Decommissioning Asset Management System for Fixed Steel Jacket

by

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Dissertation submitted in partial fulfilment

of the requirement for the

Bachelor of Engineering (Hons)

(Civil Engineering)

SEPTEMBER 2017

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A project dissertation submitted to the
Civil Engineering Programme
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in partial fulfilment of the requirement for the
BACHELOR OF ENIGINEERING (Hons)
(CIVIL)

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2017

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ABSTRACT

Malaysia has approximately 362 offshore platforms and most of these platform has exceeded the design life and thus leading to decommissioning study for dismantling the offshore structures. Several decommissioning alternatives are listed which include total removal and partial removal for reuse, onshore disposal, artificial reefs and topple in-situ. In addition, Malaysian waters are classified into four region namely, Peninsular Malaysia Asset (PMA), Sabah Asset (SBA), Sarawak Gas (SKG) and Sarawak Operation (SKO). In this study, design and characteristic data for fixed offshore platforms in SKO were collected and kept as a database. Hence, platforms selection can be identified for decommissioning and study the cost of previous successful decommissioning project. In summary, the main goal for this study aims to develop an asset management system for decommissioning strategy to reduce overall decommissioning cost and explore potential alternative such as reefing.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia has a huge number of offshore platforms for oil and gas industry and most of them has exceeded their design life. In Malaysia, about 50% of offshore platforms have reached their design life. Moreover, most of the offshore facilities in Malaysia, the design life is between 25 – 30 years. Among all, three project of offshore platform has successfully been decommissioned, which were Ketam field in 2003, Baram-8 in 2004 and Samarang SM4 and SMV in 2012 (OEC, 2017). Hence, Malaysia is still green for the decommissioning area and strategy. As Best Practicable Environmental Option (BPEO) for decommissioning study, BARAM-8, SM4 and SMVA, these offshore platforms have successfully decommissioned by using the method of conversion to artificial reef for BARAM-8 while complete removal for both SM4 and SMVA, which are these two platforms located at Sabah. A few of offshore facilities in Malaysia has undergone asset life extension and which is the purpose to identify the recommendation and actions as well as estimated costs necessary to maintain the assets for a further 15 years operation.

In oil and gas industry, for operating the offshore platforms five stages are involved before the operation started and for the process of maintaining the structural integrity which involve engineering stage, procurement, construction, commissioning and decommissioning. Decommissioning is the last stage of operation for fixed steel jacket where offshore platforms already be abandoned for the purpose of economics and safety. In Thailand, Ministry of Energy has outlined that the facility unused longer than one year need to decommission (OEC, 2017). But in Malaysia, the specific regulation is yet to implement. In addition, decommissioning itself refer to term the act of withdrawal from the service and the term is applicable to all assets, for instance, wells, facilities, pipelines

(PPGUA, 2013). The options for decommissioning include complete removal, partial removal, artificial reef and reuse of offshore facilities. Furthermore, each option be determine with respect to criteria of fatigue, reserve strength ratio, corrosion, number of piles, water depth, wave climate and platform location are vital for decommissioning planning (Zawawi et al., 2014).

Costs play a vital rule in oil and gas industry. With the current low oil prices, this situation contribute in reducing of a few strategies for operating and decommissioning of offshore facilities. In addition, according to Stokes (2014), during the actual decommissioning work, cost can be reduced by three criteria involve contracting strategy, use of previous experience and by using new technology.

1.2 Problem Statement

Research by Potty (2013) and OEC (2017) support that 51% of offshore platforms in Malaysia has exceeded the design life of 25 years which mostly the platform aged about 30 – 40 years. The structures have been subjected to the environment for a prolonged period and thus the probability for the structures to fail are very high.

Ageing platform tends to have less safety as it has exposed to the ocean for a long duration and thus affect the integrity of the structures. It is vital to prioritize the elements of candidate platforms in order to safeguard the personnel and environment as the ageing platforms normally corroded and have significant damages on the structures. Decommissioning as a technical term "process involves closing down operations at the end of field life" which include the wells abandonment, platform safety and facilities removal and thus safe for navigation and preservation of marine environment (PPGUA, 2006; API RP 2SIM, 2014)

Moreover, lack of information and understating of offshore platform status leading to poor costing and planning and decommissioning option. According to Jais et al. (2016), Asia operators are still in infancy stage of decommissioning as they are still focused on developing technologies to produce new strategy for decommissioning area. Lack of proper management system in addressing the above has led to high cost in decommissioning process and during decommissioning.

1.3 Objective

This study aims to develop an asset management system for decommissioning to reduce overall decommissioning cost and explore potential reuse or more feasible option such as reefing and disposal. Given the aim, the specific objectives are:

1) To populate database of asset status and asset details in order for better dismantle planning.
2) To identify the candidate assets for decommissioning campaign based on the database.
3) To take up the case study from previous decommissioning project in order to study the marine spread cost (for application to decommissioning campaign).

1.4 Scope of Study

This research is emphasizing on decommissioning asset management system for fixed steel jacket. Moreover, the research addresses on the decommissioning for substructure and excluded for covering on topsides. To ensure the project is in correct timeline and for the precision of this research, data gathering and data validation from the previous experience and previous information on offshore facilities will be collected. Thus, the scope in this research is collecting data for Sarawak Operation (SKO) of fixed offshore structure in order to obtain design life for each platform and therefore can provide information on decommissioning strategy. In addition, the experts' survey will be conducted for taking measurement to compare on the result of decommissioning planning. The study focusses on the ranking for decommissioning option with respect to certain criteria and cost.

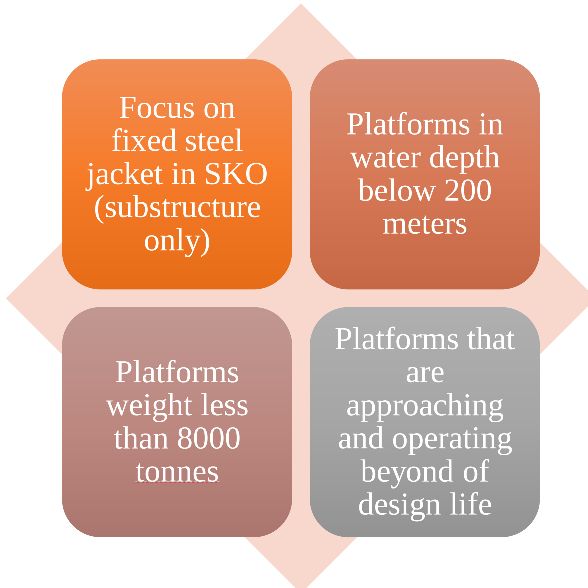


FIGURE 1.1 Scope of study

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This study will be covered on decommissioning of fixed offshore structures which focus on the jacket removal. Offshore structures are encompasses of topside and jacket. Fixed steel jackets are vertical sections made of tubular steel members and are usually piled into the seabed. Previous research has been done in developing decommissioning strategy and involve of the costing element for the facilities removal. Thus, the literature review aims to get a general idea and issue on decommissioning throughout the worldwide.

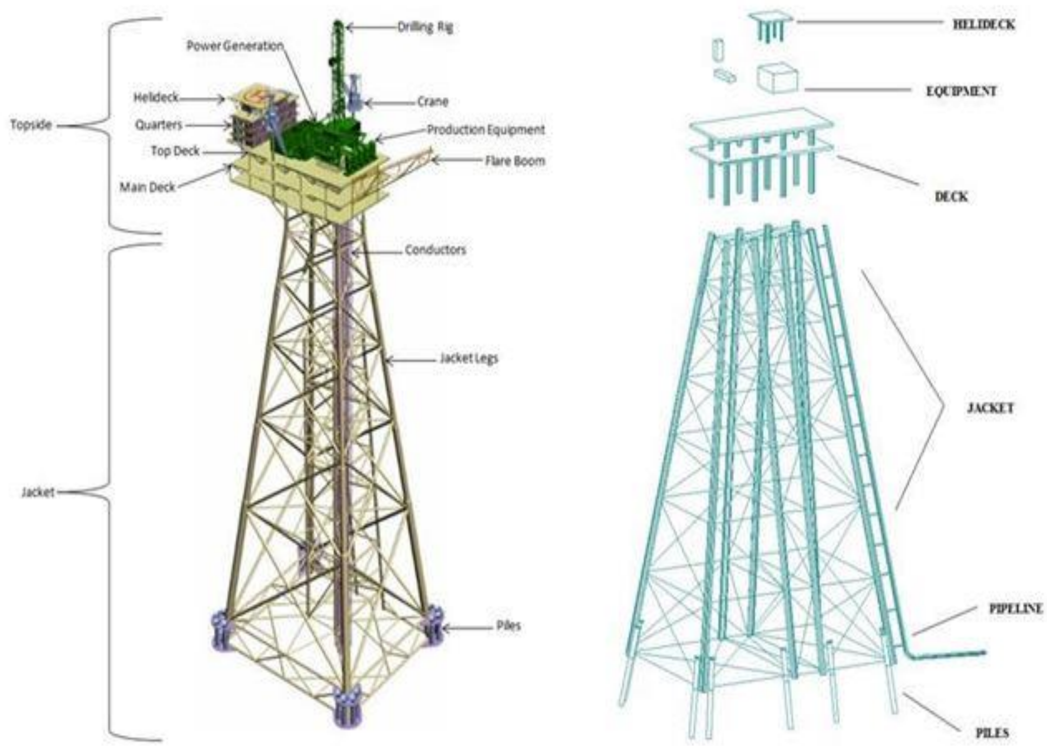


FIGURE 2.1 Image of Fixed Offshore Structures

2.2 Decommissioning Alternatives

Decommissioning as referred to IMO 1989 is the "abandoned or disused offshore installations or structures on any continental shelf or in any exclusive economic zone are required to be removed. All activities to cause no significant adverse effect upon navigation or marine environment." Normally, offshore structures were designed between 25 to 30 years of design life, and at the end of platform life, offshore structures need to be decommissioning to safeguard the personnel, environment, asset and resources.

As Best Practicable Environmental Option in Malaysia, three successful decommissioning project were done using rig to reef. Figure below shows the decommissioning alternatives that can be taken into account for dismantling purposes.

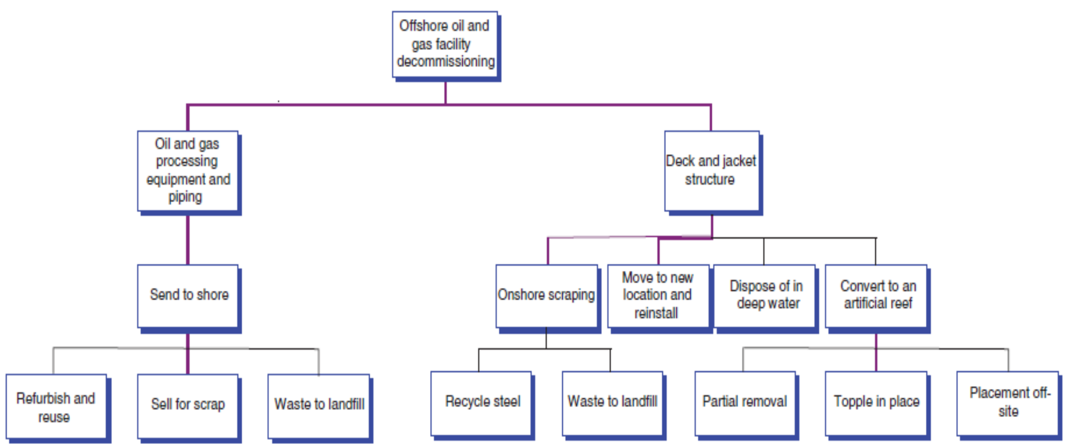


FIGURE 2.2 Oil and Gas Facility Decommissioning Tree (Source: M.J. Kaiser/ Marine Policy 30 (2006) 605-623)

2.3 Planning for Decommissioning

As stated by Grifin (1998) for Society of Petroleum Engineers, for a successful decommissioning, six elements need to be considered and take into account which involve environment concern, technology, cost, safety, regulations and views of the public. Environment issue is a significance for decommissioning as the emission of carbon dioxide to the atmosphere by using vessel for transportation and lifting purposes for instance.

