CHAPTER 5

RESULTS, ANALYSIS AND DISCUSSIONS

5.1 Introduction

This chapter presents the results of the survey and analysis. The first part discusses statistical analysis of the quantitative data that was achieved through questionnaire survey. Statistical Package for Social Sciences Software (SPSS) was used for data analysis. The second part is comprised of four case studies from infrastructure, housing, upgradation and building projects in order to explore the knowledge and applications of EVM method. It seeks to determine and evaluate the effectiveness and efficiency of the EVM monitoring system in practical scenarios. The last part of this chapter includes a discussion which is based on two semi structured interviews for gaining views and substantial arguments from senior officials of participating organizations.

5.2 Survey Results

A total number of 130 questionnaires were sent to the professionals of different trades. Out of which, 30 complete responses were received, leading to a return rate of 23%. The findings of the survey are as follows;

5.2.1 Respondents Background

Figure 5.1 shows their pie-chart distributions which describe their percentage as primary job function. The data analysis indicates that the feedbacks from senior management are relatively higher (39%) as compared to the other categories of respondents.
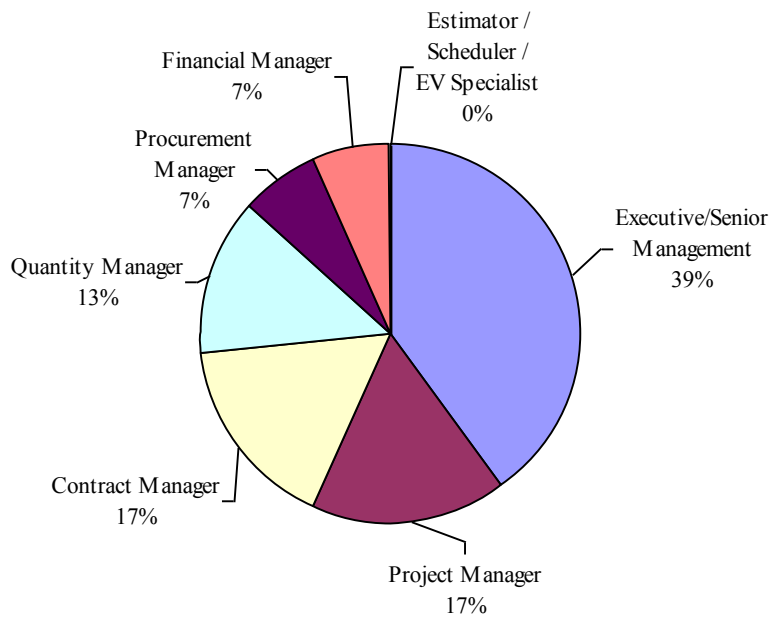
Figure 5.1: Distribution of Respondents Primary Job function.

5.2.2 Role of Organization in Projects

The role of organizations involved in construction projects were also sought through the survey. Figure 5.2 represents pie chart distribution of the participating organizations.
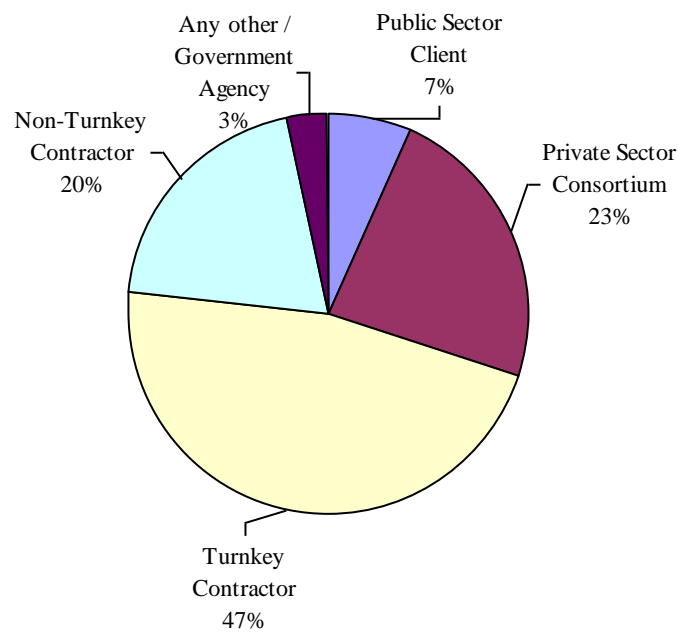

Figure 5.2: Distribution of Organizational Role in Projects.

The findings show that 47% of the respondents belonged to turnkey contractors. Whereas, participation from the private sector consortiums and non turnkey contractors remained 23% and 20% respectively. It is noteworthy that inputs from government ministries / public sector clients were relatively very low. Table 5.1 shows the distribution of cross tabulation between organizational roles and their industrial associations in two groups.

Table 5.1: Distribution of Cross Tabulation between Organizational Roles and Industrial Associations

| S. No. | Respondents Role | Industrial Associations | | | | | Total |
		Heavy/ Civil Engg.	Industrial	General / Commercial	Housing	Any other / Construction	
1	Public sector	1	0	0	0	2	3
2	Private sector	6	5	8	6	2	27
	Total	**7**	**5**	**8**	**6**	**4**	**30**

The data from Table 5.1 indicates that the respondents from public sector (n = 3) are mainly concerned to construction categories. On the other hand, the private sector (n = 27) is more associated to general/commercial sectors, heavy/civil engineering and housing areas. The above data reveals that the respondent's feedbacks have covered varying sectors of construction.

5.2.3 Respondents Project Management Experience

Table 5.2 shows the project management experience of the respondents. It is found that 50% of the respondents have working experience within the range of five to ten years. Whereas, 33% pertained ten to fifteen years. Nearly 10% of the respondents have more than fifteen years working experience.

Table 5.2: Distribution of Respondents Project Management Experience

S. No.	Project Management Experience	Frequency	Percentage
1	Less than 5 year	2	6.7
2	5 to 10 years	15	50.0
3	10 to 15 years	10	33.3
4	More than 15 years	3	10.0
Total		**30**	**100**

5.2.4 Understanding and Usage of Earned Value Management (EVM) Method

5.2.4.1 EVM Usage

The responses of the questionnaire survey indicate that the understanding of EVM method was already established in the Malaysian construction industry as 23% of the respondents sent their complete feedbacks. However, from the survey analysis, it has been revealed that 80% of the respondents are not practicing EVM method. The percentage wise distribution for this data is shown Table 5.3.

Table 5.3: Distribution of EVM Usage

S. No.	Respondents	EVM Usage			Total
		Not used at all	Used only for few non-PPPs/PFI projects	Used for large critical/infrastructure projects	
1	Public sector	3	0	0	3
2	Private sector	21	2	4	27
Frequency		**24**	**2**	**4**	**30**
Percentage		**80**	**6.7**	**13.3**	**100**

5.2.4.2 Barriers for EVM Usage

As a part of the survey, the respondents were asked to select and ranked the barriers from a list of seven common barriers drawn from literature review. In this regard, the respondents have ranked different reasons for the limited usage of EVM method. Table 5.4 below shows the ranking of EVM barriers on the basis of average index analysis.

Table 5.4: Average Index Ranking for EVM Barriers

S. No.	Reasons	Frequency Analysis										Average Index	Rank
		1		2		3		4		5			
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%		
1	Lack of EVM knowledge, expertise and experience	3	10	2	6	4	13	10	33	11	36	4.0	1
2	Too many rules and requirements to learn and implement	1	3	6	20	4	13	12	40	7	23	3.60	2
3	High cost and time commitment	0	0	7	26	8	26	10	33	5	16	3.43	3
4	Current control system works, no need to change	2	6	9	30	9	30	6	20	4	13	3.03	4
5	Not suitable for your organization	1	3	10	33	14	46	3	10	2	7	2.83	5
6	Not cost effective to implement	4	13	8	26	10	33	6	20	2	6	2.8	6
7	Lack of computer and software infrastructure	12	40	13	43	5	16	0	0	0	0	1.76	7

From the Table 5.4, it is shown that the "Lack of EVM knowledge, expertise and experience" and "Too many rules and requirements to learn and implement" have high average index values i.e. 4.0 and 3.60 respectively and considered as the important barriers. Among other "High cost and time commitment", "Current control system works, no need to change", "Not suitable for your organization" and "Not cost effective to implement" have average level of significance. Moreover, "Lack of computer and software infrastructure" is not considered as critical issue as a limitation for EVM usage.

5.2.4.3 Correlation Analysis

The barriers to EVM implementation were also analyzed through correlation analysis by using Spearman's correlation test. It is a non-parametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale. It is denoted by the symbol r_s (or the Greek letter ρ, pronounced rho). As shown in Table 5.5, not all independent variables (i.e. EVM barriers) were significantly related to each other. This shows a non-monotonic relationship between the variables. However, among the significant factors, there was a strong, positive correlation between "Non-suitability of EVM" with respect to its "Cost effectiveness" and it was statistically significant at ($r_s = .465$, $P = .010$). In addition, the cost of EVM validation has also a high correlation with "Lack of EVM knowledge, expertise and experience". This shows that the initial start-up cost to validate EVM can be higher for those contractors/users who are new to this approach.

Table 5.5: Spearman' Correlation Test for EVM Barriers

S. No.	Reasons	Not suitable for your organization	Current control system works, no need to change	Not cost effective to implement	Lack of EVM knowledge, expertise and experience	High cost and time commitment	Too many rules and requirements to learn and implement	Lack of computer and software infrastructure
1	Not suitable for your organization	1.000	.078	.465[**]	.151	.211	.071	.268
2	Current control system works, no need to change	.078	1.000	.135	.198	.114	-.140	.150
3	Not cost effective to implement	.465[**]	.135	1.000	.438[*]	.119	-.091	.259
4	Lack of EVM knowledge, expertise and experience	.151	.198	.438[*]	1.000	.164	-.132	-.080
5	High cost and time commitment	.211	.114	.119	.164	1.000	.358	-.229
6	Too many rules and requirements to learn and implement	.071	-.140	-.091	-.132	.358	1.000	.053
7	Lack of computer and software infrastructure	.268	.150	.259	-.080	-.229	.053	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5.2.4.4 EVM Implementation Plan

The respondents were asked regarding their future plan for implementing EVM method. The results are contained in the Table 5.6. The data indicates that the respondents from the public sector are 'Not sure' about the anticipated usage of EVM method. Nevertheless, 60% respondents from the private sector express their positive intentions towards adoption of EVM method.

Table 5.6: Distribution of Future EVM Implementation Plan

S. No.	Respondents	EVM Implementation Plan			Total
		Yes, within 5 years	**Not sure**	**No plan to implement**	
1	Public sector	0	3	0	3
2	Private sector	18	4	5	27
	Frequency	**18**	**7**	**5**	**30**
	Percentage	**60**	**23.3**	**16.7**	**100**

5.2.4.5 Perception about EVM Implementation

Table 5.7 indicates that about 20% of the respondents rated their perception about the implementation of EVM as "difficult" compared with 80% who remain neutral. It is also interesting to note that no organization rated their perception about EVM implementation as "quite easy" or "very easy". This nil percentage indicates that the respondents from the construction industry have an unclear view about the processes of EVM system.

Table 5.7: Distribution of Perception about EVM Process

S. No.	Respondents	Respondents Perception about EVM Process					Total
		Very Difficult	**Quite Difficult**	**Neutral**	**Quite Easy**	**Very Easy**	
1	Public sector	0	0	3	0	0	3
2	Private sector	2	4	21	0	0	27
	Frequency	**2**	**4**	**24**	**0**	**0**	**30**
	Percentage	**6.67**	**13.33**	**80**	**0**	**0**	**100**

5.2.4.6 Primary Motivation For EVM Implementation

The respondent's inspirational view towards implementation of EVM in their future practices was also sought in the survey. Figure 5.3 shows the percentage wise distribution for their primary motivation in EVM system.
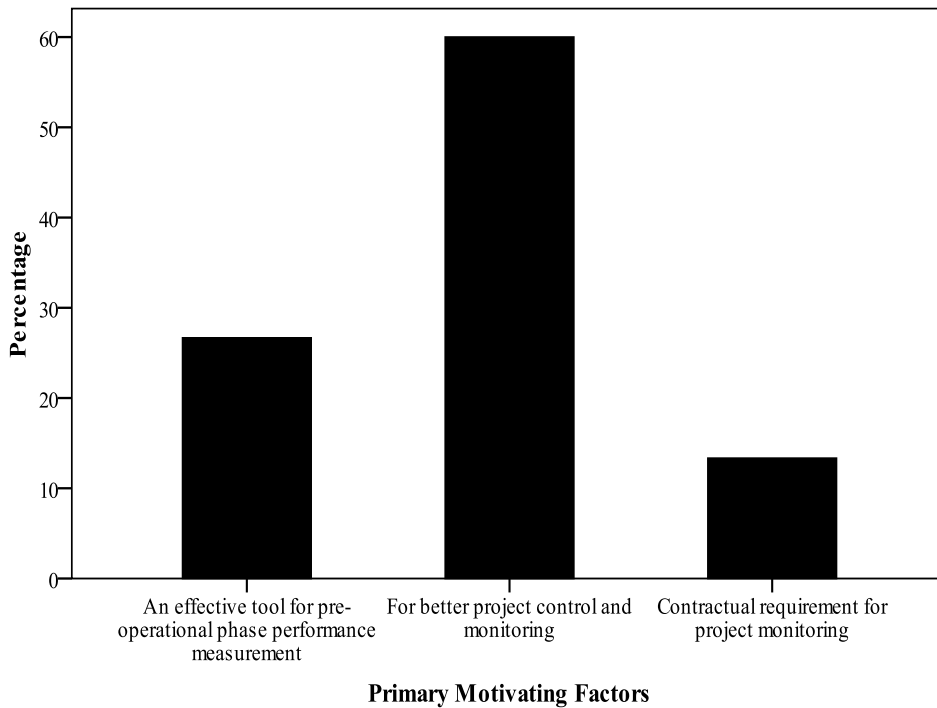
Figure 5.3: Distribution of Primary Motivation for EVM Implementation.

