ANALYSIS AND DESIGN OF JACKET OFFSHORE PLATFORM USING SACS SOFTWARE

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by

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Dissertation submitted in partial fulfilment of
the requirements for the
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CERTIFICATION OF APPROVAL

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Approved:

Assoc. Prof. Dr Narayanan Sambu Potty
Final Year Research Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD NAZMI BIN HASSAN

ABSTRACT

The study is focused on the design analysis for both jacket and topside. The analysis will follow both working stress design and load & resistance factor design respectively. The comparison of both cases will be developed by the end of this project. This progress report contains introduction, literature review, methodology, result, discussion and conclusion for this final year project. In introduction part, the discussion is about background of study, problem statement, objectives and scope of study. This will give brief ideas about what actually this project is all about. The main objective of this project is to make comparison for design analysis using working stress design and load & resistance factor design. In literature review part, the theoretical part of the project has been discussed. Since this project completion is based on software, there is also an introduction of this SACS software used. Methodology part discussed what the steps are taken for completion of this project. The design methodology had been decided after the long detailed study and extensive researches. After surveying and researching via the internet, library and shops, the list of software and books required listed. The background of the real project used also been discussed in this part. As for the result and discussion part, the finding through research which is comparison between working stress design and load & resistance factor design discussed. Added to the result and discussion part also the work done which is inplace analysis under Working Stress Design (WSD) and also under Load & Resistance Factor Design (LRFD).

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Offshore is one of the areas with most rapid growing technology and engineering worldwide today. One of the most effected engineering fields is civil engineering where to design this offshore structure, it will be going beyond their imaginary level and it will be a very tough industry. So far, these industries have open thousands of work opportunity in all fields of engineering.

One of the most critical processes in building an offshore structure is the design phase where this phase will be conducted by professional engineers work in Consultant Company. The reference used in design this offshore structure is based on "Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms- Working Stress Design (WSD)" which is American Petroleum Institute (API) Recommended Practice. Currently limit state design or load & resistance factor design (LRFD) and working stress design (WSD) are used for design offshore platforms. While the design of buildings follows the Limit State Design Methods, the design of offshore platforms is done using the Working Stress Design Methods. Petronas Technical Specification (PTS 20.073) follow this Working Stress Design as their main reference in designing the platforms.

Researchers now has complete incorporated the Load & Resistance Factor Design (LRFD) into offshore design practice with the first edition of the "Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms- Load and Resistance Factor Design" which has been published by the American Petroleum Institute (API). Shell Technical Specification follow this Load & Resistance Factor Design as their main reference in designing the platform.

1.2 Problem Statement

Petronas Carigali uses Petronas Technical Specification based on Working Stress Design (WSD) revision from American Petroleum Institute (API) as their main source of reference. The Load Resistance Factor Design (LRFD) which is upgraded by American Petroleum Institute (API) and been used as Shell Technical Specification for perhaps. This two (2) stress design state analysis are both have their advantages and disadvantages in terms of time consuming, cost etc.

1.3 Objective of Study

1) To do inplace analysis using two methods analysis; (1) Working Stress Design (WSD) and (2) Load and Resistance Factor Design (LRFD).
2) To make comparison on the design using Working Stress Design (WSD) and Load and Resistance Factor Design (LFRD).
3) To compare the results of the design.

1.4 Scope of Study

The project which is considered for the case study for this final year project is the Laho Drilling Platform (LHDP-A) Substructure and Topsides. This project is one of the RNZ Integrated (M) Sdn Bhd projects under client Petronas Carigali Sdn Bhd. The details of the project are used with consent from the company for current study. Background of the project will be discussed in detail later in methodology chapter.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction to Offshore Structure.

Offshore platforms are used widely for exploration of oil and gas under seabed and processing. Its use is, however, not limited solely to this industry and important applications also exist for military and navigational purpose. Thomas H. Dawson (1983) stated that the first ever platform was installed in 1947 off the coast of Louisiana in 6m depth of water. Today, there are over 7000 offshore platforms around the world in water depths up to 1850m.

The design and analysis of this offshore structure is in accordance with the recommendations from American Petroleum Institute (API).

Offshore platforms can be broadly categorized to 2 types:

i. Floating platforms: Platform floating on the water surface.
ii. Fixed Structure: Platform with full support by jacket which extends to the seabed.

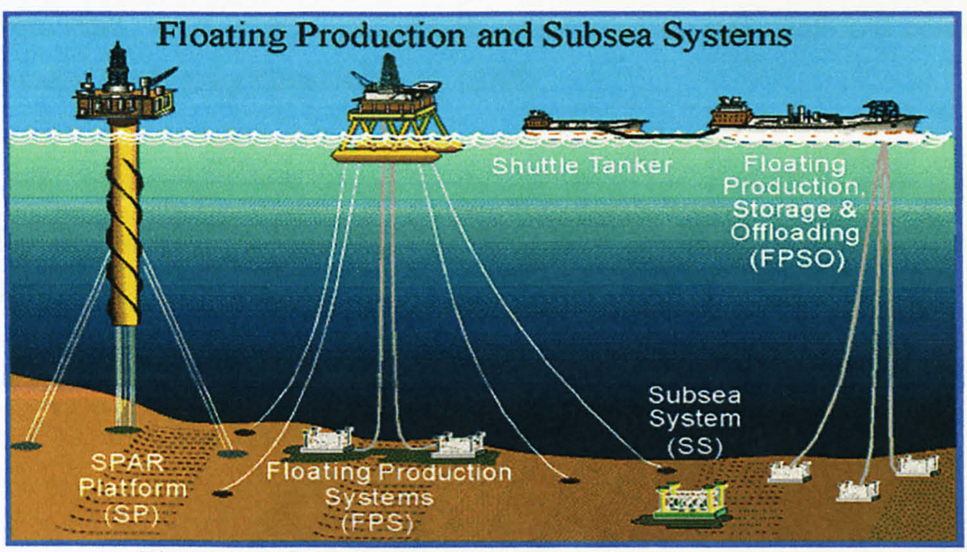

Figure 2.1 : Floating Production and Subsea Systems.

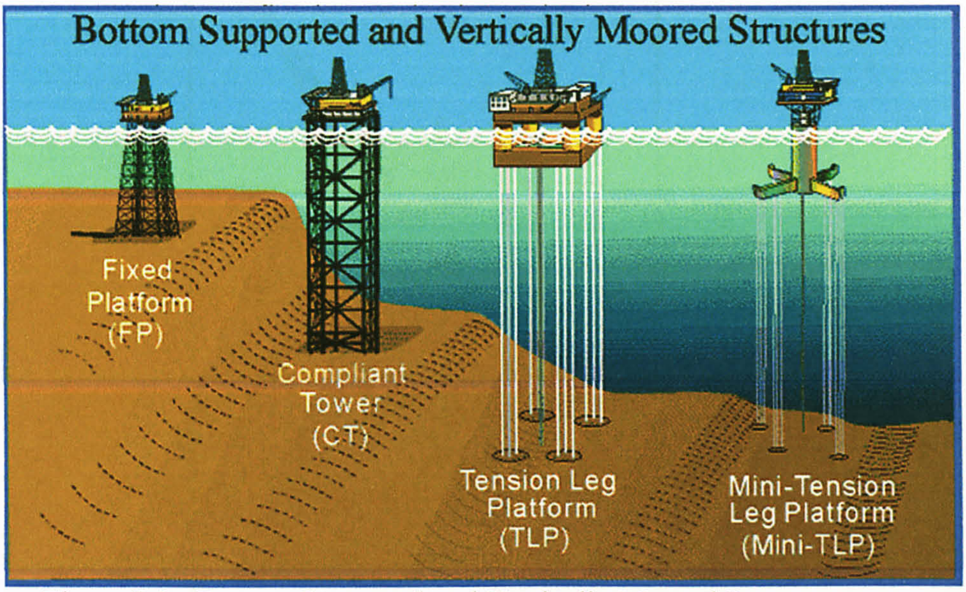

Figure 2.2 : Bottom Supported and Vertically Moored Structures.

