STRUCTURAL ANALYSIS OF FLOATING OFFSHORE REMOTE TERMINAL FOR DEEP SEA FISHING

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DEDICATION

"I can't change the direction of the wind, but I can adjust my sails to always reach my destination".

To the one and only Azura Ahmad Radzi… *"your love is boundary-less"!* You gives me strength and courage. You make me want *to be a better man* in your life.

To my son Aqiff Nuqman …*you kept me going no matter what.*

To my daughter Azalea Eiman told …*"they tried to bury us, they didn't know we were seeds. We falls seven times, stand up eight".*

To Aisyea Zayyan your words inspired me *"good job, mate! It's challengin' work, outta doors. I knew you'd hit the target".*

To my father, mother, father in law and mother in law…thank you very much.

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…awie 2018…Good onya, mate!

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ABSTRACT

Productivity of offshore fishing can increase if there are offshore terminals providing services such as fish unloading and repair of crafts and gears to the fishing fleets. This research proposed the use of FORT (fishing offshore remote terminal) as a very large floating structure (VLFS). Structural analysis is key in the design of VLFS. The research developed an adaptable framework to simulate FORT's hydroelastic interaction and motion using Newtonian's harmonic method. The governing partial differential equation of motion including the effect of deformation and torsional inertia was expressed in a dimensionless form. A finite difference algorithm was employed to transform the differential equations into linear algebraic equations. Linear and nonlinear dynamic responses was obtained using Hamilton principle with modal superposition coupled with finite element methods. Sensitivity tests are performed to quantify the effect of changing numerical parameter. Variety of plate models is investigated. Techno-economic model is also developed. The solution for a selected load condition has been presented. The result on hydroelastic response for several wavelength ϱ (0.12, 0.23 and 0.43) to structural length ratios (1:1, 2:1 and 4:1) revealed longish FORT experiences higher elastic deformations as compare a square FORT for higher wavelength. In continuous springing freeboard reaction, the safe margin decreases from 4m to below 2m at higher wavelength ratio. At small wave length the hydroelastic response is the smallest for the lower ratio orientation. It is found that hydroelastic response is minimal as aspect ratio close to 1. Resultant stress on FORT stiffness when aspect ratio approaches 1 amplifies response amplitude by 35%. Sensitivity test indicates, for full load condition, larger structure will experience larger deformation stress (0.928 MN/m^2 for 250m, 1.035MN/m^2 for 500m, 1.035MN/m^2 for 1000m). Permanent plastic deformation starts occurring at 20^0 and worsen at 45^0 causing higher shear force and moment. Maximum torsional force exceeds 51.25N/m^2. For long crest of 0.43 maximum torsional deflection measured are 250m (19.32N/m^2 for 250m), 500m (27.55N/m^2 for 500m), and 1000m (28.63N/m^2 for 1000m). Net present value of FORT is NPV of 146mil, internal rate of return of 22.94% over15 years. FORT as a new concept is thus techno economically feasible. The analytical model developed is a comprehensive tool for FORT designers.