5.2.4.7 Advantages For Using EVM

Table 5.8 represents the results of tests for Kendall's coefficient of concordance (*w*) and the ranking of the supportive factors of EVM as perceived by all the respondents. Kendall's coefficient of concordance (*w*) for the ranking of constraints among all the respondents is 0.050 (*w*). The Kendall's coefficient of concordance is significant at the 0.000 level and therefore it can be concluded that there is a good degree of agreement among the respondents regarding the potential advantages achieved by using EVM method.

Table 5.8: Ranking of EVM Supportive Factors

Factors	Mean	Rank
EVM contributes to achieving project schedule objectives.	3.83	1
EVM provides early warning of performance problems.	3.78	2
EVM allows people to communicate objective progress to stakeholders, and keep the project team focused on achieving progress.	3.53	3
EVM contributes to achieving project cost objectives.	3.47	4
Overall, EVM is a cost-effective tool for performance management.	3.37	5
EVM contributes to improving project scope definition and prevents scope creep.	3.02	6
Kendall's coefficient of concordance (w)	0.050	
Level of Significance	0.000	

5.3 Case Study Analysis

The results of the questionnaire survey as discussed in the previous section, gathered the useful informations and details on the understanding and usage of EVM method in the Malaysian construction industry. This survey has elicited informations from public sector clients and as well as private contractors. Now, this section of the research aims to explore the knowledge and applications of EVM method through case studies. The case studies permit an informal setting of data collection and analysis in order to reflect the real scenarios as prototypes. This approach also allows probing of the contextual data in order to gain insights of the effectiveness and efficiency of the EVM method. For this research, four different case studies from infrastructure, housing, upgradation and building projects were selected that helps to generate a more general EVM analysis. These case studies included project scope of work, schedule charts, progress reports, budgeted and actual cost reports and other documents as secondary data. The raw project data is then regenerated according to the steps as defined by the EVM Framework (Chapter No. 3) in order to set up a systematical interpretation of Earned Value performance measures. However, the acquired data has its own constraints as it is derived from those projects where underlying principals EVM method were not being applied. Therefore, such data is in short of details which are considered to be compulsory for the calculation of EVM matrices. Moreover, in some cases, the acquired data has partial information regarding the project progress with respect to the actual cash flows. It has not got adequate details to find out the values of SPI and CPI. Therefore, the following assumptions were made for applying the EVM Framework on the acquired data;

- Physical progress is estimated by dividing the actual number of complete working days with the total time/duration of the work package activity.

- Planned Value (PV) or Budgeted Cost of Work Performed (BCWP) is divided uniformly over the entire duration of work package activity.

The next sections will describe the case studies in detail.

5.4 Case Study 1: Infrastructure Project

5.4.1 Description

This case study describes the proposed Earned Value Management (EVM) method for the Larut tunnel section of Electrified Double Track Project (EDTP) in the Western part of peninsular Malaysia. The EDTP is a Government funded project of worth RM 12.485 billion and awarded in December 2007 on design and build basis. An equal joint venture was established between two Malaysian construction groups to undertake the project. The overall scope of work includes design and construction of an electrified double tracking railway line between Ipoh (capital of Perak) and Padang Besar (a town near Thailand border in Perlis) measuring 329 Kilometre. This project is expected to complete in 2013. Table 5.9 shows the synopsis of project scope [75].

Table 5.9: Project Scope of EDTP

(Source: MMC – Gamuda Joint Venture Sdn Bhd)

Scope of Work			
Route:	Overall Length – 329 km		
Sector 1	Kedah Line – 158 km (Bukit Mertajam – Padang Besar)		
Sector 2	Mainline – 171 km (Butterworth – Ipoh)		
Station	Major = 7, Minor = 14, Halt = 10, Depot = 3		
State	Perlis	Kedah	P.Pinang	Perak
Tunnel	Bukit Berapit – 3.3 km (Perak)		
	Larut – 0.33 km (Perak)		
Bridges	Road Over Bridge (ROB) – 66 No		
	Road Under Bridge (RUB) - 8 No		
	River Bridge (RB) – 75 No		
	Motorcycle/ Pedestrian Bridge – 45 No		
Special Structure	Prai Swing Bridge – 282 m		
	Marine Viaduct (Bukit Merah) – 3.5 km		
KTMB Quarters	220 Units		
Systems	Electrification Signalling & Control Communication		

5.4.2 Larut Tunnel Site and Location

The site of Larut tunnel is situated near Air Kuning, Taiping, Perak. The site work started in the first quarter of 2008. It is 342 meter in length; the single Larut tunnel has a "horse shoe" diameter shape which is 13 meter in width and 10 meter in height. For drilling this tunnel a combined method was adopted for drilling simultaneous holes at a time (drilling jumbo; high speed drill) and control blasting was used depending upon the requirements.

5.4.3 Application of EVM Framework on Larut Tunnel Project

The implementation of the EVM Framework will be performed in the following steps:

5.4.3.1 Development of WBS

The development of Work Breakdown (WBS) is the core process of an EVM system. It is the hierarchical decomposition of project activities into manageable work packages. It is of particular importance because as it provides a basis for calculating the EVM matrices. This study considers the "Larut Tunnel" as a whole project with WBS level 0. It is then decomposed into two major heads as mentioned below and having WBS Level 1.

    A. Civil & Structural Works

    B. Mechanical & Electrical Works

Each of these heads can then be divided into section (Level 2) and subsection (Level 3). Down to this level, Work Package Activity level i.e. Level 4 exists. At this point, cost and schedule performances are measured and then compared to Earn Value (EV) for evaluating the performance measurement. Appendix 'B' shows a summary WBS for Larut tunnel section of EDTP.

5.4.3.2 Organizational Breakdown Structure

Organization breakdown structure (OBS) generally illustrates the position description of project team members. It is also used to define the project team relationships and to assign the roles and responsibilities. The OBS provides a hierarchical type organizational chart rather than a task-based outlook of the overall project. The hierarchical structure of the OBS allows the aggregation of project information to higher levels. When project roles and responsibilities are defined, the OBS and WBS are merged together to develop a Human Resource Plan. In using WBS and OBS, it is assured that all elements (scope) of a project will be assigned to each project team members on the basis of Responsibility Assignment Matrix (RAM). Appendix 'C' shows an organizational chart of Larut tunnel project team.

5.4.3.3 Project Schedule

A work break down (WBS) provides firm basis for establishing a project schedule. It comprises of a detailed list of work package activities with intended start and finish dates. In construction industry, usually the project scheduler are responsible for making the schedules. Appendix 'D' shows a drill and blast construction programme for Larut tunnel section.

5.4.3.4 Budget Allocation

The "Electrified Double Track Railway Project" was awarded at a fixed price contract for which the baseline cost is RM 12.485 billion. The project cash flow report for the Larut tunnel section was obtained for the period of March 2008 to May 2010 in order to establish a time-phased budget. In construction industry, the cumulative illustration of budgeted cost is very common in the form of a non-linear graphical image, known as S-curve as shown in Figure 5.4. It shows a trend of budgeted expenditures over a period of time. It is also known as the Performance Measurement Baseline (PMB) which is the summation of budgets of work scheduled with in a stated period (Planned Value).
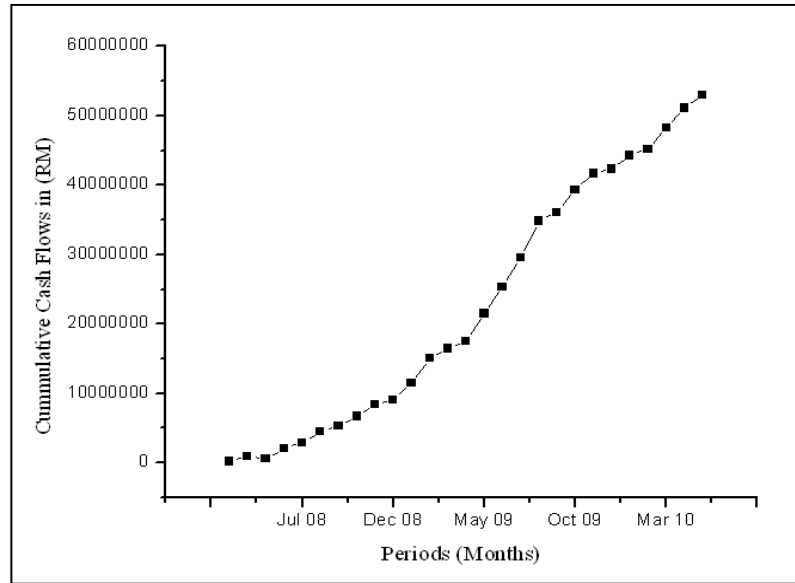
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Figure 5.4: S-Curve for Cumulative Cash Flows.

5.4.3.5 Earned Value Analysis

Table 5.10 shows Earned Value Analysis on quarterly basis from a period of March 2008 to March 2010. A scheduling software package is used to carry out the EV analysis of the schedule activities. It is apparent from the data that during the entire project duration the Actual Cost has remained less than planned and has earned less than Planned Values. Figure 5.5 shows a graphical analysis of the PV, AC and EV on quarterly basis.

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Table 5.10: PV, AC and EV Values for Larut Tunnel Section

(Amount in RM)

S.No.	Description	PV	AC	EV	Remarks
1	1st Quarter	1,854,918.03	1,604,918.00	1,436,056.57	PV>AC>EV
2	2nd Quarter	8,603,278.69	8,592,000.00	8,342,622.95	PV>AC>EV
3	3rd Quarter	12,600,000.00	12,450,000.00	12,339,344.26	PV>AC>EV
4	4th Quarter	23,073,034.19	21,749,000.00	21,311,445.83	PV>AC>EV
5	5th Quarter	33,375,000.00	30,979,000.00	30,398,461.54	PV>AC>EV
6	6th Quarter	37,233,695.65	35,239,000.00	33,990,217.00	PV>AC>EV
7	7th Quarter	43,930,710.00	43,405,000.00	42,228,277.09	PV>AC>EV
8	8th Quarter	56,684,029.85	56,015,000.00	55,000,869.77	PV>AC>EV
9	9th Quarter	58,873,283.58	56,857,000.00	55,903,712.08	PV>AC>EV
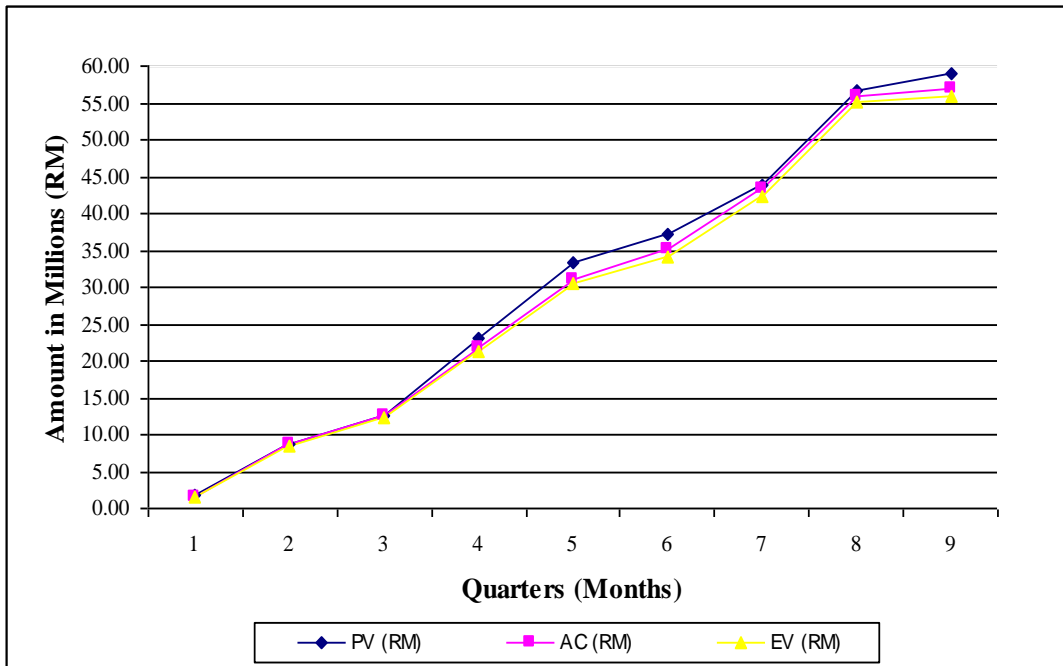
Figure 5.5: PV/AC/EV Graphical Analysis.

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5.4.3.6 Lessons Learned

By knowing the basic EVM parameters i.e. PV, AC and EV in the previous section, the schedule and cost analysis can be summarized as follows;

i. Schedule Analysis:

Case study 1 depicts a scenario in which the EV schedule analysis was carried out quarterly. Table 5.11 show Schedule Variance (SV), SV%, SPI and actual physical progress.