Examples of floating platform are SPAR Platform (SP), Floating Production System (FPS), Floating Production, Storage & Offloading (FPSO) & Semi Submerged. Examples for fixed structures are fixed platform (FP), Compliant Tower (CT), Tension Leg Platform (TLP) and Mini-Tension Leg Platform.

All types of platforms whether its is floating type or fixed structure types are steel type where all the tubular members and beams used as a support made totally 100% from steel. There is only one type of platform which uses reinforced concrete which is called the Gravity Based Structure (GBS).

The one that will be dealt with for this project is only fixed platform. This type of platform is the most prolific and prevalent in the offshore industry today. 95% of offshore platform around the world nowadays are fixed platform. (figure 2.3)

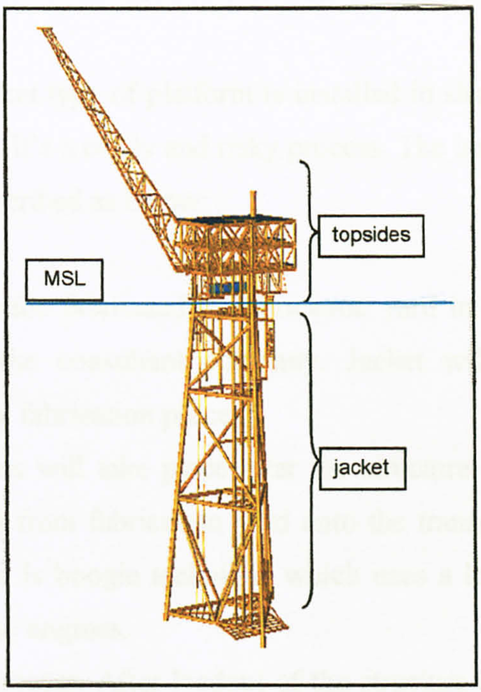

Figure 2.3 : Fixed Jacket Platform.

Fixed platform consist of two major parts; topsides and jackets. Topsides is above mean sea level (MSL) side and jacket is below MSL and extend to the seabed. The topside is supported by the piles driven through the legs of the jacket into the seafloor. These piles not only provide support for the topside but also fix the structure in place against lateral loading from winds, waves and currents. The use of this type of platform has been generally limited to a water depth up about 500-600ft (152-183m), even though today in recent development several platforms have been installed in deeper water. To date, design of this jacket structure type has been extended to about 1600ft (488m) of water depth.

Major functions for jacket are to provide substructure to topside and keep its stability and also provide protection for well conductors and the pipeline riser. The functions of the topside are:

i. Well control
ii. Support for work-over equipment.
iii. Separation of oil and gas and non-transportable component.
iv. Support for pump compressor.
v. Accommodation for operating and maintenance.

Although a jacket type of platform is installed in shallow deep water, it is not easy job for installation. It's a costly and risky process. The installation sequence for the topside and jacket is described as below:

i. Jacket and topside fabricated in fabrication yard in accordance to the design provided by the consultant company. Jacket will follow jacket erection sequence in the fabrication process.

ii. Loadout process will take place after the structure fabricated. This structure will be moved from fabrication yard onto the transportation barge. Common technique used is boogie technique which uses a line of tires as the support and powered by engines.

iii. Seafastening process. After loadout of the structure successfully on top of the barge, this structure has to be tied or locked to the transportation barge to prevent sudden movement during transportation process.

iv. Transportation or Sailaway process. This is the transportation process where from the fabrication yard this structure will be transported to its final offshore site where it will be planted or installed.

v. Installation process is the last process and most critical since there have been a lot of damage cases or even structure lost during this process. Many methods used in this process, for jacket used launching and the upending using lifting sling meanwhile for topside used lifting method using also lifting sling.

2.2 Planning & Management for an offshore structure

Adequate planning should be done before actual design is started in order to obtain a workable and economical offshore structure to perform a given function. The initial planning should include the determination of all criteria upon which the design of the platform is based.

a) Operational Considerations

Function – The function for which a platform is to be designed is usually categorized as drilling, producing, storage, materials handling, living quarters, or a combination of these.

Location – The location of the platform should be specified before the design completed.

Orientation – The orientation of the platform refers to its position in the plan referenced to a fixed direction such as true north.

Water Depth – Information on water depth and tides is needed to select appropriate oceanographic design parameters.

Exposure – Design of all systems and components should anticipate extremes in environmental phenomena that may be experienced at the site.

b) Environmental Considerations

- General meteorological and oceanographic considerations
- Winds – exerted upon that portion of the structure that is above the water
- Waves – wind-driven waves are a major source of environmental forces
- Tides – classified as astronomical tide, wind tide & pressure differential tide.
- Currents – affecting the location & orientation of boat landings & barge bumpers
- Active Geologic Processes

c) Site Investigation – Foundations

As a minimum requirement, the foundation investigation for pile-supported structures should provide the soil engineering property data needed to determine the following parameters:

1) Axial capacity of piles in tension and compression,

2) load- deflection characteristics of axially and laterally loaded piles,

3) Pile drivability characteristics and

4) Mudmat bearing capacity.

d) Selecting the Design Environmental Conditions

The design environmental criteria should be developed from the environmental information and may also include a risk analysis where prior experience is limited.

e) Platform

- Fixed Platform
- Jacket or Template
- Tower
- Gravity Structures
- Minimum Non-Jacket and Special Structures
- Compliant Platform

f) Exposure Categories

Structures can be categorized by various levels of exposure to determine criteria for the design of new platform and the assessment of existing platforms that are appropriate for the intended service of the structure.

g) Platform Reuse

Existing platforms may be removed and relocated for continued use at a new site. When this is to be considered, the platform should be inspected to ensure that it is in an acceptable condition.

h) Platform Assessment

An assessment to determine fitness for purpose may be required during the life of a platform. This procedure is normally initiated by a change in the platform usage such as revised manning or loading, by modifications to the condition of the platform such as damage or deterioration, or by a reevaluation of the environmental loading or the strength of the foundation.

i) Safety Considerations

The safety of life and property depends upon the ability of the structure to support the loads for which it was designed, and to survive the environmental conditions that may occur.

j) Regulations

Each country has its own set of regulations concerning offshore operations. It is the responsibility of the operator to determine which rules and regulations are applicable and should be followed, depending upon the location and type of operations to be conducted.

The criteria stated above are a basic guide to be followed before considering a construction of offshore structure.

2.3 Structural Analysis Computer System (SACS) Software

According to Supplement SACS manual release 6, Structural Analysis Computer System (SACS) is a computer program/software used to design structures. SACS software also uses to design and analyze platform for oil and gas production which includes substructure and topsides. The SACS Executive program has been designed to provide the user with an easy to use and efficient front end utility for the SACS system. It controls and connects all elements of the SACS system by providing access to all SACS interactive programs, utilities and system settings. The Executive also provides access to batch program module execution in addition to user defined program utilities. The SACS Executive program may be used to control the entire SACS system. The user may execute any SACS program or utility in addition to system utilities directly from the SACS Executive.

