

Cost Estimation Model of Structural Steel for Super Structure of Wellhead Platform in Oil and Gas Industry

**Ahmad Ammar Luqman Abdullah¹, Syed Ahmad Helmi^{1,2}, Aini Zuhra Abdul Kadir¹,
Muhammad Hisjam³**

¹Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia,
81310 Johor Bahru, Johor, Malaysia

²Center for Engineering Education
Universiti Teknologi Malaysia,
81310, Johor Bahru, Johor, Malaysia

³Department of Industrial Engineering, Faculty of Engineering,
Sebelas Maret University
Surakarta, Indonesia

Abstract

In this paper, an approximate and quick estimation model is proposed based on engineering oriented methodology to support the existing bidding practice which consumed more time due to Material Take Off (MTO) preparation. The cost estimation model is based on standard quantity of structural steel for superstructure/topside which calculated from the mean value of respective steel section and strength classification. 44 offshore structures were collected and analysed for model development and 5 for model verification. 7 steel sections consist of plate, welded tubular, seamless tubular, beam, miscellaneous steel, grating and stair tread with respective strength classification such that 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% and can be considered acceptable in construction of fixed offshore structure.

Keywords

Cost Estimation Model, Structural Steel, Wellhead Platform, Standard Quantity

²[Corresponding Author: helmi@utm.my](mailto:helmi@utm.my)

1. Introduction

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. 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. The cost estimation approach in early stage of construction works can be seen in various fields of constructions. In oil and gas industry, cost estimation is crucial for offshore contractor/fabricator to compete with other competitors locally or internationally to win bids and generate profits. With the cost competence as key and primary basis during bidding stage, it is required an efficient method or practice which not only will yield an accurate cost, but also quickly to tackle stringent bidding duration set by

Client. Among the researches relevant to this field of study, very few researchers devoted their study on the cost estimation for offshore structure yet alone with the focused of certain discipline such as structural steel which significantly contribute to the overall offshore structure construction cost.

Numerous researchers have proposed approximate cost models to accurately estimate construction costs during early project stage, for instance, parametric models based on statistics Singh (1990), regression model (Kim et al., 2004; Kouskoulas and Koehn, 1974; Trost and Oberlender, 2003). Pearce et al. (1996) developed a technique for generating range estimates to evaluate the risk of cost escalation in building construction using neural networks. In particular, Hegazy and Aayed (1998) developed a parametric cost model for road and bridge construction based on past highway construction costs and the neural network. Kim et al. (2005) introduced Neural Networks Genetic Algorithms for building construction while Sodikov (2005) proposed Artificial Neural Network for Highway projects. Kim et al. (2000) suggested a cost model for road construction through time series analysis on the construction cost index and multi-regression analyses on historical unit price data. Park and Lee (2002a) and Park and Lee (2002b) recommended a regression model based on historical data for road construction as well as Stevens (1995) which based on historical unit price. Adeli and Wu (1998) were successful in introducing a regularization neural network model based on a solid mathematical foundation for estimating the cost of construction projects. For bridge construction industry, Kim and Kim (2010) offered a cost estimation model for preliminary design stage. The model is based on Case-Based Reasoning (CBR) and Genetic Algorithm (GA). Kim (2011) also, proposed the cost estimation model which utilizing CBR for the railroad bridge. Pure multiplicative formulations (Wilmot and Cheng, 2003), extrapolations of past trends/time-series analyses (Hartgen and Talvitie, 1995) and cost indexes (Park and Lee, 2003) have also been used to estimate overall construction costs. All these models and approaches were developed based on the financial aspect rather than quantity engineering methodology, latest study by Kim et al. (2013) showed that cost estimation model were developed based on standard quantity of major work items, they analysed the trend of bridge component size and made the frequent size as their standard dimension of bridge component. Also, Kim et al. (2009) suggested an approximate cost estimate model for superstructure of the PSC beam bridges that is based on unit quantity of standard works

2. Problem Statement

Most cost estimate models have been limited for building, road and bridge construction or the focused has been concentrated to onshore projects. A model which reflects the estimation cost for offshore structure such as Wellhead Platform (WHP) fabrication has been very limited and were hardly discussed. For evaluation on design alternatives and value engineering at the bidding stage, a more accurate cost estimation method based on focused engineering oriented methodology is required regardless the minimal or preliminary data from the Client. Furthermore, stringent bidding duration is also become a constraint which required a quick approach to tackle time restriction.