In addition, as cited by Stokes (2014), major cost contribution for offshore facilities are at end-of-the-field life as in North Sea for a shallow offshore platform about 80 meters and produce 65,000 barrels oil per day and has operated for 15 years, the final decommissioning cost is about 800 million USD which is resulting in negative cash flow. The cost of decommissioning can be reduced by giving the priority for work to execute. For instance, by efficiency and reducing number of days for vessel take to execute decommissioning scope shall reduce cost for diesel and overall cost for project team. Furthermore, in line with the cost for decommissioning, Jais et al. (2016) for Offshore Technology Conference, to capture all activities and associated cost related; pre & post decommissioning and execution phase it is vital to have Decommissioning Cost Estimating Model as it give direction for decommissioning to follow the time and workflow for the estimator.

In other hand, for decommissioning technology challenges, as stated by Prasthofer (1998) for Offshore Technology Conference, issues and problems that must be overcome to remove and dispose of the installation successfully both technical and operational. For instance, the ability to cut steel into sections safely for choosing either diamond wire cutting or abrasive water jets are the challenge faced.

For safety purposes, to decommissioning an offshore platform it is not easy to safeguard the personnel as every steps taken is considered as a risk. Consequently, decommissioning team is significance for managing and handling from the planning up until the platform successfully decommissioned and monitoring for post decommissioning. As stated in Grifin (1999), diversified team representing a wide range of disciplines will be easier to assemble.

2.4 Research on Decommissioning Option

Based on the research by Kanmkamnerd et al. (2016), the case study is related to give ranking for five distinct project option for offshore platform jacket dismantle with regard to evaluation of ten ecological perspectives. Physical and chemical quality of air, water and sediments at the project location are environmental aspects that be taken into account for this research. To date, several innovative tools for decision making process has been developed and this research using NEBA which is Net Environmental Benefit Analysis to identify the ecologically superior project alternative and aid managers in selection of management alternatives that provide environmental benefit. Based on NEBA assessment, the result for this research shown the most significance for environmental concerns was by towing jacket and reef at alternate site option.

In other hand, research by Zawawi et al. (2014) was regarding development of a management decision making tool which incorporated throughout the operation life for offshore platform on Malaysia fleet. In addition, the research aimed by developing a tool by prioritizing the pre-decommissioning strategy of fixed offshore structures during the life cycle. By using Relative Importance Index (RII), the criteria be ranked through calculation and thus demonstrate to the existing asset management system. To further have the significance of the research, project manager, consultant and contractor were the appointed experts for this research by conducting surveys.

Furthermore, research by Na et al. (2016) established Asset Integrity Management System by developing a knowledge based advisory expert system to address the life cycle of fixed jacket structures in the selection of feasible decommissioning option. Besides, in order for managers to plan ahead and optimize resources, this research proposes a model for the planning of offshore structures dismantle and thus give rank of best practicable decommissioning alternatives.

2.5 Risk Matrix

With a specific end goal to speak to the risk level of the stages, a risk level can be shown as in risk matrix. The risk framework for the risk level is passed on by 5 x 5 matrix to order each risk level for PETRONAS field of offshore structures (RBUI, 2014). To date, current risk matrix with respect to PETRONAS HSE Matrix as March 2015 is displayed underneath.

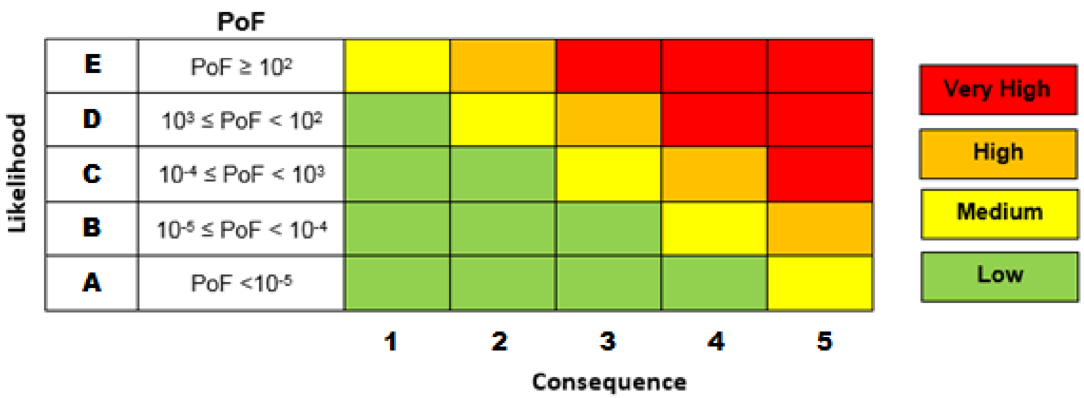


FIGURE 2.3 Typical Risk Matrix (Seismic Assessment for Fixed Offshore Structures Procedure Draft, 2017)

The likelihood scores will show that whether the jacket structures are sufficiently vigorous to withstand the earth occasion in the area. The matrix appeared in figure above gives five classifications of consequences (1 to 5) and five classes of likelihood (A to E) of failure. Four risk levels are recognized, spoken to by the accompanying four zones:

- Zone Very High (Red) represents Very High Risk Exposure
- Zone High (Orange) represents High Risk Exposure
- Zone Medium (Yellow) represents Medium Risk Exposure
- Zone Low (Green) represents Low Risk Exposure

The division between the consequences of failure and likelihood of failure categories is chosen taking into consideration the absolute magnitude of the values, their ranges, and the need for consistent reporting when comparing different platform structure. The risk matrix followed PETRONAS HSE Risk Matrix (HSERM) refer to Appendix 1.

2.6 Cost Drivers for Facilities Removal

Overall costs will be reduced if any of the cost drivers are reduce. For instance for the marine spread, if vessel required to execute the tasks within number of days that are below that planning previously, the associated cost will be reduce. As stated in Byrd (2014), the marine spread gave the highest amount of total cost for decommissioning strategy.

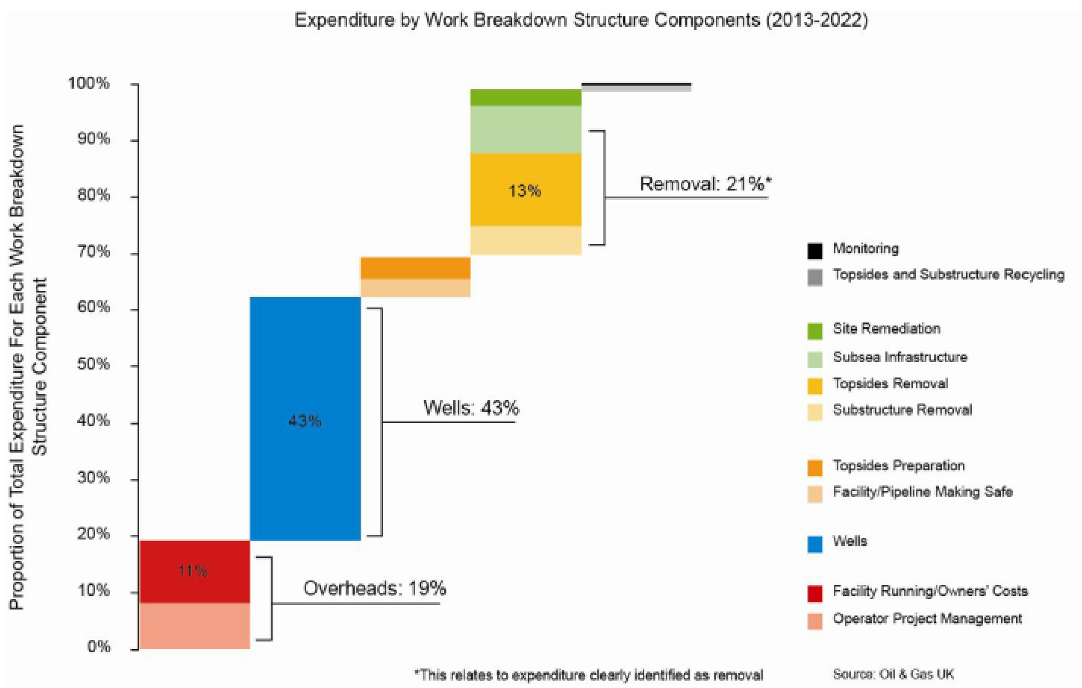


FIGURE 2.4 Decommissioning Cost Estimation as stated in Stokes (2014)

As referring to Stokes (2014), the cost for facility removal was about 21% which encompasses of site remediation, subsea infrastructures, topside and substructure removal.

2.7 Decommissioning Campaign

According to Thornton (2016), operators must begin right on time in arranging (5 – 7 years before COP) to recognize and realize conceivable cost funds for decommissioning. This is a key empowering agent for the supply chain as they require data and early access to the task.

It has been anticipated that, by disposing of various spread preparations and performing simultaneous operations over a nonstop campaign of decommissioning work, the work extension could be finished in a fraction of the time, with add up to costs lessened by 33% (Siems, 2012).

2.8 Codes & Standards

As stated in PETRONAS Technical Standard (PTS): Design of Fixed Offshore Structures – PTS 11.22.02, June 2015, design life of platforms should be 30 years unless stated otherwise. PTS.11.22.02 is widely used in Malaysia as a guideline for PETRONAS operation of fixed offshore structures and thus be used in this study area.

In addition, the guidelines and requirements referred for this study:

1. PETRONAS Procedures and Guidelines for Upstream Activities Decommissioning Guidelines (PPGUA), March 2006.
2. International Maritime Organization (IMO) Guidelines and Standards for the Removal Offshore Installation and Structures, October 1989.
3. American Petroleum Institute Recommended Practice (API RP 2SIM), 2014.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

To have methodology for research is a vital in order to make sure the research is in correct timeline and follow the work flow. For research methodology, data gathering and data validation are the most significance as with information, it can strengthen and defense the research topic. The process methodology for this research are divided into two phases as follow:

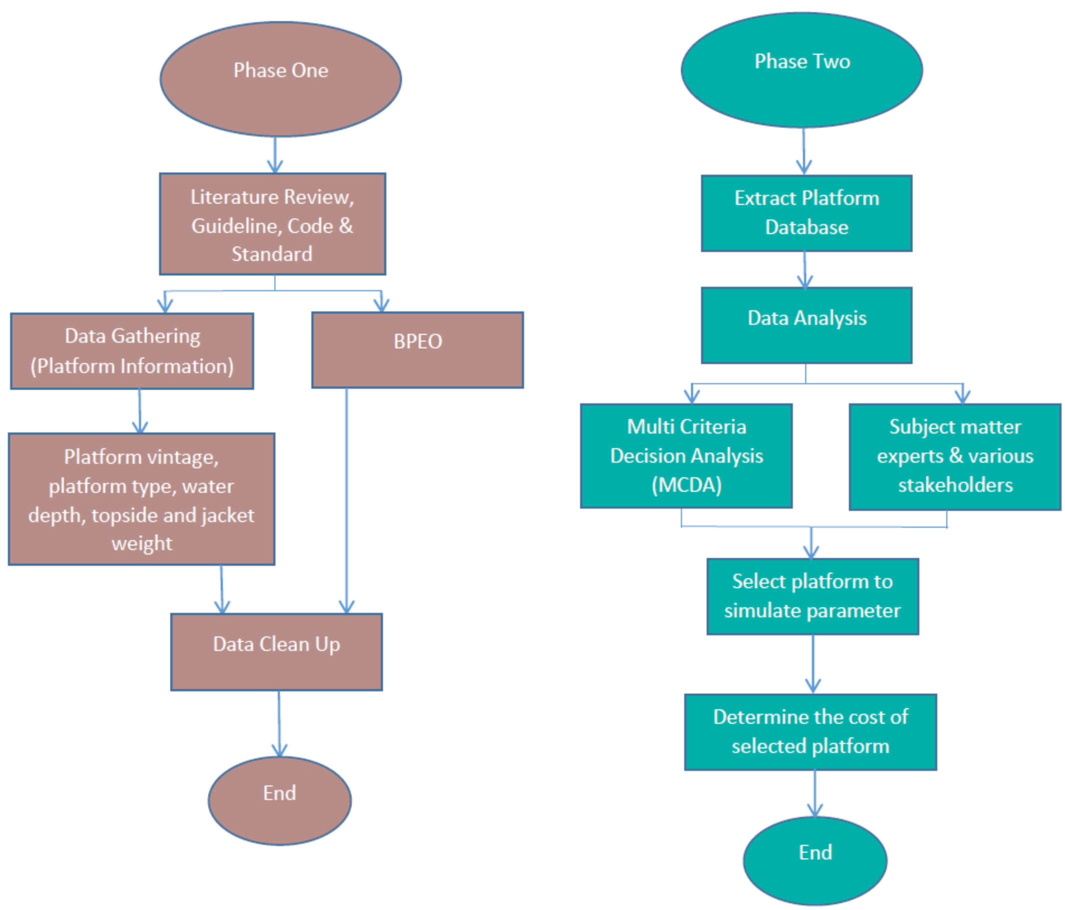


FIGURE 3.1 Method of Study

3.2 Data Mining

As for phase one, first step is data gathering which can be obtained from Structural Integrity Compliance System (SICS) owned by PETRONAS Upstream. Design and characteristics data of offshore structures can be obtained through SICS and weight control report if data are missing. Platform data will include the platform age, weight, type, and bracing were obtained from web-based tool. Since Sarawak Operation has many platforms that are operated beyond design life and has oldest platforms among all four regions, thus the data of fixed offshore structures in SKO were selected for this study. Data is populated using spreadsheet of Microsoft Excel to ease distinguish certain characteristics accordingly.

3.3 Data Validation

Next step after collecting data is data validation. Data will be validated with the database owned by department in order to check the accuracy on the data and correctness of recent data. After data obtained be verified, next step is to determine the total number of offshore structures in SKO and remaining life of the asset. In order to do the decommissioning study, it is important to know the status of the asset for better dismantling strategy. For data clean up, some of data in SICS maybe not up to date and for this study, data recentness is important to clean up the web-based tool.

3.4 Data Analysis

For phase two, data analysis is takes place to do the decommissioning study based on database populated earlier. Factors to be considered for decommissioning strategy includes technical, cost, safety, environmental and stakeholder perceptions. In order to consider of stakeholder perception, survey will be conducted to get additional information and opinion on decommissioning alternative. A case study of decommissioned platform will be used in this study to see the robustness of the aid. The selection of platforms are based on the cluster and the tonnage of jacket that can be accommodate in a single derrick barge of marine spread for decommissioning campaign. Decommissioning campaign will take place to overhaul all the selected platforms in one take off. Then, the cost of decommissioning campaign of jacket removal will be determined for this study.

Figure 3.2 shows the process of decommissioning study for offshore structures.

FIGURE 3.2 Process of Decommissioning Fixed Steel Jacket

3.5 Project Key Milestone

For project management system, specific milestones can reflect decommissioning process and thus the methodology allows development and assessment of potential solution prior to execution. (M.M. Jais et al., 2016).

The significance of having key milestone is for monitoring the progression of the research. The process of completing this research for FYP1 and FYP2 is represented by key milestone below.

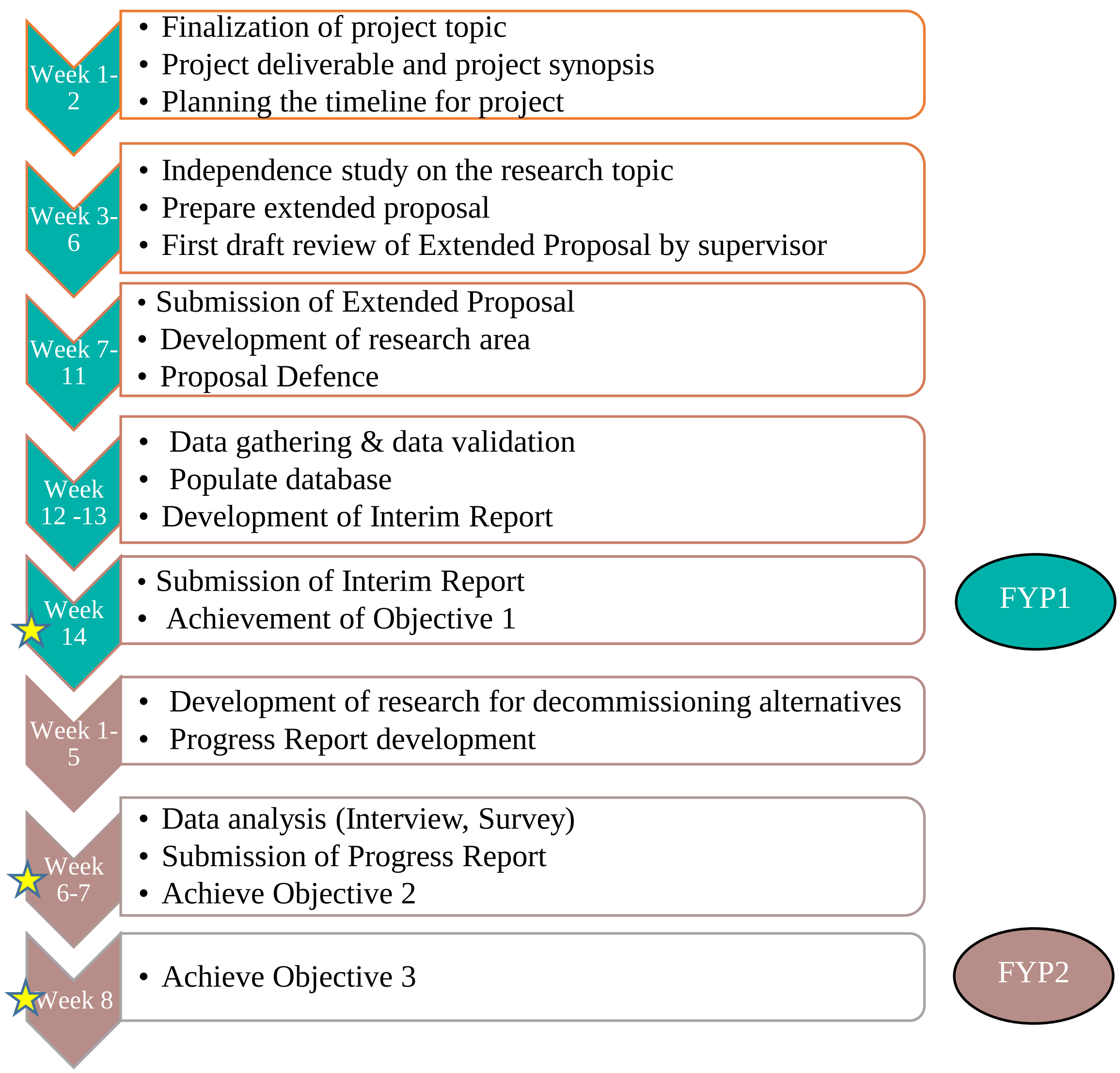


FIGURE 3.3 Key Milestone for FYP1 and FYP2

3.6 Gantt Chart

Date marks for completing certain task is vital for progression of work flow. Thus, Gantt chart for this research on FYP1 and FYP2 as figure below.