ABSTRAK

Produktiviti perikanan luar pantai boleh ditingkatkan jika ada terminal luar pantai yang menyediakan khidmat seperti memunggah ikan, pembaikan bot dan peralatan kepada armada penangkap ikan . Kajian ini mencadangkan penggunaan FORT (terminal penangkapan ikan jauh luar pantai) sebagai struktur terapung yang sangat besar (VLFS). Analisis struktur adalah utama dalam merekabentuk VLFS. Kajian ini membangunkan kerangka boleh sesuai untuk mensimulasi interaksi hidroelastik dan gerakan FORT dengan kaedah harmonik Newtonian. Persamaan gerakan pembezaan separa sebagai penentu kepada kesan ubah bentuk dan inersia kilasan telah dinyatakan dalam bentuk tanpa dimensi. Algorithma perbezaan terhingga digunakan untuk mengubah persamaan kebezaan ke persamaan algebra linear. Tindak balas linear dan bukan linear diperolehi dengan menggunakan prinsip Hamilton dengan superposisi mod dan kaedah unsur tak terhingga. Ujian kepekaan dilakukan bagi mengukur kesan perubahan parameter berangka. Pelbagai model plat dikaji. Model teknoekonomi juga dibangunkan. Penyelesaian bagi kes beban terpilih telah dibentangkan. Keputusan tindak balas hidroelastik bagi beberapa gelombang panjang, ρ (0.12, 0.23 dan 0.43) pada nisbah panjang struktural (1:1, 2:1, dan 4:1) menunjukkan FORT yang panjang mengalami ubah bentuk anjal yang lebih tinggi berbanding FORT segiempat sama pada gelombang yang lebih tinggi. Bagi tindak balas lambung bebas pegas berterusan margin keselamatan menurun dari 4m ke bawah 2m bagi nisbah panjang gelombang yang lebih tinggi. Bagi panjang gelombang yang kecil tindak balas hidroelastik adalah terkecil untuk orientasi bernisbah yang lebih rendah. Juga ditemui tindak balas hidroelastik adalah minimum bila nisbah aspek menghampiri 1. Tekanan paduan pada kekakuan FORT bila nisbah aspek menghampiri 1 menguatkan ampitud tindak balas sebanyak 35%. Ujian kepekaan menunjukkan bagi keadaan beban penuh, struktur yang lebih besar akan mengalami tekanan perubahan bentuk yang lebih besar ;0.928 MN/m^2 (250m), 1.035MN/m^2 (500m) dan 1.035MN/m^2 (1000m). Perubahan bentuk plastik kekal mula pada 20^0 dan bertambah buruk pada 45^0 dan menyebabkan daya ricih dan momen yang tinggi. Daya kilasan maksimum melebihi 51.25N/m^2. Bagi puncak maksimum 0.43 pesongan kilasan maksimum ialah 19.32N/m^2 (250m), 27.55N/m^2 (500m) dan 28.63N/m^2 (1000m). Nilai masa kini FORT ialah RM 146juta dan kadar pulangan dalaman 22.94% untuk tempoh 15 tahun. Dengan ini FORT sebagai konsep baru adalah, secara tekno ekonomik boleh dilaksanakan. Model analitikal yang dibangunkan adalah alat menyeluruh bagi pereka FORT.

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LIST OF ABBREVIATIONS

A_C	-	Operational Cost / Expenditure
A_I	-	Income
A_{IM1}	-	Cluster 1
A_{IM2}	-	Cluster 2
A_{IM3}	-	Cluster 3
A_{IM4}	-	Cluster 4
A_{IM5}	-	Cluster 5
API	-	American Petroleum Institute
CAPEX	-	initial and capital expenditure
DCG	-	Clean & Green
DL	-	Legal Requirement
DNV	-	Det Norski Veritas
DOFM	-	Department of Fishery, Malaysia
DR	-	Remedy
DW	-	Wrecking
DWL	-	Designed Water Line
EEZ	-	Exclusive and Economic Zones
EN	-	Equipment number
FAO	-	Food and Agriculture Organization
FORT	-	Floating offshore remote terminal
GA	-	General arrangement
IACS	-	International Association of Classification Societies
IRR	-	Internal Rate of Return
LCC	-	life cycle cost
LCCA	-	life cycle cost analysis
LKIM	-	*Lembaga Kemajuan Ikan Malaysia*

M1FT - Fresh fish trades
M1LU - Loading and unloading
M1PF - Processed/ Frozen Fish
M1TS - Storage
M2ES - Emergency / Salvage
M2MA - Fishing Gears
M2MS - Vessel Modification
M2R - Vessel Maintenance & Repair
M3A - Accommodation
M3AR - Area Rental & Shops
M3FB - Cafeteria for Foods & Beverage
M3T - Tourism
M4B - Vessel Bunkerage
M4H - Vessel household items
M4HC - Health Care
M4L - Vessel Anchorage
M5P - Entrance Fee & Membership
M5V - Vessel Entry
MOF2S - Mega offshore floating structures
MS - Sell Structure
MSM - System, Machineries, Outfitting & Tools
NPV - Net present value
OD - Concept and Details Design
O_{H1} - Overhead 1 -Administrative
O_{H2} - Overhead 2 –Crew
O_{H3} - Overhead 3 -Utilities
O_{H4} - Overhead 4 -Onboard
O_{H5} - Overhead 5 - Disposal
OID - Infrastructure Development
OL - Legal requirement
OMS - Main system and machineries
OPEX - operating expense
OSS - Supporting system and tools

