COST ESTIMATION MODEL OF STRUCTURAL STEEL FOR SUPERSTRUCTURE OF WELLHEAD PLATFORM IN OIL AND GAS INDUSTRY

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Industrial Engineering)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JANUARY 2015

To My beloved Wife

Mama and *Abah*

Family and Friends

For all your faith, supports and encouragement

May Allah bless you all

ACKNOWLEDGEMENT

Bismillahirrahmanirrahim

Alhamdulillah praise to Allah S.W.T for giving the permission to complete this project smoothly and well without much difficulty. In this opportunity, I would like to express my deepest appreciation and gratitude to my supervisor, Dr. Syed Ahmad Helmi bin Syed Hassan and co-supervisor Dr. Aini Zuhra binti Abdul Kadir for all precious guidance, advice and motivation for this Master project. Without them, this project is not likely to complete.

I would also like to thank my parent and family for encouragement which inspired me throughout my studies in UTM and during the process of finishing this project. Their contributions and sacrifices I will not be able to repay and will be remembered until the end of life.

Not forgetting friends and colleagues for their support, help and involvement whether direct or indirect in making this project successful. Hopefully all their contribution will be rewarded with better return by Him. *Insha'Allah*

.

ABSTRACT

Cost estimation during early stages of construction should be accurate and quick as possible. For accurate and quick cost estimates for steel structure material of offshore structure such as Wellhead Platform with minimum input of data, this study proposed an approximate cost estimation model that is based on standard quantities of structural steel for superstructure/topside. These standard quantities were calculated from the mean value of percentage for respective steel section to the overall structural steel weight and the mean value of percentage for respective steel strength to the weight of each steel section. Forty four (44) bid projects from bidding data of Wellhead Platform by Engineering, Procurement, Construction, and Commissioning (EPCC) contractor were collected and analysed for model development and five (5) projects for model verification. Seven (7) steel sections consist of plate, welded tubular, seamless tubular, beam, miscellaneous steel, grating and stair tread with respective strength of High Strength, Through Thickness Properties (TTP) and Mild Strength steel were identified that accounted for overall structural steel costs. The completed cost estimation model were validated through inter-rater agreement between Subject Matter Expert (SME) in the field and verified by comparing the estimated cost calculated by the model and the actual bidding cost. The result showed that the model yield an error range less than +8%. It is expected that the model presented in this study will support the existing estimation practice while increasing the level of confidence in engineered costs for fixed offshore structures

ABSTRAK

Penganggaran kos di peringkat awal pembinaan perlu tepat dan cepat. Untuk menganggarkan kos yang tepat dan cepat bagi struktur pesisir keluli seperti *Wellhead Platform* dengan input data yang minimum, kajian ini mencadangkan suatu model penganggaran kos berdasarkan kuantiti piawai keluli bagi *superstructure/topside*. Kuantiti-kuantiti piawai ini dikira berdasarkan nilai min peratusan bagi setiap bentuk keluli kepada keseluruhan berat struktur keluli dan nilai min peratusan bagi setiap jenis kekuatan keluli kepada berat setiap bentuk keluli. Sebanyak empat puluh empat (44) projek bidaan diambil dari data bidaan bagi *Wellhead Platform* oleh kontraktor *Engineering, Procurement, Construction, and Commissioning (EPCC)* dan dikumpul serta dianalisis bagi pembangunan model manakala lima (5) projek telah digunakan untuk pengesahan model. Tujuh (7) bentuk struktur keluli yang terdiri daripada *plate, welded tubular, seamless tubular, beam, miscellaneous steel, grating and stair tread* dengan kekuatan *High Strength, Through Thickness Properties (TTP) and Mild Strength* masing-masing telah dikenal pasti dimana ia menyumbang kepada kos keseluruhan bagi struktur keluli. Model penganggaran kos yang lengkap telah diakui ketepatannya melalui persetujuan diantara penilai yang pakar dalam bidang tersebut dan disahkan melalui perbandigan kos yang dianggarkan oleh model dengan kos bidaan sebenar. Hasil kajian menunjukkan bahawa model ini mampu menghasilkan julat kesilapan kurang daripada + 8%. Ia dijangkakan bahawa model yang telah dibentangkan dalam kajian ini akan menyokong praktis penganggaran kos yang sedia ada di samping meningkatkan tahap keyakinan dalam kejuruteraan kos bagi struktur tetap pesisir.