SACS suite of computer programs will be used to perform the major analyses for the topsides and jacket;

- Program – analysis
- Precede – interactive modeling and plotting.
- Seastate – environmental load and mass generation. Combination of basic load cases.
- Pre/Solve – static analysis
- Post – results reporting and member code checking
- Joint can – tubular joint check
- Tow – generation of inertial loads for transportation analysis
- Gap – compression or tension only elements
- MTO – material take off

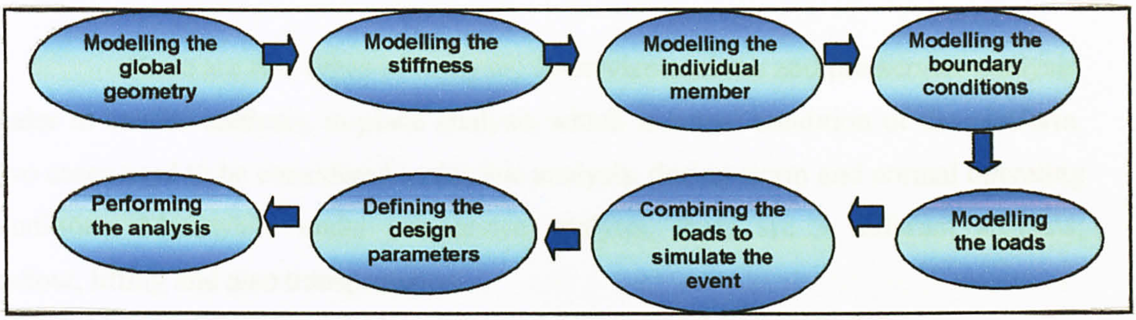

Figure 2.4 : Geometry Modeling using SACS (computer modeling).

The most important thing in any structural analysis is applying load to the model in SACS software. There are two (2) types of loads measured; gravity load and environmental load. Gravity load consists of dead load, live load, installation load as well as future load. While environmental load is only wind load.

Dead loads are the weights of the structure, appurtenance structures and any permanent equipment that will not change during the phase being considered. The example of dead loads are; weight of the structure in air, weight of equipment and appurtenance structures permanently mounted, weight of installation aids and drilling load.

Live loads are loads which may vary in magnitude, position and/or direction during the phase being considered, and which are not related to accidents or exceptional conditions. They are forces exerted on the structure from operations (i.e. drilling, mooring, crane usage, etc), stored materials, equipment and liquids, fluid pressure, open area live load or personal load. This load is usually defined in terms of pressure. Installation loads are loads imposed on the structure as a result of loading-out, transportation, launching, lifting and upending.

Only wind load is considered for topside in-place analysis. However the wind loads from x and y directions are measured in two conditions; operating and storm condition. The wind load assumed to act concurrently with wave in the same direction and the wind speed is assumed to be omni-directional.

2.4 Design Analysis

There are two types of analysis; in-service analysis and pre-service analysis. Under in-service analysis, in-place analysis which is actual condition of the platform. Two cases need to be considered under this analysis; during storm and normal operating conditions. Meanwhile under pre-service analysis, there are 3 different analysis; loadout, lifting and also transportation.

Inplace Analysis

The major objective of this inplace analysis is to ensure structural members capable to support topsides facilities under normal operating condition and extreme storm conditions throughout the design life of the platform.

This analysis is adequately design during:

a) Fabrication
b) Normal operating condition at field
c) Extreme storm condition at field.

During this inplace analysis, the platform is supported under 4 positions also known as its boundary condition. Boundary condition defines as actions and constraints on a section of a structural components or a group of structural components by other structural component or by the environment surrounding it (ISO19902:2007).

Loadout Analysis

The major objective of the loadout analysis is to ensure no structural members are over-stressed when the structures are being loaded out from yard to the transportation barge.

During this analysis, the only gravity load required is structural selfweight, unmodelled structural weight and equipments dry weight plus rigging weight. Rigging weight is referring to sling and shackle which will be used during lifting analysis. No environmental load is applied since only considering the structural weight of the structure.

There are three (3) cases considered during this analysis, differ in its support at main deck. These cases analyzed to make sure if during real loadout process, if support of the structures loss during through on uneven flooring the structure still can support without members over-stressed.

There are few techniques used for loadout includes boogie, skidding and lifting. Each technique applied depending on the characteristics of the structure to be loaded out. The most common technique used is boogie which used tens of wheels.

Figure 2.5 : Loadout process from fabrication yard to the transportation barge.

The major objective of this transportation analysis is to ensure no members are over-stressed when the structures and installed facilities within are being transported form fabrication yard to the final offshore site.

Two (2) cases considered during this analysis, both differ in structure orientation on the transportation barge; longitudinal and transverse. The loads applied are the same as loadout analysis, except for the inertial load and wind load.

Figure 2.6 : Jacket transportation process by tug boats.

Inertial load is generated by SACS tow associated with barge motion. Two types of inertial loads are angular and translation acceleration. Angular acceleration consists of pitch, roll and yaw, while translational acceleration is sway, surge and heave. The figures 2.7 and 2.8 show the inertial loads and wind direction.

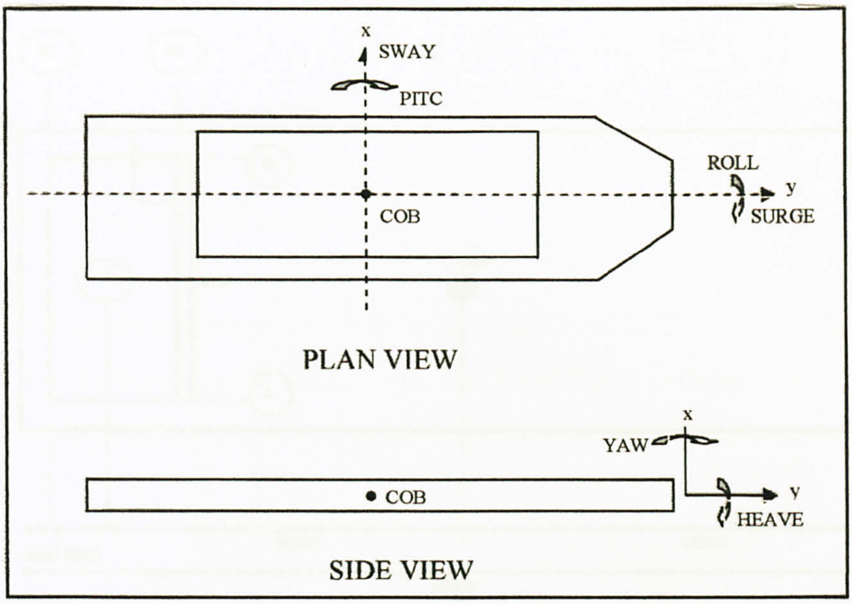

Figure 2.7 : Inertial load on the barge.

Whereas, wind load is generated by 26 m/s wind speed and applied on (+) X and (+) Y direction of the structure. However this time wind conditions are beam-on seas, oblique seas and head-on seas instead of operating and storm.

