QUALITY COST CONSIDERATIONS IN CONSTRUCTION

by

Abdul Rahman Ayub, Ahmad Hilmy Abdul Hamid
Faculty of Civil Engineering, UiTM Pulau Pinang
13500 Permatang Pauh, Pulau Pinang

Paper presented at the Civil Engineering Seminar,
National Defense University Malaysia
11th. April, 2007

ABSTRACT

A Quality Project is defined as a project that meet the requirements or satisfaction of the customer as stated in the contract's documents. A successful completion of project refers to project that is completed on time and meets the required quality as defined in the contract documents. Extension of Time (EOT) or delays in completing a project should be avoided as much as possible by a contractor. Government projects involve taxpayers' money. Delays normally involve extra cost that could have been used for other badly needed infrastructures. Certain measures must be taken by the government, the custodian and manager of taxpayers' money, to avoid the delays so that it will not jeorpadize the successful completion of a project.

Some common causes of delay in a project are the lack of commitment by the contractor, poor management and ineffective project planning and lack of manpower, equipment and materials on the project. In this paper, the considerations of cost quality, will be identified and presented. Recommendations and suggestions on how to overcome the problems related to quality cost will also be discussed in this paper.

1. INTRODUCTION

Contractor's ability to complete government's projects within time, cost and quality as stipulated in the contract documents is a challenging issue that requires immediate rectification plan by all parties involved in the construction industries, including local government authorities. Quality projects come from quality contractors. Under the 9th. Malaysian Plan (RMK9) just announced by the government, the total development spending will go up to RM200 Billion and the Construction Sector will be the direct beneficiary of the RMK9. However, as reported by Utusan Malaysia on 8th. February 2006, almost 40 % of the 34,241 registered Class F Contractors are not competent enough to undertake the government's projects.

Delays or late deliveries, sub-standard workmanship and materials, poor safety management on sites and cost over-run of government's projects are some the issues that have been seriously discussed by the government. Several actions can be taken by the government in ensuring a quality project such as improving the contractors selection process whereby only competent contractors should be allowed to participate in government projects, all design calculations and construction plan must be approved by professional engineers and subject to audit process by the Public Works Department and lastly more training in design, monitoring and supervising skills should be given to all personnel involved in the process.

Failures to perform to the quality expectations is a common cause of problems among the contractors in government projects. The quality of contractors in implementing the government projects have often been subject to questions, criticisms and underating. and completion of a project. Improving the contractors selection process is one of the preventive action plan to overcome the quality problems in government projects.

Project failures is not only about delays, cost over-run or shoddy workamanship but it also include, among innumerable others, environmental degradation and physical eye-sores, lack of green fields or playgrounds, deforestation of all kind of pollution, pervasive soil erosion, flash floods, ozone depletion and mediocre building designs.

Projects failures create a lot problems directly or indirectly to all parties involved in the project such as the government or its agencies, the community where the project is implemented and the project's contractor whose reputation and opportunity to secure future contracts will be at stake.

Project failures are due to variey of factors but what is more important is to search for the solutions and ways to prevent future occurance of the problems. The reasons for project failures especially among the bumiputera contractors should be looked as challenges that need to be highlighted especially when considering the fact that certain government projects are restricted for the bumiputra contractors. Therefore, to ensure a sucessful completion of a project, the procedures for award of contracts need to be evaluated and appraised to ensure that only the best contractor for the job will we selected .

2. RESEARCH OBJECTIVES

It is the aim of this paper to study and identify the quality cost parameters by analysing the responses of parties involved in the construction.

3. LITERATURE REVIEW

Managing projects within time, cost and performance is easier said than done. As shown in Figure 3.0, time, cost and performance are the main constraints of a project. If the project is executed for an outside customer, then the project has a fourth constraint which is good customer relation or customer friendly. The definition of project success also has been extended or modified to include completion :

- Within the allocated time period
- Within the budgeted cost
- At the proper performance or specification level
- With acceptance by the customer/user
- When you can use your customer's name as a reference

- With minimum or mutually agreed upon scope changes
- Without disturbing the main work flow of the organization
- Without changing the corporate culture

(Harold Kerzner, 2001)