3. Cost Element and Model Development

It is important to identify the cost element in the structural steel for Wellhead Platform as the basis of standard quantity approach. The foundation of cost elements was referred to international standards such that Norsok Standard Z-014 as an initial cost element identification as shown in Figure 1. Then, the structural steel elements were further developed into the Work Breakdown Structure (WBS) categories for structural steel as in Figure 2.

During cost estimation of structural steel using standard quantity, some of the steel section might not be accounted such that the amount of the particular steel are too small or they are not exist in the design of the typical Wellhead Platform. For instance, High Strength (HS) steel and Through Thickness Properties (TTP) for Misc. Steel, Grating, and Stair Tread whereby they are unlikely to present due to fact that these steel section are commonly not applicable for critical member (non-critical member) and categorized under Mild Steel (MS). The common steel sections used for typical wellhead design are treated as standard section and strength before standard quantities are developed.

Standard quantity for this research are based on average or mean of percentage of structural steel section weight to the overall structural steel weight and percentage of respective steel strength weight to the weight of respective steel sections. Control chart are the statistical tool used to analyze the data whereas Minitab® 16.2.0 are used as the software to identify the standard quantity and Microsoft Excel 2010 are used for cost estimation model development. In the event of established standard quantity with respect to each structural steel's section and strength, the percentage will be applied to a particular total structural weight for superstructure/topside of Wellhead Platform from Weight Control Report (WCR) in FEED or conceptual design to obtain the quantity of each section according to its strength. Then, wastage contingencies will be added to take the cut and loss norms were put into consideration.

Finally the total cost will be obtained by employing the unit rate to the quantities of respective section and strength. In general, the cost estimation model can be shown in Figure 3. Based on 44 bid projects ranging from year 2004 to year 2014 from a local fabricator in Malaysia, the mean value for each steel section with respective strength can be referred in Table 1. These central tendencies of mean will be applied to the total weight given by the Client during conceptual design or preliminary stage of bidding thus producing the weight breakdown for each section and strength respectively.

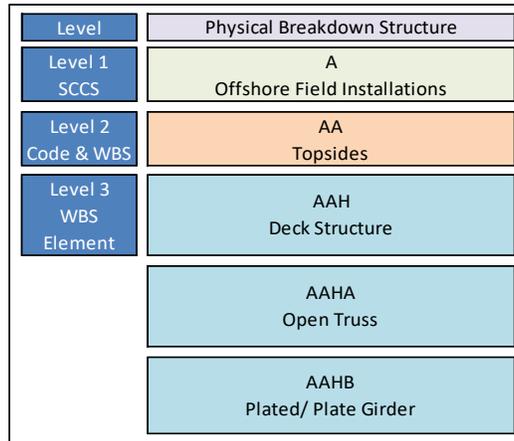


Figure 1. Work Breakdown Structure for offshore structure

(Source: Norsok Standard Z-014 Standard Cost Coding System)