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LIST OF ABBREVIATION

BOQ	-	Bill of Quantity
CPP	-	Central Processing Platform
EIA	-	Energy Information Administration
EPCC	-	Engineering, Procurement, Construction and Commissioning
HS	-	High Strength
HUC	-	Hook Up and Commissioning
ITB	-	Invitation To Bid
MRPC	-	Malaysia Petroleum Resources Corporation
MS	-	Mild Steel
MTO	-	Material Take-Off
PETRONAS	-	Petroliam Nasional Berhad
PTS	-	Petronas Technical Specification
TTP	-	Through Thickness Properties
WBS	-	Work Breakdown Structure
WHP	-	Wellhead Platform

LIST OF SYMBOLS

D, d	-	diameter
$\bar{x}$	-	x-bar

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter discusses on the introduction of cost estimation in oil and gas industry. Beginning with the background of oil and gas industry in Malaysia, then the prospect of EPCC contractor/fabricator and the current demand for oil and gas resource as the competitive price determines the secureness of a project during bidding phase. Structure steel are one of the major cost for offshore structure such that Wellhead Platform. Then, the problem statement, research question, objectives, scope as well as the research significant are defined in this chapter.

1.2 Research Background

Malaysia had a long history of petroleum exploration which commenced at the turn of the century and resulted in an early success in 1910 with the discovery of the onshore Miri Field. By the 1950s, attention turned to offshore exploration with

the new improvement in offshore petroleum technology (Hamdan et al. 2005). Most of Malaysia's oil comes from offshore fields. The producing continental shelf is consisting of 3 producing basins such that the Malay basin offshore peninsular Malaysia in the west and the Sarawak and Sabah basins in the east. Nearly all country's oil reserves are located in the Malay basin and likely to be of high quality. Nowadays, Malaysia has some 28.35 billion barrels of oil (BBOE) reserves and around 1.2 per cent of the world's natural gas reserves (2.35 trillion cubic metres) of recognized reserves, as well attained a current production rate of 730,000 barrels per day of crude oil products according to Malaysia Petroleum Resources Corporation (MPRC) and continuously becoming important to world energy markets because of its oil and natural gas reserves.

In Malaysia, the oil, gas and other petroleum natural resources are governed by the Petroleum Development Act (1974). Under the Act, Petroliam Nasional Berhad or PETRONAS in short, holds exclusive Ownership rights to all oil and gas exploration and production projects in Malaysia (Said, 1981), and is responsible for all licensing procedures. It is the single largest contributor of Malaysian government returns, (over 40 percent in 2010), by taxes and dividends and grown to be an integrated international oil and gas company with business interests in over 30 countries (IEA, 2014). Under enactment legislated in 1985, Petronas need to hold at least 15-percent equity in production sharing contracts (PSC) with all private and foreign companies. By 2012, Petronas signed 13 PSCs, a new record for high number of agreements for any single year. Shell, ExxonMobil, and Murphy Oil are the largest foreign oil companies by volume of production, with Shell is the main foreign investor in Malaysia's oil sector.

An analysis prepared by U.S Energy Information Administration (EIA), International Energy Statistic, in Short-Term Energy Outlook (October 2014), show that Malaysia's oil production and consumption, from year 2000 until year 2014 Malaysia's domestic oil consumption has risen despite the fact production has been declined over the past decade (Figure 1.0), leaving smaller volumes of oil available for exports. Malaysia government is pursuing to bring oil production back to prior

levels of 800,000 bbl/d by 2015 while Petronas plans to spend $90 billion by 2016 to boost oil and natural gas production.