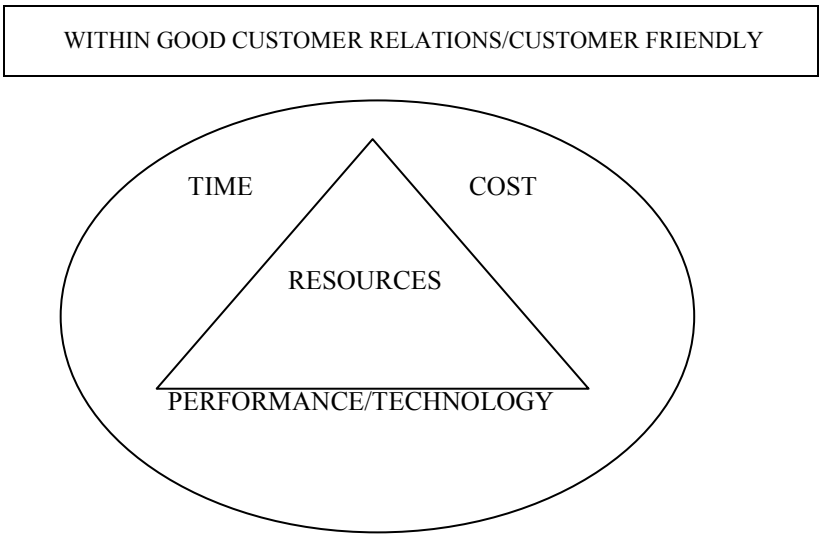


Figure 3.0 : Main Constraint of A Project

There are several factors that are important in ensuring a successful completion of a project. Those factors are :

i. A good field construction representative must be present to represent the interest of the owner and designer
ii. Availability of good and detailed construction schedule that is developed by the contractor of the project
iii. A good project control system must be developed to monitor, measure and evaluate the cost, schedule, labor-hours and quality of works.
iv. Good communication among all parties in a project

(Oberlender, 1993)

As mentioned above, a good successful completion depends very much on the ability of the owner representative or project manager to direct and supervise the project from beginning to the end. Some important roles of a project manager are listed below:

i. The project manager must define the project, reduce the project to a set of manageable task
ii. The project manager must set the final goal of a project and must motivate the project team members to complete the project on time
iii. A project manager must be equipped with technical skills. These should include financial planning, contract management, creative thinking and problem solving techniques
iv. Project manager must learn to adapt to changes

Contractors are independent business organizations and are awarded the projects to produce the required end product as stipulated in the contract documents. In the case of the owner and the contractor may disagree on certain things, the achievement of the end product must always be the top priority of both parties. A good relationship between owner and the project contractor must be maintained so that the contractor's expertise, labor and and equipment can be best utilised to achieve the objectives of the project. The contractor is also required to produce a quality control plan to maintain a job surveillance of its own, to perform tests and keep records to ensure the works conform to the contract requirements. The owner should monitor and supervise the contractor's quality plan and make a sport checks inspection from time to time during the construction process (Oberlender, 1993)

Quality in construction is directly related to time and cost, and vice-versa. A poor quality managed project can result in extra cost and time extensions, a poor time, and cost controlled project can affect the conformance of requirements, example quality. It is therefore vital for understand the client's requirements in terms of cost, quality and time (Hamzah Abdul Rahman, 1997). Management has to be aware of customer requirements and be responsible for creating the right environment for a stewarded and progressive improvement. It also has to produce realistic estimates that match these requirements. The quality cost concept illustrates the importance of prevention rather than merely handling failure. The implication of quality cost and its information in

construction is that any decision taken early in the project will have an influence on the project quality.

The concept of quality costs was first mentioned by Juran (1993) and this concept was applied in the manufacturing industry in the early 1950s. In the construction industry, increasing attention has been given to improve the overall construction quality costs since the early 1980s. Quality costs are a measure of costs specially associated with the achievement or non achievement of product quality, as defined by all product requirements established by the company and its contracts with the customers and society (Juran JM, 1983).