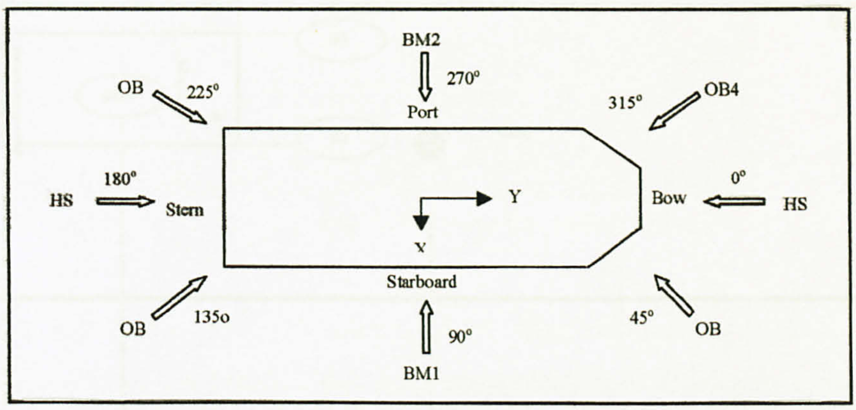

Figure 2.8 : Wind direction on the barge.

The orientation of the module on barge for both cases; longitudinal and transverse is shown in figures 2.9 and 2.10.

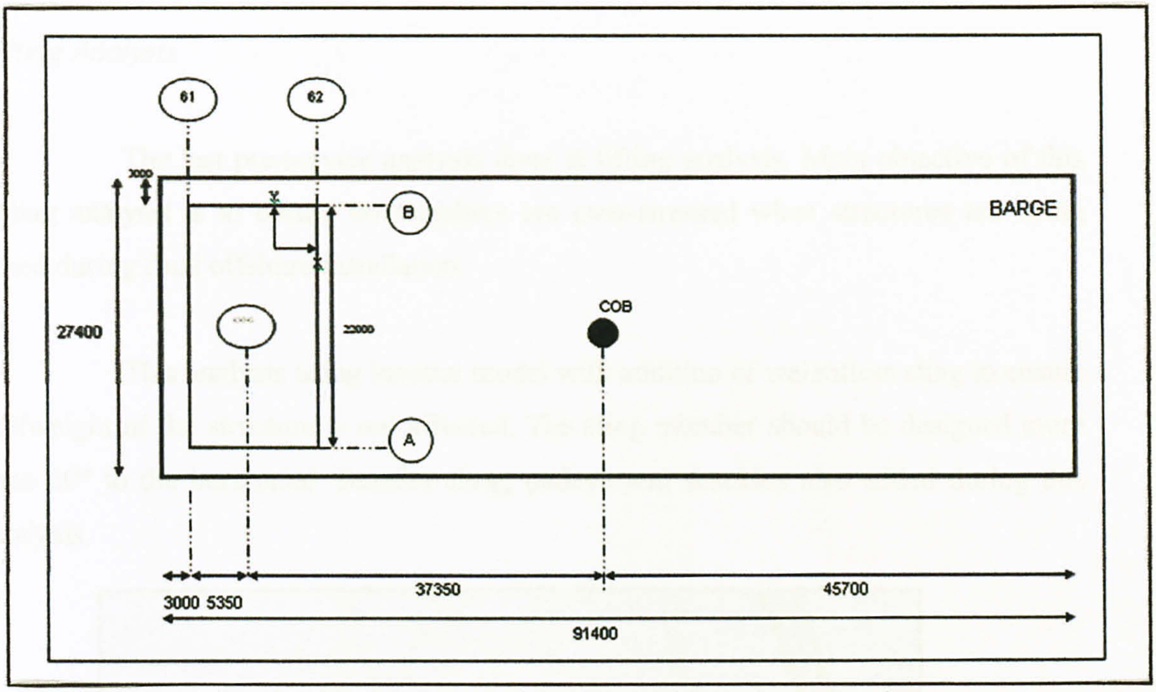

Figure 2.9 : Orientation of module on barge (transverse).

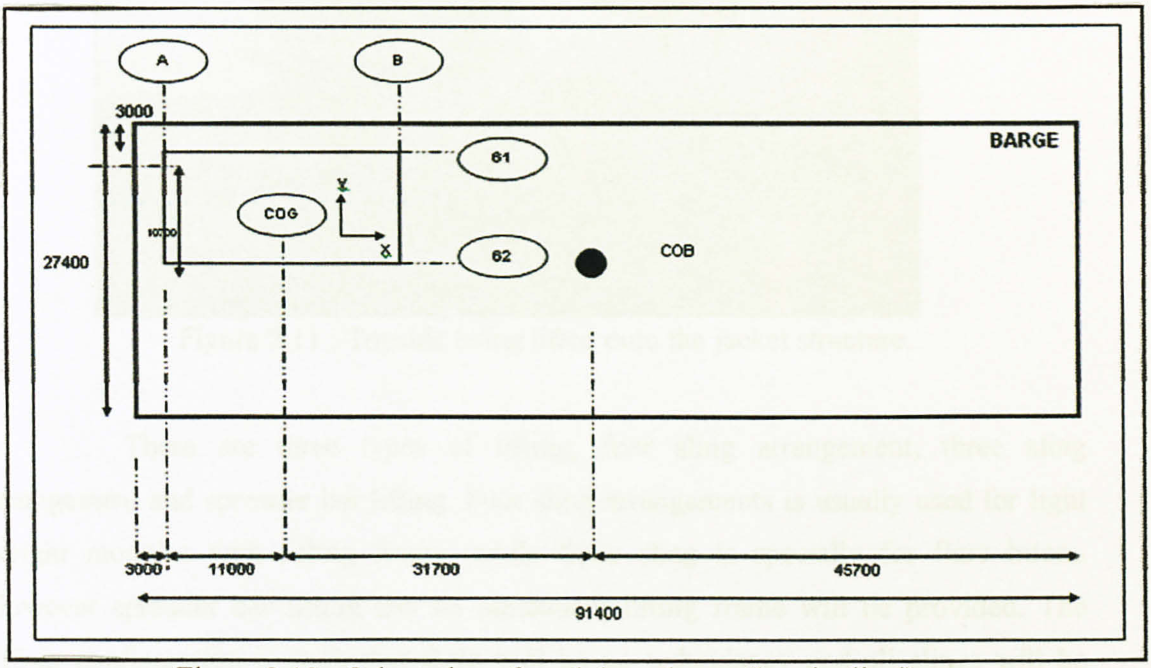

Figure 2.10 : Orientation of module on barge (longitudinal).

The last pre-service analysis done is lifting analysis. Main objective of this lifting analysis is to ensure no members are over-stressed when structures are being lifted during final offshore installation.

This analysis using loadout model with addition of weightless sling to ensure selfweight of the structure is not affected. The sling member should be designed more than 60° to the horizontal. Besides sling, padeye and shackles also added during this analysis.

Figure 2.11 : Topside being lifted onto the jacket structure.

There are three types of lifting; four sling arrangement, three sling arrangement and spreader bar lifting. Four sling arrangements is usually used for light weight modules with lifting frame, while three sling is specially for flare boom. However spreader bar lifting has no permanent lifting frame will be provided. The lifting configuration is such that there will be no redundancy and all slings will be active. All lifting types are illustrated below.