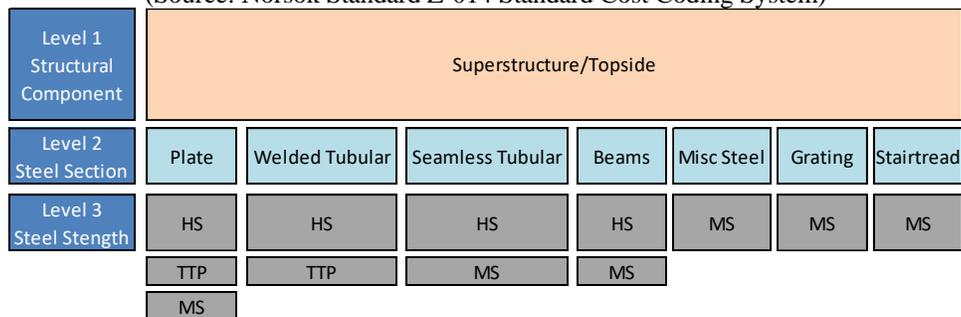


Figure 2. Work Breakdown Structure for structural steel of wellhead platform

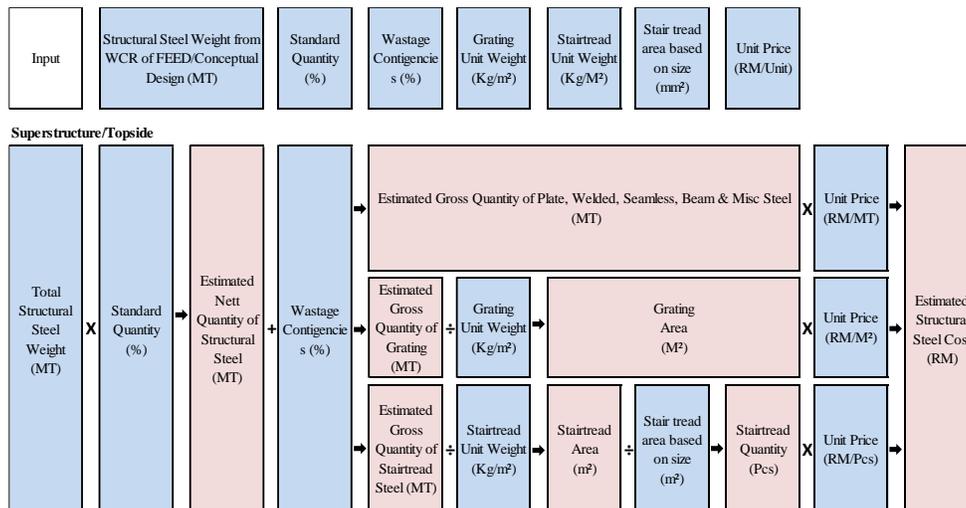


Figure 3. Cost estimating model of structural steel for superstructure/topside of wellhead platform

Table 1. Standard quantity by steel section and strength

Section	Section Mean	Strength	Strength Mean
Plate	29.81%	HS	27.75%
		TTP	21.93%
		MS	50.33%
Welded Tubular	16.01%	HS	66.07%
		TTP	33.94%
Seamless Tubular	13.88%	HS	62.11%
		MS	37.90%
Beam	31.84%	HS	79.89%
		MS	20.12%
Misc. Steel	1.80%	MS	100.00%
Grating	6.34%	MS	100.00%
Stair Tread	0.34%	MS	100.00%

HS: High Strength, TTP: Through Thickness Properties, MS: Mild Steel

Other inputs such that wastage contingencies or cut and loss contingencies were also important in order to obtain the estimated gross weight for the structural steel element of Wellhead Platform. This is done by taking into account the quantity loss of steel due to the cutting plan requirement during project execution. The norms of cut and loss for steel sections in term of percentage typically used by contractor/fabricator during bidding stage are shown in Table 2.

Table 2. Steel section Cut and Loss Percentage Norm

Section	Cut and Loss Percentage Norm
Plate	20%
Welded Tubular	10%
Seamless Tubular	10%
Beam	12%
Misc. Steel	15%
Grating	15%
Stair Tread	15%

In addition, these percentages can be reduce during project execution with optimized cut and loss configuration or cutting plan during fabrication engineering phase. Apart from that, the model required the unit weight of grating and stair tread since the market unit price for both steel sections were normally calculated in term of area (m²) and pieces (pcs) respectively. In addition to unit weight, the areas of stair tread were divided by the specification area to acquire the number of pieces. Based on PETRONAS Technical Standards (2011), the size for both grating and stair tread are shown in Table 3.

