(Hz)
natural_frequency_5     = [0.19188 0.2301 0.40378 1.4328 2.1338 2.2316 3.4498 3.783 4.2302 6.4227];          %(Hz)
natural_frequency_8     = [0.12311 0.15506 0.22128 1.3075 1.6478 1.8101 2.1169 2.1187 2.487 3.7176];         %(Hz)

damping_ratio           = [0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05];

%coeffs of generalized responses to derive particular responses
%coef_modal_amp          = [1   0.012 1 1 1 1 1 1 1 1    %first particular response
%                           1   0.012 1 1 1 1 1 1 1 1];   %second particular response
impulse_method          = 'definition';  %choose between 'definition' and 'DFT'
```

```
cylinder_surface        = 'Rough';   %Choose 'Smooth', 'Rough', 'Drag'(Cd=.7&Cm=0.0) or 'Inertia' (cm=1.7)
simulation_type         = 'NSA';     %'DSA' or 'NSA' for deterministic or non-deterministic amplitude type
x_surface_elevation     = 0.1;       %simulate surface elevation at this reference point (meter)
twosided_fr_spctrm_lngth= 2^11;      %No. of data points of the two-sided frequency spectra
impulse_response_length = 2^10;      %No. of impulse response function data points
global_water_depth      = 110.0;     %meter
NM                      = 120;       %No. of members (nodal forces) which receive wave load
NRV                     = 2;         %No. of reponse variables
NMD                     = 10;        %No. of modal responses
RHOW                    = 1.025;     %(1000 kgs/cubic meter)
global_WLW              = 0.100;     %Lower frequency limit ratio; take 0.1 for Pierson-Moskowitz spectrum
global_WUW              = 8.00;      %Upper frequency limit ratio; take 8.0 for Pierson-Moskowitz spectrum
COEF                    = 1.00;      %Horizontal coordinate scaling coefficient

predominat_wave_direction = 0;       %predominant wave direction in degrees
number_of_angle_intervals = 2*16;    %Number of angle intervals for directional seas; must be an even number
coef_n                    = 4;       %the spreading function coeficient for directional seas; normally equal to 4

%Z: vertical elevation of nodal points is measured from seabed and is positive upwards

%  (1)      (2)      (3)        (4)        (5)        (6)         (7)     (8)      (9)
% Node NO    X        Y          Z      node_below  node_above  DIAMETER  CD       CM
MATRIX_A = ...
   [1     -19.0    -17.5       0.0         1          2          1.5     1.05     1.20
    2     -19.0    -17.5       8.0         1          9          1.5     1.05     1.20
    3      19.0    -17.5       0.0         3          4          1.5     1.05     1.20
    4      19.0    -17.5       8.0         3         10          1.5     1.05     1.20
    5      19.0     17.5       0.0         5          6          1.5     1.05     1.20
    6      19.0     17.5       8.0         5         11          1.5     1.05     1.20
    7     -19.0     17.5       0.0         7          8          1.5     1.05     1.20
    8     -19.0     17.5       8.0         7         12          1.5     1.05     1.20
    9     -19.0    -17.5      16.0         2         13          1.5     1.05     1.20
   10      19.0    -17.5      16.0         4         14          1.5     1.05     1.20
   11      19.0     17.5      16.0         6         15          1.5     1.05     1.20
   12     -19.0     17.5      16.0         8         16          1.5     1.05     1.20
```