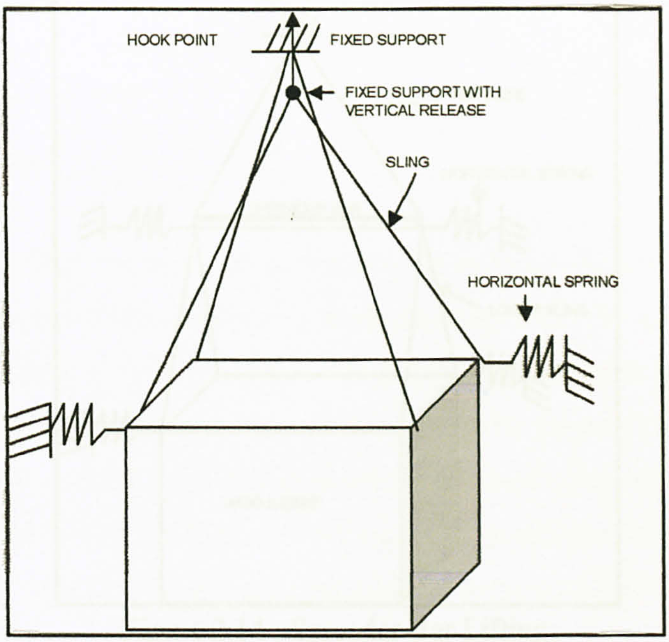

Figure 2.12 : Four Sling Arrangement.

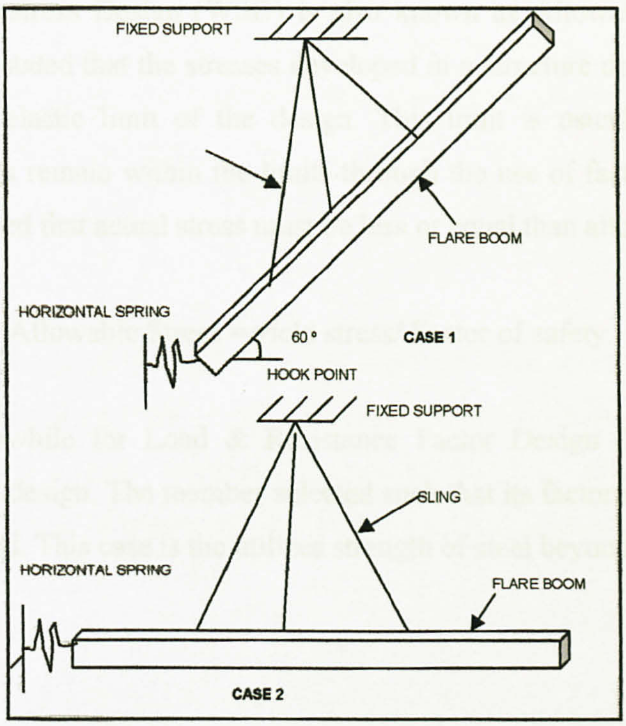

Figure 2.13 : Three Sling Arrangement.

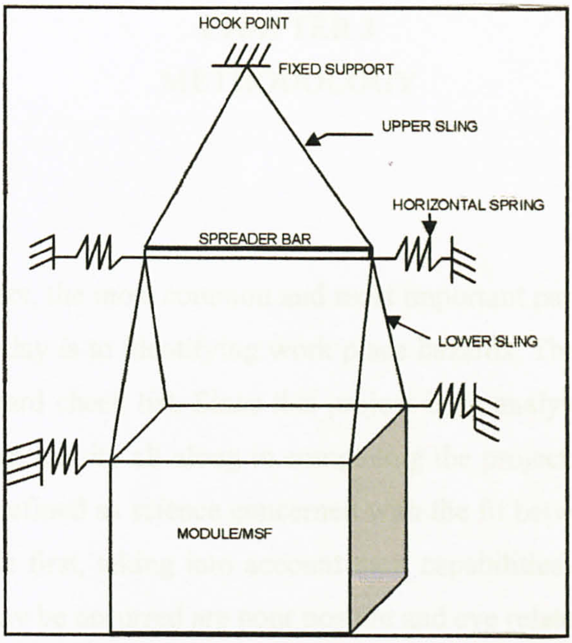

Figure 2.14 : Spreader Bar Lifting.

2.5 Working Stress Design Vs Load & Resistance Factor Design

Working stress Design (WSD) is also known as Allowable Stress Design (ASD). This design stated that the stresses developed in a structure due to service loads do not exceed the elastic limit of the design. This limit is usually determined by ensuring that stresses remain within the limits through the use of factor of safety. This design state also stated that actual stress must be less or equal than allowable stress.

Allowable Stress = yield stress/ Factor of safety.

Meanwhile for Load & Resistance Factor Design (LRFD) also well known as limit state design. The member selected such that its factored strength is more than the factored load. This case is the utilizes strength of steel beyond yield point.

CHAPTER 3
METHODOLOGY

3.1 Introduction

Before start with project, the most common and most important part that been forgot by most of researchers today is to identifying work place hazards. The most common way is to developing a hazard check list. Since this project is an analysis project, there will be in front of computer activity all along in completing the project. This also known as ergonomics which is defined as science concerned with the fit between people and their work and it put people first, taking into account their capabilities and limitations. The hazards that mostly may be occurred are poor posture and eye related hazard.

Analysis of the jacket and topsides structures is to be done using SACS software. A thorough search will be made first through the internet and books from the library to collect as much as can the available and useful information about the project that going to be done. Besides that, also learnt a lot about Working Stress Design and Load & Resistance Factor Design since the analysis will be using both designs. The result of both analyses then will be compared.

3.2 Case Study

As for the case study, one of the RNZ (M) Sdn Bhd will be used with permission from both company and also from their client. The project that will be used is Laho Drilling Platform (LHDP-A) Jacket and topsides. Both project and both structures are own by Petronas Carigali Sdn Bhd. The schematic plan of the project is shown in the figure 3.1.

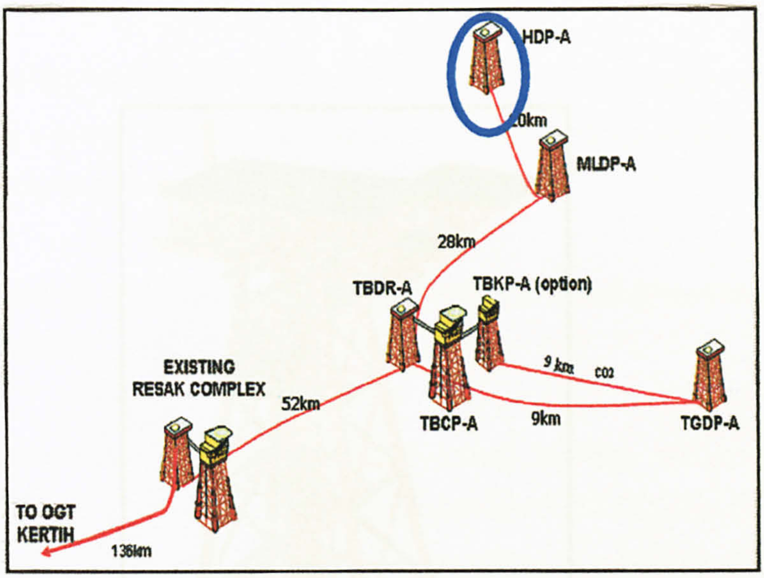

Figure 3.1 : Tangga Barat Cluster Schematic Plan.