3.1 Defining Quality Costs

Quality linked activities are those activities performed because poor quality may or does exist. The costs of performing these activities are referred to as costs of quality. Quality cost is the cost associated with preventing, finding and correcting defective work (Gryna,1988). This definition implies that quality costs are associated with two subcategories of quality related activities which are control activities and failure activities. Control activities are performed by an organization to prevent or detect poor quality because poor quality may exist. Thus control activities are made up of prevention and appraisal activities. Control costs are the costs of performing control activities (Don R.Hansen, Maryanne M.Mowen, 2002). Failure activities are performed by an organization or its customers in response to poor quality. If the response to poor quality occurs before delivery of a bad (nonconforming, unreliable, not durable, and so on) product or service to customers, the activities classified as internal failure activities, otherwise, they are classified as external failure activities. Failure costs are incurred

when it is necessary to correct the products that fail to satisfy the customer or do not meet company quality specifications (Wen Hsien Tsai, 1996). The definitions of quality-related activities also imply four categories of quality costs which are:-

i. Prevention costs
ii. Appraisal costs
iii. Internal costs
iv. External costs

3.1.1 Prevention Costs

Prevention costs are those resulting from quality activities used to avoid deviations and errors (Juran JM, 1993). Examples of such costs are design reviews, education, training, supplier selection, capability reviews and process of improvement projects.

3.1.2 Appraisal Costs

Appraisal costs include all costs associated with measuring, evaluating, or auditing products to determine whether they conform to their requirements. Examples of appraisal costs include inspections, material reviews, and calibration of measuring and testing equipment.

3.1.3 Internal Failure Costs

Internal failure costs are those costs associated with product failures found before the product is delivered to the customer such as scrap and rework costs for the materials, labour, and overhead associated with production.

3.1.4 External Costs

External failure costs are the costs that occur when a non-conforming product reaches the customer such as those due to customer complaints and those associated with receipt, handling, repair, and replacement of non-conforming products Warranty charges

and product liability costs are also external failure costs. (Aynur Kazaz, M. Talat Birgonul, Serdar Ulubeyli, 2003)

3.1.5 Project Quality Cost Parameters

The major project quality cost parameters which may affect the quality cost can be classified into groups related to financiers, owners, contractors, consultants (including designer), coordination, and environment.

a. Financier Related Criteria

Financier criteria related to financing domain. High cost of financing, difficulty in getting loans and insufficient finance during stage of construction is a factor identified under this criteria. Furthermore, interference in owner's decision and funding shortages are other common problems attributed to financiers (N.D Long et al, 2003).

b. Owner Related Criteria

Owner related criteria are the criteria for which clients are responsible. Finance and payment for completed work, excessive changes orders, slow owner's decision making process, and owner interference are factors frequently cited in these criteria.

c. Contractor Related Criteria

Contractor related criteria concern on adverse factors caused by contractors. They include inadequate experience, construction errors caused by the wrong method of construction, poor site management and

supervision, equipment failures, adequate skill labour, insufficient raw material during construction progress, improper planning and scheduling, inaccurate estimation, and poor contract management.

d. Consultant Related Criteria

Consultant related criteria are criteria attributes to designers or consultants. Preparation and approval of drawings, design error, delays in work approval, and uncompromising attitude are common criteria for related to consultants.

e. Coordination Related Problems

Coordination related criteria are problems or adverse factors such as poor communication, excessive bureaucracy, fraudulent practices, and kickbacks.

f. Environmental Related Criteria

Environmental related criteria are external criteria's factor. They may be caused by natural conditions such as inclement weather or socioeconomic conditions such as material shortage or delivery, labour shortage and price fluctuations.

5.0 METHODOLOGY

The guidelines for identifying the quality cost parameters in construction, is based on a range of data. These include:

i. Literature reviews on the main causes of project failures
ii. Interview with parties involved in the project
iii. Data garthered through questionnaires

6.0 CASE STUDY

The population for this study is the contractors in Pulau Pinang area. The sampling frame is obtained from the Construction Industry Development Board Malaysia (CIDB) Directory (2006-2007). The directory contains the list of grade 1 to rade 7 contractors in Malaysia . The contractors are also divided into building construction, civil engineering, electrical engineering, mechanical engineering and suppliers. This research specifically focused on the buiding construction and civil engineering works contractors.

Stratified random sampling is used in this research. Stratification is the process of grouping members of the population into relatively homogeneous subgroups before sampling (Wikipedia, 2007). There are 3 groups (Grade 7 and Grade 6, Grade 5 and Grade 4, Grade 3, Grade 2 and Grade 1). Therefore, by using stratified random sampling, data from each group can be obtained efficiently.

The pilot questionnaires were tested among 5 contractors from Grade 7 to Grade 2 in area of Bukit Mertajam. The main purposes of this survey were to identify the steps taken by firms to ensure quality and how professionals would react to the issue of quality cost. Responses from respondents were analyzed using SPSS version 13.0.