```
13     -19.0     -17.5     24.0         9          17          1.5     1.05      1.20
14      19.0     -17.5     24.0        10          18          1.5     1.05      1.20
15      19.0      17.5     24.0        11          19          1.5     1.05      1.20
16     -19.0      17.5     24.0        12          20          1.5     1.05      1.20
17     -19.0     -17.5     32.0        13          21          1.5     1.05      1.20
18      19.0     -17.5     32.0        14          22          1.5     1.05      1.20
19      19.0      17.5     32.0        15          23          1.5     1.05      1.20
20     -19.0      17.5     32.0        16          24          1.5     1.05      1.20
21     -19.0     -17.5     39.0        17          25          1.5     1.05      1.20
22      19.0     -17.5     39.0        18          26          1.5     1.05      1.20
23      19.0      17.5     39.0        19          27          1.5     1.05      1.20
24     -19.0      17.5     39.0        20          28          1.5     1.05      1.20
25     -19.0     -17.5     46.0        21          29          1.5     1.05      1.20
26      19.0     -17.5     46.0        22          30          1.5     1.05      1.20
27      19.0      17.5     46.0        23          31          1.5     1.05      1.20
28     -19.0      17.5     46.0        24          32          1.5     1.05      1.20
29     -19.0     -17.5     53.0        25          33          1.5     1.05      1.20
30      19.0     -17.5     53.0        26          34          1.5     1.05      1.20
31      19.0      17.5     53.0        27          35          1.5     1.05      1.20
32     -19.0      17.5     53.0        28          36          1.5     1.05      1.20
33     -19.0     -17.5     60.0        29          37          1.5     1.05      1.20
34      19.0     -17.5     60.0        30          38          1.5     1.05      1.20
35      19.0      17.5     60.0        31          39          1.5     1.05      1.20
36     -19.0      17.5     60.0        32          40          1.5     1.05      1.20
37     -19.0     -17.5     67.0        33          41          1.5     1.05      1.20
38      19.0     -17.5     67.0        34          42          1.5     1.05      1.20
39      19.0      17.5     67.0        35          43          1.5     1.05      1.20
40     -19.0      17.5     67.0        36          44          1.5     1.05      1.20
41     -19.0     -17.5     74.0        37          45          1.5     1.05      1.20
42      19.0     -17.5     74.0        38          46          1.5     1.05      1.20
43      19.0      17.5     74.0        39          47          1.5     1.05      1.20
44     -19.0      17.5     74.0        40          48          1.5     1.05      1.20
45     -19.0     -17.5     79.0        41          49          1.5     1.05      1.20
46      19.0     -17.5     79.0        42          50          1.5     1.05      1.20
47      19.0      17.5     79.0        43          51          1.5     1.05      1.20
48     -19.0      17.5     79.0        44          52          1.5     1.05      1.20
```

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49     -19.0     -17.5      84.0         45          53          1.5     1.05      1.20
50      19.0     -17.5      84.0         46          54          1.5     1.05      1.20
51      19.0      17.5      84.0         47          55          1.5     1.05      1.20
52     -19.0      17.5      84.0         48          56          1.5     1.05      1.20
53     -19.0     -17.5      88.0         49          57          1.5     1.05      1.20
54      19.0     -17.5      88.0         50          58          1.5     1.05      1.20
55      19.0      17.5      88.0         51          59          1.5     1.05      1.20
56     -19.0      17.5      88.0         52          60          1.5     1.05      1.20
57     -19.0     -17.5      93.0         53          61          1.5     1.05      1.20
58      19.0     -17.5      93.0         54          62          1.5     1.05      1.20
59      19.0      17.5      93.0         55          63          1.5     1.05      1.20
60     -19.0      17.5      93.0         56          64          1.5     1.05      1.20
61     -19.0     -17.5      98.0         57          65          1.5     1.05      1.20
62      19.0     -17.5      98.0         58          66          1.5     1.05      1.20
63      19.0      17.5      98.0         59          67          1.5     1.05      1.20
64     -19.0      17.5      98.0         60          68          1.5     1.05      1.20
65     -19.0     -17.5     102.0         61          69          1.5     1.05      1.20
66      19.0     -17.5     102.0         62          70          1.5     1.05      1.20
67      19.0      17.5     102.0         63          71          1.5     1.05      1.20
68     -19.0      17.5     102.0         64          72          1.5     1.05      1.20
69     -19.0     -17.5     105.0         65          73          1.5     1.05      1.20
70      19.0     -17.5     105.0         66          74          1.5     1.05      1.20
71      19.0      17.5     105.0         67          75          1.5     1.05      1.20
72     -19.0      17.5     105.0         68          76          1.5     1.05      1.20
73     -19.0     -17.5     108.0         69          77          1.5     1.05      1.20
74      19.0     -17.5     108.0         70          78          1.5     1.05      1.20
75      19.0      17.5     108.0         71          79          1.5     1.05      1.20
76     -19.0      17.5     108.0         72          80          1.5     1.05      1.20
77     -19.0     -17.5     110.0         73          81          1.5     1.05      1.20
78      19.0     -17.5     110.0         74          82          1.5     1.05      1.20
79      19.0      17.5     110.0         75          83          1.5     1.05      1.20
80     -19.0      17.5     110.0         76          84          1.5     1.05      1.20
81     -19.0     -17.5     112.0         77          85          1.5     1.05      1.20
82      19.0     -17.5     112.0         78          86          1.5     1.05      1.20
83      19.0      17.5     112.0         79          87          1.5     1.05      1.20
84     -19.0      17.5     112.0         80          88          1.5     1.05      1.20
```

```
  85     -19.0     -17.5     114.0         81          89         1.5     1.05      1.20
  86      19.0     -17.5     114.0         82          90         1.5     1.05      1.20
  87      19.0      17.5     114.0         83          91         1.5     1.05      1.20
  88     -19.0      17.5     114.0         84          92         1.5     1.05      1.20
  89     -19.0     -17.5     116.0         85          93         1.5     1.05      1.20
  90      19.0     -17.5     116.0         86          94         1.5     1.05      1.20
  91      19.0      17.5     116.0         87          95         1.5     1.05      1.20
  92     -19.0      17.5     116.0         88          96         1.5     1.05      1.20
  93     -19.0     -17.5     118.0         89          97         1.5     1.05      1.20
  94      19.0     -17.5     118.0         90          98         1.5     1.05      1.20
  95      19.0      17.5     118.0         91          99         1.5     1.05      1.20
  96     -19.0      17.5     118.0         92         100         1.5     1.05      1.20
  97     -19.0     -17.5     120.0         93         101         1.5     1.05      1.20
  98      19.0     -17.5     120.0         94         102         1.5     1.05      1.20
  99      19.0      17.5     120.0         95         103         1.5     1.05      1.20
 100     -19.0      17.5     120.0         96         104         1.5     1.05      1.20
 101     -19.0     -17.5     122.0         97         105         1.5     1.05      1.20
 102      19.0     -17.5     122.0         98         106         1.5     1.05      1.20
 103      19.0      17.5     122.0         99         107         1.5     1.05      1.20
 104     -19.0      17.5     122.0        100         108         1.5     1.05      1.20
 105     -19.0     -17.5     124.0        101         109         1.5     1.05      1.20
 106      19.0     -17.5     124.0        102         110         1.5     1.05      1.20
 107      19.0      17.5     124.0        103         111         1.5     1.05      1.20
 108     -19.0      17.5     124.0        104         112         1.5     1.05      1.20
 109     -19.0     -17.5     126.0        105         113         1.5     1.05      1.20
 110      19.0     -17.5     126.0        106         114         1.5     1.05      1.20
 111      19.0      17.5     126.0        107         115         1.5     1.05      1.20
 112     -19.0      17.5     126.0        108         116         1.5     1.05      1.20
 113     -19.0     -17.5     128.0        109         117         1.5     1.05      1.20
 114      19.0     -17.5     128.0        110         118         1.5     1.05      1.20
 115      19.0      17.5     128.0        111         119         1.5     1.05      1.20
 116     -19.0      17.5     128.0        112         120         1.5     1.05      1.20
 117     -19.0     -17.5     130.0        113         117         1.5     1.05      1.20
 118      19.0     -17.5     130.0        114         118         1.5     1.05      1.20
 119      19.0      17.5     130.0        115         119         1.5     1.05      1.20
 120     -19.0      17.5     130.0        116         120         1.5     1.05      1.20
```

```
   121        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   122        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   123        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   124        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   125        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   126        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   127        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   128        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   129        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   130        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   131        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   132        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   133      -19.0      -17.5      135.0      132.5        67.5           1.5     1.05     1.20
   134       19.0      -17.5      135.0      132.5        67.5           1.5     1.05     1.20
   135      -19.0       17.5      135.0      132.5        67.5           1.5     1.05     1.20
   136       19.0       17.5      135.0      132.5         0.0           1.5     1.05     1.20
   137        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   138        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   139        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   140        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   141        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   142        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   143        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   144        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   145        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20
   146        0.0        0.0        0.0        0.0         0.0           1.5     1.05     1.20];

% NODAL FLEXIBILITY COEFFICIENTS FOR THE FOLLOWING RESPONSES

% NODE No.  BASE     OVERTURNING
%           SHEAR     MOMENT
MATRIX_B = ...
   [1       1.0        0.0
    2       1.0        8.0
    3       1.0        0.0
```

```
 4       1.0        8.0
 5       1.0        0.0
 6       1.0        8.0
 7       1.0        0.0
 8       1.0        8.0
 9       1.0       16.0
10       1.0       16.0
11       1.0       16.0
12       1.0       16.0
13       1.0       24.0
14       1.0       24.0
15       1.0       24.0
16       1.0       24.0
17       1.0       32.0
18       1.0       32.0
19       1.0       32.0
20       1.0       32.0
21       1.0       39.0
22       1.0       39.0
23       1.0       39.0
24       1.0       39.0
25       1.0       46.0
26       1.0       46.0
27       1.0       46.0
28       1.0       46.0
29       1.0       53.0
30       1.0       53.0
31       1.0       53.0
32       1.0       53.0
33       1.0       60.0
34       1.0       60.0
35       1.0       60.0
36       1.0       60.0
37       1.0       67.0
38       1.0       67.0
39       1.0       67.0
```

```
40       1.0      67.0
41       1.0      74.0
42       1.0      74.0
43       1.0      74.0
44       1.0      74.0
45       1.0      79.0
46       1.0      79.0
47       1.0      79.0
48       1.0      79.0
49       1.0      84.0
50       1.0      84.0
51       1.0      84.0
52       1.0      84.0
53       1.0      88.0
54       1.0      88.0
55       1.0      88.0
56       1.0      88.0
57       1.0      93.0
58       1.0      93.0
59       1.0      93.0
60       1.0      93.0
61       1.0      98.0
62       1.0      98.0
63       1.0      98.0
64       1.0      98.0
65       1.0     102.0
66       1.0     102.0
67       1.0     102.0
68       1.0     102.0
69       1.0     105.0
70       1.0     105.0
71       1.0     105.0
72       1.0     105.0
73       1.0     108.0
74       1.0     108.0
75       1.0     108.0
```

```
 76       1.0     108.0
 77       1.0     110.0
 78       1.0     110.0
 79       1.0     110.0
 80       1.0     110.0
 81       1.0     112.0
 82       1.0     112.0
 83       1.0     112.0
 84       1.0     112.0
 85       1.0     114.0
 86       1.0     114.0
 87       1.0     114.0
 88       1.0     114.0
 89       1.0     116.0
 90       1.0     116.0
 91       1.0     116.0
 92       1.0     116.0
 93       1.0     118.0
 94       1.0     118.0
 95       1.0     118.0
 96       1.0     118.0
 97       1.0     120.0
 98       1.0     120.0
 99       1.0     120.0
100       1.0     120.0
101       1.0     122.0
102       1.0     122.0
103       1.0     122.0
104       1.0     122.0
105       1.0     124.0
106       1.0     124.0
107       1.0     124.0
108       1.0     124.0
109       1.0     126.0
110       1.0     126.0
111       1.0     126.0
```

```
112       1.0    126.0
113       1.0    128.0
114       1.0    128.0
115       1.0    128.0
116       1.0    128.0
117       1.0    130.0
118       1.0    130.0
119       1.0    130.0
120       1.0    130.0
121       1.0      0.0
122       1.0      0.0
123       1.0      0.0
124       1.0      0.0
125       1.0      0.0
126       1.0      0.0
127       1.0      0.0
128       1.0      0.0
129       1.0      0.0
130       1.0      0.0
131       1.0      0.0
132       1.0      0.0
133       1.0    135.0
134       1.0    135.0
135       1.0    135.0
136       1.0    135.0
137       1.0      0.0
138       1.0      0.0
139       1.0      0.0
140       1.0      0.0
141       1.0      0.0
142       1.0      0.0
143       1.0      0.0
144       1.0      0.0
145       1.0      0.0
146       1.0      0.0];
```

Appendix B Correlation-*r* and *r*-squared Values for the Short-term Analysis

Table B-1 The coefficient of extreme surface elevation and their corresponding extreme responses between MCTS, ETS-R$_{SE}$ and ETS-R$_{LR}$ methods based on model development of ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ regression models for base shear quasi-static responses with Hs = 5 m, Tz = 7.95 sec and T = 128sec

a) Drag-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (*r*)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.5157	0.6241	0.9268	0.3895	0.8590
Polynomial	-	-	-	0.4250	0.8798
Cubic	-	-	-	0.4597	0.8844
Current (U = 0.0 m/s)					
Linear	0.7689	0.8837	0.9343	0.7809	0.8729
Polynomial	-	-	-	0.8179	0.8743
Cubic	-	-	-	0.8279	0.8746
Current (U = + 0.9 m/s)					
Linear	0.7182	0.8534	0.9678	0.7283	0.9366
Polynomial	-	-	-	0.7384	0.9367
Cubic	-	-	-	0.7443	0.9368

b) Inertia-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (*r*)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.5800	0.7353	0.9885	0.5407	0.9772
Polynomial	-	-	-	0.5472	0.9773
Cubic	-	-	-	0.5629	0.9775
Current (U = 0.0 m/s)					
Linear	0.6607	0.8089	0.9902	0.6543	0.9805
Polynomial	-	-	-	0.6546	0.9807
Cubic	-	-	-	0.6546	0.9809
Current (U = + 0.9 m/s)					
Linear	0.7366	0.8673	0.9930	0.7523	0.9861
Polynomial	-	-	-	0.7525	0.9862
Cubic	-	-	-	0.7534	0.9863

c) Total responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.4430	0.5851	0.9598	0.3424	0.9213
Polynomial	-	-	-	0.3708	0.9378
Cubic	-	-	-	0.3997	0.9409
Current (U = 0.0 m/s)					
Linear	0.7240	0.8444	0.9626	0.7131	0.9265
Polynomial	-	-	-	0.7360	0.9291
Cubic	-	-	-	0.7377	0.9292
Current (U = + 0.9 m/s)					
Linear	0.7377	0.8659	0.9719	0.7497	0.9446
Polynomial	-	-	-	0.7635	0.9448
Cubic	-	-	-	0.7661	0.9455