Tangga Barat Cluster, which consists of Melor, Laho, Tangga and Tangga Barat gas fields are located about 185 kilometers offshore Peninsular Malaysia in the PM-313 Block at an average water depth of 70 meters. Tangga Barat Cluster Development consists of developing three (3) gas fields with the total of 23 producing wells. The gas from Tangga Barat Cluster contains high level of CO_2. Treatment and removal of CO_2 is necessary to meet the export gas specifications of less than 8 mole percent CO_2 content.

Tangga Barat Cluster Development (Phase 1) consists of the following:

- 1 Central Processing Platform (TBCP-A)
- 1 Drilling Riser Platform (TBDR-A) bridge connected to TBCP-A
- 1 Flare Tripod Platform (TBFP-A) bridge connected to TBDR-A
- 2 Remote Drilling Platforms (LHDP-A, MLDP-A)
- 2 intra field pipelines
- 1 trunk line from TBDR-A to Resak Complex

The one that will be used in this final year project is Laho Remote Drilling Platform (LHDP-A). The model structure of LHDP-A topside and jacket showed in figure 3.2.

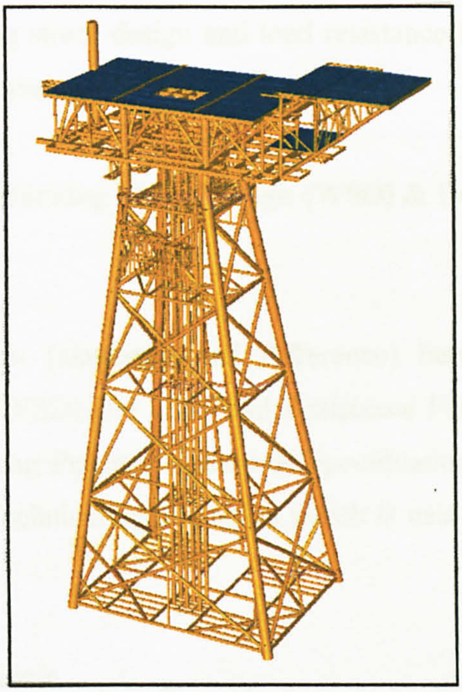

Figure 3.2 : Model of LHDP-A jacket and topside.

There are 4 analyses that have to be done for completion of the real project. As for this project, the most critical analysis only will be analyzed due to the time given. The one that will be analysis is inplace analysis for both jacket and topsides and for both design; working stress design and load & resistance factor design. Under in place analysis, the loading will be applied as the real loading that acting during real time life of the structures. Two cases will be considered which are operating condition and storm or critical condition.

After all analysis for both working stress design and load & resistance factor design done using SACS software, then the result will be compared for both cases. From the analysis results, the utilization ratios and also reliability of the structure will be discussed.

CHAPTER 4
RESULT AND DISCUSSION

This chapter discussed about two things; the finding that I've come out with after doing some research on working stress design and load resistance factor design and also all the work done in analysis part using SACS software.

4.1 Comparison on Working Stress Design (WSD) & Load & Resistance Factor Design (LRFD)

Below is the comparison (similarity and difference) between design criteria for Working Stress Design (WSD) and Load and Resistance Factor Design (LRFD). The comparison is mainly using Petronas Technical Specification which is using working stress design and Shell Technical Specification which is using load & resistance factor design.

1. Environmental criteria

   Throughout the specification, following definitions are used:

   Operating case: 1 year return period

   Extreme storm: 100 year return period.

2. Loading conditions

   For substructure design, load combinations shall follow API RP 2A-WSD and API RP 2A-LRFD respectively.

   Critical wave and current attack direction and wave crest position should be determined by considering up to eight wave attack directions and by employing at least eight wave steps for each direction.

   For each of the above conditions, once the critical wave and current attack direction and position have been determined, tabulation shall be made showing the following:

   a) Shear take-out by piles and conductors at mudline

b) Horizontal batter component of pile axial loads

c) Pile axial loads

d) Total platform shear load

3. Wave and Current Force calculations.

a) Global wave and current coefficient.

In computing global wave forces on the structure with Morrison's equation, drag and mass coefficients for tubular members shall be determined as functions of wave and current parameters and surface roughness, size and orientation as per API code requirements.

The wave kinematics shall be developed using an appropriate deterministic wave theory (Stokes 5th or Deans stream function) taking account of appropriate values of wave height to water depth ratio (h/d) and water depth to wave period (d/T) as dictated by seabed topography and specified environmental criteria for the area.

b) Local wave and current coefficients for isolated member.

In computing local wave forces on isolated members (e.g... sumps, caissons, riser walkways, stairs and ladder) with Morrison's equation, the following equation shall be used.

Table 4.1 : Drag and inertia coefficient.

	Tubular members	Non-tubular members
Drag coefficient, C_d	1.0	2.0
Inertia coefficient, C_m	2.0	2.0

c) Marine growth

Allowance should be made for marine growth in wave force computations. The following layer thicknesses shall be assumed unless an approved marine growth prevention system is employed.

For working stress design that been used by Petronas, two conditions of sea water were considered; Offshore North West Borneo and Offshore East Peninsular Malaysia. Dry unit weight of marine growth shall be taken as $10kN/m^3$ (64lb/cu.ft)

Table 4.2 : Offshore North West Borneo.

Depth,m (ft) From – to	Layer thickness,mm (inches)	Surface roughness,mm (inches)
MSL – -12 (-40)	100 (4)	64 (2.5)
-12(-40) – -21(-70)	50 (2)	25 (1.0)
-21(-70) – Mudline	0 (0)	13 (0.5)

Table 4.3 : Offshore East Peninsular Malaysia.

Depth,m (ft)	Layer thickness,mm (inches)	Surface roughness,mm (inches)
MSL	51 (2)	25 (1.0)
-4.6 (-15)	153 (6)	64 (2.5)
-48.8 (-160)	102 (4)	64 (2.5)
Mudline	25 (1)	13 (0.5)

Meanwhile for Load & Resistance Factor Design (LRFD) as been used by shell. Weight of marine growth shall be considered, marine growth density shall be taken as $1.4t/m^3$

d) Simulated members

Adequate wave force on non-structural members shall be included in the analysis model to simulate boat landings, walkways, stairs, caissons, anodes, risers, protective fenders and marine growth there upon. The analysis of the local loads imposed on the substructure by support clamps/stubs of the boat landings, caissons, risers, fenders etc. shall also be fully covered by the design consultant.

e) Vortex induced vibration (VIV)

The possibility of vortex induced vibration due to the design current velocity profiles shall be considered for all appurtenances and any individual members considered potentially susceptible.

f) Anodes

If anodes are modelled individually, the relevant C_d and C_m for both design cases are shown as below. However, alternatively the global C_d on jacket tubular may be increased by 5% as an allowance for the effect of anodes.

For Working Stress Design (WSD),

Individual anode, $C_d = 2.0$

Individual anode, $C_m = 2.0$

For Load & Resistance Factor Design (LRFD),

Individual anode, $C_d = 1.0$

Individual anode, $C_m = 2.0$

4. Wind Force Calculations.

a) Shape factors

The shape factors use for both cases is the same. The shape coefficients are shown as below:

Flat surfaces	= 1.5
Tubulars	= 0.5
Overall projected platform area	= 1.0

In computing the wind velocity height variations, exponent for sustained winds in the open ocean, (1/n = 1/8) shall be used. The wind speed shall be referenced to +10 metres MSL.

b) Enclosed deck areas

For wind loads, the area between the main deck and lower deck shall be considered fully closed. Shielding effects shall not apply to equipment on the main deck.