Descriptive statistic was conducted to analyze the data. 3 types of analyses that were frequency analyses, descriptive analyses and cross tabs analyses had been performed to analyse the data from respondents. The purpose of descriptive statistics is to facilitate the presentation and interpretation of data in terms of mean, frequency and variance of the variables. Then it followed by level all variables using Contribution Weightage Formula.

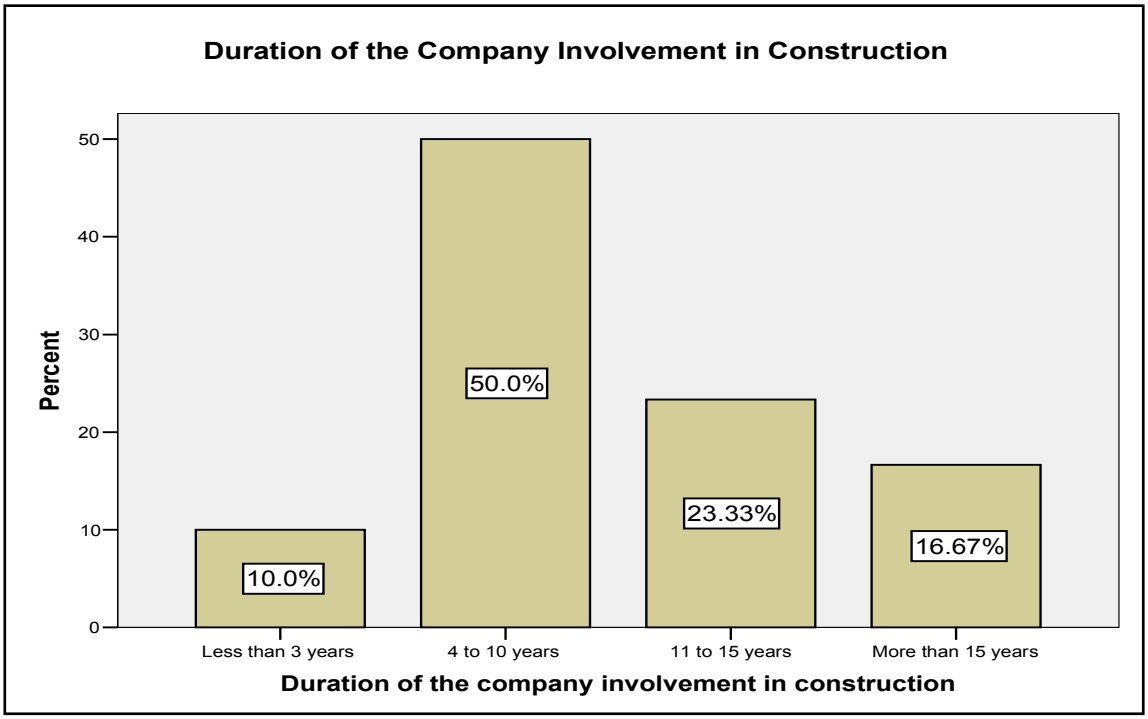
7.0 DATA AND RESULTS

7.1 Contractor Analyses by Duration Involvement in Construction Industry

Bar Chart 4.3 shows the duration of the company involvement in construction industry which answers the questionnaire. It shows that the majority of contractors which answer the questionnaire had been involved in construction industry between 4 to 10 years with the total of 50%. Then, it is followed by duration of 11 to 15 years with the total of 23.33% and 16.67% for contractors which had been involved in construction industry more than 15 years. Finally, the lowest percentage of contractors which had been involved in construction industry is less 3 years with the total of 10%.

Table 4.3 shows the relationship between the grade of contractor and duration of

contractor involvement in construction industry. It clearly shows that most contractors which answer the questionnaire had been involved in construction industry between 4 to 10 years with the total of 30 contractors from 60 contractors which answered the questionnaire.