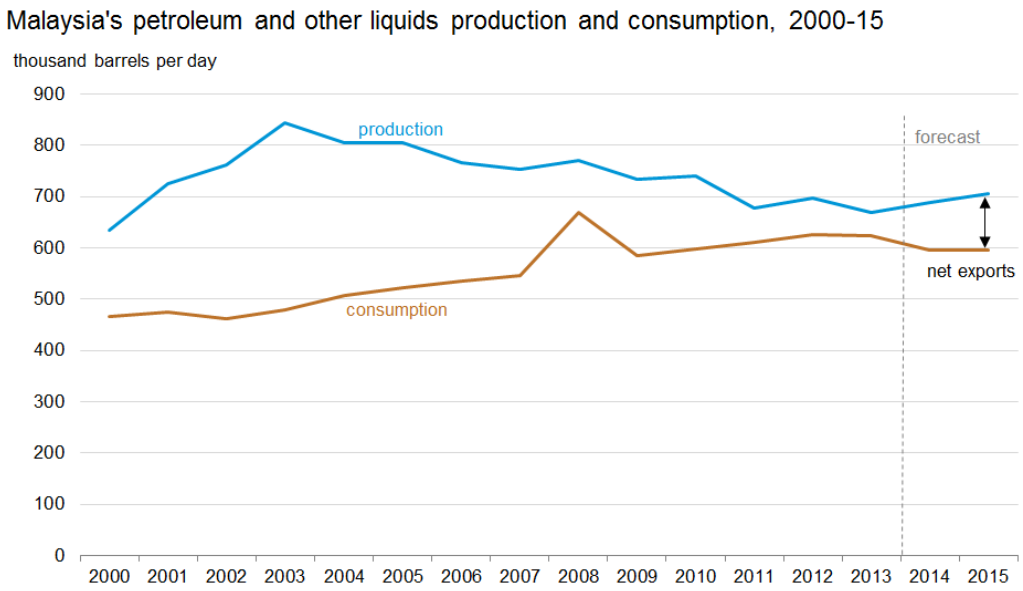

Figure 1.0: Malaysia's oil production and consumption for year 2000 until year 2015 (EIA, 2014)

In doing so, Petronas and its various Production Sharing Contract (PSC) partners have been most actively exploring offshore fields, especially in deep-water areas that pose high operating and development costs and require substantial technical expertise (Masoudi et al. 2014). According to Westwood (2003), about 3% percent of the world's oil and gas supply were obtained from deep-water offshore at water depth greater than 1000 ft (305m). Several major projects are under development in the deep water area offshore the Sabah state, which could boost Malaysia's oil production over the next decade. The Kikeh oil field, for instance, operated by Murphy Oil in partnership with Petronas, is one of Malaysia's producing deep-water oil field which came on stream in 2007 (Jenkins et al. 2008). Also, Shell-operated Gumusut/Kakap deep-water fields began production in 2010 and expected to begin oil production at the deep-water Malikai field by 2012, although no production timetable is been set (Khalid and Audrey, 2012). Nevertheless, shallow water projects still remain contributor to Malaysian oil and gas demand with various brownfield (marginal and mature field development) contracts still on going.

Petronas has commenced several overseas projects of Exploration and Production (E&P) prior to offset the declining domestic oil reserves. At the moment, there were 29 countries invested by Petronas, with an upstream component in 23 of these countries including Turkmenistan, Syria, Pakistan, Iran, China, Vietnam, Burma, Libya, Algeria, Tunisia, Angola, and Sudan. Most of the company's international participation is conducted by its overseas investment arm known as Petronas Carigali International Sdn. Bhd (PCSB). Now, overseas operations make up nearly one-third of Petronas's revenue (Khalid and Audrey, 2012).

Due to the escalation level of oil production and consumption demand in Malaysia, more crude oil required to be drilled out, processed and finally transported to the end users. All offshore operations of extracting, processing and unloading to onshore can be divided into three main phases, such that exploration phase, development phase and production phase. Brief descriptions of these upstream phases are discussed in Chapter 2. Engineering, Procurement, Construction and Commissioning (EPCC) companies have involved a lot in this line market segment of oil and gas industry. Therefore, they depend much on their commercial abilities which comprise of project cost estimating during development phase to get more contracts and fulfil the requirements of production and consumption demand.

EPCC Company is also known as fabricator is a contractor which responsible to fabricate offshore structure platform owned by Client such that Petronas, Shell, Exxon Mobile, etc. They competed with other fabricators, with cost competence as primary basis during bidding stage. Offshore structure such that Wellhead Platform (WHP) is the focused in this research due to the fact that the number of Wellhead Platform is greater than Central Processing Platform (CPP) which impacts the overall profit of an enterprise. Also, the overall cost of offshore structure is depending on the structure itself which is structural steel. The weight is the main criteria during cost estimation of structural steel. This research addresses the correlation among the weight of structural steel according to respective section and strength with the percentage of overall steel weight for Wellhead Platform as a guide to estimate the cost for structural steel by EPCC contractor/fabricator.