5. Allowable stresses (WSD) and Stress check (LRFD)

All members and joints shall be designed in accordance with the latest editions of API RP 2A and AISC for both design cases, WSD and LRFD.

All tubular members shall be designed to satisfy the relationship:

KL/r less than or equal to 120

Where L = unbraced member length

r = radius of gyration

K = effective length factor

And D/t > 20

< 60 unless stiffened

Where D = member diameter

t = member wall thickness

6. Foundations

a) Pile design

For working stress design, the following factors of safety on pile axial loads shall be used.

Operating loads alone	= 2.0
Operating loads & soft mooring	= 1.5
Extreme storm loads	= 1.5
Boat impact	= 1.0

For load & resistance factor design, the following factors of safety on pile axial loads shall be used.

Operating loads alone	= 0.7
Operating loads & soft mooring	= 0.8
Extreme storm loads	= 0.8
Boat impact	= 1.0

b) Scour

For working stress design, unless otherwise specified the foundation/jacket shall be designed for a local sour of 900 mm.

For load & resistance factor design, unless otherwise specified the foundation/jacket shall be designed for a local sour of 900 mm, one pile diameter or actual jacket bottom can diameter (whichever is higher)

7. Boat impact

Platform shall be designed for following two boat impact conditions; operational boat impact and accidental boat impact.

a) Operational boat impact

For working stress design, it is defined as the impacts resulting from a contact with a vessel operating in the vicinity of the platform (normally 1000 to 2500 tonnes displacement supply boat) travelling at 1 knot (0.5m/s) shall be considered in the ship impact zone. The following added mass coefficients shall be employed.

Stern/ bow approach = 1.1

Broadside approach = 1.4

The ship impact zone is defined as +4.0 metres MSL to -4.0 metres MSL.

For load & resistance factor design, it is defined as load resulting from the impact of a 907 tonnes displacement supply boat travelling at 0.514 m/s (1 knot) shall be considered in the ship impact zone. The following added mass coefficients shall be employed.

Stern/ bow approach = 0.1

Broadside approach = 0.4

Below is all information about the 2^{nd} half of the project which is analysis part. Two analyses have to be done which are inplace analysis under Working Stress Design (WSD) and inplace analysis under Load Resistance Factor Design (LRFD). As to this progress report submitted, one analysis done which is inplace analysis under Working Stress Design (WSD) and all the data regarding second analysis have been gathered.

4.2 Modeling the structure into SACS software

Each deck modeled in the SACS software. All modeling part according to the drawing provided by both designers and drafters. At the same time, modeling of the member is according to the geometry of the structure; wall thickness and outer diameter for tubular member, flange width and flange thickness for beam member. This data about geometry of the structure referred to table of dimensions and gross section properties for steel members.

Figure 4.1 shows how the model looks in SACS software. All the modeling according to the decks and trusses.

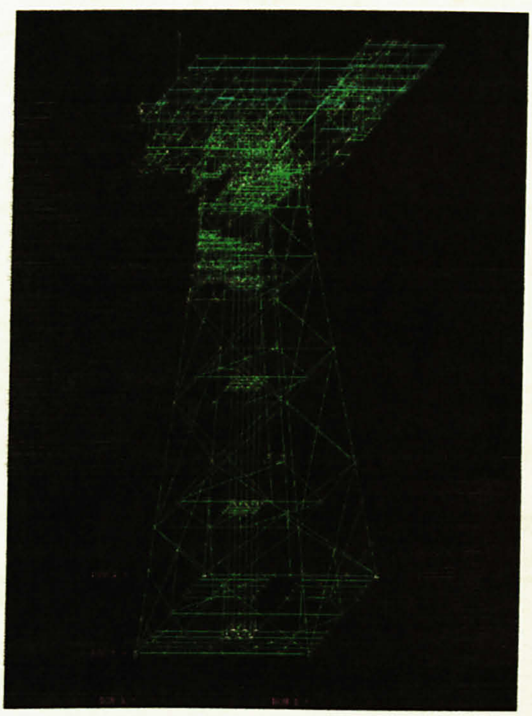

Figure 4.1 : SACS model for whole structure (topside & jacket).

4.3 Member Properties

The member properties such as Modulus of Elasticity (E), density (ρ), and yield strength (F_y) are depending on the member section. The F_y value depend on the member size, where the bigger the size, the greater the F_y. The tables below show the various values F_y and the steel properties used in this project.

Table 4.4 : Yield Strength of Steel Members.

Category	Size	Type	Min.Yield Strength (MN/m²)	Yield Strength used in Analysis (MN/m²)
	$t < 12$	Type III	275	240
	$12 \leq t \leq 40$	Type I	355/345	345
	$40 < t \leq 63$	Type I	340	340
	$63 < t \leq 100$	Type I	325	325
	< W12	Type III	275	248
	W 12 & Above	Type I	355/345	345/340*
	< 273 ϕ	Type III	248	240
	273 ϕ - 406ϕ	Type I	345	345
	$t < 12$	Type III	275	240
	$12 \leq t \leq 40$	Type I	355/345	345
	$40 < t \leq 63$	Type I	340	340
	$63 < t \leq 100$	Type I	325	325

*** For flange thickness greater than 40mm, Fy = 340MPa.**

Table 4.5 : Steel Properties.

Material	Property	Value
Steel	Density	7850 kg/m³
	Modulus of elasticity	210000 MPa
	Shear modulus	80000 Mpa
	Poisson's ratio	0.3

4.4 Loading the model in SACS software.

One of the most crucial and important part in analysis is to model the loads applied on SACS model. This part is crucial because once the system is analyze, its will simulate how the member will react on the presence of loads on it.

Generally there are 4 types of load applied to the SACS model which are:

i. Metocean data load

This type of loading normally will be referred to the metrological ocean statistic data which will state the value of loading for all those environmental data. Examples for this type of loads are wind load and waves load.

Wind load is only considered for topside analysis meanwhile wave load is only considered for substructure analysis. However the wind loads from x and y directions are measured in two conditions; operating and storm condition. The wind load assumed to act concurrently with wave in the same direction and the wind speed is assumed to be omni-directional. The following figure shows wind in eight directions.

Figure 4.2 : Wind Directions.

ii. Discipline load

This is loading provided from each department. Normally there are piping weight from piping department, mechanical equipment weight from mechanical department, electrical equipment weight from electrical department and instrument equipment weight from instrumentation department.

For this type of load, the data from each department is important. Equipment layout is one of the data that need to be referred. This equipment layout showed the orientation of each department items on the deck. With this information, the loading applied according to how it is placed on the deck. One more important data is equipment list. This equipment list showed the load weight in kilo Newton of each items acting on the deck.

iii. Live load

Live load consists of open area live load, walkway live load, live load at laydown area and live load at helideck. This live load indicated that no fix loading applied on this particular area but they will be subjected to loading that change time by time. This load is differing according to the PTS. For an example, open area live load on main deck is 10kPa meanwhile open area live load on cellar deck is 7.5kPa and etc.

iv. **Appurtenances load**

Appurtenances load including unmodelled structural loads such as stair, handrail, grating, firewall and etc.

4.5 Working Stress Design (WSD) Analysis

Two members for this analysis have UC >1, and other members all have UC <1 meaning that only two members can't sustain the loads that acting on it. Identified the maximum or critical UC and classified it by its elevation.