Bar Chart 4.3: Duration of the Contractor Involvement in Construction Industry

			Duration of the company involvement in construction				
			Less than 3 years	4 to 10 years	11 to 15 years	More than 15 years	Total
Grade of contractor	Grade 7 & Grade 6	Count	0	7	5	8	20
		% within Duration of the company involvement in construction	.0%	23.3%	35.7%	80.0%	33%
	Grade 5 & Grade 4	Count	2	12	4	2	20
		% within Duration of the company involvement in construction	33.3%	40.0%	28.6%	20.0%	33%
	Grade 3, Grade 2 & Grade 1	Count	4	11	5	0	20
		% within Duration of the company involvement in construction	66.7%	36.7%	35.7%	.0%	33%
Total		Count	6	30	14	10	60
		% within Duration of the company involvement in construction	100.0%	100.0%	100.0%	100.0%	****

Table 4.3: Grade of Contractor and Duration of the Company Involvement in Construction Industry

			Duration in the construction industry				
			Less than 3 years	4 to 9 years	10 to 14 years	15 years and more	Total
Position in the company	Project Manager	Count	3	12	6	3	24
		% within Duration in the construction industry	20.0%	40.0%	54.5%	75.0%	40.0%
	Assistance Project Manager	Count	0	3	1	1	5
		% within Duration in the construction industry	.0%	10.0%	9.1%	25.0%	8.3%
	Site Engineer	Count	5	1	2	0	8
		% within Duration in the construction industry	33.3%	3.3%	18.2%	.0%	13.3%
	Project Engineer	Count	2	2	2	0	6
		% within Duration in the construction industry	13.3%	6.7%	18.2%	.0%	10.0%
	Supervisor	Count	2	6	0	0	8
		% within Duration in the construction industry	13.3%	20.0%	.0%	.0%	13.3%
	Others	Count	3	6	0	0	9
		% within Duration in the construction industry	20.0%	20.0%	.0%	.0%	15.0%
Total		Count	15	30	11	4	60
		% within Duration in the construction industry	100.0%	100.0%	100.0%	100.0%	

Table 4.3: Position and Duration of the Respondents in Construction Industry

7.2 Analysis on Extra Measures to Expedite Work Schedule

This study is to determine extra measures that respondents usually apply to expedite work schedule. Respondents were requested to rated based on the range or scale 1 to 5 (1: most important to 5 : most unimportant)

Table 7.0 shows that majority of the respondents were in the opinion that "Adds more machines or equipments" and "Used alternative techniques in management" is important in expedite work schedule. The majority of the respondents also think that " Adds more worker or adds more man power" and " Work Overtime" is slightly important in expediting the work schedule.

		Adds More Workers /Adds More Man Power	Work Overtime	Adds More Machines /Equipments	Used Alternative Technique in Management
N	Valid	60	60	60	60
	Missing	0	0	0	0
Mean		3.67	3.32	3.67	3.72
Median		4.00	3.00	4.00	4.00
Mode		3	3	4	4
Sum		220	199	220	223

Table 7.0 : Central Tendency and Dispersion of the Extra Measures To Expedite in work schedule

7.3 Data Analyses for Project Success Criteria that Effect on Quality Cost

In this research, questionnaires are distributed to 80 contractors in Pulau Pinang. A total of 60 responses were returned back and analysed. In section B of the questionnaire, respondents were requested to mark the degree of contribution of each effect on quality cost based on the scale to 5.

Table 4.5 shows the project success criteria that effect on quality cost. There were 24 variables that had been determined from the literature review.

Project Criteria	Description
A	Time emphasis in construction process
B	Excessive change order
C	Adequate modern equipment and machineries
D	Government permits and approval
E	Fraudulent practises and kickback
F	Proper planning and scheduling
G	Top management responsibilities and involvement
H	Site management and organization
I	Improper project design
J	Financial problems
K	Project cost estimation
L	Cost monitoring and control
M	Safety awareness on site
N	Project environment assessment
O	Project social assessment
P	Disputes resolution
Q	Cooperation of all parties in the project
R	Quality of raw material
S	Size and value of the project
T	Well defined project scope and objectives
U	Climatic condition at site
V	Monitoring and feedback by client
W	Selection of PM with proven track record
X	Poor labour skill

Table 4.5: Project Quality Cost Parameters Affecting Quality Cost

7.4 Central Tendency and Dispersion Analysis

Central tendency and dispersion of variables were used to observe to response of the respondents for all variables stated in questionnaire. Descriptive analyses such as mod, median, mean, sums were obtained from the variables.

The highest mean is project criteria (R) with the value of 4.18. Then it followed by project criteria (H) with the value of 4.15. The lowest mean is project criteria (E) with the value of 3.12. From all this value it is indicated that majority of the respondents were in the opinion that the main project criteria “Quality of Raw Material” is significant towards the effect on quality cost. The majority of the respondents also in the opinion that “Fraudulent Practises and Kickback” was slightly significant toward effect on quality cost. Table 4.6 shows the overall ranking of mean value for each project criteria.