Table 5.11: EV Schedule Analysis

S.No.	Description	EV Schedule Analysis			% of Completed Work
		SV	*SV%*	*SPI*	
1	1st Quarter	-418,861.46	-22.581	0.77	2.17
2	2nd Quarter	-260,655.74	-3.029	0.97	12.58
3	3rd Quarter	-260,655.74	-2.068	0.98	18.60
4	4th Quarter	-1,761,588.36	-7.634	0.92	32.13
5	5th Quarter	-2,976,538.46	-8.918	0.91	45.83
6	6th Quarter	-3,243,478.65	-8.711	0.91	51.24
7	7th Quarter	-1,702,432.91	-3.875	0.96	63.66
8	8th Quarter	-1,683,160.08	-2.969	0.97	82.92
9	9th Quarter	-2,969,571.50	-5.044	0.95	84.28

The results of the EV schedule analysis indicate that the project progress is unfavourable and it can be discussed as follows:

a) The Schedule Variance (SV) values are consistently negative within the first 09 quarters which shows that the project has fallen behind the original schedule.

b) The SV% varies between -22.581% to -2.068% indicating that the percentage of works which have not been accomplished against the planned schedule.

c) The efficiency of project team is demonstrated by SPI which is less than 1.00. It shows that the team has performed work less efficiently and the schedule objectives are achieved within the range of 77% (Min.) to 98% (Max.) efficiency at different quarters.

d) Figure 5.6 shows a very useful comparison of SV% and actual percentage of completed work. This type of relationship can not be possible without EV analysis. The percentage of completed work shows that project is succeeding well. However, corresponding SV% indicates that work has not been accomplished as per original planned. For example, at the end of quarter 4, the project is 32.13% completed. But its corresponding SV% point out that 7.63% of planned work is still remaining. Hence, the project progress is unfavourable and it requires some remedial measures to fill up this gap.
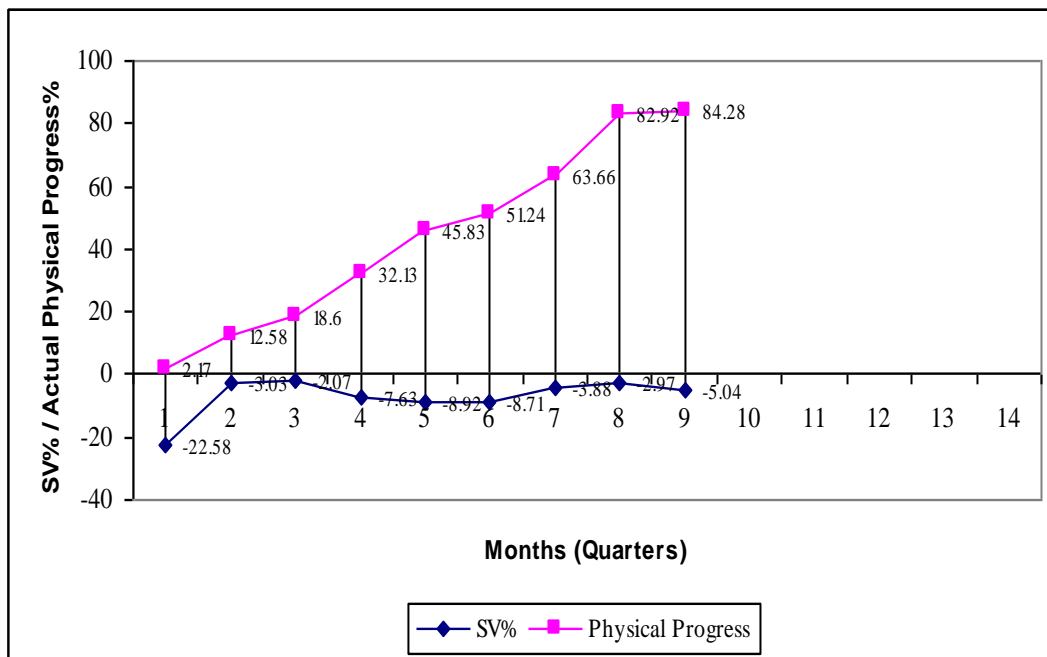
Figure 5.6: SV% and Actual Physical Progress Analysis.

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ii. Schedule Forecasting:

The original schedule completion time for this project was 27 months. However, due to the less efficient performance of the project team, it is predicted that project will fall behind the schedule. Therefore, Time Estimate at Completion (EAC_t) at the end of March 2010 will make possible to forecast any additional time required for project completion. By using equation 2.4 and taking the corresponding values the time estimate is;

$$EAC_t = 28.5 \ Months$$

The EAC_t shows that if the current progress trend continues, the project will likely to finish in 28.5 months (approx.) as compared to initial scheduled completion time which is 27 months.

iii. Cost Analysis:

The EV cost analysis make possible to measure and forecast the project progress cost-wise. Table 5.12 shows the value of CV, CV% and CPI.

Additional analysis can be done as follows;

a) The Cost Variance (CV) is calculated by subtracting the EV from the AC. For this project, it has a consistently negative value which depicts an unfavourable scenario. It can also be expressed as a percentage by dividing the CV by the EV as shown in Table 5.12. The CV% values lie in the range of -0.90% (Min.) to -11.76% (Max.) during the entire period. It indicates that the project progress was fairly good at the end of 3rd quarter of 2008 when it was 0.90% over budget compared to 11.76% over budget at the end of 1st quarter of 2008.

b) Refer to Table 5.12, it shows CPI values at different project durations. CPI indicates the efficiency of project resource utilization. For a best-case scenario, it must be equal to 1.00 or higher than 1.00. However, for the current case study the CPI values are in-between 0.89 and 0.99. This shows that the project has a low cost efficiency as compared to its spending.

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Table 5.12: EV Cost Analysis

S.No.	Description	EV Cost Analysis		
		CV (RM)	CV%	CPI
1	1st Quarter	-168,861.43	-11.76	0.89
2	2nd Quarter	-249,377.05	-2.99	0.97
3	3rd Quarter	-110,655.74	-0.90	0.99
4	4th Quarter	-437,554.17	-2.05	0.98
5	5th Quarter	-580,538.46	-1.91	0.98
6	6th Quarter	-1,248,783.00	-3.67	0.96
7	7th Quarter	-1,176,722.91	-2.79	0.97
8	8th Quarter	-1,014,130.23	-1.84	0.98
9	9th Quarter	-953,287.92	-1.71	0.98

iv. Cost Forecasting:

The future project progress in terms of cost-wise is determined by using Estimate at Completion (EAC), Variance at Completion (VAC) and Estimate to Complete (ETC) methods. They are calculated as follows;

a) Estimate at Completion

The forecast Cost at Completion i.e. Estimation at Completion (EAC$_c$) is determined at the end of 1st quarter of 2010. It is calculated by using Equation 2.8;

$$EAC = RM\ 60,074,779.16$$

This shows that if the current CPI trends continue the project could finish over budget. In other words, if the project has to achieve its planned BAC values, its CPI must be improved from the current performance level.

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b) Variance at Completion

Variance at Completion (VAC$_c$) is calculated at the end of 9th reporting period by using Equation 2.9;

$$VAC_c = RM\ 1,201,495.58\ (\text{-ve})$$

Here, a negative value of VAC indicates that with the current performance trends the project will be finished over budget. It can also be expressed in the form of percentage.

$$VAC\% = -2.04$$

VAC% shows that project will be 2.04% over budget with the current CPI = 0.98.

c) Estimate to Complete

At the end of 9th reporting period, the remaining project cost is determined by Estimate to Complete (ETC) factor. It is calculated by using Equation 2.10;

$$ETC = RM\ 3,030,175.00$$

5.5 Case Study 2: Housing Project

5.5.1 Introduction

This case study describes the usage of Earned Value Management (EVM) for the property development project in Malaysia. It describes the steps which are involved for the implementation of EVM System in the property development construction project. The EVM Framework is applied in the building of 164 unit of terrace house at a site of Bandar Seri Iskandar, Perak. This is a private sector funded project of worth RM 9.437 million and awarded on 24th May 2005 to the contractor. The scope of work includes construction and completion of main building works incorporating mechanical and electrical works and all associated external works. The overall scope was splited into two sections which are as follows;

- Construction and completion of Priority 1 (70 units)

- Construction and completion of Priority 2 (94 units)

The main participants that were contracted for this property development housing project involved:

- Architecture and structural consultant

- Main civil construction contractor

- Civil engineering consultant

- Mechanical and Electrical engineering consultant

- Quantity surveyor

5.5.2 Development of WBS

A successful implementation of an EVM method mainly depends upon a well detailed Work Breakdown Structure (WBS). The project activities of Seri Iskandar housing project can be decomposed into Level 3 WBS format. Appendix 'E' shows a summary of WBS based on the data obtained from the contractor of Seri Iskandar Housing Project. It is comprising of Level 3 hierarchy and describes the overall project scope that is the prime responsibility of civil contractor. This housing project comprises of the following levels;

Level 0: Seri Iskandar Housing Project

Level 1: System Design

Level 2: Construction Works

Level 3: Work Packages

5.5.3 Site Organization Chart

The formation of WBS facilitates the Project Manager to assign the role and responsibilities to its team. As the work package activities are the lowest level of the WBS and so it can be directly assigned to a project team member. Appendix 'F' shows the hierarchical type contractor site organization chart for the Seri Iskandar Housing Project. Since the project is a fixed price contract and the contractor is solely responsible for the practical completion of all the works. Therefore, all provisions regarding standard specification and workmanship were provided in detail within the contract document. Table 5.13 shows the Responsibility Assignment Matrix (RAM) or RACI chart for this housing project.

S. No.	Activities	Team Members																						
		SO/Arch.	Contract PM	Site Supervisor	Surveyor	Mech. Operator	Lorry Driver	Carpenter	Painter	Concretor	G. Worker	Tiler	Plaster	Bricklayer	Roofer	Ceiling	Plumber	Electrical	Firefighter	Equipment Installer	Drainage worker	Sewerage Worker	General Workers for Roads & Carpark, Fencing & Gates
1	Earth Work	I&C	C	A	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R
2	Structural Works	I&C	C	A	R	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-
3	Architect Works	I&C	C	A	R	-	-	-	-	-	-	R	R	R	R	R	-	-	-	-	-	-	-
4	M & E Works	I&C	C	A	R	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-
5	Infrastructure Works	I&C	C	A	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R

5.5.4 Project Schedule

The project schedule for Seri Iskandar Housing Project comprises of work package activities with anticipated start and finish dates. The obtained project data was reproduced by using MS Project scheduling software which can do much of the tedious work of calculating the schedule automatically. Appendix 'G' shows the summary project schedule in Gantt chart format for this case study. It was stated in the contract document that a "Day" is defined as a normal working day from 8.00 a.m. to 5.00 p.m. (with 1 hour break). Also the project schedule is based on 208 working hours/month and 26 working days/month.

5.5.5 Budget Allocation

The Seri Iskandar Housing Project was awarded at a fixed price contract for which the baseline cost is RM 9.437 million. The project cash flow reports were obtained for the period of July 2005 to December 2007 in order to establish a time-phased budget. Figure 5.7 shows non-linear (S-curve) budgeted expenditures over a period

of time. It is also known as the Performance Measurement Baseline (PMB) which is the summation of budgets of work scheduled with in a stated period (Planned Value).
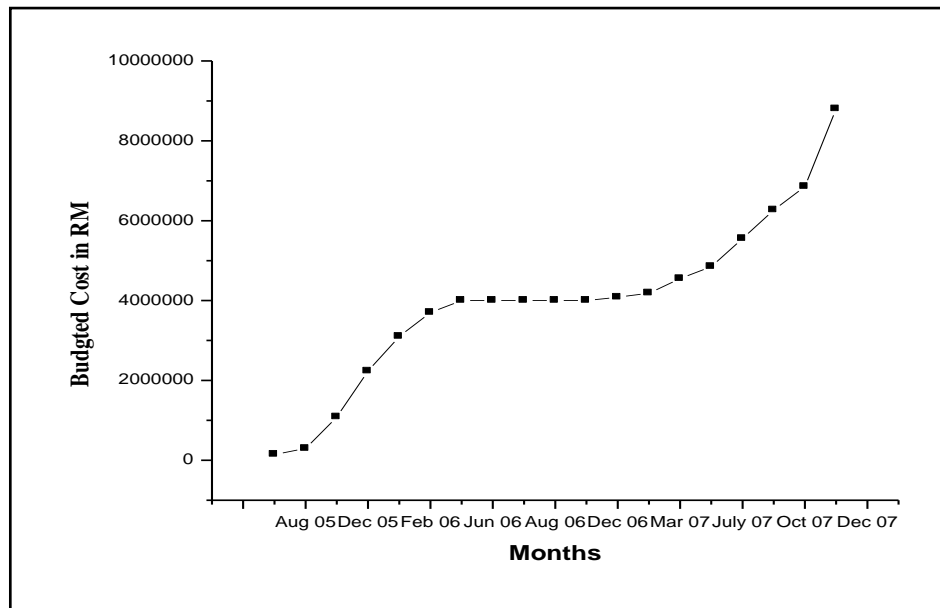

Figure 5.7: Seri Iskandar Housing Project Budgeted Cost Curve.