Table 3. Grating and stair tread dimension and unit weight

Section	Dimension	Unit Weight
Grating	Bearing bar : 35mm deep x 5mm thick	49.6 kg/m ²
	Load bearing bar : 30mm c/c pitch	
	Cross bar pitch : 100mm c/c pitch	
Stair tread	Bearing bar : 35mm deep x 5mm thick	49.6 kg/m ²
	Load bearing bar : 30mm c/c pitch	
	Cross bar pitch : 100mm c/c pitch	
	Length : 1200mm	
	Width : 245mm	
	Area : 0.29m ²	

4. Model Validation and Verification

Proposed model were validated based on the inter-rater agreement method of Cohen’s Kappa. Cohen's Kappa coefficient is a statistical measure of inter-rater agreement between 2 appraisers by calculating the coefficient of kappa, k. Kappa values range from -1 to +1. The higher the value of kappa, the stronger the agreement between the rater. The calculation of kappa value, k were given in (1).

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)}, \quad \dots\dots\dots (1)$$

Where:

Pr(a) = Probability of actual observed agreement

Pr(e) = Probability of expected agreement/agreement occurred by chance

According to Altman (1991), the guidelines for k value are shown in the Table 4. Two Subject Matter Expert or SME of related field consisting senior lead structural estimator and lead structural estimator were taken into consideration and their feedback on the validity of the model were recorded and analysed. Both appraisers were to estimate on how many percent of wellhead platforms can be accurately applicable using the cost estimation model and their both need to justify their decision. The recorded data for both Subject Matter Expert are shown in Table 5.

Table 4. Kappa coefficient guideline

Value of K	Strength of agreement
< 0.20	Poor
0.21 - 0.40	Fair
0.41 - 0.60	Moderate
0.61 - 0.80	Good
0.81 - 1.00	Very good

Table 5. Agreement/disagreement score

		Appraiser 1		
		Yes	No	Sum
Appraiser 2	Yes	90%	0%	90%
	No	5%	5%	10%
	Sum	95%	5%	100%

From the result, it shows that both appraiser agreed that 90% of Wellhead Platform can be accurately estimate using the cost estimation model assuming they are with the exact same design and similar specification. They also agreed that 5% of Wellhead Platform cannot be estimate due to different design and different specification which is significantly affecting the overall cost of structural steel for wellhead platform.

On the other hand, appraiser 2 disagrees with appraiser 1 with 5% of the total wellhead structure stated that it generates a slightly accurate outcome due to some different design or specification. However, appraiser 1 believed that these small differences is too marginal and not affecting the accuracy of the estimated cost. From Table 3.1 above, the Pr(a), Pr(e) and kappa value were calculated and tabulated in Table 6.

Table 6. Kappa value calculation

Description	Value
Pr(a)	0.950
Pr(e)	0.860
Pr both say "yes"	0.855
Pr both say "no"	0.005
Kappa, K	0.643

Kappa value of agreement between both appraiser indicated that the agreement is good and both appraiser believed that the model were valid and applicable for future Wellhead Platform projects especially bid with less data such that for budgetary purposes. For model verification, 5 sample (namely project A, B, C, D and E) from actual bid project complete with weight and unit rate for each section and respective strength were selected and inserted into the model, the the estimated cost generated by the model were compared with actual bid cost. The error rates between cost estimation model and the actual bid cost were summarized in Table 7.