Table B-2 The coefficient of extreme surface elevation and their corresponding extreme responses between MCTS, ETS-R$_{SE}$ and ETS-R$_{LR}$ methods based on model development of ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ regression models for base shear quasi-static responses with Hs = 10 m, Tz = 11.23 sec and T = 128sec

a) Drag-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8214	0.8925	0.9462	0.7966	0.8953
Polynomial	-	-	-	0.8438	0.9011
Cubic	-	-	-	0.8461	0.9011
Current (U = 0.0 m/s)					
Linear	0.8605	0.9291	0.9884	0.8632	0.9770
Polynomial	-	-	-	0.8946	0.9772
Cubic	-	-	-	0.8946	0.9773
Current (U = + 0.9 m/s)					
Linear	0.8763	0.9433	0.9898	0.8895	0.9797
Polynomial	-	-	-	0.9129	0.9799
Cubic	-	-	-	0.9132	0.9801

b) Inertia-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8058	0.9187	0.9936	0.8440	0.9873
Polynomial	-	-	-	0.8475	0.9875
Cubic	-	-	-	0.8477	0.9877
Current (U = 0.0 m/s)					
Linear	0.8347	0.9287	0.9951	0.8625	0.9903
Polynomial	-	-	-	0.8652	0.9905
Cubic	-	-	-	0.8662	0.9909
Current (U = + 0.9 m/s)					
Linear	0.8445	0.9329	0.9965	0.8704	0.9931
Polynomial	-	-	-	0.8719	0.9934
Cubic	-	-	-	0.8728	0.9935

c) Total responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8319	0.9043	0.9649	0.8178	0.9311
Polynomial	-	-	-	0.8518	0.9423
Cubic	-	-	-	0.8524	0.9435
Current (U = 0.0 m/s)					
Linear	0.8799	0.9322	0.9891	0.9013	0.9783
Polynomial	-	-	-	0.9026	0.9786
Cubic	-	-	-	0.9178	0.9788
Current (U = + 0.9 m/s)					
Linear	0.8822	0.9444	0.9914	0.8919	0.9829
Polynomial	-	-	-	0.9108	0.9830
Cubic	-	-	-	0.9111	0.9835

Table B-3 The coefficient of extreme surface elevation and their corresponding extreme responses between MCTS, ETS-R$_{SE}$ and ETS-R$_{LR}$ methods based on model development of ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ regression models for base shear quasi-static responses with Hs = 15 m, Tz = 13.75 sec, T = 128sec

a) Drag-induced responses

Methods / Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8761	0.9145	0.9819	0.8364	0.9642
Polynomial	-	-	-	0.9119	0.9707
Cubic	-	-	-	0.9146	0.9719
Current (U = 0.0 m/s)					
Linear	0.9127	0.9393	0.9926	0.8824	0.9852
Polynomial	-	-	-	0.9252	0.9852
Cubic	-	-	-	0.9263	0.9853
Current (U = + 0.9 m/s)					
Linear	0.9302	0.9553	0.9894	0.9126	0.9788
Polynomial	-	-	-	0.9392	0.9788
Cubic	-	-	-	0.9397	0.9788

b) Inertia-induced responses

Methods / Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8475	0.9194	0.9938	0.8452	0.9876
Polynomial	-	-	-	0.8471	0.9876
Cubic	-	-	-	0.8479	0.9877
Current (U = 0.0 m/s)					
Linear	0.8507	0.9334	0.9945	0.8713	0.9890
Polynomial	-	-	-	0.8722	0.9890
Cubic	-	-	-	0.8724	0.9890
Current (U = + 0.9 m/s)					
Linear	0.8448	0.9296	0.9951	0.8642	0.9902
Polynomial	-	-	-	0.8653	0.9902
Cubic	-	-	-	0.8655	0.9903

c) Total responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8873	0.9151	0.9820	0.8375	0.9644
Polynomial	-	-	-	0.9173	0.9723
Cubic	-	-	-	0.9212	0.9741
Current (U = 0.0 m/s)					
Linear	0.9164	0.9408	0.9931	0.8851	0.9862
Polynomial	-	-	-	0.9284	0.9863
Cubic	-	-	-	0.9296	0.9864
Current (U = + 0.9 m/s)					
Linear	0.9319	0.9555	0.9903	0.9131	0.9801
Polynomial	-	-	-	0.9393	0.9806
Cubic	-	-	-	0.9399	0.9806

Table B-4 The coefficient of extreme surface elevation and their corresponding extreme responses between MCTS, ETS-R$_{SE}$ and ETS-R$_{LR}$ methods based on model development of ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ regression models for overturning moment quasi-static responses with Hs = 5 m, Tz = 7.95 sec, T = 128sec

a) Drag-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.5283	0.6298	0.9083	0.3966	0.8249
Polynomial	-	-	-	0.4551	0.8572
Cubic	-	-	-	0.4943	0.8592
Current (U = 0.0 m/s)					
Linear	0.7674	0.8838	0.9324	0.7811	0.8695
Polynomial	-	-	-	0.8201	0.8707
Cubic	-	-	-	0.8306	0.8707
Current (U = + 0.9 m/s)					
Linear	0.7439	0.8775	0.9570	0.7701	0.9159
Polynomial	-	-	-	0.7837	0.9161
Cubic	-	-	-	0.7891	0.9161

b) Inertia-induced responses

Methods Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.5580	0.7113	0.9839	0.5060	0.9681
Polynomial	-	-	-	0.5187	0.9682
Cubic	-	-	-	0.5397	0.9683
Current (U = 0.0 m/s)					
Linear	0.6437	0.7918	0.9854	0.6270	0.9711
Polynomial	-	-	-	0.6293	0.9711
Cubic	-	-	-	0.6293	0.9713
Current (U = + 0.9 m/s)					
Linear	0.7310	0.8667	0.9875	0.7512	0.9751
Polynomial	-	-	-	0.7513	0.9751
Cubic	-	-	-	0.7521	0.9755

c) Total responses

Methods Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.4346	0.5826	0.9470	0.3394	0.8968
Polynomial	-	-	-	0.3815	0.9212
Cubic	-	-	-	0.4189	0.9238
Current (U = 0.0 m/s)					
Linear	0.7126	0.8360	0.9528	0.6988	0.9078
Polynomial	-	-	-	0.7345	0.9103
Cubic	-	-	-	0.7386	0.9105
Current (U = + 0.9 m/s)					
Linear	0.7509	0.8770	0.9644	0.7692	0.9300
Polynomial	-	-	-	0.7881	0.9301
Cubic	-	-	-	0.7914	0.9310

Table B-5 The coefficient of extreme surface elevation and their corresponding extreme responses between MCTS, ETS-R$_{SE}$ and ETS-R$_{LR}$ methods based on model development of ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ regression models for overturning moment quasi-static responses with Hs = 10 m, Tz = 11.23 sec, T = 128sec

a) Drag-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8120	0.8831	0.9462	0.7799	0.8953
Polynomial	-	-	-	0.8344	0.9011
Cubic	-	-	-	0.8368	0.9011
Current (U = 0.0 m/s)					
Linear	0.8621	0.9272	0.9882	0.8597	0.9765
Polynomial	-	-	-	0.8930	0.9765
Cubic	-	-	-	0.8931	0.9770
Current (U = + 0.9 m/s)					
Linear	0.8866	0.9431	0.9884	0.8895	0.9769
Polynomial	-	-	-	0.9129	0.9770
Cubic	-	-	-	0.9132	0.9774

b) Inertia-induced responses

Methods	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
Models	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.7913	0.9048	0.9849	0.8186	0.9701
Polynomial	-	-	-	0.8228	0.9704
Cubic	-	-	-	0.8228	0.9704
Current (U = 0.0 m/s)					
Linear	0.8339	0.9239	0.9886	0.8808	0.9687
Polynomial	-	-	-	0.8570	0.9777
Cubic	-	-	-	0.8580	0.9778
Current (U = + 0.9 m/s)					
Linear	0.8544	0.9352	0.9912	0.8820	0.9684
Polynomial	-	-	-	0.8764	0.9825
Cubic	-	-	-	0.8773	0.9827

c) Total responses

Methods / Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8091	0.8773	0.9697	0.7697	0.9403
Polynomial	-	-	-	0.8146	0.9557
Cubic	-	-	-	0.8156	0.9559
Current (U = 0.0 m/s)					
Linear	0.8688	0.9233	0.9878	0.8525	0.9758
Polynomial	-	-	-	0.8819	0.9759
Cubic	-	-	-	0.8821	0.9764
Current (U = + 0.9 m/s)					
Linear	0.8888	0.9420	0.9894	0.8873	0.9788
Polynomial	-	-	-	0.9095	0.9789
Cubic	-	-	-	0.9096	0.9796