OT - Transportation

PP - Payback Periods

ROI - return on investment

SA - Administration

SB - Crew Benefits

SC - Communication

SCI - Consultation for Improvement

SCM - Crew Mobilization

SCS - Security

SFS - Water

SL - Legal & Fees

SM - External Administrative

SML - Mortgage / Loan / Insurance

SP - Promotion

SPST - Part (s) / System/ Tools

SS - Fuel

ST - Capital Development & Training

StRM - Structure Repair & Maintenance

SUE - Electrical

SWH - Significant wave height

SWH - Significant wave height

SWI - Salary/Wages

SyRM - System Repair & maintenance

LIST OF SYMBOLS

A_j - the annual cash flow of the investment

CF_o - is the initial investment

DCG_{total} - Disposal – Clean and Green

DL_{total} - Disposal – Legal

DR_{total} - Disposal – Remedy

DW_{total} - Disposal – Wrecking

$M1FT_{total}$ - Cluster 1 Income: Fish Trade

$M1LU_{total}$ - Cluster 1 Income: Loading Unloading

$M1PF_{total}$ - Cluster 1 Income - Processed Fish

$M1TS_{total}$ - Cluster 1 Income - Storage

$M2ES_{total}$ - Cluster 2 Income – Emergency / Salvage

$M2MA_{total}$ - Cluster 2 Income – Fishing Gears

$M2MS_{total}$ - Cluster 2 Income – Vessel Modification/Alteration

$M2R_{total}$ - Cluster 2 Income – Vessel Maintenance & Repair

$M3AR_{total}$ - Cluster 3 Income - Area rental & Shops

$M3A_{total}$ - Cluster 3 Income – Accommodation

$M3FB_{total}$ - Cluster 3 Income – Café

$M3T_{total}$ - Cluster 3 Income – Tourism

$M4B_{total}$ - Cluster 4Income - Vessel Bunker

$M4HC_{total}$ - Cluster 4 Income – Healthcare

$M4H_{total}$ - Cluster 4 Income – Vessel Household items

$M4L_{total}$ - Cluster 4 Income - Vessel Anchorage

$M5P_{total}$ - Cluster 5 Income - Entrance Fee and membership

MOT_{total} - Vessel Entry

MSM_{total} - Sell – System, Machineries, Outfitting & Tools

MS_{total} - Sell Structure

OD_{total} - Total of initial investment – design
OID_{total} - Initial Investment - Infrastructure Development
OL_{total} - Initial Investment - Legal requirement
OMS_{total} - Initial Investment - Cluster main system and machineries
OSS_{total} - Initial Investment - Cluster supporting system and tools
OT_{total} - Initial Investment –Transportation
SA_{total} - Operating cost – administration
SB_{total} - Operating Cost - Crew Benefits
SCI_{total} - Consultation for Improvement
SCM_{total} - Operating Cost - Crew Mobilization
SCS_{total} - Operating Cost – Security
SC_{total} - Operating Cost – Communications
SFS_{total} - Operating Cost – Water
SL_{total} - Operating Cost – Legal & Fees
SML_{total} - Operating Cost – Mortgage / Loan / Insurance
SM_{total} - Initial Investment – External Administrative
$SPST_{total}$ - Part /System/Tools
SP_{total} - Operating Cost – Promotion
SS_{total} - Operating Cost – Fuel
ST_{total} - Operating Cost – Capital Development & Training
SUE_{total} - Operating Cost – Electrical
SWI_{total} - Operating Cost - Salary/Wages & Incentives
$StRM_{total}$ - Structure Repair Maintenance
$SyRM_{total}$ - System Repair Maintenance
Δ - moulded displacement
A - vertical projected area of each surface exposed to wind
AP - aft perpendicular
B - greatest moulded breadth
CB - Block coefficient
C_{Cx} - current force coefficient
C_{Cy} - current force coefficient on the beam
C_{h} - height coefficient
C_{S} - shape coefficient

d - estimated operational depth
D - Plate flexural rigidity, Nm
Df - freeboard depth
E - the elastic modulus, N/m_2
f_1 - materials factor depending on materials strength group
F_{Cx} - Current force on the bow
F_{Cy} - current force on the beam
FP - forward perpendicular
f_T - proposed freeboard
F_W - wind force
g - Gravitational acceleration, $9.81 m/s^2$
G - Shear modulus, N/m^2
h - effective height or thickness, m
H - Water depth, m
H_w - Non-dimensional water depth, H/L
I - value of total inertia about the neutral axis
k - ratio value
L - the length of FORT
Lf - freeboard line
M - amidships
M_y - bending moment
N - Number of modes
p_w - Wave pressure
r - the discount rate
s - length of catenary line
S - wetted surface
t - the life time of the investment
T - mean moulded summer draught
V_c - current speed
V_W - wind speed for South China Sea
w - submerged weight of catenary chain per meter
Z - section modulus
Z_o - section modulus