Table 7. Error rate between model's estimated cost and actual bid cost

	Project A	Project B	Project C	Project D	Project E
Cost Model (RM)	6,589,471	6,275,231	5,455,104	4,277,787	5,992,865
Actual Bid (RM)	6,141,720	5,985,319	5,549,820	4,091,577	5,672,825
Delta (%)	+7.29%	+4.84%	-1.71%	+4.55%	+5.64%

From Table 7, it showed that the differences between actual bid cost and model estimated cost ranged between -1.71% and +7.29%. According to AACE Recommended Practice (2016), the model error rate located between Class 1 (on the low side, L) and Class 2 (on the high side, H).

Table 8. Cost estimate classification matrix for process industries

ESTIMATE CLASS	Primary Characteristic	Secondary Characteristic		
	MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

The different between the actual bid cost and the estimated cost were due to 2 possible reasons. First, there were difference in term of weight between the actual bid weight and model estimated weight of respective section and strength. Secondly, there were differences unit rate of respective steel section and strength which fluctuated from one projects to another according to market value for that particular time. However, this indicated that the error rate is still small with slightly higher on the positive side which showed that the model is tend to be impervious to cost overrun during project execution but the risk of loss bid can still occur. Nevertheless, the model is considered acceptable to be used for future Wellhead Platform projects.

5. Conclusion

Cost estimation model for structural steel can be developed using standard quantity of respective steel section and strength. The central tendencies of mean values are used to represent the standard quantity of structural steel element. The structural steel elements are categorized with the respective steel section namely plate, welded tubular, seamless tubular, beam, miscellaneous steel, grating and stair tread and further breakdown by strength of High Strength (HS) steel, Through Thickness Properties (TTP) and Mild Steel (MS). The contribution of this research is that there is a very limited research on cost estimation in oil and gas industry especially in EPCC Company. Therefore, this study is the first pioneering step towards cost estimation of structural steel for superstructure/topside of Wellhead Platform (WHP) by EPCC contractor/fabricator as well as a reference for future cost estimation in oil and gas industries.

As a conclusion, this study met its objective to propose an approximate cost estimation model for bidding purposes. Also, this study has accomplished to developed a reliable standard quantity for cost estimation model of structural steel with model validation using inter-rater agreement by experts of Cohen Kappa (value of 0.643) and model verification by comparing model's estimated cost with actual bidding value which generated error range between +7.29% and -1.71%.

6. Limitation

There are very limited existing research or study on cost estimation method for oil and gas industry especially on individual discipline such that structural steel. Therefore, the study needed to be started from the ground level. Also, to access financial information is hardly possible for any contractor to reveal their price since the budget are used for bid purpose. Hence the name of contractor/fabricator and the name of bid projects are disclosed to ensure the discretion of bid value.

7. Research Significance and Contribution

There is a very limited research on cost estimation in oil and gas industry especially in EPCC Company. Therefore, this study is the first pioneering step towards cost estimation of structural steel for superstructure/topside of Wellhead Platform (WHP) by EPCC contractor/fabricator. 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.

8. Future Works

For future work identical to this area of study, there are recommendations which can be highlighted to improve or extend the study of cost estimation for structural steel of offshore structure in oil and gas industry. First, the study is only focused on superstructure/topside of Wellhead Platform, excluding substructure/jacket of Wellhead Platform (WHP). For a complete offshore structure of Wellhead Platform, future study can analyse the trend or pattern of structural steel weight for substructure/jacket to identify the standard quantity and propose an approximate cost estimating model for substructure/jacket to be used for bidding purposes. Secondly, future works can also focus on heavier structure such as Central Processing Platform (CPP) which can range to 18,000 MT to 22,000 MT for both topside and jacket. Using similar methodology, standard quantity for structural steel can be identified. Hence, an estimation model of structural steel for superstructure/topside and substructure/jacket of Central Processing Platform can be established.