Table B-6 The coefficient of extreme surface elevation and their corresponding extreme responses between MCTS, ETS-R$_{SE}$ and ETS-R$_{LR}$ methods based on model development of ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ regression models for overturning moment quasi-static responses with Hs = 15 m, Tz = 13.75 sec, T = 128sec

a) Drag-induced responses

Methods / Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8708	0.9146	0.9885	0.9174	0.9772
Polynomial	-	-	-	0.9146	0.9794
Cubic	-	-	-	0.8365	0.9810
Current (U = 0.0 m/s)					
Linear	0.9126	0.9372	0.9919	0.8783	0.9838
Polynomial	-	-	-	0.9294	0.9838
Cubic	-	-	-	0.9307	0.9841
Current (U = + 0.9 m/s)					
Linear	0.9345	0.9548	0.9892	0.9116	0.9785
Polynomial	-	-	-	0.9463	0.9785
Cubic	-	-	-	0.9470	0.9785

b) Inertia-induced responses

Methods Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8414	0.9162	0.9851	0.8395	0.9703
Polynomial	-	-	-	0.8442	0.9704
Cubic	-	-	-	0.8449	0.9704
Current (U = 0.0 m/s)					
Linear	0.8555	0.9385	0.9842	0.8808	0.9687
Polynomial	-	-	-	0.8835	0.9688
Cubic	-	-	-	0.8835	0.9688
Current (U = + 0.9 m/s)					
Linear	0.8568	0.9392	0.9841	0.8820	0.9684
Polynomial	-	-	-	0.8851	0.9684
Cubic	-	-	-	0.8853	0.9687

c) Total responses

Methods Models	MCTS	ETS-R$_{SE}$	ETS-R$_{LR}$	ETS-Reg$_{SE}$	ETS-Reg$_{LR}$
	Coefficient of correlation (r)			Coefficient of determination (r^2)	
Current (U = - 0.9 m/s)					
Linear	0.8727	0.9128	0.9889	0.8331	0.9780
Polynomial	-	-	-	0.9161	0.9804
Cubic	-	-	-	0.9193	0.9823
Current (U = 0.0 m/s)					
Linear	0.9129	0.9376	0.9922	0.8792	0.9844
Polynomial	-	-	-	0.9304	0.9845
Cubic	-	-	-	0.9317	0.9846
Current (U = + 0.9 m/s)					
Linear	0.9347	0.9548	0.9898	0.9116	0.9794
Polynomial	-	-	-	0.9461	0.9799
Cubic	-	-	-	0.9467	0.9802

Appendix C Verification Criteria of the ETS-Regression Model

In order to define the robustness of model development, the accuracy criterion was the main part of the measurements to be considered. Accuracy expresses how closely the estimated value corresponds to its actual value of the benchmark. The accuracy in the short-term perspective needs to identify as the first measurement. It is possible to avoid inaccurate readings, which will contribute to the worse results in the long-term analysis. The guideline, as in this appendix, included in this analysis is to avoid such unexpected happen. Also, they will clarify the sign of the proposed model in good condition.

i) Confidence Intervals for Pearson's Correlation Analysis

A hypothesis assessment implies that there is merely not enough depend on the relationship only without knowing how the good model was taken into account. In this section, the proper analysis which is the scientific technique can be derived via the confidence interval (Bewick *et al.*, 2003). In order to measure the confidence interval, the distributed sample data (scatterplot) must be converted into the Gaussian distribution so as to determine the standard error using the Fisher transformation (Kirkwood and Sterne, 2010).

By this technique, the estimation on the lower and upper limits of the confidence interval could be reached by the level of 95 percentiles for the correlation coefficient. Thus, the range between these limits is used to calculate any size of sample data for obtaining a specified level of accuracy (Whitley and Ball, 2002). Once the correlation was analysed, regression analysis would be employed to determine the function for this regression line. Normally, such line is responded to as the regression model.

For this pilot test, the analysis was considered for the cases of low and high sea states without current impact based on the difference of relationship. With reference to Figure 3.19, the pattern of ETS-R_{SE} was chosen due to this relationship was the weak relationship and lowest of *r*-squared among the ETS's relationship from *Sub-*

Subsections 3.6.1.1 and *3.6.1.2*. Below is the more description in Table C-1 for the correlation and its relating regression analysis.

Table C-1 ETS-Reg$_{SE}$ standard error estimates and confidence intervals for the cases of total base shear; quasi-static, *Hs* = 5 m, *Tz* = 7.94 sec and *U* = 0 m/s

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	169.4906	169.4906	641.1766	0.0000
Residual	258	68.2005	0.2643		
Total	259	237.6912			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.4569	0.0915	15.9197	0.0000	1.2767	1.6371
Variable SE	8.1673	0.3225	25.3215	0.0000	7.5321	8.8024

Following this findings, an ETS-Reg$_{SE}$ model was applied to these two variables, which analysed based on the confident interval producing 0.3225 standard error, as shown in Figure C-1.

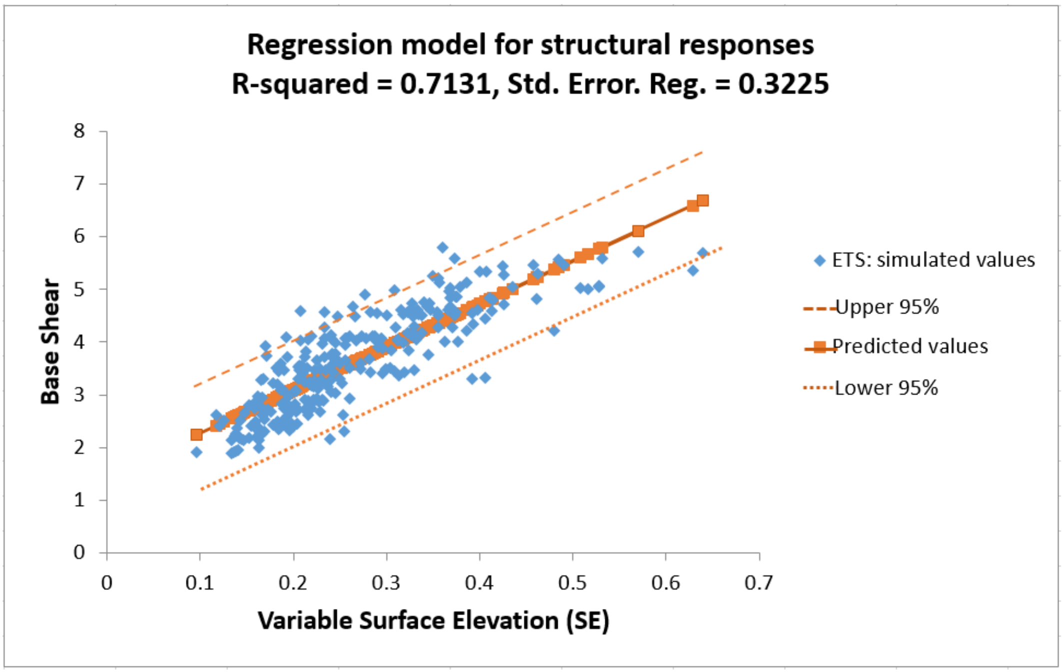
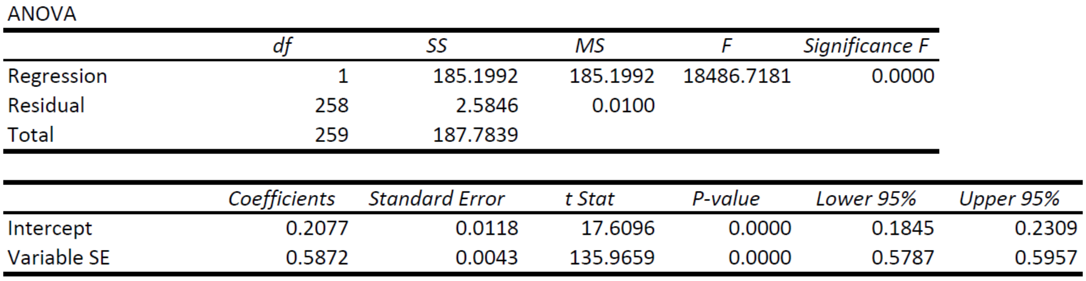


Figure C-1 The ETS-Reg$_{SE}$ model fit scatterplot related to the confidence interval

Based on the previous relationship in Figure 3.20, it demonstrate that the ETS-R$_{LR}$ was the strong relationship and the highest value of *r*-squared from the relationship based on the ETS method. Consequently, the outcome show that the smallest standard error obtained was 0.0043, as shown in Figure 2. The small error will help the model to predict the values accurately. This investigation has proven that is why the input parameter of linearised responses could reduce the minimal error, as revealed in Table C-2.