δ	-	vertical deflection
W, ψ_x, ψ_y	-	Plate deflection, rotations about x and y axes
x,y,z	-	Cartesian coordinates
$x=(x,y,z)$	-	Field points
$\zeta\xi$	-	Source points
$G(x)$	-	Three-dimensional free surface Green function
α	-	wavelength-to-structure length ratio
ν	-	Poisson's ratio
ω	-	Wave frequency, *rad/s*
λ	-	wavelength, *m*
Φ	-	Velocity potential of the fluid
$\varepsilon_{xx}, \varepsilon_{yy}, \varepsilon_{zz}$	-	Normal strains
$\gamma_{xy}, \gamma_{yz}, \gamma_{zx}$	-	Shear strains
$\tau_{xy}, \tau_{yz}, \tau_{zx}$	-	Shear stresses
$\sigma_{xx}, \sigma_{yy}, \sigma_{zz}$	-	Normal stresses
$[K_f]$	-	Global flexural stiffness matrix
$[K_s]$	-	Global shear stiffness matrix
λ	-	Length between wave crests
κ	-	Wave Number ($2\pi/\lambda$) units of 1/length
ω	-	Angular Frequency ($2\pi/T$) units of 1/time
2a	-	Wave Height or twice wave amplitude

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Recently, very large floating structures (VLFS) have received considerable attention in civil and ocean engineering fields (Tripathy and Pani, 2014). These floating structures have great width and length and relatively small flexural rigidity. There is an extensive attention to understand the anomalies of wave interaction with floating structures to build infrastructures. The VLFS concepts are unique ocean structures primarily because of unprecedented lengths and displacements which consequently, hydroelastic response becomes dominant and has driven supporting research and development in global analytical methods for VLFS. Therefore, this chapter highlights the importance of structural hydroelastic effects in modelling of VLFS under multi parametric value. The research problems were extracted and compensated in this research for the inadequacy of previous works. The objectives have been defined in providing the resolution for the problem identified. The scope of the study and the significance the research has all been elaborated in show casing the research boundary and its contribution respectively within the state of the art of theories, concepts and fundamentals. The thesis has been structured in normal research approach in identifying, formulating, attaining, synchronizing and delivering the research deliverables are accessible.

1.2 Research Background

Very large floating structures (VLFS) have attracted the attention of architects, planners, and engineers because they provide an exciting and environmentally friendly solution for land creation from the sea as opposed to the traditional land reclamation method. The applications of VLFS such as piers, hotels, fuel storage facilities, bridges, airports, and even floating cities have triggered extensive research studies in the past two decades. The VLFS technology has developed considerably and there are many innovative methods proposed to minimize the structure motion, especially on elasticity behaviour as illustrated in Figure 1.1. These characteristics of the global response with respect to the characteristic length are summarised in the map of Figure 1.2 (Suzuki, 2005). Therefore most researches were concentrated on mooring system and structural integrity of the VLFS (Wang and Tay, 2011). The size (Thai et al., 2017) of a VLFS presents an essential challenge since it is difficult to scale directly the structural and hydrodynamic properties. A brief overview of the history, application and uniqueness of very large floating structures and the recent developments in the scientific arena of VLFS as well its significance level are in future scope of work (Tripathy and Pani, 2014). Collectively, the research on hydroelastic analysis of pontoon-type very large floating structures can be summarized to include, but not limited to wave forces, non-wave forces, VLFS models, VLFS shapes, mooring system, breakwaters, profiles of seabed, and anti-motion devices (Watanabe et al., 2004a).