5.5.6 Selection of Earn Value Technique (EVT)

EVT is a quantification of work performed by the project team. In construction project, most of the physical activities are of tangible in nature and hence can be measured directly. Due to the considerable time duration required for their completion, it is proposed that a combination "Weighted Milestone" and "Percent complete" techniques are appropriate for measuring the earned value of the work package activities. The physical progress report of Seri Iskandar Housing project reveals that progress is being monitored via "Percent Complete" technique only. Although, it is the easiest and simplest way of measuring performance, yet it lacks in objectivity to address the factual progress.

5.5.7 Earn Value Analysis

The project data shows that the actual progress was measured on monthly basis by using percentage complete rule. The Actual Cost comes from the financial documents or contractor claim invoices. Milestones Professional software is used to

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calculate these values for the work packages. Table 5.14 illustrate an Earned Value Analysis of the work package activities. It shows the columns of Planned Value, Actual cost and Earned Value which are calculated for the whole construction period i.e. June 2005 – June 2006. Figure 5.8 shows a graphical analysis of the three variables i.e. PV, AC and EV on a single diagram using cumulative values.

Table 5.14: EVM Performance Review

(Amount in RM)

S.No.	Months	PV	AC	EV	Remarks
1	Jun 05	86,966.61	86,000	68,008.49	PV>AC>EV
2	Jul 05	211,077.98	197,000.00	177,414.00	PV>AC>EV
3	Aug 05	278,571.15	274,363.00	249,692.23	PV>AC>EV
4	Sep 05	408,858.03	374,363.00	346,349.65	PV>AC>EV
5	Oct 05	654,714.68	503,363.00	491,897.13	PV>AC>EV
6	Nov 05	995,537.03	844,363.00	747,079.36	PV>AC>EV
7	Dec 05	1,378,962.26	1,150,363.00	1,107,001.77	PV>AC>EV
8	Jan 06	1,985,909.28	1,788,363.00	1,519,384.92	PV>AC>EV
9	Feb 06	2,545,134.02	2,509,126.00	2,029,391.84	PV>AC>EV
10	Mar 06	3,118,055.00	3,190,879.00	2,695,074.85	AC>PV>EV
11	Apr 06	3,491,669.85	3,655,238.00	3,242,954.76	AC>PV>EV
12	May 06	3,754,085.71	3,975,376.00	3,598,694.00	AC>PV>EV
13	Jun 06	3,872,844.40	4,072,681.00	3,873,527.00	AC>EV>PV
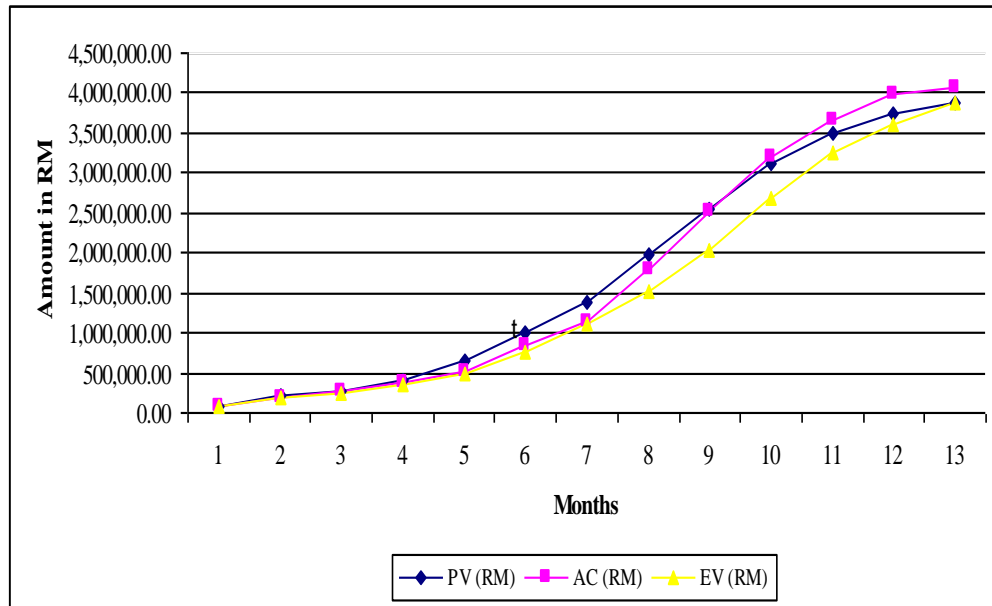
Figure 5.8: Graph of Earned Value Analysis.

5.5.8 Lessons Learned

The three fundamental values of an EVM i.e. PV, AC and EV are calculated in this case study. Figure 5.8 depicts that during the initial 09 months, the PV remained greater than the AC. However, the trend changes in the 10th month when AC started increasing than the PV. The final Cost Account reports show that it was mainly due to the delay of schedule and scope changes during this plan period. The detailed schedule and cost analysis are as follows;

5.5.8.1 Schedule Analysis

Table 5.15 shows the EV schedule analysis for this project.

Table 5.15: EV Schedule Analysis

S.No.	Months	EV Schedule Analysis		
		SV (RM)	*SV%*	*SPI*
1	Jun 05	-18,958.12	-21.79	0.78
2	Jul 05	-33,663.98	-15.94	0.84
3	Aug 05	-28,878.92	-10.36	0.90
4	Sep 05	-62,508.38	-15.28	0.85
5	Oct 05	-162,817.55	-24.86	0.75
6	Nov 05	-248,457.67	-24.95	0.75
7	Dec 05	-271,960.49	-19.72	0.80
8	Jan 06	-466,524.36	-23.49	0.77
9	Feb 06	-515,742.18	-20.26	0.80
10	Mar 06	-422,980.15	-13.56	0.86
11	Apr 06	-248,715.09	-7.12	0.93
12	May 06	-155,391.71	-4.139	0.96
13	Jun 06	682.60	0	1.00

The results deduced from this analysis are as follows;

i. Schedule Variance (SV) remained negative during all the reporting periods, indicating that the project is behind schedule. As per original plan, all the project activities completed by April 2006. However, due to negative SV, the project was finished on June 2006.

ii. SV% indicates the volume of planned work in percentage that remained unfinished for the reporting periods. In Figure 5.9, if SV% is greater than or equal to zero, then the performance of the project is favourable. However, SV% for this project remained in the negative quadrant during the whole construction period. This shows that the performance was unfavourable and affected the timely completion of project.
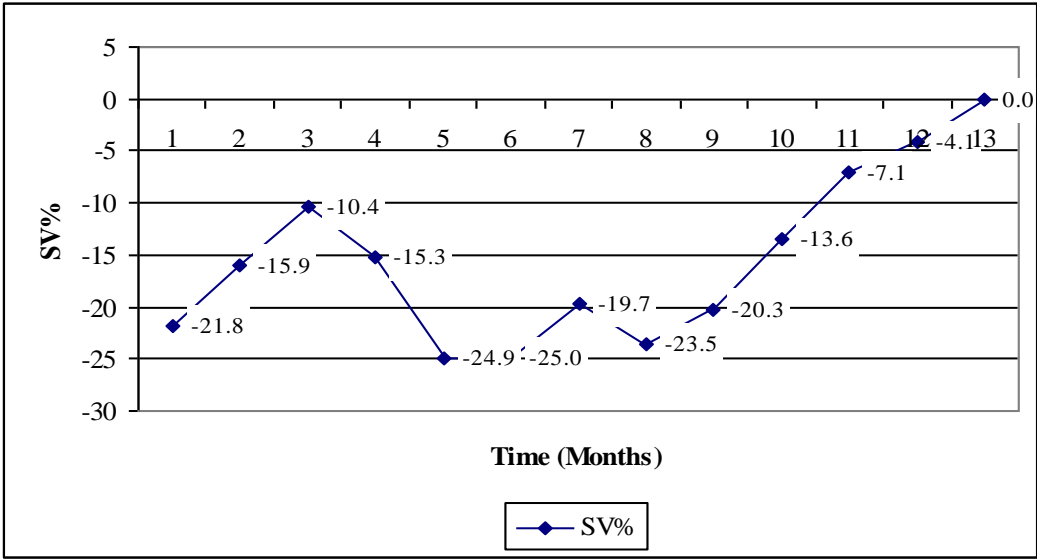
Figure 5.9: Graph of Schedule Variance Percentage.

iii. Figure 5.10 depicts a trend of SPI for the entire project duration which is less than 1.00. Hence, it is concluded that the planned work was performed less efficiently.
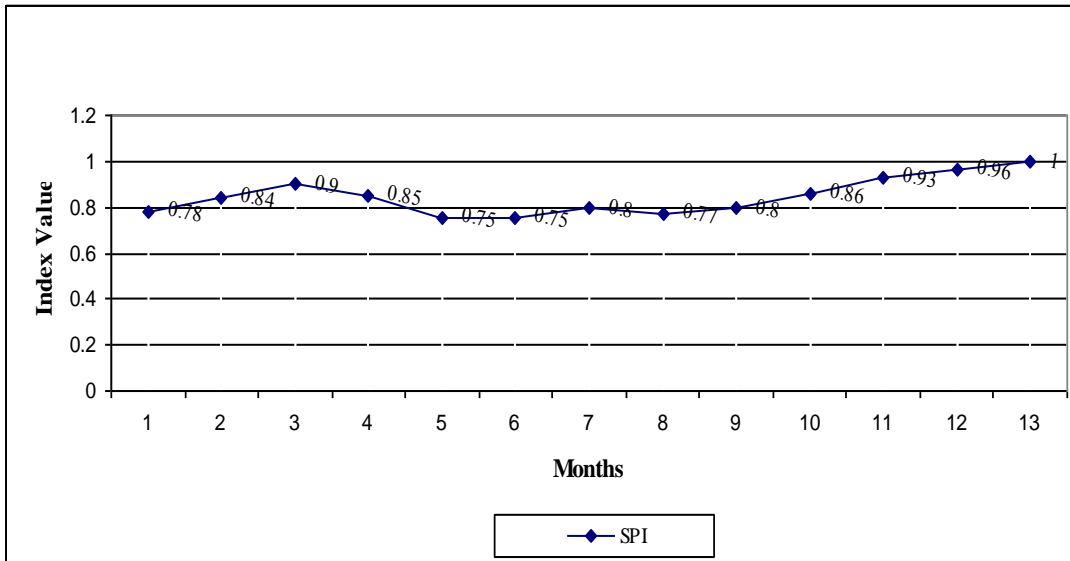
Figure 5.10: Graph of SPI Values.

5.5.8.2 Cost Analysis

EV cost analysis makes it possible to determine the cost-wise condition of the project. Its main intention is to reduce the cost overruns. Table 5.16 shows a month wise EV cost analysis for this project.

Based on the EV cost analysis, the results are summarized as follows;

i. Not a single reporting period achieved a positive value of Cost Variance (i.e. $CV \geq 1.0$) indicating over expenditures for the work performed.

ii. CV% from Table 5.16 indicates the monthly percentage volume of resources that were spent more than the planned amount.

iii. Average Cost Performance Index (CPI) is calculated from the above table which is 0.89. It can also be interpreted in terms of currency i.e. RM. It means that for every 1 RM spending the project achieved a worth of 0.89 RM.

Table 5.16: EV Cost Analysis

S.No.	Months	EV Cost Analysis		
		CV (RM)	*CV%*	*CPI*
1	Jun 05	-17,991.51	-26.45	0.79
2	Jul 05	-19,586.00	-11.04	0.90
3	Aug 05	-24,670.77	-9.88	0.91
4	Sep 05	-28,013.35	-8.09	0.93
5	Oct 05	-11,465.87	-2.33	0.98
6	Nov 05	-97,283.64	-13.02	0.88
7	Dec 05	-43,361.23	-3.92	0.96
8	Jan 06	-268,978.08	-17.70	0.85
9	Feb 06	-479,734.16	-23.64	0.81
10	Mar 06	-495,804.15	-18.40	0.84
11	Apr 06	-412,283.24	-12.71	0.89
12	May 06	-376,682.00	-10.47	0.91
13	Jun 06	-199,154.00	-5.14	0.95

5.6 Case Study 3: Upgradation of Highway

5.6.1 Introduction

This case study demonstrates the Earned Value Analysis for Upgrading of Senai Skudai Road Project. It is one of the infrastructure projects in Iskandar Malaysia under the Ninth Malaysian Plan. It is envisaged that RM 600 million will be spent over the next five years to upgrade existing roads and improve road accessibility to all parts of Johor. This is a government funded project of total cumulative budget RM 61 million and awarded in 2008. The planned completion timeline for this project is March 2011. The scope of work includes up-gradation of existing Senai Skudai Highway.

5.6.2 Project Schedule

Appendix 'H' shows a Gant chart of Senai Skudai upgrading highway project in a summary schedule form. The bars show the activity start and end dates as well as anticipated duration. Bar charts are easy to understand and present an explicit view of the project scheduled. This is an ongoing project and is expected to be completed by the March 2011.