4.5.1 Basic Load Case Factor.

A summary of the basic load factors is tabulated in Table 4.6 below.

Table 4.6 : Basic Load Factor.

BLC	Descriptions	Load Factor
1	SACS Computer Generated Selfweight	1.15
2	Topside Appurtenances Load	1.15
3	Equipments Dry Weight	1.25
4	Piping Dry Weight	1.25
5	Electrical Bulk Weight	1.25
6	Instrument Bulk Weight	1.25
7	Equipment Content Weight	1.25
8	Piping Content Weight	1.25
9	Crane Dead Weight	1.25
15	OALL on Main Deck (10 kN/m^2)	0.50
17	OALL on Cellar Deck (7.5 kN/m^2)	0.667
19	OALL on Closed Drain Deck	1.00
21	Widow Maker	1.00
22	OALL at Laydown Area (15 kN/m^2)	0.333

23	OALL on Helideck (0.5 kN/m^2)	1.00
24	Upward Live Load for Well 1,3,5 (10 kN/m^2)	0.50
25	Upward Live Load for Well 2,4,6 (10 kN/m^2)	0.50
26	Upward Live Load at TAD Approach (10 kN/m^2)	0.50
27	Wind Inplace 0.0 Degree	1.00
28	Wind Inplace 90.0 Degree	0.63
36	Wind +X-Dir (Rig), Rig at TAD Approach	0.16
37	Wind +X-Dir (Rig), Rig Over Condition 1,3,5	0.16
38	Wind +X-Dir (Rig), Rig Over Condition 2,4,6	0.16
39	Wind +Y-Dir (Rig), Rig at TAD Approach	0.101
40	Wind +Y-Dir (Rig), Rig Over Condition 1,3,5	0.101
41	Wind +Y-Dir (Rig), Rig Over Condition 2,4,6	0.101
201	Jacket Appurtenances Load	1.15
203	B/landing & R/guard Appurtenances Load	1.15
204	Jacket Miscellaneous Buoyancy Load	1.00
205	Riser Bearing Force	1.00
206	Open & Closed Drain	1.20
211	Operating Wave/Current 0.0 Degrees	1.152
212	Operating Wave/Current 52.43 Degrees	1.152
213	Operating Wave/Current 90 Degrees	1.152
214	Operating Wave/Current 127.57 Degrees	1.152
215	Operating Wave/Current 180 Degrees	1.152
216	Operating Wave/Current 232.43 Degrees	1.152
217	Operating Wave/Current 270 Degrees	1.152
218	Operating Wave/Current 307.57 Degrees	1.152
221	Storm Wave/Current 0.0 Degrees	1.138
222	Storm Wave/Current 52.43 Degrees	1.138
223	Storm Wave/Current 90 Degrees	1.138
224	Storm Wave/Current 127.57 Degrees	1.138
225	Storm Wave/Current 180 Degrees	1.138
226	Storm Wave/Current 232.43 Degrees	1.138
227	Storm Wave/Current 270 Degrees	1.138

228	Storm Wave/Current 307.57 Degrees	1.138
246	Soft Mooring Wave/Current 232.43 Degrees	1.152
247	Soft Mooring Wave/Current 270 Degrees	1.152
248	Soft Mooring Wave/Current 307.57 Degrees	1.152

4.5.2 Member Unity Check

Member code checks are performed in accordance with AISC Allowable Stress Design (ASD) specification [Ref 5] and API RP2A Working Stress Design (WSD) [Ref 3]. Basic allowable stresses are used for normal operating conditions.

One member has unity check (UC) ratio more than 1.0.All other members with unity check (UC) ratio less than 1.0. A summary of maximum member unity check (UC) is given in Table 4.7 below.

Table 4.7 : Maximum member unity check

Location	Max Member UC
Helideck elevation (+) 28500	0.16
Main deck (+) 24000	0.74
Mezzanine Deck (+) 17800	0.40
Cellar Deck (+) 15000	0.91
Deck Elevation (+) 6000	1.37
Deck Elevation (-) 9000	0.83
Deck Elevation (-) 27000	0.30
Deck Elevation (-) 49000	0.12
Mudmat Elevation (-) 71000	0.09

4.5.3 Joint Unity Check

All tubular to tubular joints are designed for punching shear requirements in accordance to API RP2A [Ref 3]. Table 4.8 below presents the summary of joint UC greater than 1.0.

Table 4.8: Joint UC Check Summary > 1.0

Joint No	Chord Size OD (cm) x WT (cm)	UC
7132	61.0 X 1.2	1.656
8071	61.0 X 2.0	1.769
5244	21.3 X 0.518	1.031
5256	21.3 X 0.518	1.083
8003	61.0 X 2.0	1.582

4.6 Load & Resistance Factor Design (LRFD) Analysis

4.6.1 Load Factor

For this LRFD analysis, the loads value applied on the deck factored accordingly to the type of the load. Type of loads and its load factor show in table 4.9 below

Table 4.9 : Factor load

Load type	Load Factor
Dead Load	1.3
Live Load	1.5
Wind Load	1.2
Wave Load	1.2
Current Load	1.2

4.6.2 Member Unity Check

All members are having unity check (UC) ratio less than 1.0. A summary of maximum member unity check (UC) is given in Table 4.11 below.

Table 4.10 : Maximum member unity check

Location	Max Member UC
Helideck elevation (+) 28500	0.19
Main deck (+) 24000	0.88
Mezzanine Deck (+) 17800	0.41
Cellar Deck (+) 15000	0.94
Deck Elevation (+) 6000	1.69
Deck Elevation (-) 9000	1.07
Deck Elevation (-) 27000	0.36
Deck Elevation (-) 49000	0.14
Mudmat Elevation (-) 71000	0.08

4.6.3 Joint Unity Check

All tubular to tubular joints are designed for punching shear requirements in accordance to API RP2A [Ref 3]. Table 4.12 below presents the summary of joint UC greater than 1.0.

Table 4.11: Joint UC Check Summary > 1.0

Joint No	Chord Size OD (cm) x WT (cm)	UC
7132	61.0 X 1.2	2.356
8071	61.0 X 2.0	2.222
5244	21.3 X 0.518	1.254
5256	21.3 X 0.518	1.494
8003	61.0 X 2.0	1.854

CHAPTER 5
CONCLUSION

5.1 Conclusion

The following conlusion are achieved at the end of the study:

1. Inplace analysis of the jacket platform was carried out using the Working Stress Design (WSD) and Load & Resistance Factor Design (LRFD).

2. The Unity Check (UC) of all member using Working Stress Design (WSD) and Load & Resistance Factor Design (LRFD) was obtained. The value were tabulated in the table 4.7 and table 4.10.

3. The Unity Check (UC) for all members using Load & Resistance Factor Design (LRFD) yielded values greater than value obtained using Working Stress Design (WSD). The supposed value is Unity Check using Load & Resistance Factor less than value obtained using Working Stress Design (WSD) .

5.2 Recommendation

Several things can be done in order to improve the project:

- All the members with Unity Check (UC) greater than 1 should be encountered. To encounter the problems :
    - Thicken the wall thickness
    - Upsize member
    - Reconfigure member support by adding braces
    - Adding external stiffner to the members
- Recheck the analysis using Load & Resistance Factor Design (LRFD) .

CHAPTER 6

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