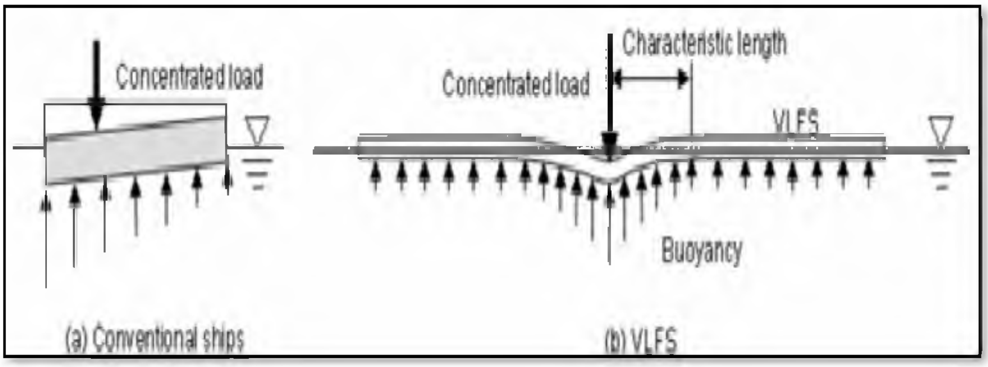

Figure 1.1: Global response under load (Suzuki et al., 1996)

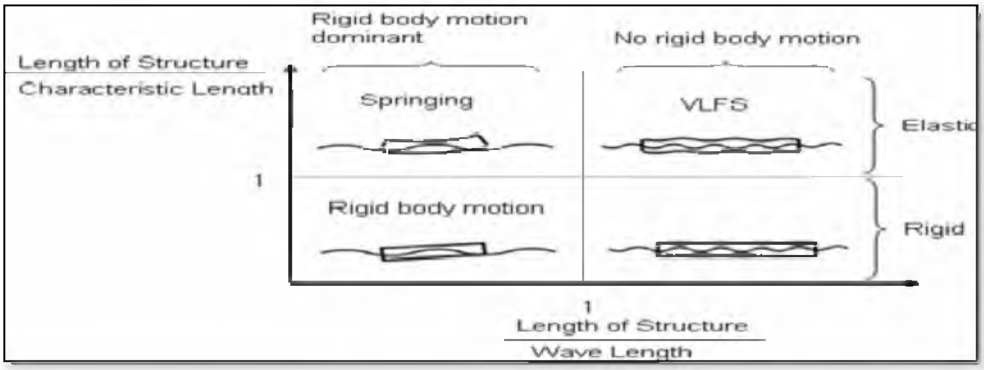

Figure 1.2: Mapping of global response of floating structures (Suzuki, 2006)

Computational method had achieved its maturity during the last three decades and efficient enough especially for preliminary design purposes. Currents works focused on developing efficient numerical tools by simplifying the structural model. Among the numerous numerical methods on the hydro elasticity of a VLFS, most of them are within the scope of linear wave theory and in frequency domain or time domain. There are only a few numerical models that consider the global hydroelastic response of a VLFS in nonlinear waves, which is a naturally complicated phenomenon. In linear hydro elasticity analysis of a mat-type VLFS, the flow is usually assumed to be governed by linear potential theory. A VLFS is generally modelled as an elastic plate and only the vertical motion is considered. It is also assumed that there is no gap between the VLFS and the free surface, i.e., no slamming is allowed. Most of the researcher works on beam method, water depth technique (Mei and Black, 1969, Andrianov and Hermans, 2003, Lee and Liew, 2014, Chen et al., 2016) for both the case of finite and infinite water depths, the application of Eigen function expansion (Gasimov et al., 2016) and orthogonal mode coupling relation, the behaviour of a flexible, porous, floating breakwater connected by mooring lines kept under tension by small buoyancy chamber at the tip (Wang and Tay, 2011). The wave induced responses was also explored (Wu et al., 2014a), the elastic plate using Eigen function expansion (Kim and Ertekin, 1998) and modal expansion matching method (Sengupta et al., 2017).

More often, the hydroelastic analysis is carried out in the frequency domain (Wei et al., 2017, Lin, 2016) since this is more straightforward than it would have been in the time domain. The fluid problem is generally solved by the boundary-integral method, i.e., by use of the Green function or by use of quantum mechanics Hamiltonian. The plate response is often solved by the finite element method (FEM), or alternatively, as part of the boundary-element of the fluid domain. There have been two major approaches to the frequency-domain analysis: the modal expansion method and the direct method. Modified modal functions have been introduced by many authors, primarily to increase the numerical efficiency of the computations. The common approaches for time-domain analysis of VLFS can be categorized as the two-dimensional direct integration method (Liu et al., 2015). The two-dimensional nonlinear model to simulate the hydroelastic response to random waves, and non-periodic nonlinear waves such as a tsunami. However, the frequency domain analysis is not valid in extreme situations such as in a large storm. Such extreme events have to be considered in the VLFS design for safety and survivability reasons. More work should be done to investigate the non-linear responses such as the transient response of VLFS under large wave impact (Wang and Tay, 2010). Thus, it shows that higher-order analysis such three dimensional approach play an important role in the prediction of VLFS response to non-linear waves (Lin, 2016) and a more sophisticated approach could resolve that issue (Taylor, 2007).