5.6.3 Monthly Cash Flow

Figure 5.11 illustrates monthly cash flows in the form of S-curve. It is established as the summation of sanctioned budgets over the total duration of the project. The graph shows monthly cash flows for a period 01 Nov 2008 to 31 Mar 2011. If a vertical line is dropped from the end point of S-curve, it indicates a total cumulative value of approximately RM 41 million at the end of March 2011.
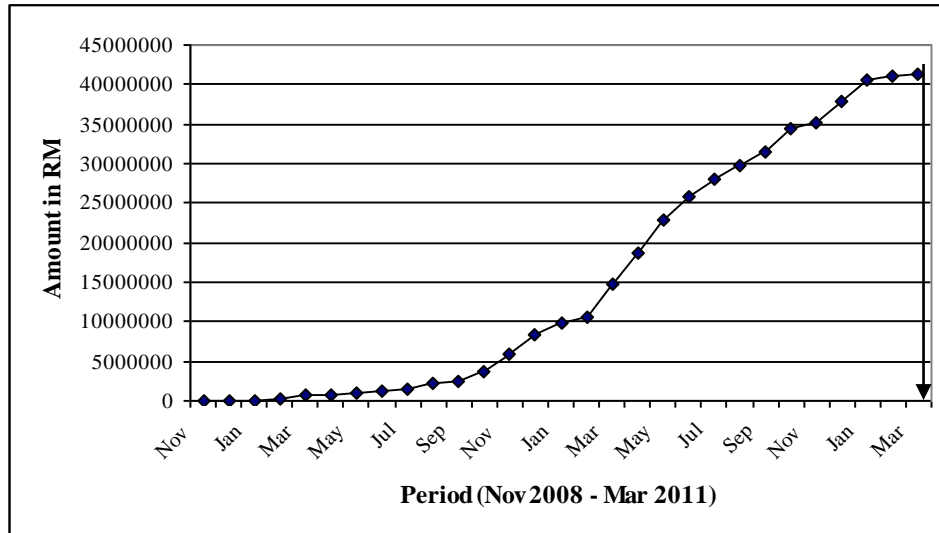
Figure 5.11: S-Curve of Cumulative Monthly Cash Flow.

5.6.4 Earn Value Analysis

Table 5.17 depicts PV, AC and EV which are calculated on quarterly basis. This data is then used for establishing EVA graph as shown in Figure 5.12.

Table 5.17: PV, AC and EV Analysis

(Amount in RM)

S.No.	Months (Quarters)	PV	AC	EV	Remarks
1	Nov 08 – Dec 08	839,184.86	821,000	952,280	EV>PV>AC
2	Jan 09 – Mar 09	6,789,683	6,771,000	7,391,301	EV>PV>AC
3	Apr 09 – Jun 09	14,268,639	13,951,000	14,870,257	EV>PV>AC
4	Jul 09 – Sep 09	21,528,478	19,220,074	22,142,755	EV>PV>AC
5	Oct 09 – Dec 09	29,102,452	27,159,074	29,716,702	EV>PV>AC
6	Jan 10 – Mar 10	37,867,842	34,990,074	38,587,439	EV>PV>AC

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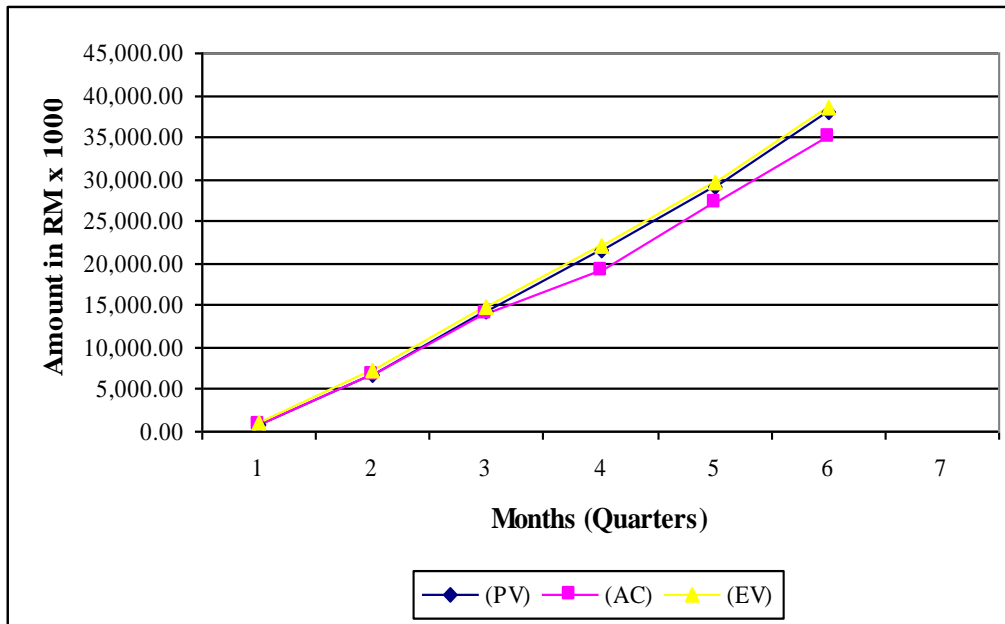
Figure 5.12: EV Graphical Analysis.

5.6.5 Lessons Learned

In comparison to Case Study 1 and 2, the EVA data from the Table 5.17 shows a favourable scenario for this project. During all the reporting periods, the EV has remained higher than the PV indicating the project is progressing well and the work packages are being delivered within the schedule and budget. A schedule and cost analysis can be helpful for understanding the project performance in a quantifiable manner.

5.6.5.1 Schedule Analysis

Table 5.18 shows the EV schedule analysis for this project.

Table 5.18: EV Schedule Analysis

S.No.	Description	EV Schedule Analysis			Percentage of Completed Work
		SV (RM)	SV%	SPI	
1	Nov 08 – Dec 08	113,096.08	13.48	1.13	1.56
2	Jan 09 – Mar 09	601,618.03	8.86	1.09	12.11
3	Apr 09 – Jun 09	601,618.04	4.22	1.04	24.36
4	Jul 09 – Sep 09	614,277.16	2.85	1.03	36.27
5	Oct 09 – Dec 09	614,250.17	2.11	1.02	48.67
6	Jan 10 – Mar 10	719,597.37	1.90	1.02	63.20

Additional investigations can be summarized as follows;

i. The results indicate that the project is ahead of schedule as SV remains positive during the all the reporting periods.

ii. Figure 5.13 shows a linear relationship between SPI and SV%. It provides a useful correlation between project team efficiency with respect to the amount of planned work that has been accomplished. From the graph, the SPI maximum value is 1.13 (which is > 1.00) and its corresponding SV% is +13.48%. It shows that during the reporting period i.e. Nov 2008 – Dec 2008, the project team has utilized its maximum time and performed more efficiently in order to achieve 13.48% additional amount of planned work. Afterwards, this positive trend declined and reached at a minimum value of SPI (1.02) and SV% (1.90%) at the end of March 2010.
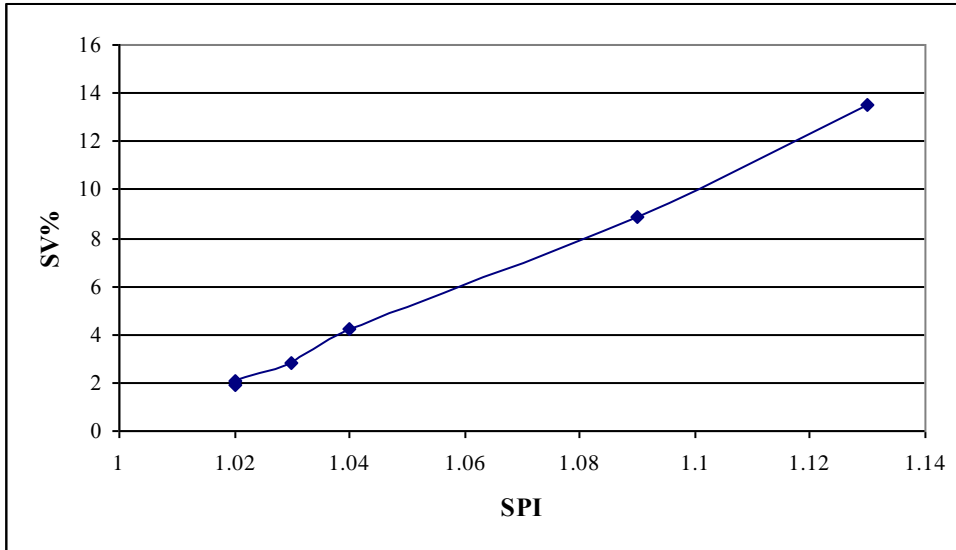
Figure 5.13: Relationship between SPI & SV%.

5.6.5.2 Schedule Forecasting

This is an ongoing project and planned to be completed by March 2011. Its original estimated duration was 28.6 months. Time Estimate at Completion (EAC_t) makes it possible to forecast an estimated finishing duration at the end each reporting period. The calculation of the projected end dates uses the SPI values and the average PV per unit time. All the EAC_t values are plotted against their corresponding reporting period. Figure 5.14 shows the forecast of the final completion duration in months made during this project.
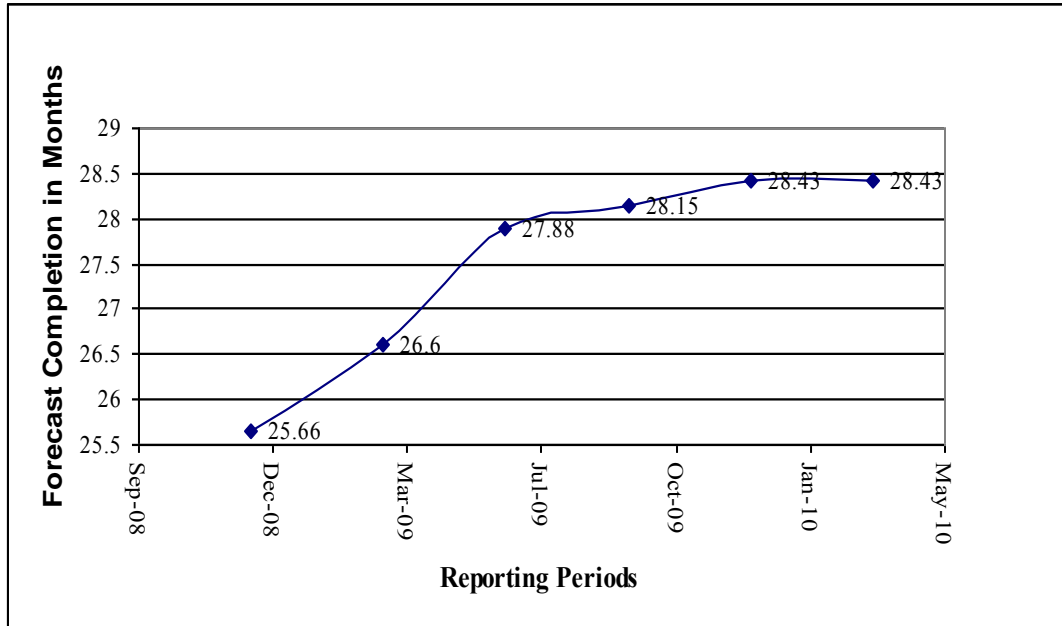
Figure 5.14: Forecast Completion Duration in Months.

5.6.5.3 Cost Analysis

The success of a construction project depends upon the ability of a project team to control the causes of cost over-runs which threatens its completion with in the approved budgets. This aim can be achieved by a periodical EV Cost Analysis. Table 5.19 shows the variances and performance indices relating to cost for this project.

The results of the Table 5.19 can be summarized as follows;

i.   This project has positive value of CV as the Earned Value is greater than the Actual Cost expenditures. Hence, the project progress is favourable in terms of cost-wise.

ii.   Figure 5.15 depicts a trend of CV% for the entire reporting period. It indicates that the project is 9.32% under budget at the end of 6th reporting period i.e. March 2010.