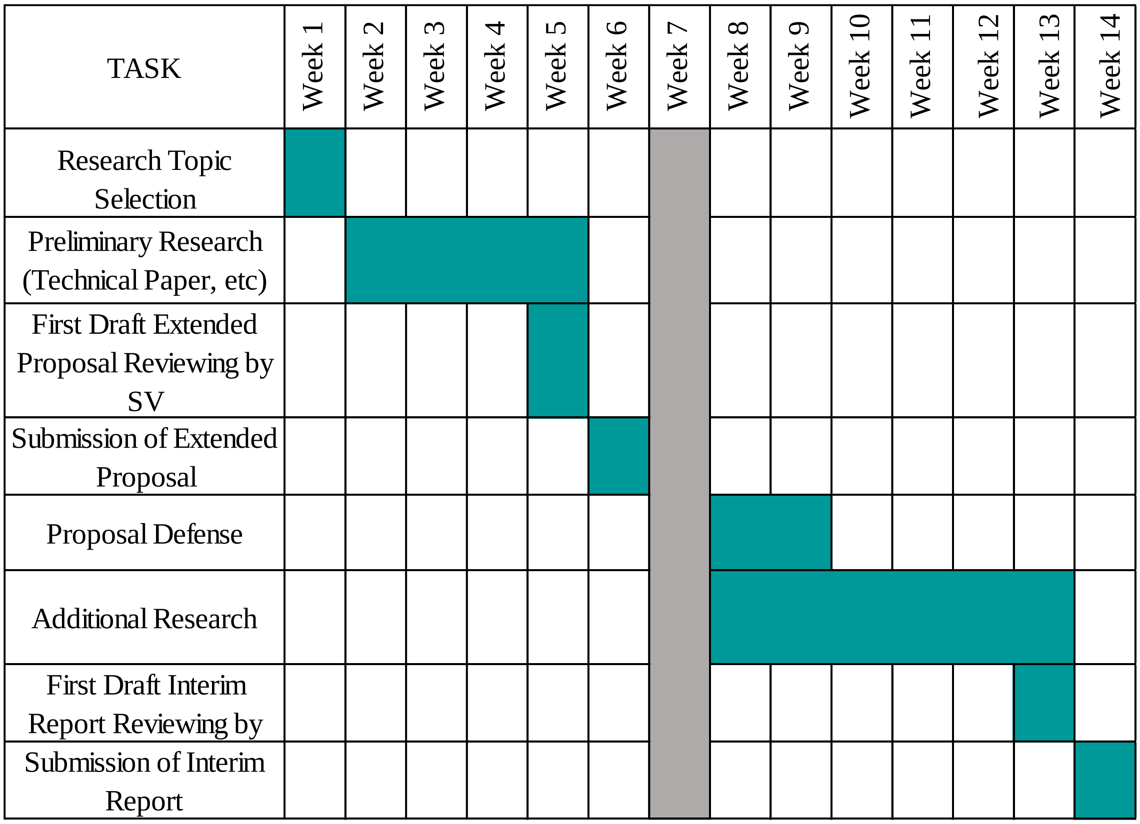


FIGURE 3.4 Gantt chart FYP1

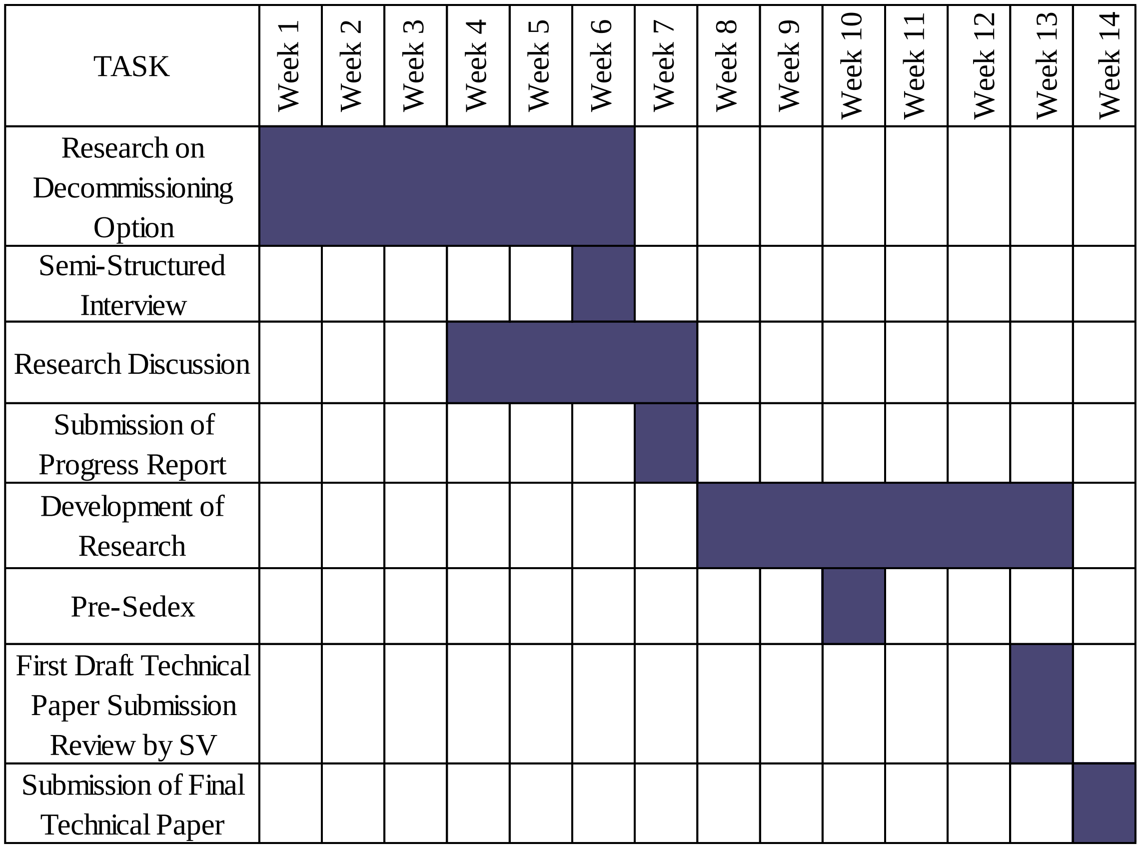


FIGURE 3.5 Gantt chart FYP2

CHAPTER 4

RESULTS AND DISCUSSION

As for preliminary result, objective 1 has been achieved which is to populate database for asset status. Malaysia waters are divided into four regions namely Peninsular Malaysia Asset (PMA), Sabah Asset (SBA), Sarawak Gas (SKG) and Sarawak Operation (SKO). For this study, data of offshore structures at SKO be collected and will be analyzed in this research on decommissioning study since most of platforms in SKO already reached the design life and even exceeded the design life. In addition, data was collected from Structural Integrity Compliance System (SICS) which is owned by PETRONAS Upstream.

Based on SICS, 107 platforms are operating under Sarawak Operation for PETRONAS Upstream among 203 of fixed offshore structures in Malaysia. A huge number of platforms have been operated in Sarawak since 1969.

TABLE 4.1 Platform in Sarawak Operation (SICS, 2017)

Platform Type	No. of Platform
Fixed Platform	99
Decommissioned Platform	2
Other Type of Platform	6

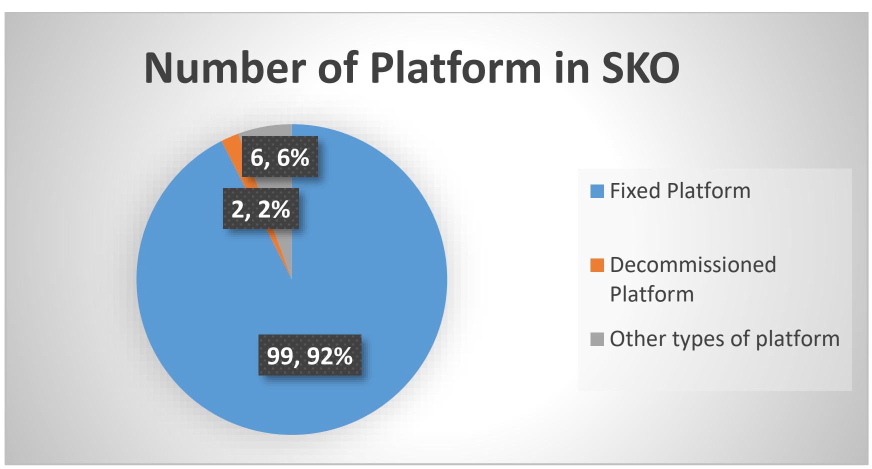


FIGURE 4.1 Number of Platform in Sarawak Operation (SICS, 2017)

4.1 Platform Age

As for platform age, it is vital to be recorded as to know the status of asset and to determine whether the structures are fit-for-purpose to the operation. Platforms are classified into range of age 0 – 10 years, 11 – 20 years, 21 – 30 years, 31 – 40 years and exceeded 41 years in order to ease the analysis for this study. Among of 99 active platforms in SKO, the dominant age of platforms are between 31 – 40 years which has 36.6% and followed by 29.7% of platforms that are more than 40 years' operating in Sarawak. Therefore, SKO has proven that most of platforms operating in the region are old and yet still fit-for-purpose for operation. Even the platforms still operating but most of platform has exceeded the design life and thus important for decommissioning study and strategy. Percentage of offshore structures' age is summarized as Figure 4.2.

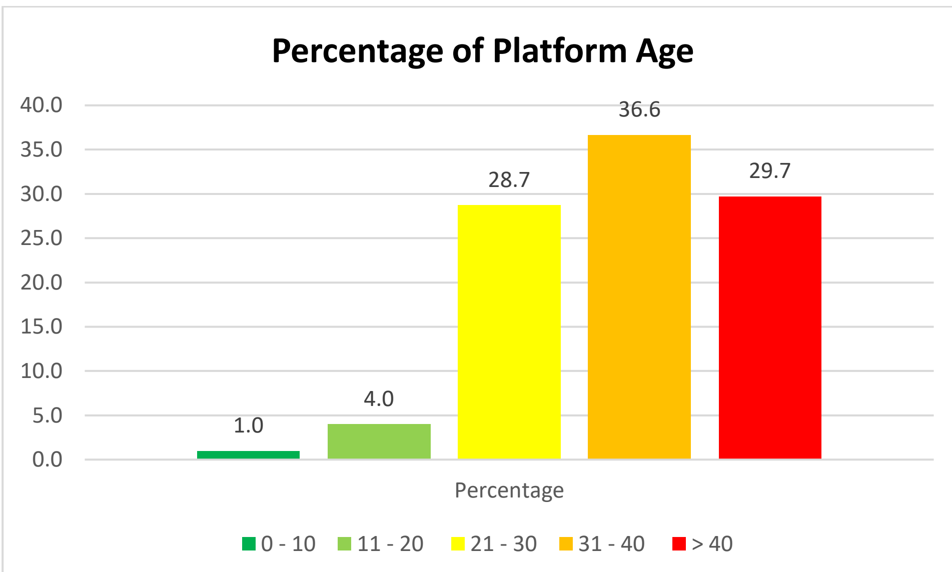


FIGURE 4.2 Percentage of Platform Age in SKO

The decommissioning plan shall be submitted by the Production Sharing (PS) Contractors for PETRONAS' approval at least twelve (12) months prior to decommissioning activities as stated in PPGUA. Thus, the platforms are classified into three categories which are platform age of design life of least than 2 years, more than 2 years of design life and exceeded design life.

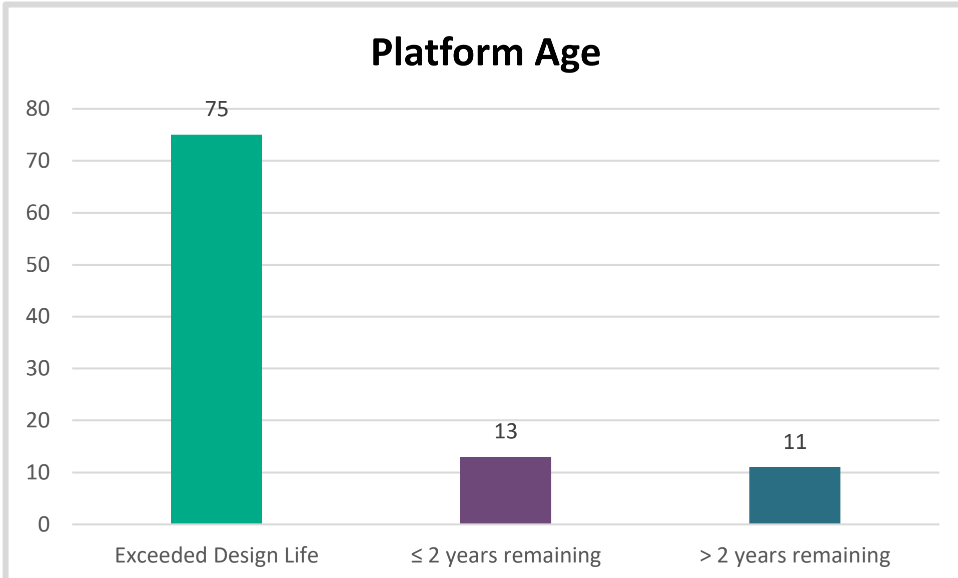


FIGURE 4.3 Platform Design Life as 2017 in SKO

According to SICS, based on 107 platforms, 3 platforms are not specified the design life and thus be assumed as 30 years of design life as stated in PPGUA. As Figure 4.3, 75 platforms in SKO have exceeded the design life which are vital in status and one of the reason that platforms still standing is because of the platforms were designed using API standard. In addition, many platforms have undergone asset life extension study which is the purpose to identify the recommendation and actions as well as estimated costs necessary to maintain the assets for a further 15 years operation because the platforms still producing for economic and society. 13 platforms have the design life less than 2 years remaining which are vital in decommissioning prioritization and 11 platforms are more than 2 years remaining life of total design life.

4.2 Platform Cease of Production (COP)

Based on extracted data belongs to department, as of 99 of active offshore platforms in SKO, there are 9 data platforms that still not being updated yet the COP year. Therefore, the remaining of 90 offshore platforms shall be assessed on COP year. COP is vital in determining on period of wells producing and until to extent it give beneficial in economic sector. It is important to determine COP for ranking the platforms that need to be focused for decommissioning purposes. For this study, we aimed to focus on strategy for the next 15 years and thus COP year below 2032 for purposing a dismantle strategy since quarter of total platforms are below the propose year. Figure 4.4 shows the number of offshore structures based on Cease of Production year.

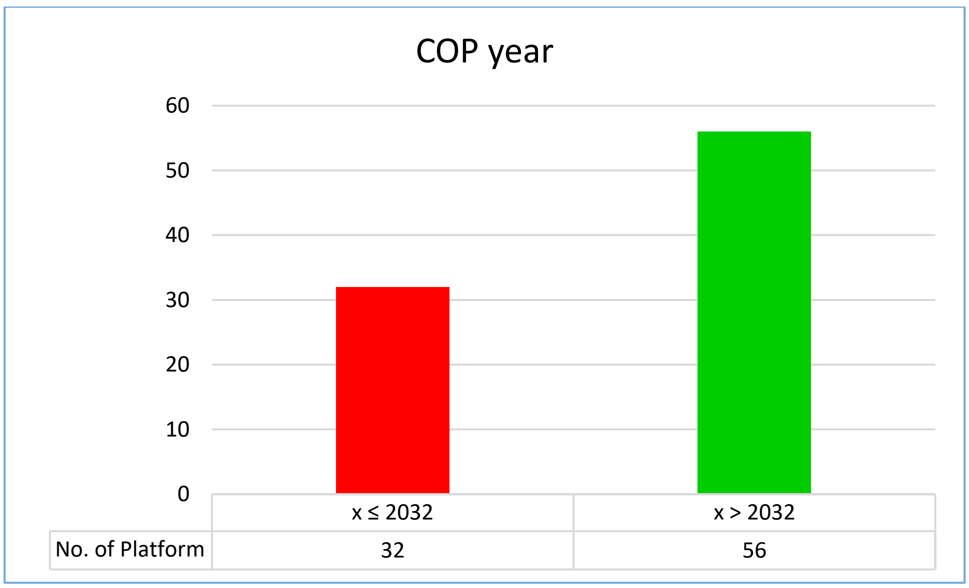


FIGURE 4.4 Data on Number of Platform for Cease of Production Year

Based on figure provided, 32 platforms were prioritized for dismantle planning since they approaching on COP year of 2032 which will be one of the parameter that need to be taken into account. The remaining 56 platforms are above 2032 of COP year that no need to look out as beyond of scope of study.