1.3 Problem Statement

In general, cost estimation are constructed by the estimator's experience, imaginative abilities, and a wide range of assumptions including appraisals of previously conducted projects that are similar in scope (Jarde and Alkass, 2007). Cost estimators need to think ahead of the project development with the intention of identify any insufficient cost. To evaluate the alternatives at the bidding stage, quick and precise decision-making is needed under a limited information and time which become constraints to the cost estimator. Most cost estimate models, however, have been limited in building, road and bridge construction. A model which reflects the estimation cost for offshore structure such as Wellhead Platform fabrication has been very limited. Furthermore, approximate cost estimate models have usually based on the average construction cost of a unit quantity (Kim et al., 2009b). For evaluation on design alternatives and value engineering at the bidding stage, a more accurate cost estimation method based on engineering oriented methodology is required.

During bidding stage by EPCC contractor/fabricator, Material Take Off (MTO) may or may not be provided from Client/Owner. If the MTO are provided in the Invitation To Bid (ITB) document, contractor/fabricator must verify the MTO by their own design team, however if the MTO does not exist in the ITB, the design team need to generate the MTO with limited time of bidding duration. Estimators usually recheck the MTO before preparing price schedule for sourcing of prices. If any inconsistencies occurred, estimator must consult with design team for verification of the prepared MTO. After a firm bidding MTO was generated, price schedule are sent to vendors before price were compared to get the most competitive price. Finally the competitive price becomes the estimated cost for bidding exercise. This normal practice usually takes a longer time for MTO preparation with limited time, skills and manpower. Therefore, the needs of an approach that not only accurate, but also quick to tackle the stringent bidding duration is necessary. The details flow of the problem statement has been shown in Figure 1.1:

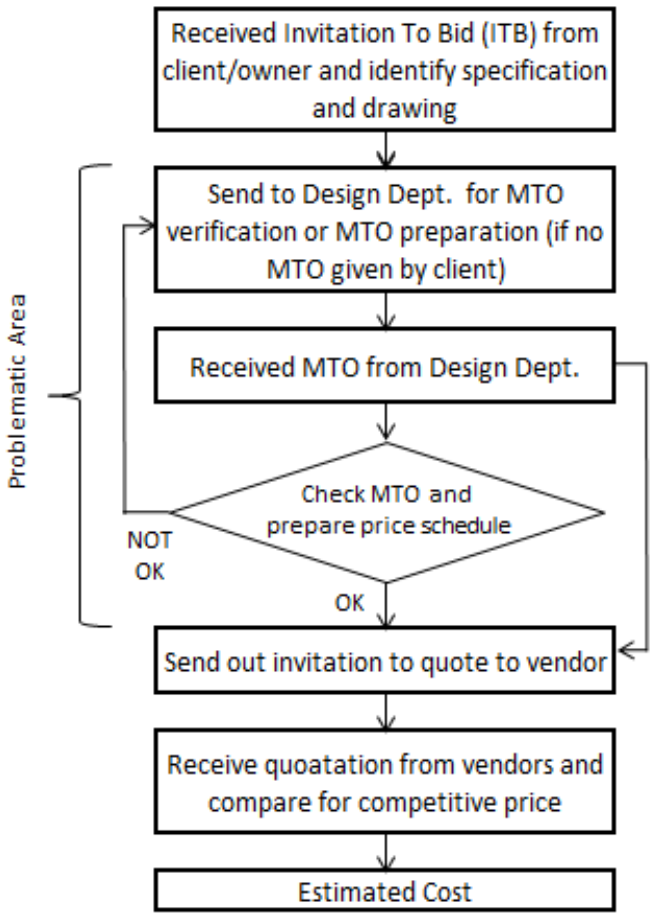

Figure 1.1: Flow of problem statement

1.4 Research Question

In order to solve the identified problem, following research questions must be answered in this study:

i. How to estimate the cost of structural steel based on engineering oriented methodology to ensure accuracy?

ii. How to establish an estimation approach for offshore structure that provides a quick cost estimate?

1.5 Research Objectives

The main objective of this research is to propose an estimation model to estimate the cost of structural steel for superstructure/topside of Wellhead Platform for bidding purposes. Hence, the sub objectives of this research are as follows:

i. To establish a standard quantity for structural steel using the mean value of structural steel percentage for each steel section and strength.

ii. To evaluate the reliability of the estimation model with the actual bidding cost of structural steel.

1.6 Scope of Research

This research is carried out at one of the EPCC contractor/fabricator in Malaysia. It is conducted as a case study from Estimating Division which is directly involved with cost estimation for any offshore structure. In order to surge the understanding of cost estimation of structural steel for Wellhead Platform, this study is focused on the following:

i. Structural steel for superstructure or topside of Wellhead Platform structure.

ii. Grouped structural steel based on respective section and strength.