Therefore, there is no extrapolation or even modification has been done based on Mindlin plate models that use various aspect ratio in both linear and non-linear conditions. Implying that the available models insufficient in demonstrating offshore floating structure behaviour especially for deep sea fishing application with its special boundary and operational conditions. As a result, the structural behaviour predictions have been under estimated and could result violating the Det Norske Veritas Classification Standards and criteria (Veritas, 2012). The present work is a study on a floating offshore remote terminal (FORT) which aims to provide researchers and engineers with an unambiguous method for obtaining structural responses using Mindlin plate analysis for both linear and non-linear perspectives as a fluid-structure interaction problem. Following this, the boundary element method (BEM), finite-element method (FEM), quantum mechanics of Hamilton's principle and linearization are introduced, and the solution approach is detailed. Finally, the results for both the linear and cnoidal wave (Ertekin and Xia, 2014) solutions of the problem and emphasize the importance of nonlinearity in the structural response predictions of a FORT in mathematical analysis and computational approach. Hence, expected use of thick plate theory (Wu et al., 2014a) should improves on hydro elasticity behaviour especially on torsional effects at end and mid location of the structure (Wang and Tay, 2011). However, the hydroelastic analysis requires a huge amount of computational time and cost. A numerical model of typical VLFS says of 300m length has more than 70,000 DOF. Many researchers have tried to reduce computational time. Nevertheless, the cost for hydroelastic analysis is still three or more times larger than only for numerical analysis of structures with the same DOF. This fact makes it hard to directly use hydroelastic analysis tools in real design procedures of VLFS (Jingyun Kim, 2011).

1.3 Floating Offshore Remote Terminal Structure (FORT)

FORT is a genuinely new concept proposed with the intention to bring all the services the offshore fishermen require closer to their fishing grounds. These services include fish landing terminal, packing, packaging and storage, business area, maintenance and services facilities, supplies and refuel centre, health and recreational services, accommodation and tourism, etc. With adequate technical and structure analysis, FORT will be strategically anchored in the middle of the ocean, close to the offshore fishing grounds. FORT will ultimately be a technology development for ocean space utilization. FORT proposes the integration of the required functions. It is expected to improve the logistics management and ensure operational effectiveness. FORT is expected reduce the 'distance barrier' and many more. Instead of the harvested fish need to be stored at limited storage capacity, and brought back to main land terminal, FORT will hold, process and keep the fish quality. At the same time is able to supply resources such as fuel, fresh water, fishing gears to the fishing vessels.

1.4 Research Gap

Figure 1.3 chronologically registers all research works directly related to studies on structural analysis of VLFS. The fundamental difference between one and the other is on method of analysis. Based on this the research works can be categorised into three groups; beam method, thin plate method and thick plate method. Sub-categorisation within each of the three group is also apparent on the basis of either the mathematical methods employed or the modelling boundaries and conditions.