Table 5.19: EV Cost Analysis

S.No.	Months	EV Cost Analysis		
		CV (RM)	CV%	CPI
1	Nov 08 – Dec 08	131,280.94	13.79	1.16
2	Jan 09 – Mar 09	620,301.40	8.39	1.09
3	Apr 09 – Jun 09	919,257.98	6.18	1.07
4	Jul 09 – Sep 09	2,922,681.36	13.20	1.15
5	Oct 09 – Dec 09	2,557,628.79	8.61	1.09
6	Jan 10 – Mar 10	3,597,365.88	9.32	1.1
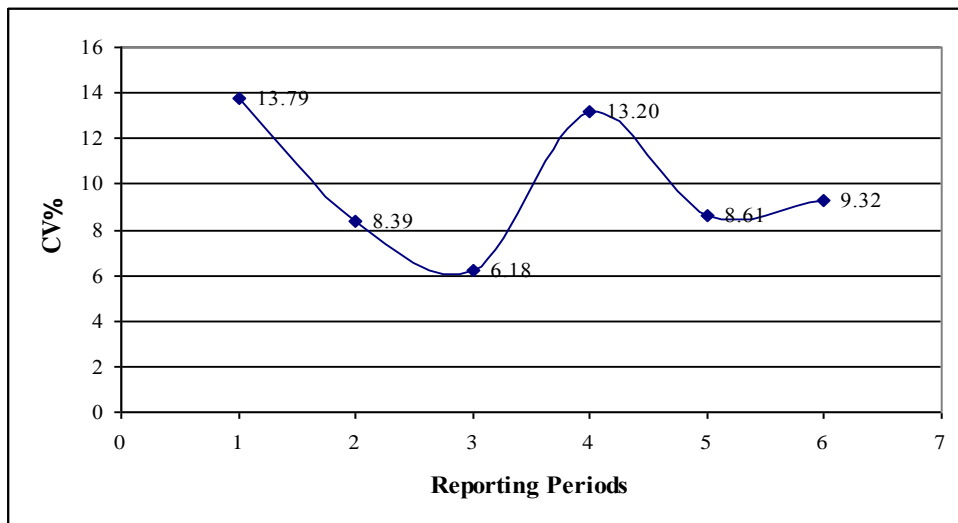
Figure 5.15: Graph of CV%.

iii.   Figure 5.16 shows a graph of CPI. As the values are greater than 1.00 which indicates that value of the work that has been accomplished is higher than the amount of money spent. Hence, the efficiency of utilizing project resources is favourable.
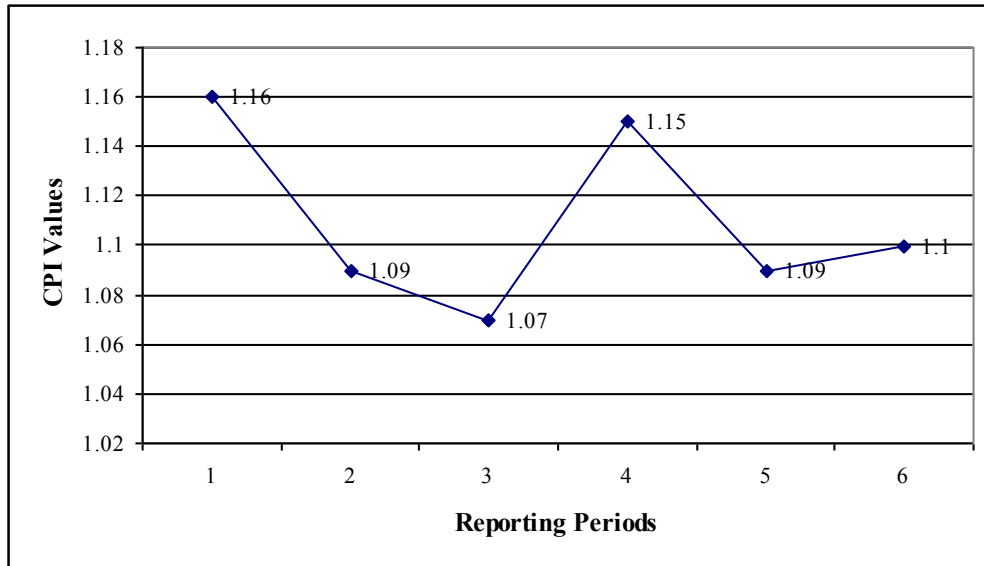
Figure 5.16: CPI Graphical Analysis.

5.6.5.4 Cost Forecasting

In order to forecast the future performance trends, cost forecasting is being made by calculating the following performance measures;

i)   Estimate at Completion (EAC)

Figure 5.17 shows the quarterly estimates of the future project cost i.e. Estimate at Completion (EAC). The reporting data is plotted by dividing total cumulative budget of the project with its corresponding performance index value (i.e. CPI) for each quarter. From the EAC graphical curve, it is clear that efficiency of project team resource use mainly affect the final estimated cost of the project. For example, at the end of quarter 3, the CPI is 1.07 and its corresponding EAC is about at RM 57 million. However, the EAC remain at the minimum during 1st and 4th quarters when the CPI values are 1.16 and 1.15 respectively.
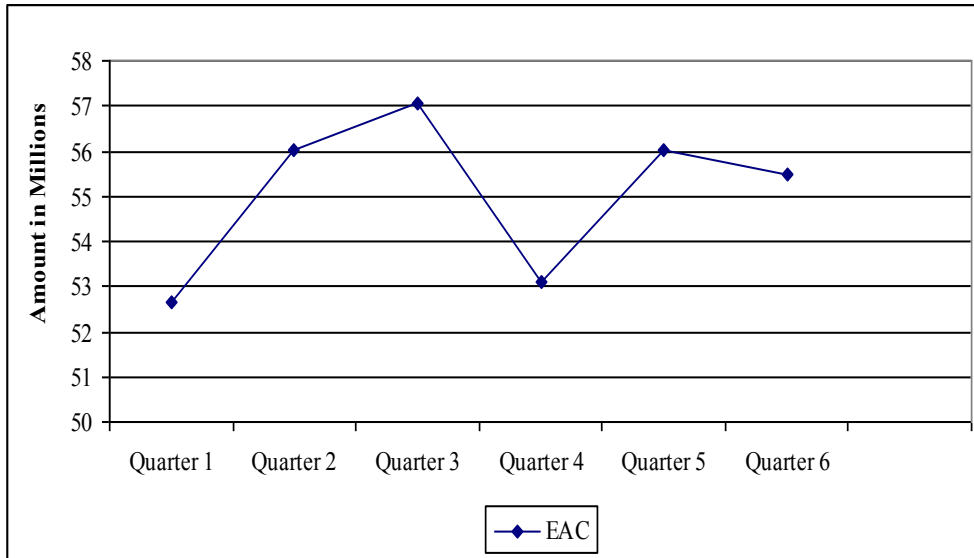
Figure 5.17: Trend of EAC.

ii) Variance at Completion (VAC)

The efficiency of resource utilization (CPI) directly effects the Variance at Completion (VAC). The higher the value of CPI the more will be the VAC and vice versa is the case for lower CPI values. Figure 5.18 shows a relationship between CPI and CV% which were calculated for the different reporting periods. Here, a positive trend of VAC% depicts that with the current performance indicators the project will finish under budget.
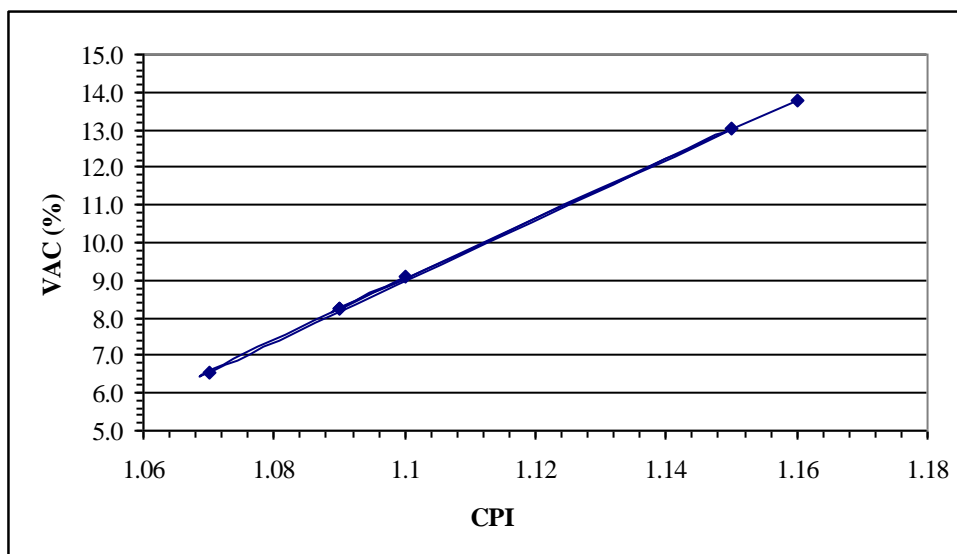

Figure 5.18: Relationship between VAC% and CPI.

iii) Estimate to Complete

The remaining cost of the project is determined by Estimate to Complete (ETC) factor. It is calculated by using Equation 2.10. Figure 5.19 shows the decreasing trend of ETC. For calculating the value of ETC in this graph, the efficiency of resource utilization by the project team i.e. CPI for the first six quarter is taken in to consideration.
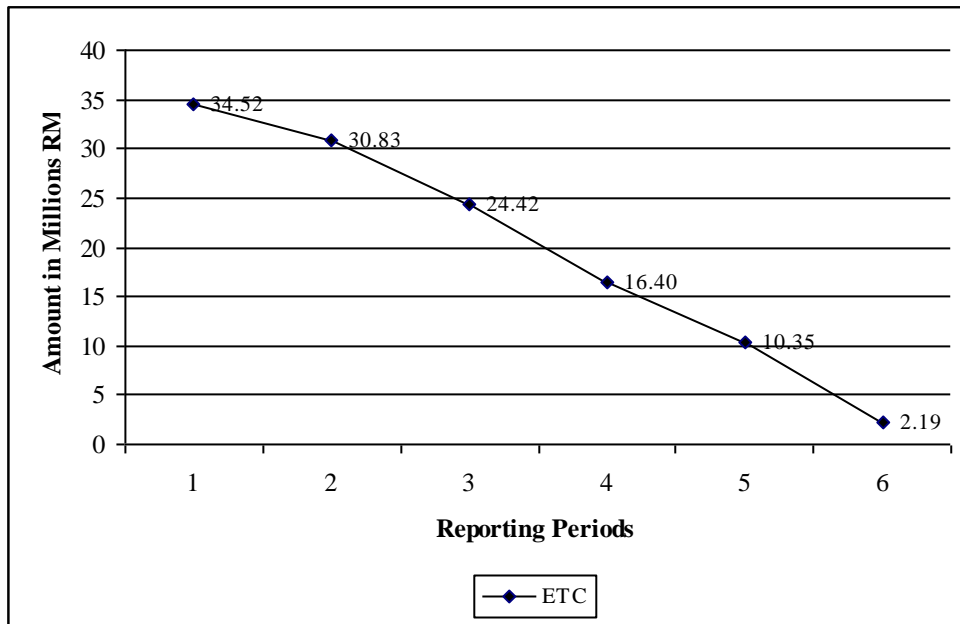

Figure 5.19: Trend of ETC.

5.7 Case Study 4: Building Project

5.7.1 Introduction

This case study describes the usage of Earned Value Analysis from the client's perspective. For a fixed price contract, the client is also willing to monitor the project progress. The case study undertaken is a design and build project for the construction of UiTM campus at Tapah, Perak. It was awarded on 2008 with a contact amount of RM 47,300,000.00/-. The planned completion date is 22 August 2010. As, it is a Government funded project, therefore, Jabatan Kerja Raya (JKR) Negeri Perak is responsible for monitoring the project progress against the planned schedule and budget and approve the interim payments to the contractor. The JKR received monthly progress reports from the consultant and seeks explanation for any expenditure that falls behind or ahead of schedule. Appendix 'I' shows a physical progress curves for the entire construction period. Its shows the following curves;

1. Initial Baseline

2. Revised Baseline

3. Actual Progress

   The data is taken from the 17th progress report for the period ended on 28th Feb 2010. The graph shows that the project is 71% complete with respect to its planned schedule completion which must be 75% during this period. So, it is behind 4%. Appendix 'J' shows the schedule of progress payments and the corresponding financial curves. It shows that 56% of the contract amount i.e. RM 26,392.300.00/- is certified as an interim payment to the contractor compared with the planned amount which is RM 30,493,653.63/-. Hence, the financial achievement is behind 8% than its budgeted value.

   The performance analysis is based on the Consultant progress report comprises of planned and actual values in terms of cost and schedule. With this approach there in no way to determine the physical amount of work performed in each reporting period. It does not indicate any information about what has actually been delivered

on site for the amount of interim payment released to the contractor. Furthermore, it does not provide any information regarding future performance trends.

Based on these limitations, the following section applies the fundamental concepts of EVA on the secondary data which is derived from the JKR project progress reports. EVA provides a three dimensional approach and is able to compare the budgeted value of work scheduled (PV) with the Earned Value (EV) of physical work completed and the Actual Value (AV) of work completed. This will provide a more in-depth view about the project current progress and future trends.

5.7.2 Earn Value Analysis (EVA)

Table 5.20 shows the monthly budgeted values as PV, AC as certified interim payments to contractor and the Earned Value (EV) which is the budgeted amount of work performed. In a fixed price contract, the client does not see the actual cost (AC) of work performed. AC incurred on completing the project activities is only available to the contractor. However, the client is liable to pay the interim payments to the contractor which is considered as the AC of completed work. It is important to note that in fixed price contract arrangement, the budgeted cost of work performed i.e. EV must be equal or greater than AC (interim payments) so that the payments are made to the contractor not on the basis of cost incurred, but rather on the completion of authorized work.

Figure 5.20 depicts a graphical view of EVA. It shows that till Jun 2009, the project is progressing less than planned as EV < PV. However, there is an increasing trend in progress during the period Jul 2009 – Jan 2010, as EV > PV. The value of EV is consistently greater than the AC since March 2009 which indicates that the contactor is under claiming its interim payments.