1.7 Significant of Research

This research suggests an approximate cost estimate method for structural steel of typical Wellhead Platform according to each respective strength and section that can be utilized at the early project phase such that bidding stage. Cost estimation model based on unit quantity of standard quantities means cost estimating approach utilizes standard quantities percentage applied to weight from Weight Control Report (WCR) provided in FEED data or conceptual information, identify quantities of each section according to respective strength, and then finally apply unit prices to them. As a result, by analyzing and utilizing the characteristic of structures, this approach can support an accurate and quick cost estimate with minimum input. The suggested method is expected to be used not only for accurate and quick cost estimation, it also can support to set target cost during early bidding stage as a criterion for management decision the possibility to earn projects based on design results.

1.8 Organisation of Research

This research is consisting of six chapters which are introduction, literature review, methodology, data collection and analysis, result and discussion, and finally conclusion. Details of research organisation are explained as follows:

Chapter 1: Introduction

Chapter 1 is an introduction to the research which describes the background of the study, statement of the problem, research question, research objectives, scope of the study, significance of research, organization of research and conclusion.

Chapter 2: Literature Review

In this second chapter, the literature review of the research is discussed concerning to relevant issues found in the journal, book, internet and also actual situation in oil and gas industry in the EPCC Company. Related definition, principles and approaches from previous as well as current were studied to find gaps of the research. Broad areas have been discussed beginning with the oil and gas activity, offshore structure, as well as structural steel classification were covered in this chapter in order to develop efficient cost method even though information and time were limited from Client/Owner. From the identified gaps, a more practical solution was recognised and established to suit the current needs accordingly.

Chapter 3: Methodology

The methodology of the research is explained in the third chapter. Justification for the methodology, research framework and methodology, cost element identification and development of the cost estimation model were explained detail in this chapter. Case study, data collection method, and data analysis are being discussed as well. Structural steel based on respective section and strength are being classified accordingly based on work breakdown structure to identify the standard section and strength which commonly used for wellhead platform. Then, cost estimation model for structural steel were established to quantify each of structural steel section with respective strength in order to estimate the overall structural steel cost.

Chapter 4: Data Collection and Analysis

In this chapter, data are gathered from the historical data of bidding weight extracted from structural cost summary. The data ranged from year 2004 to 2014 of various Wellhead Platform projects. Then data were initially analysed using Pearson correlation to determine the strength of relationship between each steel section to the overall structural steel weight. Then, standard quantity for respective steel section

and strength are developed as the main input to be inserted by the user into the cost estimation model by using mean value of percentage for respective steel section and strength. After all input were identified, the cost estimation model is validated using inter-rater agreement of Cohen Kappa by two Subject Matter Expert (SME) personnel in the field. Finally, the cost estimation model is verified by comparing the estimated cost generated by the model and the actual bidding cost before conclusion for the chapter was made.

Chapter 5: Discussion and Conclusion

Last chapter describes research findings, application of the model, research significance and contribution, limitation, final conclusion as well as future works of the research. In summary, the organization of research for Master Project is summarized in Figure 1.2 below:

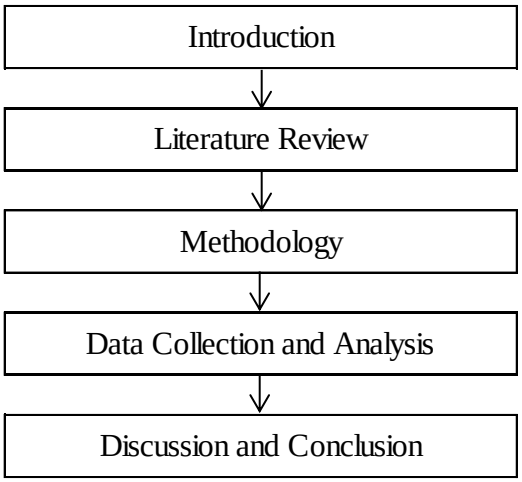

Figure 1.2: Organization of research

1.9 Conclusion

This chapter has described a situation whereby with the increasing demand of production and consumption of natural resource, more exploration are required to meet the demand in Malaysia. EPCC contractor/fabricator must take this opportunity to optimize their profit margin by grabbing as much as possible contract offered by Client/Owner. The values of contracts determined the competition between these contractors/fabricators making the cost estimation a crucial part during bidding stage. An accurate and quick estimation is necessary regardless the minimal or preliminary data from the Client.

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