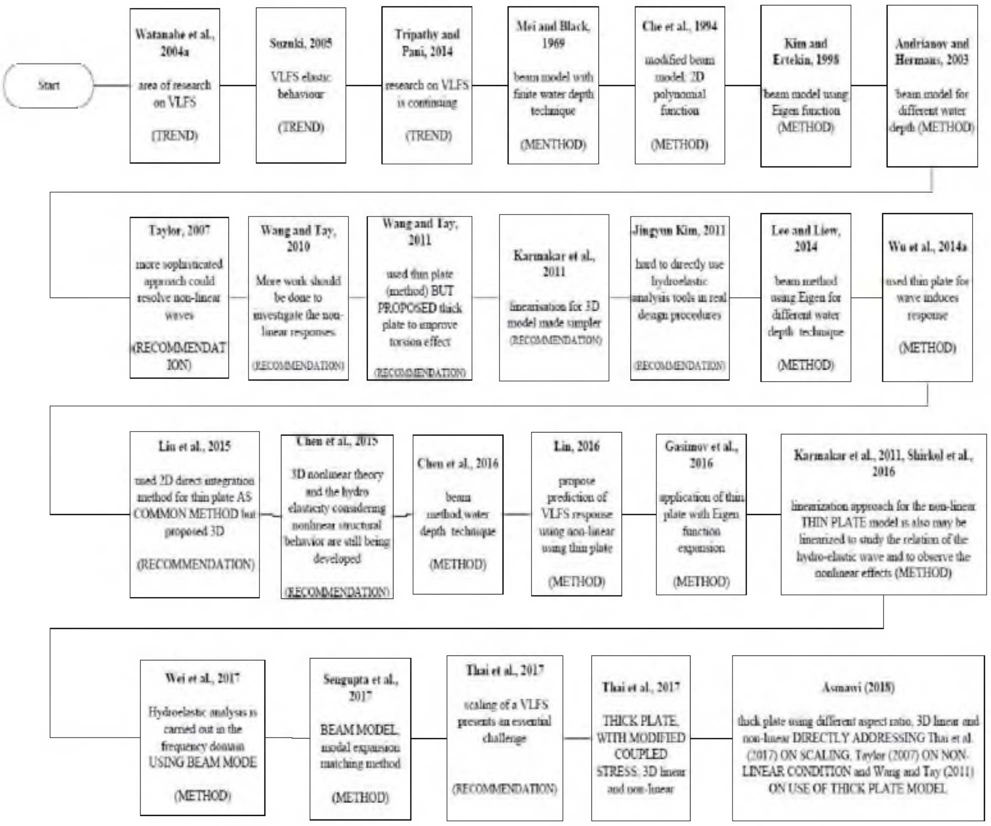

Figure 1.3: Past research related to FORT structural analysis

Structural analysis of VLFS using beam method was pioneered by Mei and Black (1969) but constrained it for finite water depth only. Che et al. (1994) used modified beam model and analyse within 2D condition using polynomial function.

Kim and Ertekin (2003) used beam model. Andrianov and Hermans (2003) picked up the finite water depth constrained of Mei and Black (1969) and used beam model for different water depth. Until then all analyses were for linear waves. Taylor (2007) recommended analysing VLFS structural analysis for non-linear waves condition. Lim and Liew (2014) pursues the work of Andrianov and Hermans (2003) on beam method for different water depth and so as Chen et al. (2016). Adoption of beam method continues to the recent years with the work of Wei et al. (2017) using frequency domain approach and the work of Sengupta et al (2017) using expansion matching beam modelling. The shift to thin plate method was pioneered by Wang and Tay (2011). Two recommendation was proposed; the used of thick plate method and for non-linear response. Wu et al. (2014a) used thin plate for wave induced response. Liu et al. (2015) used thin plate in 2D environment but recommended an analysis for 3D environment. Lin (2016) pursued the recommendation by Wang and Tay (2011) and used thin plate for non-linear situation. Karmakar et al. (2011) applied thin plate and proposed linearization of the analysis. Chen et al. (2015) highlights the growing interest in further developing the 3D non-linear approach of analysing VLFS structure. Gasimov et al. (2016) applied thin plate method and adopted Eigen function expansion. Shirkol et al. (2016) agrees with Karmakar (2011) on the possibility of linearization strategy but stick on thin plate method. The shift to thick plate method is by Thai et al (2017). His analysis is on coupled stress in 3D non-linear response. The important remarks-cum-recommendation by Thai et al (2017) is the challenge of scaling.

1.5 Problem Statement

Floating offshore remote terminal (FORT) as a thick plate in linear and non-linear operations involves static and dynamic wave height representing various operating condition, such as loading and unloading. However, comparison of mathematical modelling using vector mechanics or variational and energetic principles, indicates that the thin plate disposed the differential element which are summed to obtain the equilibrium or motion equations (Ismail, 2016). Meanwhile, in obtaining equation for the energetic methods, the thick plate includes various types of virtual work principles, such as minimum potential energy or the complementary potential energy. Structurally, the thick plate will show a softer crystallization deformation behaviour due to the presence of potential energy. Such simplistic practise which is presumably due to the inadequacy of data and knowledge in the field inevitably causes large errors in the predictions as much as 10 to 20% difference in the relative error of the displacement in the middle of the plate (Vrabie and Baetu, 2013). As a result, the predictions violate the Det Norske Veritas Classification Standards and criteria (Veritas, 2012). Additionally, the current approaches has led to underestimation of properties as non-linear wave approaching and hitting the structure (Wang and Tay, 2010). The effect of nonlinear waves has to be considered as it is common practice of linear waves analysis and it is not valid in extreme situations such as large storms (Andrianov, 2005). Despite its utmost importance to reliability of the prediction results and convenience of the modelling, until now no mathematical model has specifically added the hydroelastic torsion formulas and aspect ratio in wave propagation. Therefore, this research begins with the hypothesis that bounding the hydroelastic torsion formulas and aspect ratio will significantly improve the modelling of structural effects under energy equilibrium perspective. It is already mentioned that hydroelastic analysis using Navier-Stokes equation are usually neglected in the hydroelastic analysis (Wang and Tay, 2010) especially within deep or offshore water where the waves with longer wave length will move faster.