Table 5.20: PV, AC and EV Values

(Amount in RM)

| S.No.	Description	Budgeted Monthly Progress (PV)	Certified Interim Amount (AC)	Budget At Completion x Actual Progress (EV)
1	Aug 08	473,000	0	0
2	Sep 08	1,892,000	0	0
3	Oct 08	3,784,000	0	0
4	Nov 08	5,203,000	0	1,419,000
5	Dec 2008	6,622,000	3,576,500.00	3,311,000
6	Jan 09	8,041,000	4,641,200.00	4,257,000
7	Feb 09	9,460,000	5,530,300.00	5,676,000
8	Mar 09	10,879,000	6,498,200.00	7,568,000
9	Apr 09	12,289,000	9,029,700.00	9,933,000
10	May 09	13,717,000	11,707,900.00	11,825,000
11	Jun 09	15,136,000	13,824,700.00	14,190,000
12	Jul 09	17,028,000	15,833,700.00	17,974,000
13	Aug 09	18,920,000	16,498,900.00	20,339,000
14	Sep 09	21,285,000	17,159,800.00	22,704,000
15	Oct 09	24,596,000	19,843,200.00	25,542,000
16	Nov 09	26,961,000	21,696,900.00	27,434,000
17	Dec 09	30,272,000	23,644,900.00	30,272,000
18	Jan 10	33,110,000	24,869,700.00	33,110,000
19	Feb 10	35,475,000	26,392,300.00	33,583,000
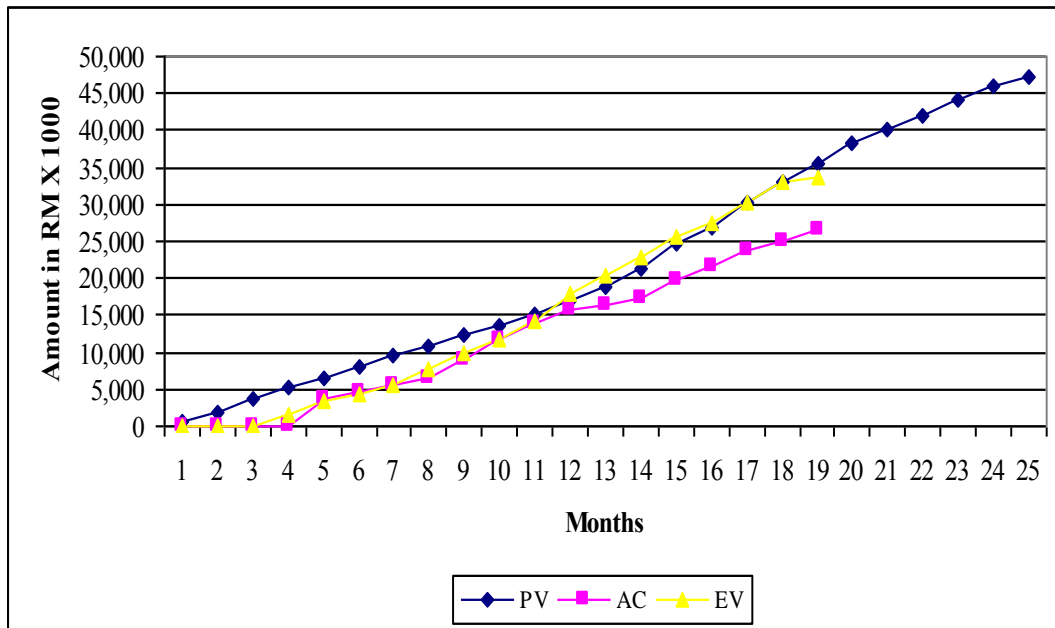
Figure 5.20: Cumulative PV, EV and AC (As of Feb 2010).

5.7.3 Lessons Learned

This case study implies the client's or buyer's perspective for evaluating the progress of their contractor by using EVM. In a fixed price contract, the client is protected from the risk of cost increase, unless the scope of the work does not change. However, EVM can benefit the client in many ways in order to complete the project from its designated contactor with in time and on approved budget. The EV schedule and cost analysis assist in measuring the current and forecast the future performance trends. As such analysis helps out the clients to monitor the physical progress with a broader vision and as well as make their project investment planning in an updated manner.

5.7.3.1   Schedule Analysis

Figure 5.21 shows a trend of SV%. It depicts that till Jun 2009, the project progress is unfavourable form client's perspective. The project is consistently falling behind the schedule. It also appears from the graph that the percentage of monthly unaccomplished work is also decreasing from 73% to 6% during this period.

However, the trend gets improved in terms of positive SV% from Jul 2009 to Jan 2010, which indicates that progress is favourable.
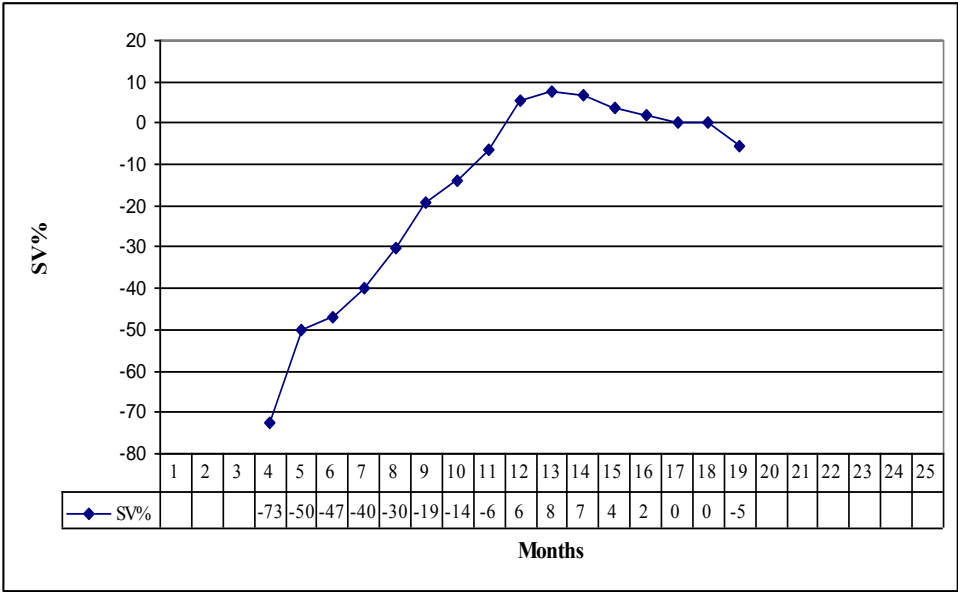

Figure 5.21: Graph of SV%.

The contractor time efficiency graph is determined by calculating SPI for the entire construction period. It is plotted in Figure 5.22. It shows that planned work is accomplished between an efficiency range of 0.27 – 1.08.
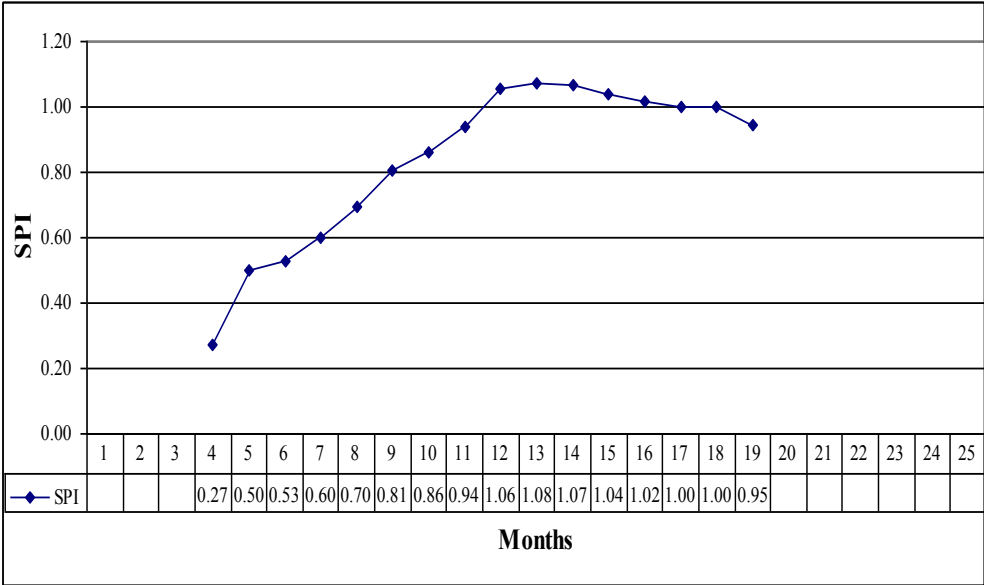

Figure 5.22: Graph of SPI.

5.7.3.2 Schedule Forecasting

Figure 5.23 shows a complete trend of forecasted end completion duration in months. It is important to note that original completion time is 24 months. The contractor progress was favourable during Jul 2009 to Oct 2009 due to the positive SPI value. During this period, the anticipated project completion time remained less than 24 months.
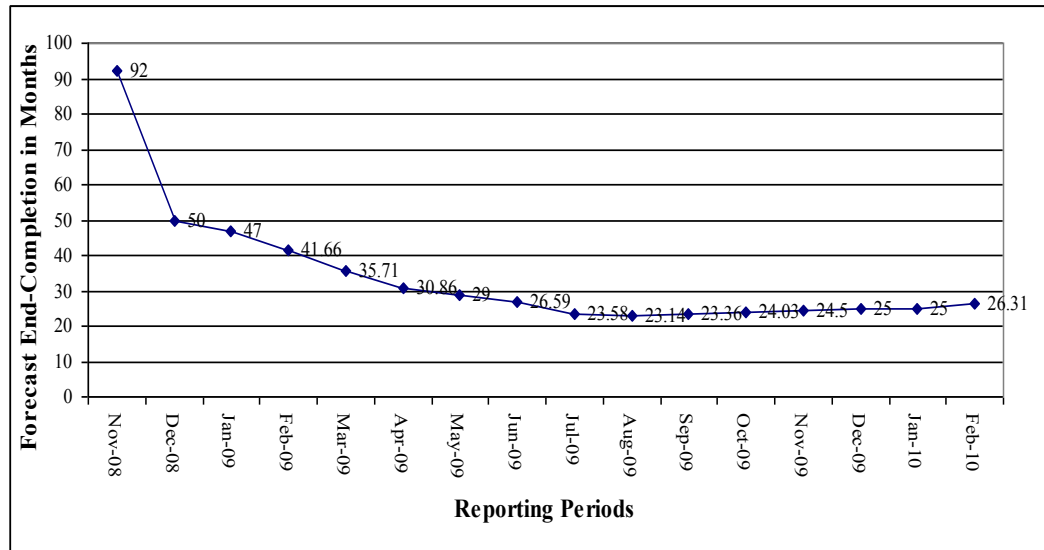

Figure 5.23: Forecast End-Completion Duration at Different Reporting Periods.

5.7.3.3 Cost Analysis

In a fixed price contract, there is no risk of cost growth at the client's side. This will only be the case, if the contract scope of work remains unchanged. The client is only responsible to pay interim amounts of payments to the contractor as progress payments. Therefore, it is not in the interest of client to pay more to the contractor against the actual completed work on site. Thus for a client, the EV cost efficiency i.e. CPI is determined by dividing the budgeted cost of work performed to actual cost incurred in terms certified interim payments.

Figure 5.24 shows a trend of CPI during the entire project progress. It is notable that during the 5th and 6th reporting periods CPI is lower than 1.0. This creates an unfavourable scenario from the client's perspective in which extra payments are

certified to the contractor as compared to the actual worth of work completed on site. However, this trend get improve in the later months as the value of CPI becomes higher than 1.0. In fixed price contract, there is no need of cost forecasting because the client is only going to pay the contract sum to the contractor.
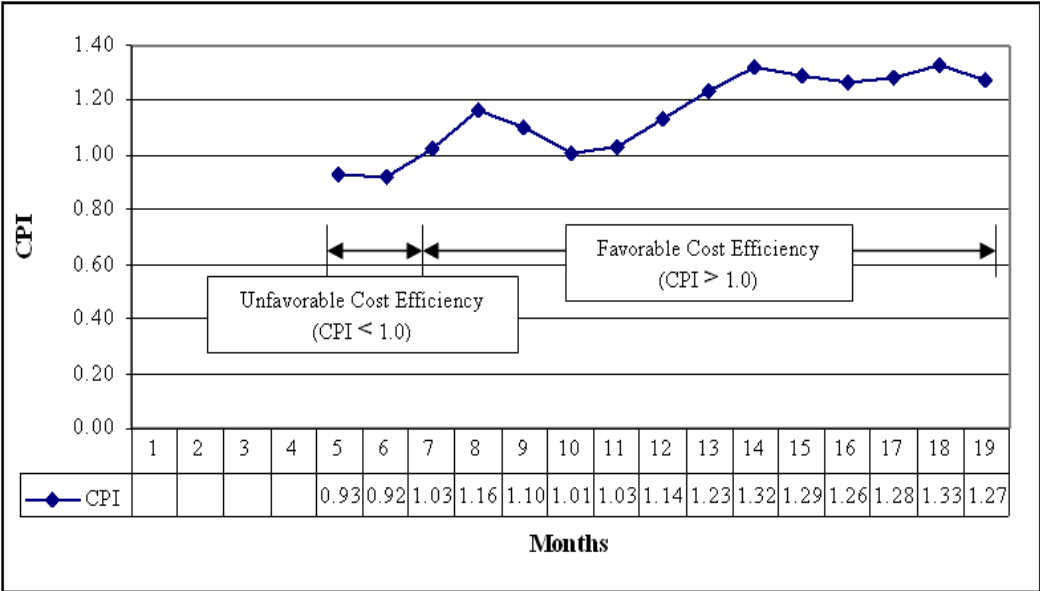

Figure 5.24: Graph of CPI.

5.8 Outline of Case Studies Research Findings

The EVM Framework as described in Chapter 3 was successfully tested on the all the four case studies. The calculation of performance indices and variances from these case studies make it possible to examine the current, and forecast the future time and cost performances in a variety of ways. Table 5.21 shows the summary of theses interpretations with respect to each case study. This project status is summarized by taking into consideration the average values from all the reporting period of respective case studies.