Table C-2 ETS-Reg$_{LR}$ standard error estimates and confidence intervals for the cases of total base shear; quasi-static, Hs = 15 m, Tz = 13.75 sec and U = 0 m/s



ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	185.1992	185.1992	18486.7181	0.0000
Residual	258	2.5846	0.0100		
Total	259	187.7839			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.2077	0.0118	17.6096	0.0000	0.1845	0.2309
Variable SE	0.5872	0.0043	135.9659	0.0000	0.5787	0.5957

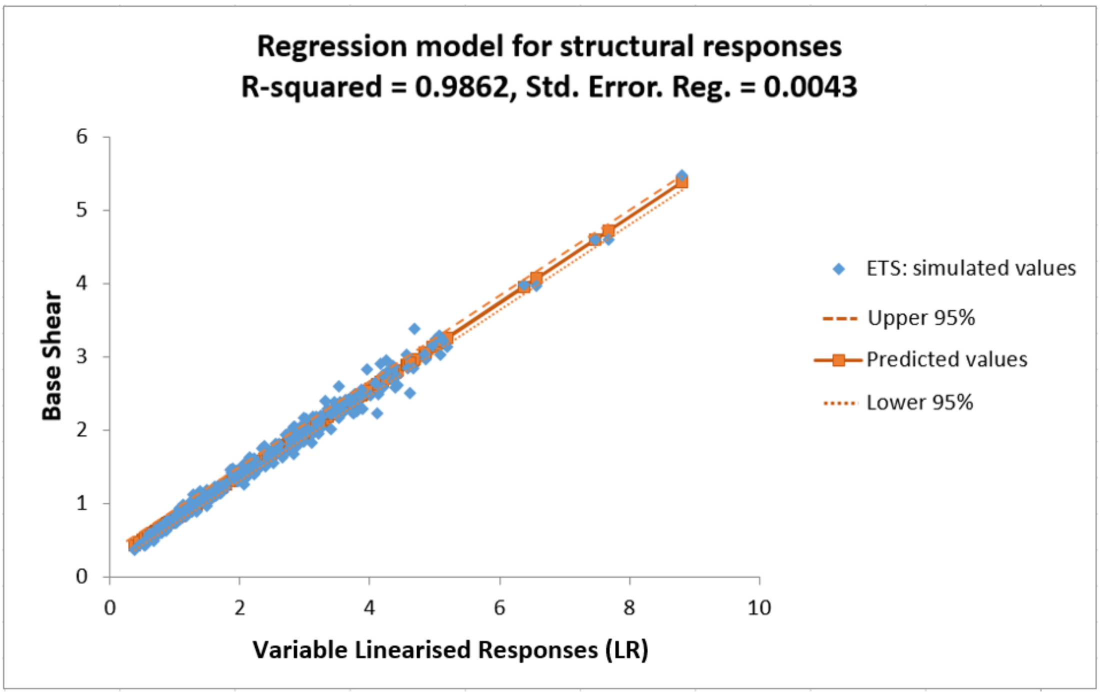


Figure C-2 The ETS-Reg$_{LR}$ model fit scatterplot related to the confidence interval

Regarding these comparison of results, the pattern of ETS-R$_{SE}$ relationship produced the wide form of scatterplot, whereas the ETS-R$_{LR}$ relationship formed the narrow (like linear) relationship. Since the ETS-R$_{LR}$ relationship possesses strong relationships, this can be viewed in residuals how the less error affected the high model accuracy. As discussed in *Chapter 2*, the improvement of the ETS-Reg$_{SE}$ model has generated a huge improvement of relationship intensity where the error in scatterplot could be minimised as much as possible. As shown in Figure C-3, the residual comparison can be seen between the ETS-Reg$_{SE}$ model and the ETS-Reg$_{LR}$ models.

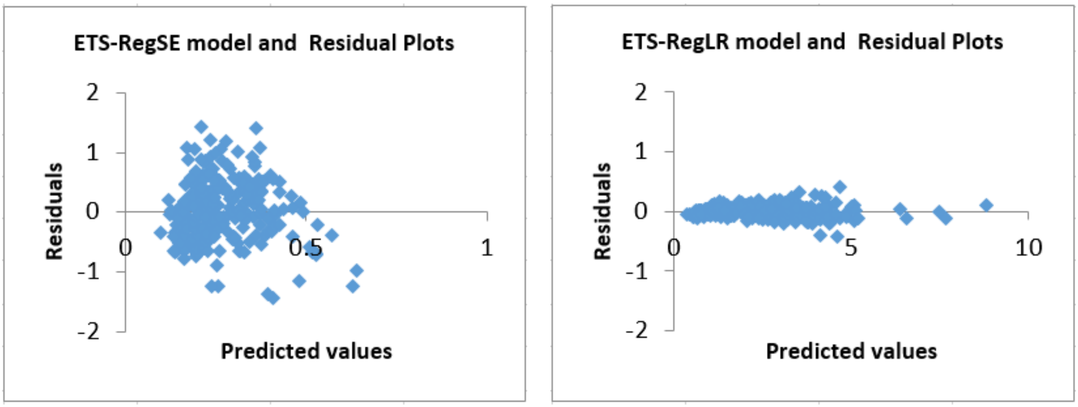
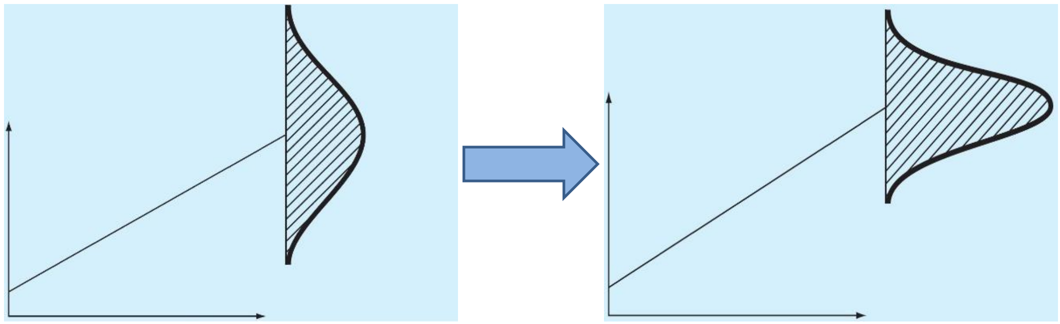


Figure C-3 Comparison the residual between ETS-Reg$_{SE}$ and ETS-Reg$_{LR}$ models related to its relationship

Regarding this preliminary analysis, the prediction of 100-year responses by ETS-Reg$_{LR}$ are better accuracy compared to ETS-Reg$_{SE}$. As expected, the improved relationship gave major impact into the model accuracy of ETS-Reg$_{LR}$ which is the most accurate result achieved due to its strength in relationship-based model development. In accordance to Table 3.6, the ETS-Reg$_{LR}$ based on cubic model is chosen for the permanent model for further studies used in completing the remaining short-term and long-term probability distribution of 100-year structural responses.