1.6 Research Objectives

This research work is utilizing the thick plate theory addressing offshore fishing issues via technology and advancement in floating structure application. The study aims:

1. To develop of a typical design of FORT structure
2. To develop a mathematical model for the identification of loading variable in linear and non-linear under thick plate theory
3. To simulate of FORT behavior under selected conditions

1.7 Research Approach and Scope

The general research approach is sequentially as follows:

1. FORT as a concept its required functions are developed through knowledge and understanding gathered on the current process of pre-to-post catching activities.
2. The elements of FORT system are identified based on (i) above so that all the various subsystems are in place and their interrelationships established.
3. Hardware and software systems for FORT selected based on a sound method and detailed out to the extent of estimating their cost magnitude.
4. The thick plate model is developed based on established methodology and comprehensive enough to capture the elements of sustainability.
5. The model developed is validated by empirical validation method.

1.8 Thesis Motivation

Applying ecosystem approach to fisheries management is considered the preferred option and best practice under the Coral Triangle Initiative. The idea of having FORT as intermediate terminal is new to its application. Therefore, the structural integrity must be evaluated based on good practice framework by using higher order modelling (Li et al., 2016) approach and simulation capability (Loukogeorgaki et al., 2012). Moreover, the inclusion of the symmetric generalized added mass matrix and the non-symmetric generalized hydroelastic in fluid-structure interaction. On the other hand, FORT is created and motivated for the research is traceable to the real shortage in fish supply in Malaysia. Malaysia has the economic ground to be explored further as done by many developing countries to pursue offshore fisheries development strategies (James et al., 2005). The research is also made in line with the blueprint for the full implementation of an ecosystem approach to fisheries management in Malaysia in 2016 (Pomeroy et al., 2015).

1.9 Research Significance

The research significance of the work developed in this thesis is the implementation of a thick plate theory on wave-structure formulation into a plate model. By identifying and implementing structure loading component procedure in the existent linear and non-linear, the FE program it is possible to perform frequency and time-dependent and evolutive construction analyses of structures under significant wave height. As the formulation is based on the fixed loading approach, the effects of structure reinforcement in the resistant mechanism of plate components are properly simulated, in contrast with existent research works. By these means and motivated by its computational efficiency, it is intended to create an alternative numerical tool to the high complex 2D/3D FE models for the linear and nonlinear assessment. Also, the proposed model aims to be a practical engineering tool to accurately assess the structural behaviour and also serving as a decision tool for floating structure-based development.

1.10 Overview of Thesis Structure

The present thesis is divided into 7 chapters. After this first opening chapter that points out the overall context, the most relevant motivations and objectives of the research work, an overall description of the state-of-the art is presented in Chapter 2. This second chapter is focused on the topics that are essentially related with the ambit of the research work carried out in this thesis. Being so, it makes a generally description of the plate models and the very high advanced state they reached for the case of wave effect analysis.

Afterwards, the complexity of the phenomenology and modelling of the structural mechanism of plate elements is revised. Existent forces, kinematic and constitutive theories are discussed, as well, as its adaptability to plate models. Subsequently, a general view on the subject of new algorithm is presented, focussing on the importance of linear and non-linear models able to assess the actual state of the structures to predict the efficiency of structure behaviour projects. Finally, a general discussion on the state-of-the-art is presented. The context in which the present research is inserted in, and the gap of knowledge that it pretends to fill, are remarked. Accordingly, the options taken in the development of the numerical model, which were supported by previous findings reported in the literature, are highlighted. It detailed down discussion on design comprehensiveness. The conclusions of the present study are summarized and presented in chapter 6. Suggestions and recommendations for future work are also included in this chapter. Finally, list of the references are given at the end of this thesis.

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