References

- AACE Recommended Practice No. 18R-97, "Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries", AACE International, Morgantown, WV, Rev, 2016.
- Adeli H. and Wu M., "Regularization neural network for construction cost estimation", *Journal of Construction Engineering and Management*, ASCE 124(1), pp 18-24, 1998.
- Altman, D.G., Practical statistics for medical research, London: Chapman and Hall, 1991.
- Hartgen, D. T. and Talvitie, A. P., "Comparative performance of transportation systems: Pitfalls and prospects.", Proc., World Conf. on Transit Research, Sydney, Australia, 1995.
- Hegazy, T. and Ayed, A., "Neural network model for parametric cost estimation of highway projects.", *Journal of Construction Engineering and Management*, ASCE, Vol. 124, No. 3, pp. 210-218, 1998.
- Kim, B. S., "The approximate cost estimating model for railway bridge project in the planning phase using CBR method.", *KSCE Journal of Civil Engineering*, KSCE, Vol. 15, No. 7, pp.1149-1159, 2011.
- Kim, G. H., An, S. H., and Kang, K. I., "Comparison of construction cost estimating models based on regression analysis, neural networks, and case-based reasoning," *Building and Environment*, Vol. 39, No. 10, pp. 1235-1242, 2004.
- Kim, G. H., Seo, D. S., and Kang, K. I., "Hybrid models of neural networks and genetic algorithms for predicting preliminary cost estimates.", *Journal of Computing in Civil Engineering*, ASCE, Vol. 19, No. 2, pp. 208-211, 2005.

- Kim, K. J. and Kim, K. M., "Preliminary cost estimation model using case-based reasoning and genetic algorithms.", *Journal of Computing in Civil Engineering*, ASCE, Vol. 24, No. 6, pp. 499- 505, 2010.
- Kim, K. J., Kim, K. M., and Kang, C. S., "Approximate cost estimating model for psc beam bridge based on quantity of standard work." *KSCE Journal of Civil Engineering*, KSCE, Vol. 13, No. 6, pp. 377-388, 2009.
- Kim, K. J., Park, C., and Oh, D.C., "Approximate cost estimation model based on standard quantities of steel box girder bridge structure." *KSCE Journal of Civil Engineering*, KSCE., Vol. 17, No. 5, pp. 877-885, 2013.
- Kim, S. K., Shin, J. S., Koo, I. W., and Kim, Y. G., "A statistical cost model for road construction project at the planning stage.", *KSCE Journal of Civil Engineering*, KSCE, Vol. 20, No. 2-D, pp. 171-180, 2000.
- Kouskoulas, V. and Koehn, E., "Predesign cost estimation function for buildings." *Journal of the Construction Division*, ASCE, Vol. 100, No.4, pp. 589-604, 1974.
- Park, J. H. and Lee, T. S., "Development of an parametric cost model by planning process for road construction.", *Journal of Civil Engineering*, KSCE, Vol. 22, No. 1-D, pp. 103-112, 2002a.
- Park, J. H. and Lee, T. S., "Development of the cost analysis format for road construction project.", *Journal of the KSCE*, KSCE, Vol. 22, No. 2-D, pp. 259-269, 2002b (in Korean).
- Park, J. H. and Lee, T. S., "Methodology for a cost estimating on the project of a composite facility.", *Journal of Civil the KSCE*, KSCE, Vol. 23, No. 1-D., pp. 69-78, 2003 (in Korean).
- Pearce A. R., Gregory, Rita A., and Williams L. "., Range Estimating for risk management using artificial neural networks", *Journal of Parametric Estimating*, 14(1), pp 88-93, 1996.
- PETRONAS Technical Standards (PTS), 37.19.10.30, April 2011.
- Singh, S., "Cost model for reinforced concrete beam and slab structures in building." *Journal of Construction Engineering and Management*, ASCVol. 116, No. 1, pp. 54-67, 1990.
- Sodikov, J. "Cost estimation of highway projects in developing countries: Artificial neural network approach". *Journal of the Eastern Asia Society for Transportation Studies*, 6, pp. 1036-1047, 2005.
- Stevens, J. D., Cost estimating and forecasting for highway work in Kentucky, Research Rep. KTC 95-12, Kentucky Transportation Center, University of Kentucky, Lexington, KY, USA, 1995.
- Trost, S. M. and Oberlender, G. D., "Predicting accuracy of early cost estimates using factor analysis and multivariate regression." *Journal of Construction Engineering and Management*, ASCE, Vol. 129, No. 2, pp. 198-204, 2003.
- Wilmot, C. G. and Cheng, G., "Estimating future highway construction costs.", *Journal of Construction Engineering and Management*, ASCE, Vol. 129, No. 3, pp. 272-279, 2003.