ii) Sampling Variability and Confidence Intervals



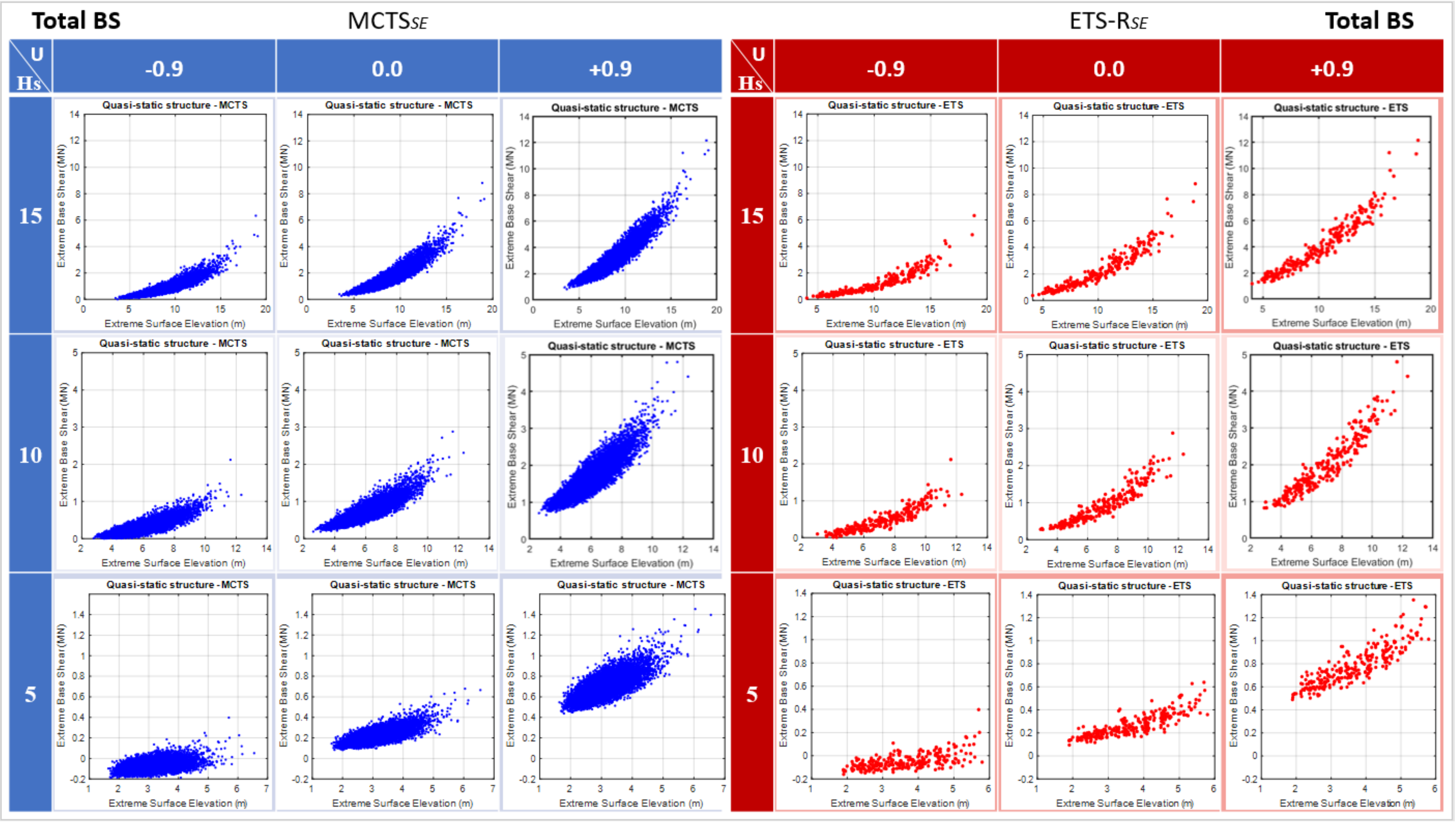
(a) Wide standard deviation

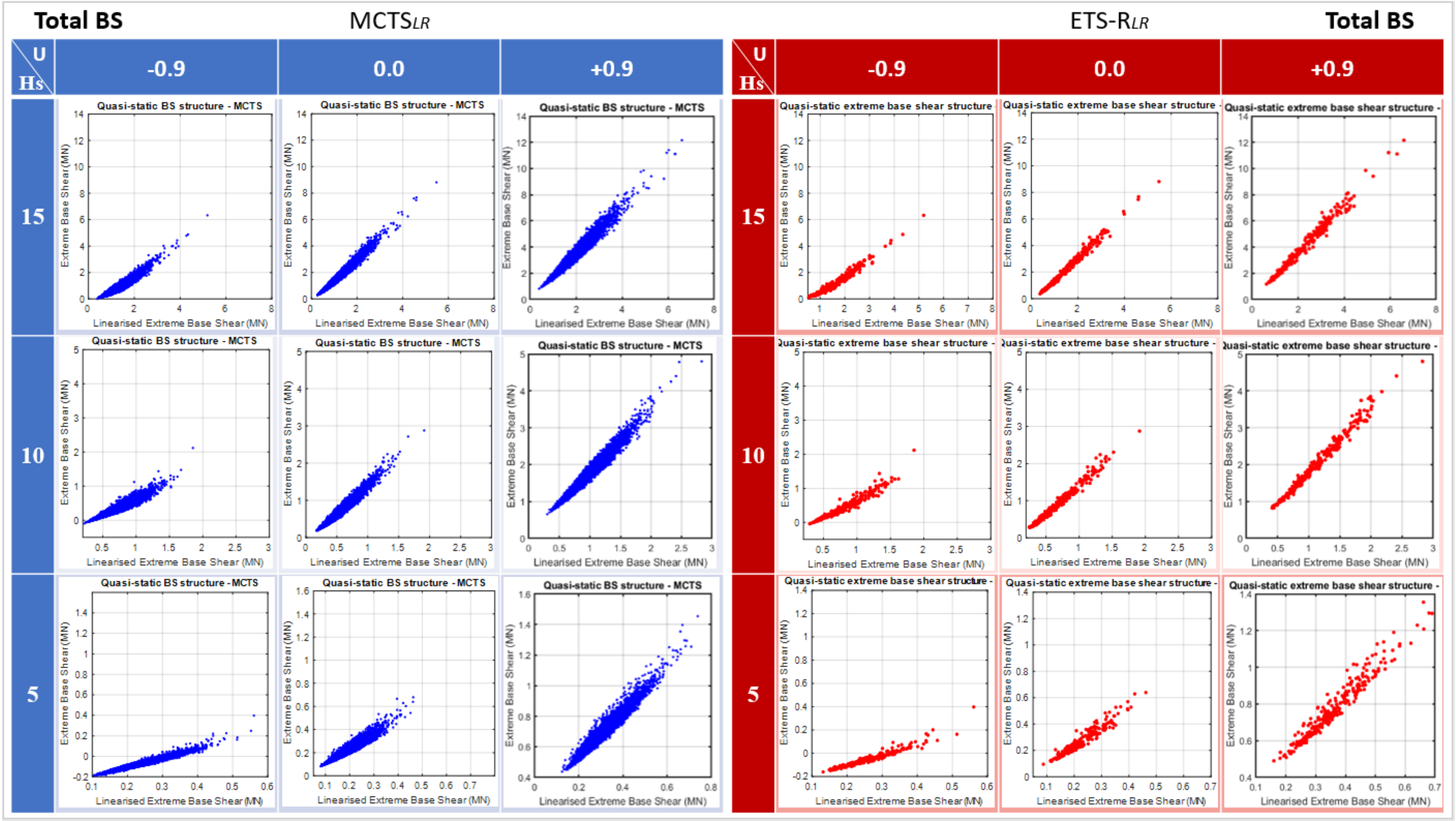
(b) Narrow standard deviation

Figure C-4 The bell-shaped curve by reduction of standard deviation from (a) to (b) seeing the improvement in accuracy

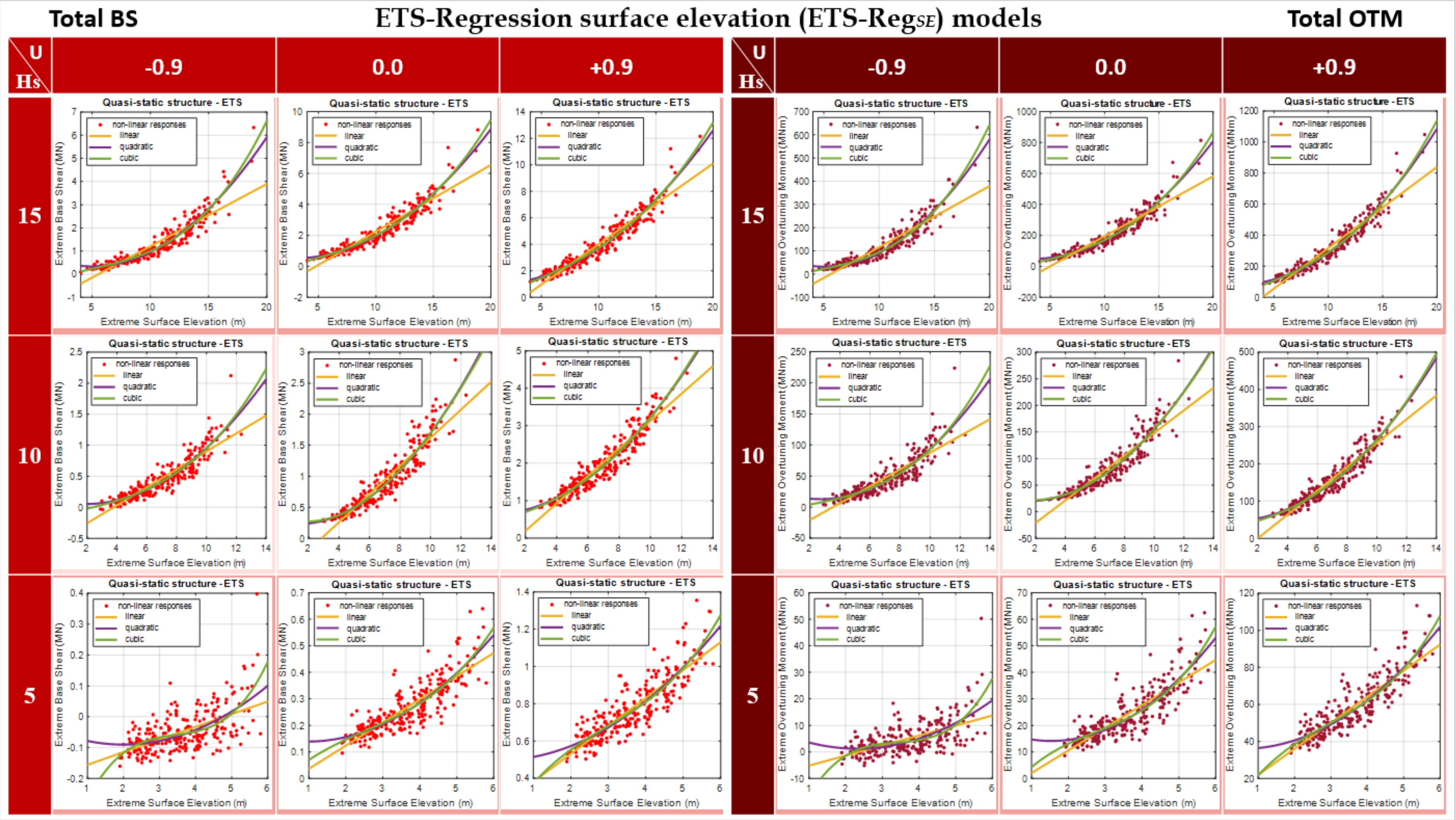
The sampling variability is referred to as the variability deriving from the sampling process. The intervals at which the sampling variability is measured are called confidence intervals. Smaller sample size or higher variability corresponds to a wider confidence interval with a larger error margin, as seen in as seen in Figure C-4(a). The confidence level also influences the width of the interval. This interval won't be as narrow if a higher level of confidence is reached. A close 95% or more confidence interval is optimal (preferable as acceptable results), as observed in Figure C-4(b).