4.3 Platform Risk Ranking

South China Sea is dominant to extreme storm and this is one of the factor affected the integrity of offshore structures. As this study is focusing on Sarawak and the offshore structures are located in South China Sea, the risk level of these platforms need to consider for the parameter on decommissioning strategy. For the risk level of offshore platforms, the extent of life safety, environment, reputation and economy were considered. Only one platform has high risk level, while 12 of platforms reside in medium risk level and the rest is in the low risk level which is the safest among all of the offshore platforms in term of risk ranking. The only one high risk level of platform need to be prioritized for the decommissioning strategy.

4.4 Platform Jacket Weight

Platform jacket weight is very significant for determine the strategy of cutting and transportation of dismantle structures. In addition, jacket weight influence on the vessel capacity to be used for the transportation of demobilization since the strategy is to take as much as can to be put into barge in one cluster for decommissioning strategy. In order to choose a size of barge which lead into total cost, the tonnage of jacket weight is vital for lifting from site to the barge. According to the data, the lowest tonnage for jacket weight is about 35 MT and the highest is 2896 MT. Hence, this data give the precise value for determining the capacity of the barge and lifting crane to transport the dismantle structures.

4.5 Selection of Platforms in SKO

As the data was validated, the platforms were selected based on the parameter of platform age, water depth, jacket weight and cease of production year. Three (3) platforms were selected as a case study to determine the costing for the jacket removal based on decommissioning campaign in a cluster. The marine spread is the most influence cost among all of the cost driven. According to Byrd (2014), the cost of derrick barge services is the primary cost driver in offshore structures removal. The platforms are adjacent to each other in one cluster in Sarawak fleet. The distance of the field from the onshore Sarawak is about 40 kilometres. In addition, the data for candidate assets for decommissioning campaign were summarized in the table as followed.

TABLE 4.2 Data of Selected Platforms for Decommissioning Campaign

Platform	Platform A	Platform B	Platform C
Platform Function	Wellhead	Production	Vent
Year Installed	1974		
Design Life (years)	25		
No of Legs	4	4	3
Water Depth (m)	54.9	54.9	54.6
Jacket Weight	180 T	250 T	102 T

As the table provided, the data shown that the design life for three platforms were 25 years and exceeded the design life which it should be decommissioned on year 1999. The average water depth of the platforms was about 55 meters and categorized as shallow water area. The total tonnage of the jacket weight for the three platforms was 532 tonnes. This data is vital for the selection of marine spread and contribute to the overall costing of jacket removal. The cost for Derrick Barge for 2000 tonnes per hour per barge as stated in Byrd (2014) was USD 7,500 in 2013.

4.6 Cost Estimation based on Successful Decommissioning Platform in Malaysia

Decommissioning encompasses of well, topside, jacket and pipeline. However due to limitation of time, this study focus on the jacket costing but still searching for overall cost estimation of decommissioning. The total estimated market volume of these three selected platforms were based on previous decommissioning project of Ketam and Samarang. For Ketam, it was successfully decommissioned on 2003 with USD 16.5 Million of 3000 MT and with water depth of 54 meters which first successful decommissioning project done by Shell in Malaysia. In addition, for Samarang, it involved two platforms and first project done by PETRONAS in 2012 for USD 8.5 Million with total weight of 180 MT in water depth of 10 meters (OEC, 2016). The total estimated market volume based on upper bound, middle and lower bound were based on topside and jacket and done by PETRONAS MPM.

TABLE 4.3 Total Estimated Market Volume for Jacket based on Upper Bound, Middle and Lower Bound

Cost Estimate	Cost (USD)	Total Estimated Tonnage, MT	Total Estimated Cost (USD)
Upper Bound (Samarang)	49,000/T	532	26,068,000
Middle	28,000/T	532	14,896,000
Lower Bound (Ketam)	7000/T	532	3,724,000

Based on candidate assets of jacket tonnage of 532 tonnes as Table 4.3, the total estimated cost for market value was about USD 3,724,000 to USD 26,068,000. The inflation rate as 2003 & 2012 was about 2.51%.

As stated in OEC (2014), Siwa was gazette as an artificial reefing site by the state government and hence the jacket removal will be reefing at Siwa field. The distance between the cluster of selected platforms and Siwa fleet was about 30 kilometers.

4.6.1 Cost Breakdown for Jacket Removal (Marine Spread)

According to Bureau of Safety and Environmental Enforcement (BSEE), the jacket removal involved of separating the structures from the foundation and transporting it in a whole or by pieces to scrap yard or any potential alternatives such as reefing. Due to research limitation, the focus of this study will estimate the cost for lift and swing jacket over the cargo barge.

Two procedures are regular to lift the jacket either altogether as a single piece or in a several pieces. The main choice requires less planning yet a HLV with huge limit. The second choice requires cutting the jacket at specific elevation either with the utilization of divers or ROV's. The jacket is then lifted piecewise which requires a HLV with significantly less limit yet longer operational time (Ellwanger et. al, 2016).

The lift and swing jacket over the cargo barge is the vital step for jacket removal. As successful decommissioning project of D30 platform by awarded contactor which was Sapura Kencana, the first step of substructure removal sequence was adjust derrick crane to the required lift radius until the final step of swing substructure via vessel stern the set onto position of material barge and commence weld tiedown. The overall steps for substructure removal of decommissioning project D30 platform will be shown in appendices.

The following Figure 4.6 extracted from technical paper of cost estimating for offshore oil and gas facility decommissioning by Dr. Robert Byrd from TSB Offshore Inc. The tasks shown for the jacket removal of drilling or production platform of 4-Pile installed in 1975 with 71 meter of water depth. The information given on the technical paper was used for the feasibility study on decommissioning strategy for the selected platforms as chapter 4.5.

4-Pile Jacket Removal Lift & Swing Jacket Over to Cargo Barge	
Task Description	Duration (Hours)
Install & Weld Closure Plate/Leg	2.0
De-ballast Jacket Legs (per leg)	1.0
Install Lift Rigging & Hook Up #2 Block	1.4
Lift Jacket	0.5
Install Side Lift Rigging & Hook Side Lift Rigging on #3 Block	7.0
Hoist #3 Block, Slack #2 Block, Upend Jacket Clear of Water	0.8
Hook Winches to Jacket & Winch Jacket Parallel to Cargo Barge	0.5
Revolve Crane to Position Jacket Over Cargo Barge	0.5
Bring Cargo Barge Under Jacket	2.0
Lower Jacket onto Load Spreaders	0.3
Start Sea Fastening	3.0
Remove Rigging	3.0
Complete Sea fastening	5.0
TOTAL	27.0

FIGURE 4.5 Typical 4-Pile Jacket Removal and Tie-down Tasks and Times (TSB Offshore, Inc.)

On the technical paper by Byrd, the cost was estimated in 2013. As 2017, the inflation will be about 1.23%. The cost estimation somehow related with Platform B which was the production platform with 4 legged and water depth of 55 meters. After piles and conductors are severed only then jacket are removed.

According to PETRONAS installation engineer, Mr. Mohd Zhafran Sulaiman, total days for DANA & D30 decommissioning campaign was about 18 days which 9 days for each platforms. The marine spread used are DP3 vessel, supply vessel named Gemia and Seputeh, transportation barge named Maritime Hope and tug boat named Omni Akira. As to propose decommissioning campaign, as Platform A, B and C are adjacent to each other and reside in the same cluster, the number of days to compete the decommissioning project will be lesser than dismantle individually.

DANA and D30 decommissioning project was a lump sum project with cost of RM 50 Million to 60 Million. The total tonnage for the jacket weight was 1,010 tonnes for two platforms. According to Sapura Kencana project manager, the estimated cost for DP3 vessel per day was about USD 269,750. In addition for a unit per day of transportation barge, anchor handling tug (AHT) and supply vessel were USD 1,764, USD 3,631, and USD 9,338 respectively.

Hence, if the total days for decommissioning three platforms take about 20 days to execute the campaign, the total estimation cost of marine spread including two supply vessels, Gemia and Seputeh is about USD 5,876,420. The percentage of marine spread rate per day was summarized as Figure 4.6. The cost is not included the ROV, the cutting tools and manpower.

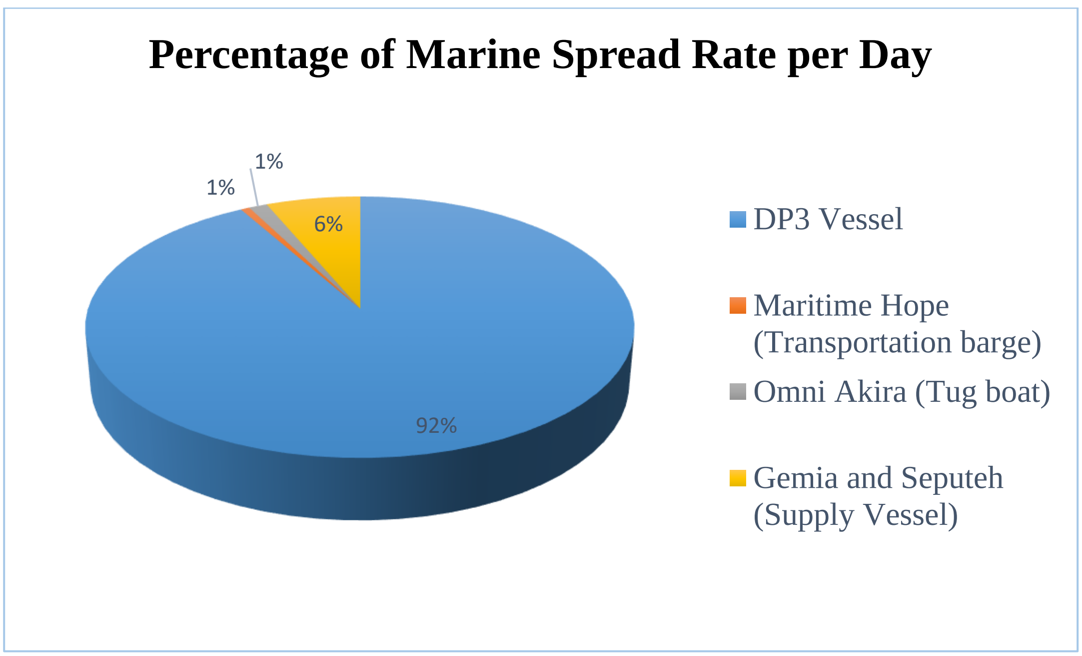


FIGURE 4.6 Percentage of Marine Spread Rate per Day for Jacket Removal

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

As for conclusion, the research needs to develop an asset management system for decommissioning to reduce overall decommissioning cost and explore potential reuse or more feasible option such as reefing. As the current low oil price, it is affected the total cost for the operation of offshore platform. Thus, an asset management system can provide the best practicable alternatives at the lower cost with certain criteria for dismantle purposes. Malaysia platform even has exceeded the design life yet it still robust for operation because of most old platforms are designed using API.

Objective 1 has been achieved which database of asset status and asset details was populated in order for better dismantle strategy. Most of design and characteristics data of offshore platforms were extracted from SICS and validate with data from department and thus see the differences and similarities in data provided.