Case 1 represents an ongoing project. Its average SV% has remained -7.2% during all the reporting period which indicates that the project progress is behind schedule. In other words, on average 7.2% of the planned work was not

accomplished during every reporting period. Also the efficiency indicator SPI remained at 0.92, indicating fairly low efficiency of the project team. Similarly, the cost wise performance (CPI) of this project is not encouraging which anticipate that the project may suffer cost overruns. Case 2 was a completed housing project. Its SV% and CV% remained negative throughout the project duration. As a result, it was delivered behind schedule and over budget. The EV performance indicators of Case 3 represent a favourable scenario for this highway upgradation project. It has been observed that during all the reporting periods, the project team of Case 3 has efficiently utilized the time and resources. It is anticipated that if this positive trend persists, the project will be completed ahead schedule and under budget. Case 4 represents an EVA from a client's perspective. The SV% has remained on an average value -19.9%, indicating inefficiency in time utilization by the contractor. However, CV% remained positive with CPI value 1.08 indicating that less payments are certified to the contractor with respect to the actual worth of completed at the site.

Table 5.21: Summary of Case Studies EVA

Case Study	Schedule Variance %	Cost Variance %	Schedule Performance Index	Cost Performance Index	Variance at Completion	Project Status
	(SV%)	(CV%)	(SPI)	(CPI)	(VAC$_c$)	
1.	-7.2	-3.2	0.92	0.96	(-) ve	*In progress* Behind Schedule Over Budget
2.	-15.4	-12.5	0.84	0.89	(-) ve	*Completed* Behind Schedule Over Budget
3.	+5.57	+9.91	1.05	1.1	(+) ve	*In progress* Ahead of Schedule Under Budget
4.	-19.9	+17.4	0.83	1.08	Nil	*In progress* Behind Schedule Under Budget

5.9 Discussion: Semi Structured Interviews

This section includes discussions which are based on two semi-structured interviews. The aim of these interviews was to examine the views and perceptions of experts about the use of standardised project monitoring methods in Malaysian construction industry. Furthermore, the interviews have also surveyed the advantages and applicability of EVM method in local construction industry. The interviews were conducted with En. Mohd Salehudin, Senior Official (Jabatan Kerja Raya, Perak) and Sr. Wan Mohd Kamarulhisham, Project Manager (Malaysian Resource Corporation Berhad). The interviews took place at the main building of JKR Perak, Ipoh and the site office of MRCB Seri Iskandar respectively. The researcher discussion and the experts views are included in the next section.

5.9.1 Importance of Standardised Project Control Methods

Researcher: In construction project management, the goal is to complete the job with in the approved time, cost and adequate quality. However, time and cost overruns are the important factors that identify the success or failure of a project. In September 2009, Ministry of Finance Malaysia issued a circular and classified the definition of a "sick" project. According to this circulation letter, a project is classified as "sick" when its actual progress is 20% or two months behind the planned progress. In this context, please provide your opinion and comments whether the implementation of standardised project control methods could help the construction industry to ensure the timely completion of projects?

En. Mohd Salehudin: In my opinion, a standardised project control method would help by:

       a) Providing a familiar format that may be applied across the board.

b) Providing a uniform method of measuring project performance which helps to compare with other projects more fairly.

c) Supporting contractors (especially those just starting-up) to pick up on proven project control methods that can be used for their projects.

As far as JKR is concerned, project control is achieved by monitoring the financial performance of the contracts. This is achieved by using the SKALA which is the project monitoring system adopted throughout the country. With this system, the performances of the projects are measured by payment made versus planned progress claims. This method has its own limitations whereby it does not really relate directly to the physical progress of the works. In conclusion, having a standardised project monitoring system would help in ensuring the timely completion of projects but it is not the sole solution for competing projects on approved schedule.

Sr. Wan Mohd: The current practice of project monitoring is based on comparison between actual and planned progress accomplishments. In my experience, the time variance is measured based on the difference between duration percent complete of project activities with their planned targets. Similar is the case for cost monitoring and its variance calculations. Contractors have to submit the progress reports to their clients on monthly/weekly/daily basis. So, if there is a delay then the client asked contractor to mitigate this and issue a reminder. From contractor's point of view, it is very much important that how they are handling the things and control their scheduled objectives. Because it gives them benefits directly that how well they plan their work and it comes directly to their cost economization. In view of the Ministry of

Finance circular for classifying 'sick' projects, it is mainly the concern for government sponsored projects rather than privately funded. However, a derailed project is always a matter of concern for all the parties across the board. Also as an optimist, I believe that a standardised and systematic project management practices certainly control the baseline skewness by making possible recovery during the early stages of project life cycle.

5.9.2 Earned Value Management Method in Malaysian Construction Industry

Researcher: Refer to the last part of Question No. 1. In many develop countries, Earned Value Management (EVM) method is to be considered as an effective and standardized methodology for time and cost monitoring in construction projects. It is widely been adopted due to its quantitative measure for integrating time and cost information. Based upon your good experience, what are your perceptions about a wider practice of EVM system on construction projects in Malaysia?

En. Mohd Salehudin: Earned Value Management (EVM) method is still not fully understood by many personnel involved in the construction industry. It is not widely utilised especially for projects in JKR, thus there is still a long way to go to have it understood throughout the organizations. In my perception, to have an idea of using EVM on a wider scale, it needs to show the benefits that can be derived by this method. If benefits are in direct relation to the successful completion of the project then it may be received by the industry players. From my point of view, still there are other fundamental issues that may influence the success of the projects in Malaysia.

Sr. Wan Mohd: Well, it's good and I agree on practicing EVM because it gives benefits to all parties. But the current level of skills and

understanding of EVM among the professionals, which I thought is still inadequate which is the main obstacle for its implementation. Although, I have an understanding of EVM but still it is not being implemented in our organization's projects. The underlying reasons may be the organization culture or lack of support from the management to explore the new fashions of performance management. However, the use of EVM in project control can be promoted if the government departments like JKR and CIDB support its practicing and give their mandate to contractors for utilizing this technique as a time and cost management tool.

Researcher: EVM is a three dimensional approach that is based on Planned Value (PV), Actual Cost (AC) and Earned Value (EV). On the other hand, the traditional approach i.e. project monitoring without EVM include PV and AC only, which neither take into consideration the amount of work actually achieved as defined by Earned Value metrics. Furnish your views about the significant advantages that can be achieved by adopting EVM method in your current project tracking practices?

En. Mohd Salehudin: I am currently tracking the progress of my projects by using:

a) SPK-SKALA system that is used by JKR Malaysia.

b) By having a weekly / bi – weekly progress tracking of work programme using Microsoft Office Project.

We are comparing the actual progress against the scheduled progress at the preset evaluation dates. Based on this, the variance on the project finish date is also observed. Projects within JKR use the financial S-curves and the physical S-curves to monitor the progress of their works. Once these

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S-curves are established, it is just a matter of plotting in the actual financial and physical performances into the graphs. So far, we have not really used the EVM method as it involves getting a lot more data which is not readily available to us. The contractors are the ones who have the relevant data. However, contractors involved with JKR projects have not really advanced to this level of analysis.

Sr. Wan Mohd: In my opinion, if EVM is taken in to consideration from the initial planning stages and implemented properly, then it will support the performance assessment procedures. Furthermore, it could contribute its effectiveness during the cost budgeting phase when funds are being locked for construction works.

Researcher: One of the important aspects of EVM methodology is its forecasting ability for future project scenarios. EVM forecasting indicators make it possible for the project managers to make an objective visibility of project future health by indicating alerts for time and cost overruns. Do you think that this approach will contribute to an effective and efficient progress monitoring system by providing 'early warning indicators' that the project is deviating from the approved baselines?

En. Mohd Salehudin: EVM forecasting can generate clear early warning indicators that identify its usefulness in project monitoring. But it needs to be careful that which parameters are used in the forecasting and whether the information derived are reliable. In my personal experience, most of the contracts being carried out by contractors in JKR projects, the main contractors are not really in full control of their projects in terms of scheduling as well as cost/budget control. Therefore, I am certain that if the EVM data are reliable and its interpretation is clear and easy, then

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this method may provide useful early warning indicators as required during project monitoring and control.

Sr. Wan Mohd: Yes, because once we finished the budgeting, it is possible to make predictions about the future based on the previous history. The limitation of conventional style is that it guesses in a subjective manner. Whereas, EVM can speculate the future trends by using Earned Value metrics. It can provide early warnings and has good impact on monitoring and triggers something to users for next step. For a contractor, it may work as an indicative tool for detailed assessment.

5.9.3 Motivating Aspects of EVM Framework and Case Studies

Researcher: A basic framework for the implementation of EVM System was developed in this research. It was derived by understanding the theory of EVM process and by reviewing the International EVM Standards. Give your opinions and views about this framework?

En. Mohd Salehudin: The EVM framework as stipulated is consistent with the processes of project management. It definitely helps the professionals to summarise the processes in a structured way without digesting the whole PMBOK or any other guiding manual. But still then, a project practitioner must possess a basic knowledge and understanding of project management and Earned Value Analysis to better understand the outputs derived from the analysis of framework.

Sr. Wan Mohd: The framework illustrates a theoretical approach that defines some procedural steps required for EVM implementation. It gives a basic idea about Earned Value calculations and analysis. In general, it's good as it guides that how to move forward with this approach. But level of knowledge and

understanding of an individual is the real issue. However, this can be overcome by more efforts and motivation towards learning of good project management practices.

Researcher: As a qualitative part of this research, descriptive case studies were also developed in order to demonstrate the practical usage of Earned Value Analysis (EVA) in construction projects. In your opinion, what are the motivating aspects of these case studies that encourage the clients and the contractors to implement EVM system as an appropriate technique to monitor time and cost?

En. Mohd Salehudin: These case studies can be viewed as simple and useful examples of EVM applications as it is more widely accepted by the bigger class contractors. We at JKR are still struggling to educate the smaller and medium contractors to monitor their projects with the proper management tools. In most cases, we have observed that this is just left to the fancy of the sub-contractors. However, for a more advance EVM applications in local construction industry, I feel that there are still more efforts and initiatives require in the future.

Sr. Wan Mohd: I have gone through the case studies especially relating to MRCB Seri Iskandar Housing Project. This case study has analysed the scenario in detail and presents a comprehensive assessment of project health. Although, the project was completed in the past but its Earned Value Analysis through this study is quite practical. In my view, if you have information and you are unable to investigate it through appropriate tools, you simply waste your efforts and it is worthless. Now I may conclude that practicing EVM in construction field is good. In fact whoever used it, will be successful criteria for a client, project manager or developers.

5.10 Summary

The summary of overall findings which is based on the results of survey, case study analysis and semi-structured interviews can be reviewed in the following paragraphs;

The questionnaire survey succeeded in gathering the current level of EVM understanding and usage in the Malaysian construction industry. The analysis confirmed that EVM method is not a very common approach for time and cost performance monitoring. It was found out that 80% of the respondents from public and private sector do not use EVM method at all. The data analysis further clarifies that the respondents has ranked seven reasons which are considered as important barriers for the limited application of EVM method in the industry. The current research introduces "Lack of EVM knowledge, expertise and experience" as the high level difficulty among the participants. Beside this, "Too many rules and requirements to learn and implement" and "High cost and time commitments" are respectively prioritized as 2nd and 3rd important barriers. It is also encouraging to note that 60% of the respondents from the private sector are intended to implement EVM System in their organizations within the next five years. This positive inclination of respondents towards acceptance of EVM method is mainly due to the potential benefits and advantages of EVM method. Among the highest advantages ranked by the respondents are EVM capabilities to ensure scheduled objectives, its early warning indication of performance problems and objective performance reporting among all stakeholders.

The results of the survey confirmed that lack of EVM knowledge; expertise and experience were the main problems towards implementation of EVM method. Therefore, in order to overcome this barrier, the knowledge and application of EVM Framework (Chapter 3) was extended through the multiple case studies. The Earned Value Analysis of these case studies provides a clear insight in to the project progress. It facilitates to carry out more in-depth assessment of project status and predicts future performance trends as well. The calculation and interpretation of performance indices and variances from these case studies make it possible to examine the current and future time and cost performances in effective ways.

Lastly, the discussions from En. Mohd Salehudin and Sr. Wan Mohd reveal the significance advantages that can be achieved through the adoption of standardised project control techniques in Malaysia. Both the interviewees expressed their views about the limitations of traditional project monitoring approach. As it offers generally a smaller degree of objective visibility in to the current and future projects scenarios. By analyzing their responses, it is recognized that the use of EVM method is not very much common in Malaysian construction industry. This is mainly due to its low level of acceptance and its understanding among the contractors, subcontractors and also in government departments. As En. Mohd Salehudin expressed that for wider EVM practices, there is a need to give some inspirations to construction industry practitioner about its atypical advantages over the traditional technique. According to Sr. Wan Mohd, EVM application can also be promoted if JKR and CIDB encourage and facilitate the industry practitioners to apply it for an effective project management. The discussions also found out that sound knowledge of project management is a prerequisite for understanding the basic principles and process of EVM. The interviewees have also expressed their additional opinions that although the proposed EVM Framework and associated case studies describe and exemplify its applications. But, still more efforts and practical initiatives are required over the period of time in order to improve the level of understanding. There are also much similar agreements between the two experts that if EVM as a standardised methodology is adopted and precisely applied, then this will positively formulate a true evaluation of project status through the objective performance reports.