Ranking	Project Criteria	Mean Value	Description
1	R	4.18	Quality of raw material
2	H	4.15	Site management and organization
3	G	4.08	Top management responsibilities and involvement
4	F	4.03	Proper planning and scheduling
5	L	3.95	Cost monitoring and control
6	Q	3.93	Cooperation of all parties in the project
7	A	3.9	Time emphasis in construction process
8	W	3.85	Selection of PM with proven track record
9	V	3.85	Monitoring and feedback by client
10	K	3.83	Project cost estimation
11	D	3.78	Government permits and approval
12	S	3.77	Size and value of the project
13	N	3.75	Project environment assessment
14	M	3.75	Safety awareness on site
15	J	3.75	Financial problems
16	C	3.73	Adequate modern equipment and machineries
17	T	3.65	Well defined project scope and objectives
18	O	3.63	Project social assessment
19	U	3.52	Climatic condition at site
20	I	3.43	Improper project design
21	X	3.42	Poor labour skill
22	B	3.42	Excessive change order
23	P	3.4	Disputes resolution
24	E	3.12	Fraudulent practises and kickback

Table 4.6: Ranking of Mean Value for Each Project Criteria

7.5 Analysis of Data using Contribution Weightage Formula

This study is to analyse all variables using Contribution Weightage Formula. Contribution Weightage formula is summation of number respondents who had chosen the specific variable with a certain of contribution (Abdul Rahman Ayub, and Janidah Eman, 2006). For this research, Contribution Weightage formula is summation of number respondents who had chose the specific project criteria with a certain of contribution towards effect on quality cost.

$$\textbf{Contribution Weightage} = \sum[\ \textbf{(Number of Respondents)} \times \textbf{(DCTQC)}\ ]$$

Where DCTQC = Degree of Contribution Toward Effect on Quality Cost

Based on table 4.6, the first column in the table represents the degree of contribution the project criteria (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V,W, X).

The number outside bracket represents the number of respondents who had chosen the specific project success criteria with a certain degree contribution toward effect on quality cost.

The last column in table 4.7 (a) and table 4.7 (b) shows the total overall contribution weightage toward effect on quality cost.

Project Criteria	Degree of Weightage Contribution Toward Effect on Quality Cost					Total Weightage
	5	4	3	2	1	
A	12 (60)	30 (120)	18 (54)	0 (0)	0 (0)	234
B	4 (20)	22 (88)	29 (87)	5 (10)	0 (0)	205
C	9 (45)	28 (112)	21 (63)	2 (4)	0 (0)	224
D	14 (70)	20 (80)	25 (75)	1 (2)	0 (0)	227
E	1 (5)	15 (60)	35 (105)	8 (16)	1 (1)	187
F	21 (106)	21 (84)	17 (51)	1 (1)	0 (0)	242
G	19 (95)	27 (108)	14 (42)	0 (0)	0 (0)	245
H	19 (95)	31 (124)	10 (30)	0 (0)	0 (0)	249
I	6 (30)	26 (104)	18 (54)	8 (16)	2 (2)	206
J	16 (80)	20 (80)	18 (54)	5 (10)	1 (1)	225
K	14 (70)	24 (96)	20 (60)	2 (4)	0 (0)	230
L	14 (70)	29 (116)	17 (51)	0 (0)	0 (0)	237
M	11 (55)	23 (92)	26 (78)	0 (0)	0 (0)	225

Table 4.7 (a) : Project Criteria Based on Contribution Weightage

8.0 Results

Quality cost parameter as shown in Table 4.8 are some factors faced by the contractor which has effect on quality cost. Based on the findings, it is shown that "Quality of Raw Material" is the main effect on quality cost with contribution weightage of 251. The finding also shows that "Fraudulent practises and kickback" is the least effect on quality cost with contribution weightage of 187.

The second project criteria was due to "Site management and organization" followed by "Proper planning and scheduling". Other prfactors in there ranking are due cost monitoring and control, cooperation of all parties in the project, time emphasis in construction process, selection of project manager with proven track record, monitoring and feedback by client, project cost estimation, government permits and approval, size and value of the project, project environment assessment, safety awareness on site, financial problems, adequate modern equipment and machineries, well defined project scope and objective, project social assessment, climatic condition at site, improper project design, poor labour skill, excessive change order, disputes resolution.