For this study, candidate assets for decommissioning campaign were based on cluster and parameter of platform age, water depth, jacket weight and cease of production year. Hence, the cost for overall decommissioning campaign was determined using case study of previous successful decommissioning projects such as Ketam and Samarang.

As for future recommendations that need to be considered, the analysis can be done using MATLAB for accuracy and more interviewers for the precision of the project.

Within eight (8) months of this study, decommissioning alternatives of offshore structures for Sarawak Operation were determined and thus can ease PETRONAS and the contractors for decommissioning activities in the future.

REFERENCES

Offshore Engineering Centre, Universiti Teknologi PETRONAS, 2017. Strategic Report on the Decommissioning and Engineering Market in Malaysia.

Berhad, P. N. 2013. *PETRONAS Procedures and Guidelines for Upstream PREAMBLE* (Vol. 1).

Byrd, R. Miller, D. and Wiese, S. 2014. *Cost Estimating for Offshore Oil and Gas Facility Decommissioning*. AACE International 2014 Annual Meeting.

Ellwanger, K. Nascimento, E.A. Mohammadi, S.F. Galgoul, N.S. 2016. *Regulations and Cost Estimation for the Decommissioning of a Sample Fixed Offshore Platform in Brazil*. International Journal of Civil & Environmental Engineering IJCEE-IJENS Vol: 16 No: 05

Kanmkamnerd, J. Phanichtraiphop, P. & Pornsakulsakdi, L. 2016, November 14. *NEBA Application for Jacket Decommissioning Techniques*. International Petroleum Technology Conference. Doi:10.2523/IPTC-18982-MS

M.M. Jais, R. Rashidi, N.A. Anis 2016. *Establishing Decommissioning Capability*. Offshore Technology Conference. OTC-26795-MS

Na, K. L., et al. 2017. "An expert knowledge based decommissioning alternative selection system for fixed oil and gas assets in the South China Sea." Ocean Engineering **130**(Supplement C): 645-658.

PETRONAS Procedures and Guidelines for Upstream Activities Decommissioning Guidelines (PPGUA), March 2006.

PETRONAS Upstream. 2017. '*'Seismic Assessment for Fixed Offshore Structures Procedure*". Draft

PTS18.04.02 PETRONAS HSE Risk Matrix

SICS. 2017. *Structural Integrity Compliance System.* Retrieved 2017, from SICS: http://pww.psims.petronas.com.my

Siems, G. L. 2016. *Decommissioning Process Optimization Methodology*. Offshore Technology Conference. doi:10.4043/26867-MS

Sulaiman, M. Z. Installation Engineer PETRONAS. Personal Interview. 2017.

Stokes, A. W. 2014, May 5. *Decommissioning Costs Can Be Reduced*. Offshore Technology Conference. doi:10.4043/25247-MS

Thornton, W. 2016. Technology Focus: Decommissioning and Abandonment. Society of Petroleum Engineers. doi:10.2118/0116-0080-JPT

Zawawi, N. A. W. A., Na, K. L., & Liew, M. S. 2014. *Development of Platform Selection Tool for Offshore Decommissioning in Malaysia.*

APPENDIX

<u>Appendix 1</u>

The PETRONAS HSERM as shown in Figure 1 below provides five (5) levels of Severity of "worst case" Consequence of release or occurrence of hazards and five (5) levels of Likelihood of the "worst case" Consequence occurring for each of four (4) categories, i.e. People, Environment, Assets, and Reputation (P, E, A & R).

Source: PTS 18.04.02

Figure-1: PETRONAS HSE Risk Matrix (HSERM)

		SEVERITY	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
Consequence		People	Slight Injury	Minor Injury	Major Injury Major Health Effects*	Single Fatality Permanent Total Disability*	Multiple Fatalities Permanent Total Disability*
		Environment	Slight Impact	Minor Impact	Moderate Impact	Major Impact	Massive Impact
		Asset	Slight Damage	Minor Damage	Local Damage	Major Damage	Extensive Damage
		Reputation	Slight Impact	Limited Impact	Considerable Impact	Major National Impact	Major International Impact
LIKELIHOOD	E Almost Certain	Incident has occurred several times per year in OPU	E1	E2	E3	E4	E5
	D Likely	Incident has occurred in OPU; or more than once per year in PETRONAS	D1	D2	D3	D4	D5
	C Possible	Incident has occurred in PETRONAS; or more than once per year in industry world wide	C1	C2	C3	C4	C5
	B Unlikely	Incident has occurred in industry, world-wide	B1	B2	B3	B4	B5
	A Remotely likely to happen	Never heard of in industry world-wide but could occur	A1	A2	A3	A4	A5

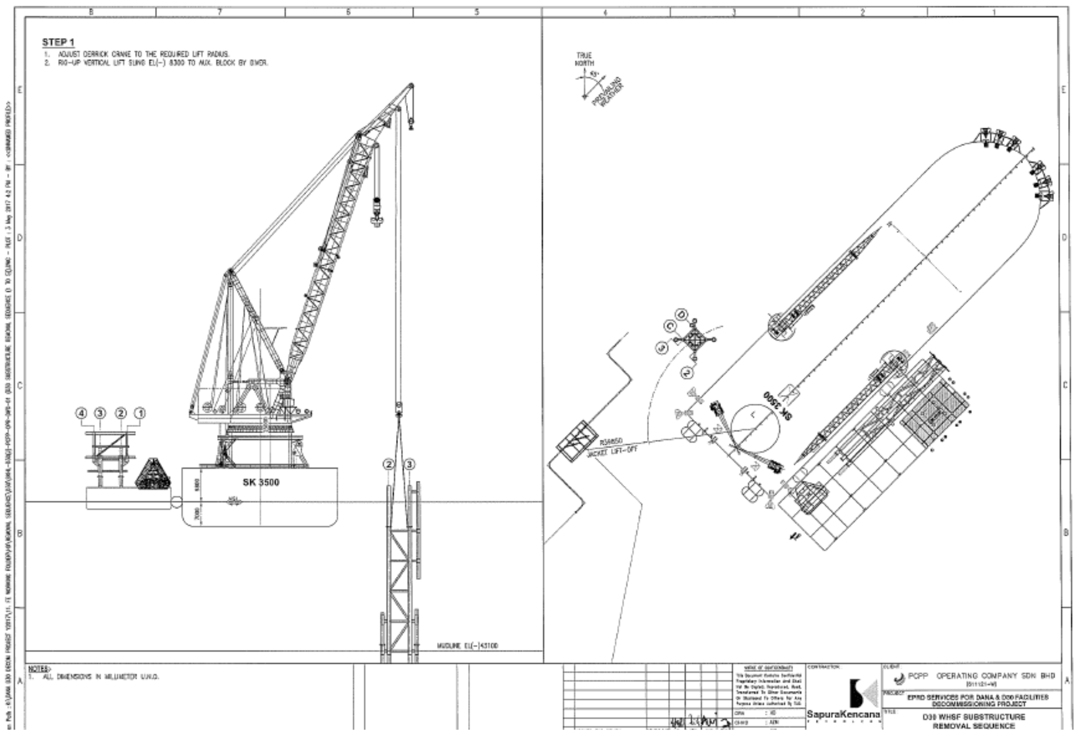
VERY HIGH
HIGH
MEDIUM
LOW

* For chronic health effects

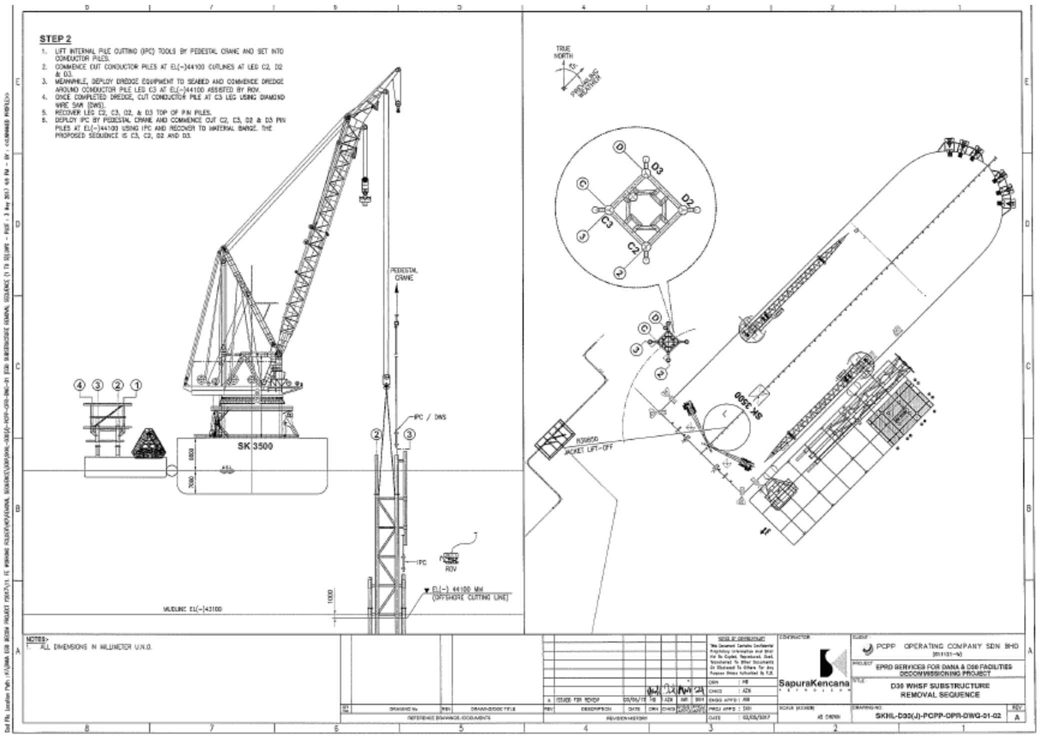
<u>Appendix 2</u>

D30 Substructure Removal Sequences

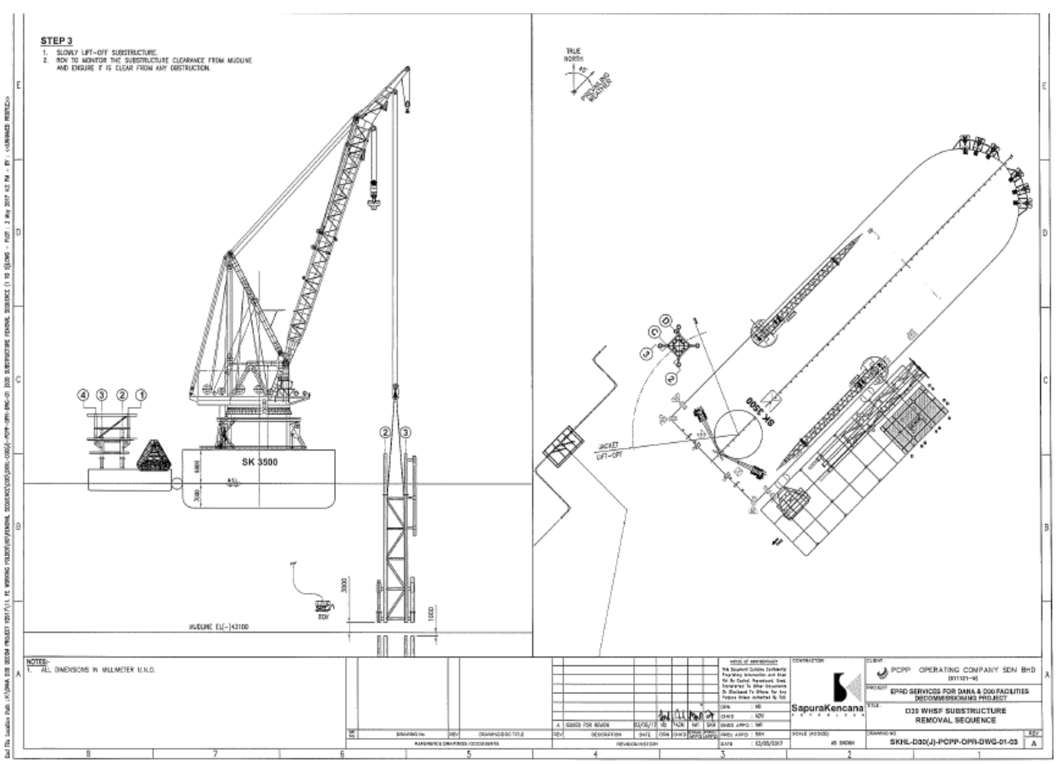
Step 1:



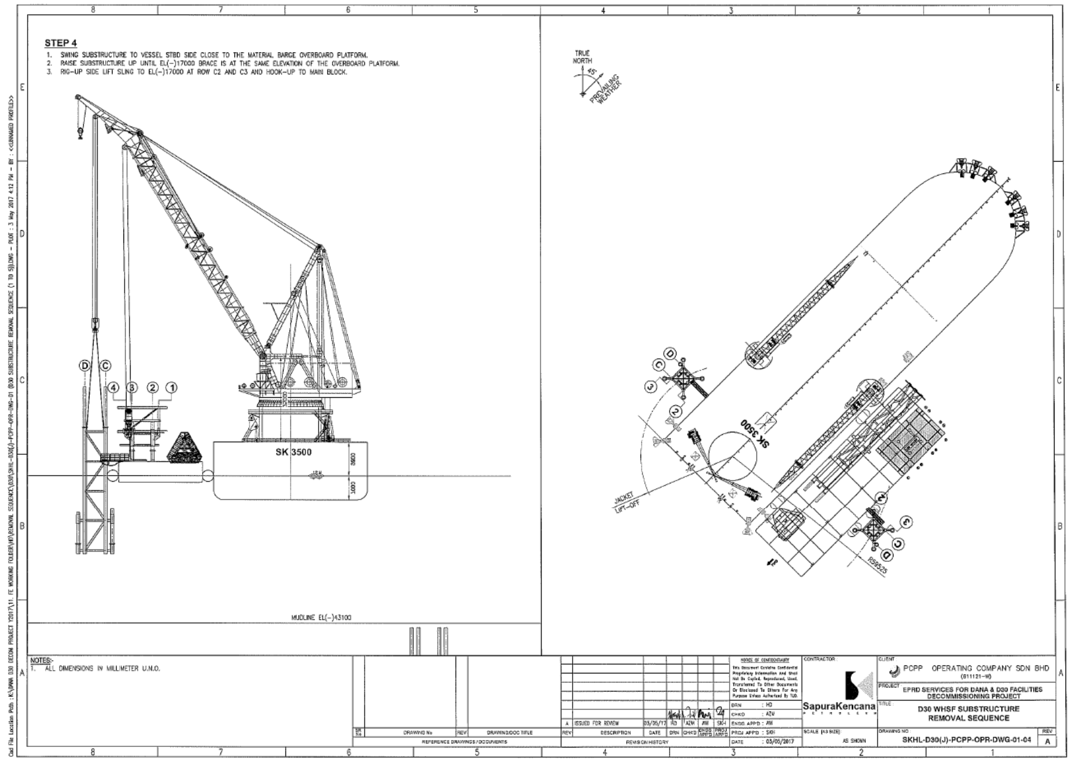
Step 2:


STEP 2
1. LIFT INTERNAL PILE CUTTING (IPC) TOOLS BY PEDESTAL CRANE AND SET INTO CONDUCTOR PILES.
2. COMMENCE CUT CONDUCTOR PILES AT EL(-)44100 CUTLINES AT LEG C2, D2 & D3.
3. MEANWHILE, DEPLOY DREDGE EQUIPMENT TO SEABED AND COMMENCE DREDGE AROUND CONDUCTOR PILE LEG C3 AT EL(-)44100 ASSISTED BY ROV.
4. ONCE COMPLETED DREDGE, CUT CONDUCTOR PILE AT C3 LEG USING DIAMOND WIRE SAW (DWS).
5. RECOVER LEG C2, C3, D2, & D3 TOP OF PIN PILES.
6. DEPLOY IPC BY PEDESTAL CRANE AND COMMENCE CUT C2, C3, D2 & D3 PIN PILES AT EL(-)44100 USING IPC AND RECOVER TO MATERIAL BARGE. THE PROPOSED SEQUENCE IS C3, C2, D2 AND D3.
TRUE NORTH
PEDESTAL CRANE
IPC / DWS
SK 3500
IPC
ROV
EL(-) 44100 MM (OFFSHORE CUTTING LINE)
MUDLINE EL(-)43100
JACKET LIFT-OFF
NOTES:
1. ALL DIMENSIONS IN MILLIMETER U.N.O.
PCPP OPERATING COMPANY SDN BHD
EPRD SERVICES FOR DANA & D30 FACILITIES DECOMMISSIONING PROJECT
SapuraKencana
D30 WHSF SUBSTRUCTURE REMOVAL SEQUENCE
SKHL-D30(J)-PCPP-OPR-DWG-01-02

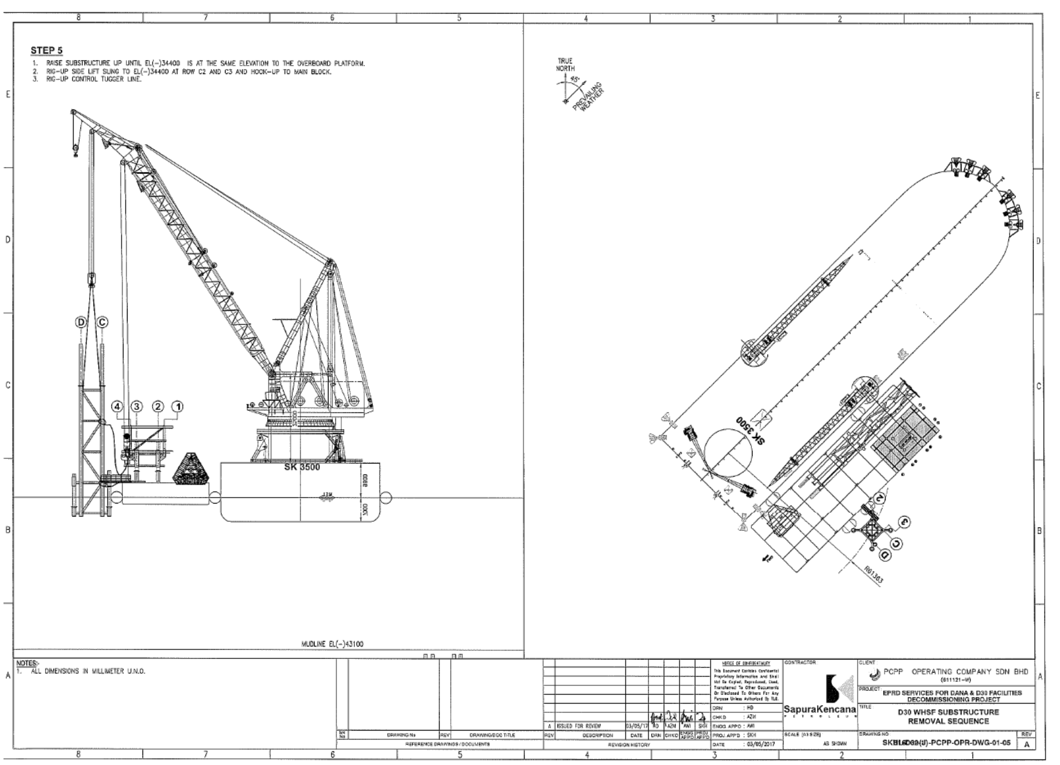
Step 3:


STEP 3
1. SLOWLY LIFT-OFF SUBSTRUCTURE.
2. ROV TO MONITOR THE SUBSTRUCTURE CLEARANCE FROM MUDLINE AND ENSURE IT IS CLEAR FROM ANY OBSTRUCTION.
TRUE NORTH
SK 3500
ROV
MUDLINE EL(-)43100
JACKET LIFT-OFF
NOTES:
1. ALL DIMENSIONS IN MILLIMETER U.N.O.
PCPP OPERATING COMPANY SDN BHD
EPRD SERVICES FOR DANA & D30 FACILITIES DECOMMISSIONING PROJECT
SapuraKencana
D30 WHSF SUBSTRUCTURE REMOVAL SEQUENCE
SKHL-D30(J)-PCPP-OPR-DWG-01-03

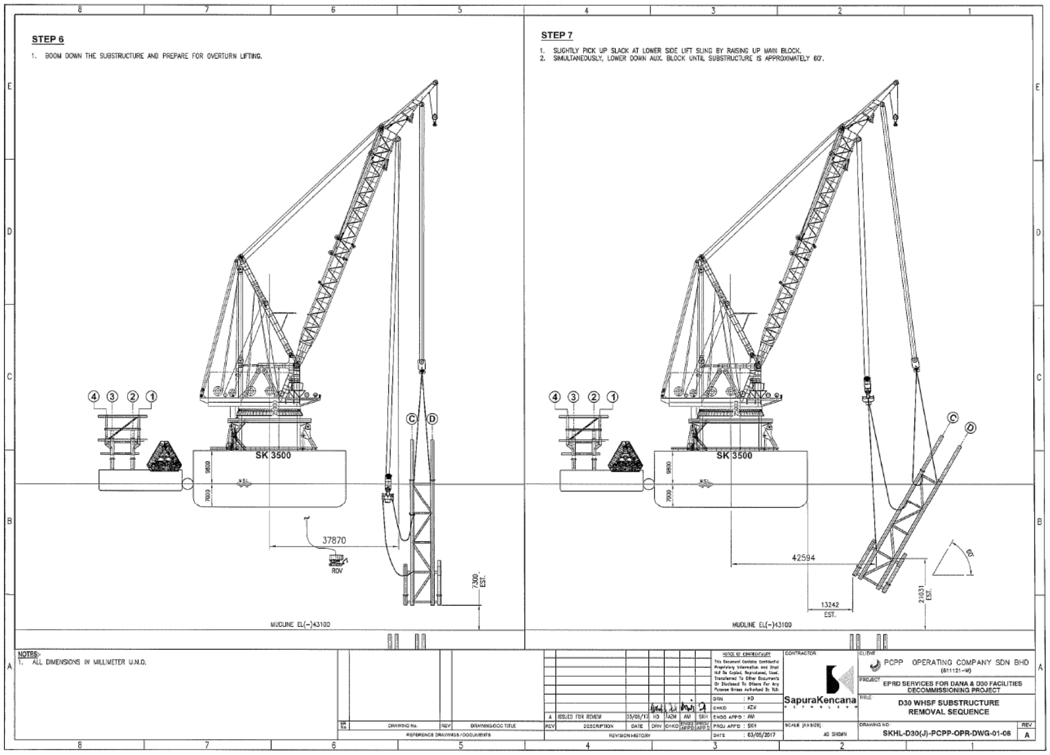
Step 4:


STEP 4
1. SWING SUBSTRUCTURE TO VESSEL STBD SIDE CLOSE TO THE MATERIAL BARGE OVERBOARD PLATFORM.
2. RAISE SUBSTRUCTURE UP UNTIL EL(–)17000 BRACE IS AT THE SAME ELEVATION OF THE OVERBOARD PLATFORM.
3. RIG–UP SIDE LIFT SLING TO EL(–)17000 AT ROW C2 AND C3 AND HOOK–UP TO MAIN BLOCK.
TRUE NORTH
SK 3500
MUDLINE EL(–)43100
NOTES:-
1. ALL DIMENSIONS IN MILLIMETER U.N.O.
PCPP OPERATING COMPANY SDN BHD
EPRD SERVICES FOR DANA & D30 FACILITIES DECOMMISSIONING PROJECT
D30 WHSF SUBSTRUCTURE REMOVAL SEQUENCE
SapuraKencana
SKHL-D30(J)-PCPP-OPR-DWG-01-04
A