Biographies

Ahmad Ammar Luqman hold his Bachelor of Engineering (Civil) and Master of Engineering (Industrial Engineering) from Universiti Teknologi Malaysia (UTM). He is currently serve as a cost engineer/estimator in Estimating Division in one of a major fabrication company in Malaysia with 7 years in experience dealing with bidding and tendering practices and also a part time PhD student in UTM focusing on the same field. His interest include cost estimation and cost control in fabrication and construction for oil and gas industry and he is a registered member of American Association of Cost Engineering (AACE) International.

Syed Ahmad Helmi is a senior lecturer at the Faculty of Mechanical Engineering, Universiti Teknologi Malaysia. He received his Bachelor of Science in Mechanical Engineering from University of Alabama, USA, and a Master in Mechanical Engineering, and a PhD in Engineering Education from Universiti Teknologi Malaysia (UTM). He is currently a fellow at the Center for Engineering Education, UTM, and the coordinator for post-graduate program at the Department of Material, Manufacturing and Industrial Engineering. Prior to joining UTM, he had worked as a maintenance engineer at INTEL, Malaysia, as research officer at Standard and Industrial Research Institute of Malaysia (SIRIM), and as mechanical and industrial engineer at Sime-Darby. His research focuses on the engineering education of higher learning institutions and prospective engineers, namely on student centered learning (SCL) and enhancement of team-based engineering problem solving skills. His recent work includes change management, complex problems, supply chain, facilities planning and design, and system dynamics modelling. Over the years, he has conducted several workshops on Outcomes-Based Education (OBE) particularly in SCL throughout Malaysian higher institutions, and international institutions such as in Indonesia, India, China, Korea, Turkey, Morocco, Pakistan, and Afganistan. He also had published numerous articles relating to his area of interest.

Aini Zuhra Abdul Kadir is currently a fulltime senior lecturer at Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM). Since 2013, she was appointed as a Postgraduate Coordinator for MSc Advanced Manufacturing Technology. Dr. Aini Zuhra obtained her Bachelor of Engineering (CAD/CAM) and Master of Engineering (Manufacturing) from University of Malaya and PhD (Mechanical Engineering) from University of Auckland, New Zealand. She is a member of American Society of Mechanical Engineer (ASME), Board of Engineer (BEM) Malaysia and Institute of Engineer (IEM) Malaysia. She has taught courses in product design, tooling for production, engineering economy, manufacturing process and work design. Her research interests include STEP/STEP-NC, CAD/CAM/CAPP, Virtual Manufacturing, Finite Element Analysis, impact/crash test, sustainable materials and product design.

Muh. Hisjam is a lecturer at Department of Industrial Engineering, Faculty of Engineering, Universitas Sebelas Maret, where he has been since 1998. He received his Bachelor degree from Universitas Gadjah Mada in 1986, and a Master degree from Institut Teknologi Bandung in 2002. He received his Ph.D. in Environmental Science from Universitas Gadjah Mada in 2016, with his dissertation title is “Sustainable Supply Chain Model in Export Oriented Furniture Industry in Indonesia (Case in Perum Perhutani)”. His research interests are in supply chain, logistics, business and sustainable development. He has published some papers in his research area. He and his colleagues have initiated and maintain some collaborations between his institution with some abroad universities, such as Ehime University, Japan and Universiti Teknologi Malaysia.