9.0 DISCUSSION, RECOMMENDATIONS AND CONCLUSION

9.1 DISCUSSION

The highest ranking of project quality cost parameters is the quality of raw material. Quality of raw material is important because it plays the important role int meeting the required quality of the project. Majority of the contractors from Grade 3, Grade 2 and Grade 1 were in the opinion that quality of raw material is extremely significant towards the effect on quality cost. On ther hand, contractors from Grade 5 and Grade 4 were in the opinion that quality of raw material is somewhat significant in the project quality cost.

The second highest ranking is site management and organization. Based on Table Grade of Contractor and Site Management and Organization Crosstabulation (refer to Appendix), it shows that contractor from Grade 5 and Grade 4 were in the opinion that site management and organization is significant towards the quality cost. However, respondents from Grade 7, Grade 6, Grade 3, Grade 2 and Grade 1 agreed that site management and organization is extremely significant towards effect on quality cost.

The lowest ranking of project factors is fraudulent practises and kickback. Majority of the respondents were in the opinion that “Fraudulent practises and kickback” is the least significant towards the effect on quality cost. From the Table of Grade of Contractor and Fraudulent Practises and Kickback crosstabulation (refer appendix), majority contractors from Grade 7 until Grade 1 agreed that fraudulent practises and kickback is slightly significant towards effect on quality cost. Fraudulent practises and kickback can occur at every phase of a construction project example during design, tender, construction and during project execution. These practices can involve giving and receiving bribes or kick-back money..

9.2 CONCLUSIONS

Based on the results of the data analysis for project criteria towards effect on quality cost, the following conclusion can be made:

a. It was found that quality of raw material is the main project criteria towards effect on quality cost. It followed by site management and organization. The third rank is top management responsibilities and involvement. It was found too that fraudulent practises and kickback is slightly significant towards effect on quality cost.

b. This research found that the level of project quality cost factors faced by contractor in Pulau Pinang is high with statistically indicated with the mean around 4.00 on five point scale. It means all the twenty four project quality cost factors are significant towards the quality cost.

c. Quality in construction is directly related to time and cost, and vice-versa. A poor quality managed project can result in extra cost and time extensions. It is therefore vital for the contractors in Pulau Pinang to understand the client's requirements in terms of cost, quality and time. Prevention is better than cure. A successful and quality project comes from quality contractors. Contractor should use quality costs parameters as tools to help justify improvement

actions. With any quality measurement, the information and improvements realized need to be applied to any future activities. Once improvements are planned, they must be acted upon to ensure that future activities will result in a new level of quality. Identifying quality costs will allow management of the project to judge improvement investment. A quality programme is as valuable as its ability to contribute to customer satisfaction and ultimately to company profit.

11.0 REFERENCES

Oberlender, G.D (1993) Project Management For Engineering And Management. McGraw-Hill Inc, New York

Tan, Andrew A.L (2004) Project Management Consultant- Myth or Reality? Venton Publishing, Kuala Lumpur

Uher, T.E, Davenport, P (2002) Fundamental of Building Contract Management, UNSW Press, Sydney, First Published, 262-263

Hughes, R.K (1996) Understanding Construction Claims and Dispute Resolution Oklahoma State University, Stillwater

Flanagan, R and Norman, G (1993) Risk Management and Construction, Blackwell, UK

Caplan F,The Quality System (Second Edition), Pennsylvania, PA: Chilton Book Company,1990.

Gerald Sundaraj, The Way Forward: Construction Industry Master Plan 2006-2015, Journal of Construction Industry Development Berhad, Malaysia, 2006, Page 12-15.

Deming WE, Out of Crisis: Quality, Productivity and Competitive Position, Cambridge University Press, 1986.

Juran JM, Quality Planning and Analysis, New York, McGraw Hill (third edition), 1993.

Don R.Hansen, Maryanne M.Mowen, Cost Management, Thomson Learning, 2002.

Wen Hsien Tsai, Quality cost measurement under activity based costing, Ph.D Thesis, National Central University of Taiwan, Republic of China, 1996.

Hays R., Conference Summary. Proceeding of the National Conference: Quality assurance in the building community, Journal of Engineering and Technology