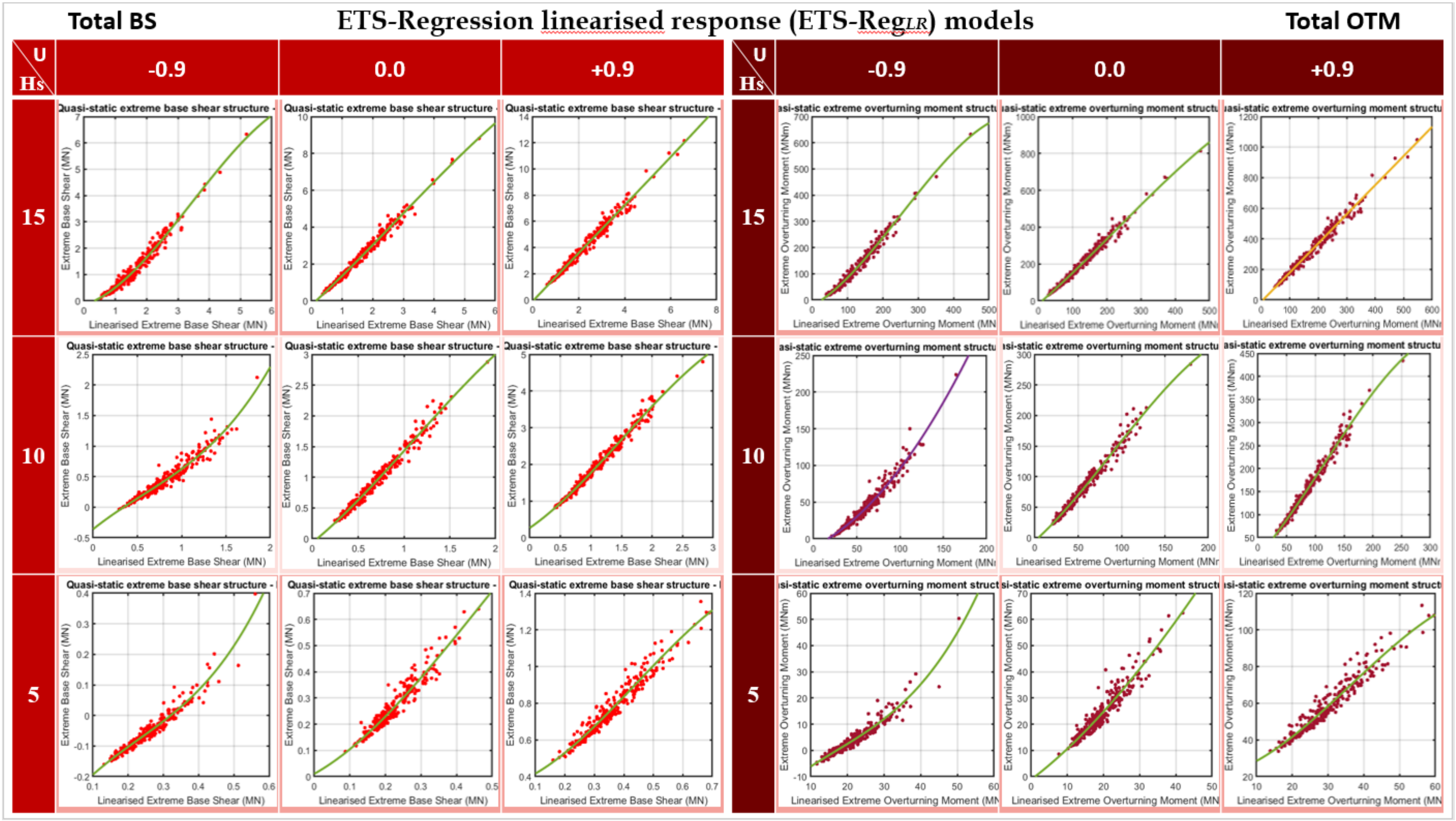
Appendix D Short-term Development of Relationship Patterns based on MCTS and ETS Procedures



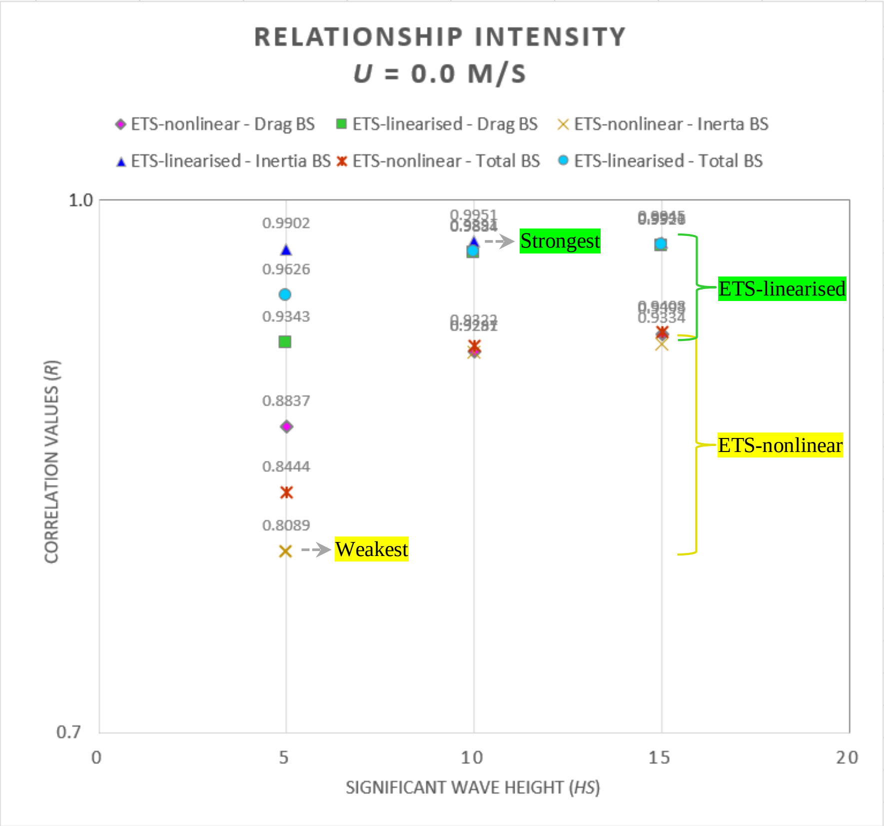

Total BS
MCTSLR
ETS-RLR
Total BS
U
Hs
-0.9
0.0
+0.9
U
Hs
-0.9
0.0
+0.9
15
10
5
15
10
5
Quasi-static BS structure - MCTS
Quasi-static extreme base shear structure -
Extreme Base Shear (MN)
Linearised Extreme Base Shear (MN)

Appendix E Short-term ETS-Regression Model Developments

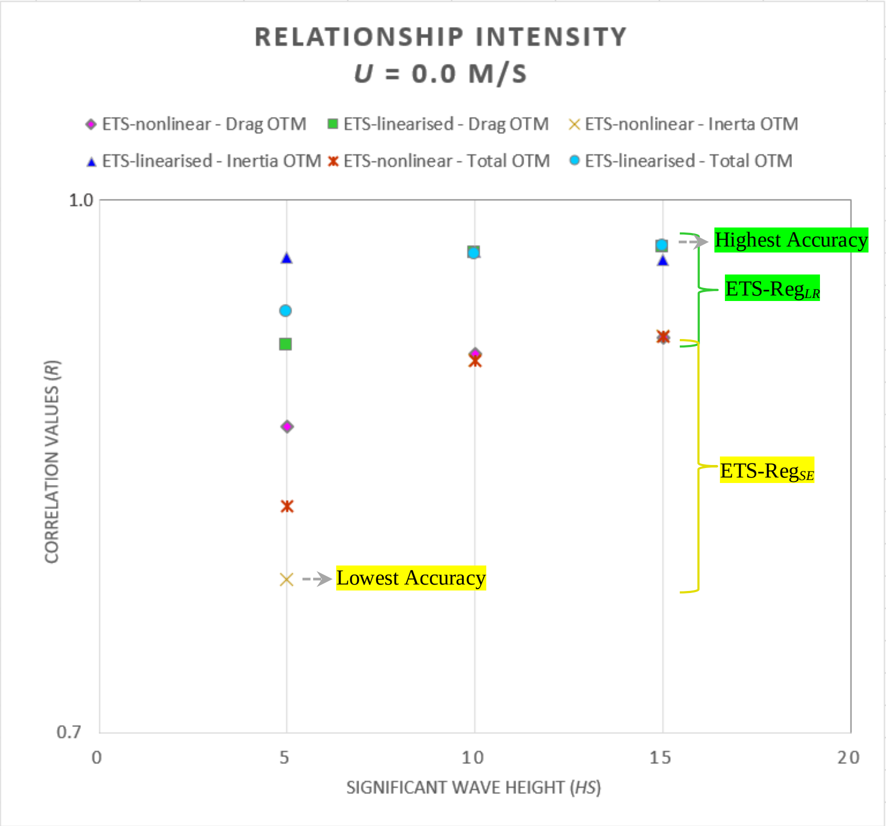



Total BS
ETS-Regression linearised response (ETS-Reg_LR) models
Total OTM
U
Hs
-0.9
0.0
+0.9
15
10
5
Quasi-static extreme base shear structure
Extreme Base Shear (MN)
Linearised Extreme Base Shear (MN)
Quasi-static extreme overturning moment structure
Extreme Overturning Moment (MNm)
Linearised Extreme Overturning Moment (MNm)