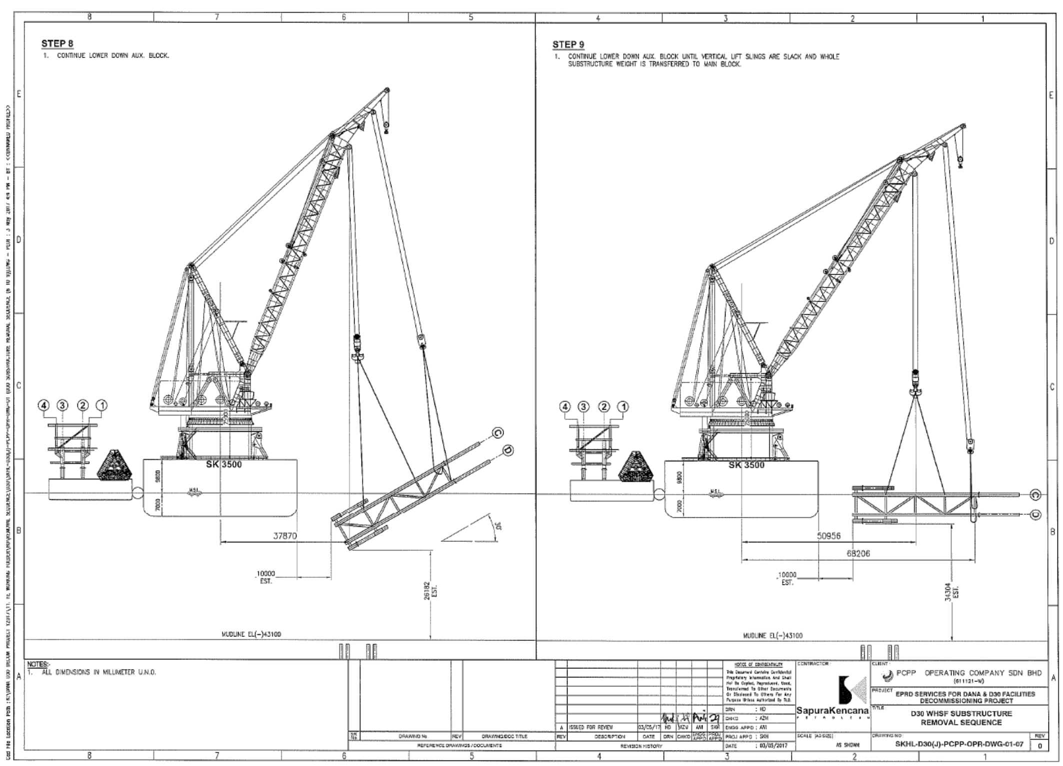
Step 5:


STEP 5
1. RAISE SUBSTRUCTURE UP UNTIL EL(–)34400 IS AT THE SAME ELEVATION TO THE OVERBOARD PLATFORM.
2. RIG–UP SIDE LIFT SLING TO EL(–)34400 AT ROW C2 AND C3 AND HOOK–UP TO MAIN BLOCK.
3. RIG–UP CONTROL TUGGER LINE.
TRUE NORTH
SK 3500
MUDLINE EL(–)43100
NOTES:-
1. ALL DIMENSIONS IN MILLIMETER U.N.O.
PCPP OPERATING COMPANY SDN BHD
EPRD SERVICES FOR DANA & D30 FACILITIES DECOMMISSIONING PROJECT
D30 WHSF SUBSTRUCTURE REMOVAL SEQUENCE
SapuraKencana
A

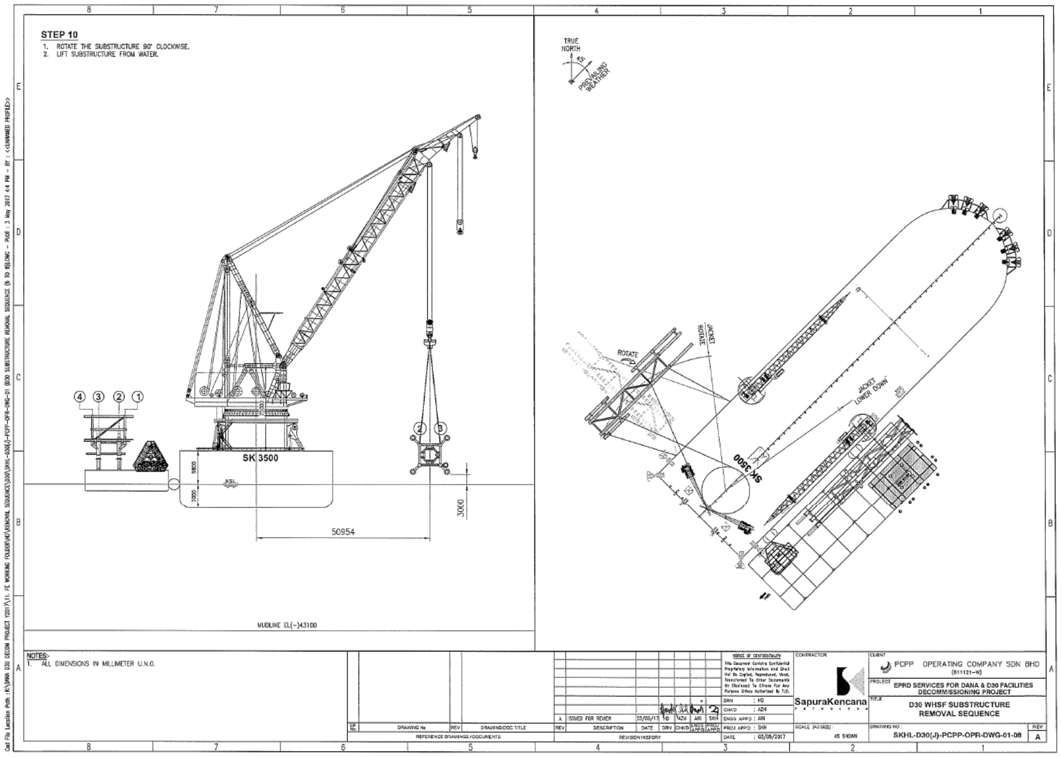
Step 6 and 7:



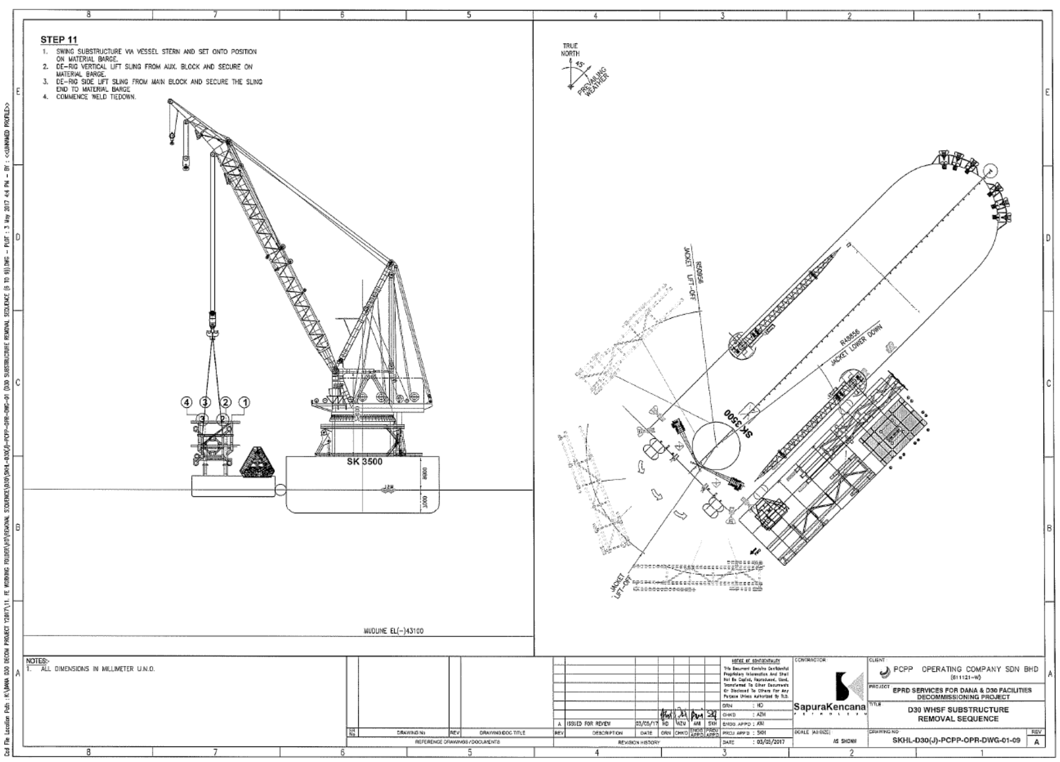
Step 8 and 9:



Step 10:



Step 11:



Appendix 3

Information on tug boat Omni Akira

OMNI AKIRA

INFORMATION

Year Built :	2007
Engine :	3200 BHP
Clear Deck Space :	150m^2
Length :	37.0 meter
Bollard Pull :	40 Tonne
Accomodation :	18 men
Fire Fighting :	1/2 FIFI

Source: http://www.iconoffshore.com.my/aht/posts/

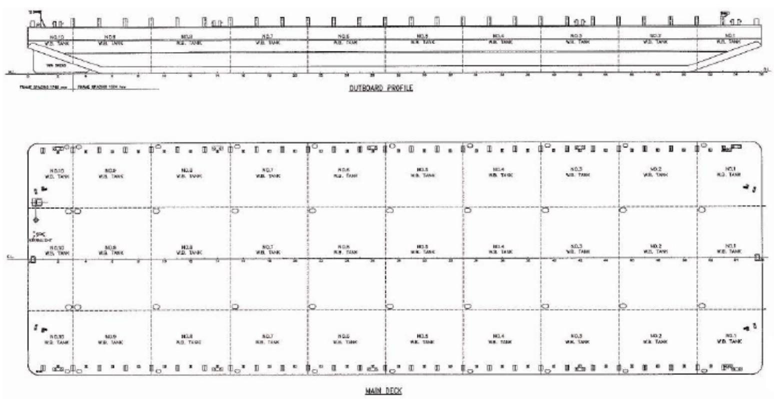
<u>Appendix 4</u>

Information of Transportation Barge Maritime Hope

POSH SEMCO Pte Ltd
No 1 Kim Seng Promenade
#06-01 Great World City
Singapore 237994

www.posh.com.sg

Maritime East / Maritime Hope



282 X 90 X 18 ft / 8,000 (TONS) DWT / DECK/ TANK BARGES

Name of Vessel	**Maritime East, Maritime Hope**
Year Built / Registry	2004 / Indonesia
Principal Dimensions	282 x 90 x 18 ft (85.95 x 27.43 x 5.49 m)
Classification	ABS + A1 Tank Barge
Draft	4.10 m approx
Deadweight	Approx 8,000 t
Deck Loading	15 t/m2
Hull Plating Thickness	Deck plating 18 mm, bottom plating 14 mm, side shell plating 14 mm
Bulkheads	2 longitudinal b/h plating thickness 10 mm 9 transverse b/h plating thickness 10 mm
Tanks	30 tanks ballastable through manholes on deck
Outfitting	1 x 2200 kg anchor with hand winch. 5 sets double bitt bollards each Port and Starboard. 3 sets towing brackets at bow and 2 sets at stern all fitted with chafing chains. 58 heavy duty tyre fenders dia min 1200 mm x 300 mm. 30 manholes on deck one for each tank with recess type in cargo area.
Cargo stanchion	26 sets deck stanchion each fitted Port and Starboard side 4 ft high at every 2 frame spacing from frame 3 to frame 53. 26 pieces eye lugs for cargo lashing each fitted at Port and Starboard side at every alternate frame from frame 2 to frame 54.