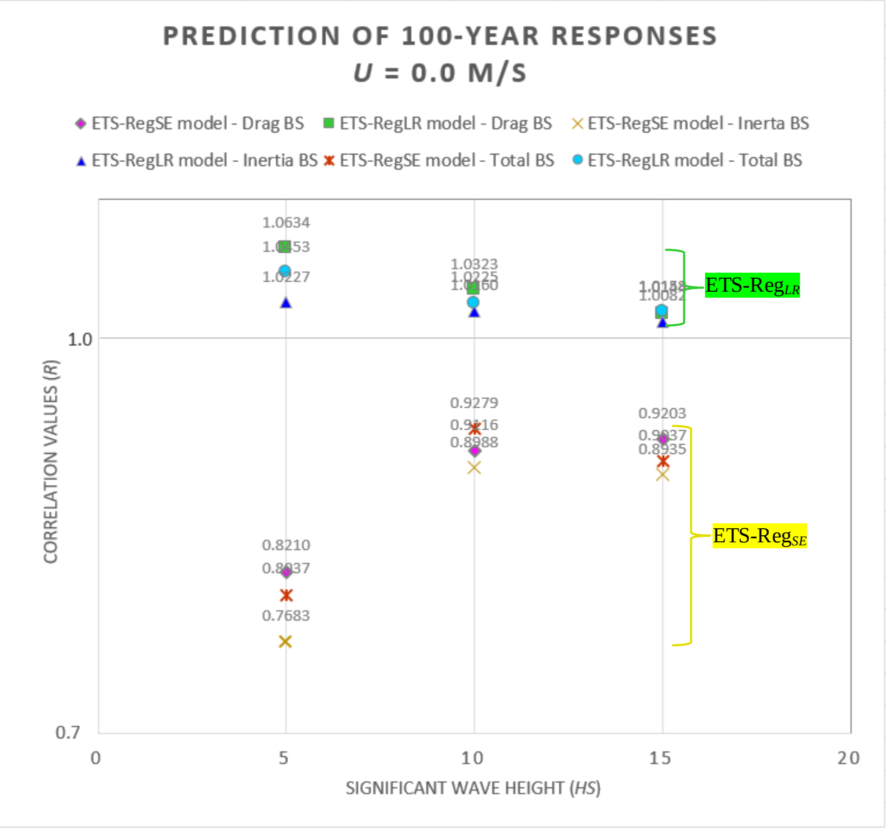
Appendix F Short-term Analysis on Relationships and its Prediction of 100-year Responses Without Current Impacts



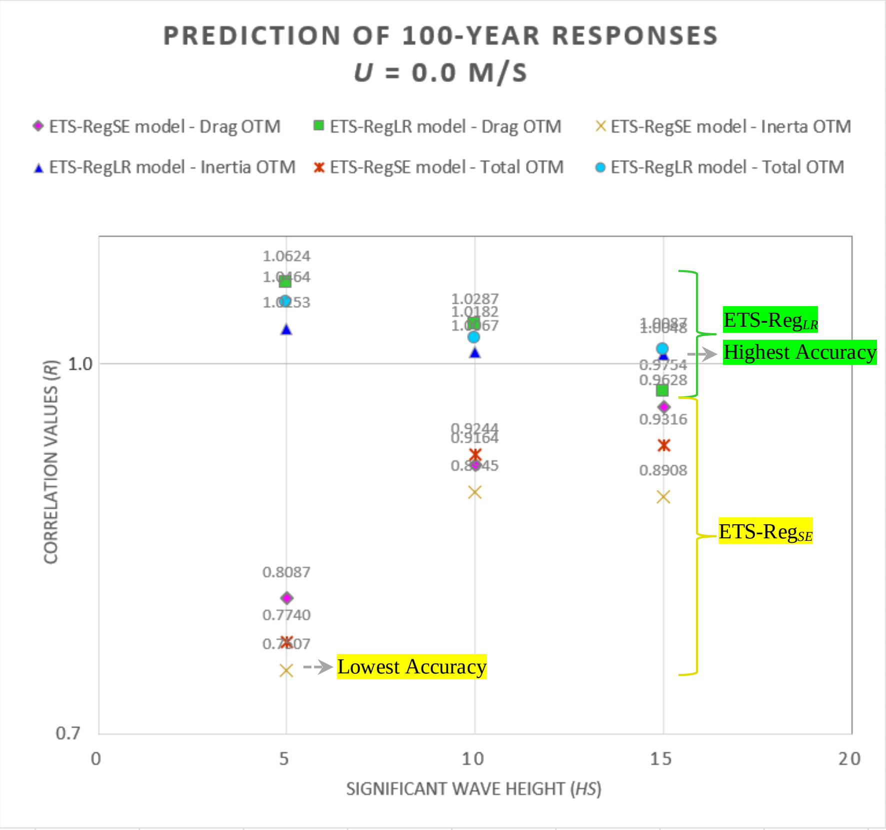
a) Relationship base shear responses



b) Relationship overturning moment responses



a) Prediction of 100-year base shear responses



b) Prediction of 100-year overturning moment responses

LIST OF PUBLICATIONS

Conference Proceedings

1. Sayyid Zainal Abidin Syed Ahmad, Mohd Khairi Abu Husain, Noor Irza Mohd Zaki, Mohd Hairil Mohd and Gholamhossein Najafian. (2018). “Comparison of Various Spectral Models for the Prediction of the 100-Year Design Wave Height”, Proceedings of International Conference on Civil, Offshore & Environmental Engineering (ICCOEE), MATEC Web of Conferences. Malaysia. Vol. 203, pp. 1-14. (Scopus indexed publication)

2. S.Z.A. Syed Ahmad, M.K. Abu Husain, N.I. Mohd Zaki, M.H. Mohd and G. Najafian. (2018). “Comparison of Various Spectral Models for 100-Year Extreme Values of Offshore Structural Response”, Proceedings of the 11th International Conference on Marine Technology (MARTEC) - Ensuring Sustainability in Marine Industry. Vol. 11, pp. 19-31. (Special issues of non-indexed proceeding)

3. S.Z.A. Syed Ahmad, M.K. Abu Husain, N.I. Mohd Zaki and M.H. Mohd and G. Najafian. (2019). “Offshore Responses using an Efficient Time Simulation Regression Procedure”, Trends in the Analysis and Design of Marine Structures: Proceedings of the 7th International Conference on Marine Structures (MARSTRUCT). (Web of Knowledge and Scopus indexed proceeding)

4. S.Z.A. Syed Ahmad, M.K. Abu Husain, N.I. Mohd Zaki and M.H. Mohd and G. Najafian. (2020). “Improvisation ETS-Regression Models by Linearisation of the Morison Equation Applied to a Fixed Offshore Platform”, Proceedings of International Conference on Civil, Offshore & Environmental Engineering (ICCOEE), Lecture Notes in Civil Engineering (LNCE). (Accepted) (Scopus indexed publication)

5. S.Z.A. Syed Ahmad, M.K. Abu Husain, N.I. Mohd Zaki, N.A. Mukhlas and M.H. Mohd and G. Najafian. (2020). “An Excellent Relationship-based Model

Development in Deriving the Short-term Probability Distribution of Offshore Structural Responses", Proceedings of the 4th International Conference on Naval Architecture and Ocean & Marine Engineering (NAOME). (Accepted) (Scopus indexed publication)

Innovation

1. INATEX 2017 - Silver Award entitled "Efficient Load Coefficient Method for Structural Reliability Assessment for Ageing Offshore Platform". UTM, Skudai, Johor. (21-23 November, 2017).

2. MTE 2018 - Gold Award entitled "Efficient Load Coefficient Method for Structural Reliability Assessment for Ageing Offshore Platform". PWTC, Kuala Lumpur. (22-24 February, 2018).

3. ITEX 2018 - Gold Award entitled "Efficient Load Coefficient Method for Structural Reliability Assessment for Ageing Offshore Platform". KLCC, Kuala Lumpur. (10-12 May, 2018).

4. PECIPTA 2019 - Gold Award entitled "Efficient Load Coefficient Method for Structural Reliability Assessment for Ageing Offshore Platform". UTHM, Batu Pahat, Johor. (22-23 Sept, 2019)

5. INATEX 2019 – Gold Award entitled "Efficient Load Coefficient Method for Structural Reliability Assessment for Ageing Offshore Platform". UTM, Skudai, Johor. (30 Sept-2 Oct, 2019)