



A Study of the Function of the Projects with the Use of Earned Value in Mahshahr's Petrochemical Projects

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ABSTRACT

The study at hand was conducted with the aim of using the system of earned value management in the petrochemical projects of Mahshahr. In terms of its objective, the project is performance-oriented and practical, and in terms of its method, it was a descriptive-survey research. The statistical society of the present research consists of the main employer, and minor contractors, experts and professional specialists in the petrochemical projects of Mahshahr at the number of 100 individuals and consensus-counting was used while the sample volume was equal to the entire research's target society amounting to 100 among whom the questionnaire was distributed. The collected data was put to analysis by the use of descriptive statistics (average, standard deviation and the etc.) and the deductive statistics. With the results attained from the variables of the earned value management system, it became clear how one can exploit this new system as a viable tool in the assessment of the performance of the projects and specially construction projects. In addition, with the reconnaissance of the effective dimensions in such indexes as time and costs, and their relation with the project's performance, we managed to come to a proper assessment of the performance of the project. What was brought into resolution through this research was the necessity of the application of this system in projects' management with the aim of gaining the maximum amount of performance in time and cost dimensions. What became established in this research was the necessity of applying and putting to use the system of the earned value management in all stages of the work and, especially, such an application was conclusively demonstrated in the petrochemical projects of Mahshahr.

Keywords: earned value management, cost, time, project control, Mahshahr's petrochemical projects

1. Introduction

With the aim of planning and a more effective control over the projects, applying the indexes suggested in EV method, by the side of the traditional indexes (like the project's physical fulfillment percentage, the percentage of budget absorption and the like) can be rendered highly effective. In a project-based organization, such indexes can be turned into consistent outputs of the planning system and control of the organization's projects and thus create viable feedback for the other parts. Budget and time related processes cannot be regarded independent from each other and the impact that each bears on the other one cannot be neglected. This is a topic disregarded in the traditional methods of project control (Martinsou et al, 2017).

The management of the earned value, conducted with the aim of controlling and planning costs in their various forms, is a common method in application for assessing the performance of the projects and it does bring to unity time, cost, and limits assessment and thus assists the project management team for evaluating and assessing the project's performance. The process of the production of the aforementioned indexes, which must be conducted in the Projects

Management Office (PMO), can in practice result in the creation of information-based surplus value over the data pool (Banihashemi et al, 2017).

The methodology of the calculation of the percentage of the project fulfilment in the management of the earned value is the most central concept to guarantee the accuracy of the results of such analyses.

The traditional and common methods used for assessing the physical progress of the activities relevant to a project and, naturally, the contractual payments is of no use here and thus for using the method of the earned value from the project in an organization, one must renew the control and calculating methods of the projects on the basis of the engineering method (Marie et al, 2017).

The information circulation in most organization regarding the financial processes, especially the financial affairs of the projects, is usually not in real time, meaning that the executed financial transactions are informed to the control units of the projects with a considerable temporal delay. As a result, gathering information in this area is one of the complications of project planning and control in companies. Assessing the liable individuals' performance in projects and even the units of one single organization is one of the most important control processes in management and also one of the outputs of the process of the improvement of the organization in the area of human resource management. The documents attained through this assessment can be put to use for improving the work process of the organization and its selected criteria for executing future activities. The first and most important stage of the process of performance assessment is to determine useful and effective indexes for doing this activity (Banihashemi et al, 2017).

The question of earned value management is quite significant in change management too. One of the determined factors in this method, with regard to the fact that it fully encircles the project, is determinant of change within the limits of the project and taking necessary corrective measures. Project managers can use this technique before the project reaching 15% of progress in its performance by studying the procedure of the project performance in order to come to an exact and reliable prediction of the final status of the project with regard to the time and costs required for completing the project; this is why the earned value management is called a light at the end of the tunnel of management. Even though the materialized earned value management is conducted for pursuing the time and costs, still the majority of the past research demonstrates that the cost aspect of it is mostly brought into attention. This is because even the existing temporal indexes are articulated on the basis of the cost unit. The research conducted recently in this area are compiled on the basis of temporal unit (Mishakowa et all, 2016).

The laws of Earned Value Management (EVM) are established on the basis of performance assessment. One of the techniques used in unifying various processes and also assessing the performance of the project from A to Z. This technique is used as a methodology in the management of the unification of the project and, in other project management areas, is used as a tool for assessing the performance against the project planning (Krikhov et all, 2016).

One of the important concerns of the project managers and individuals involved is to be able to finalize the project in accordance with the predetermined and scheduled planning and doing so with regard to the complications and added sensitivities in projects especially in the project-



based organizations is particularly important. One can daresay that a manager can become aware of the ways in which the objectives are met and operations are pursued with the help of the control process and thus become enabled to assess and correct them.

In this area, earned value management is a technical tool completed for the first time by the American Academy of Project Management (AAPM) can be of great assistance to the managers. One of the most important objectives of the project management teams is that they should be able to finish a project in accordance with the budget, time-table, and by the key coverage of the work limits. As a result, it is felt that these factors are required to be under constant control. Now, with the use of the system of earned value management, we are in pursuit of address the performance of the managerial system in the petrochemical projects of Mahshahr.

2. The Methodology of the Research

With regard to the points mentioned above, the project's method is descriptive and in kind it is a survey method. In addition, in terms of its objective the present research is practical and in terms of its status is a field study. It is practical given the fact that one of the issues or problems existing in the organizations and economic sectors of country and the conclusions drawn on the basis of its findings can be helpful for the managers in providing answers to their questions. And, with regard to the method, it is descriptive-correlation. Its statistical society consists in individuals or units with at least one share attribute. The statistical society of the present research consists of the main employer and the minor contractors, experts and professional specialists in the petrochemical projects of Mahshahr amounting to 100 individuals involved as staff. In this research and due to the limited volume of the statistical society, there is no sampling done and instead a consensus-survey is applied and thus the sample volume equals the entire society under research equal to 100 individuals. In this research, two methods of statistical analysis will be used: 1) descriptive analysis. 2) The application of the methods of time-related and cost-related information-analysis, and the performance of the projects will be conducted through Gantt chart, cpm, pert, and its comparison with EMV, project management software, in addition to the use of deductive analysis and for processing and analyzing the normal data and investigating research assumptions in which structural equations, software psl and spss software, 22nd version, will be used.



Research Questions:

1. What is the relationship between project management techniques in surplus value management which consists of resource planning and technical costs, and also the requirements of such planning?
2. What is the relationship between earned value management system and its indexes in the improvement of the projects' performance?
3. What is the relationship between the earned value management system and its indexes in the improvement of the projects' performance and time?
4. What is the relationship between the earned value management system and its indexes in the improvement of the projects' performance and cost?

3. Research Findings:

Table 1: The data's normalcy through Kolmogorov-Smirnov (S-S) test

The result of the distribution's (lack of) normalcy	Significance level	k-s amount	number	Variables
normal	0/563	/860	100	Project performance
normal	0/512	/880	100	costs
normal	0/529	/760	100	time

According to the above table, it can be observed that all scales of a significance level over 0/50; thus, they have a normal distribution. For gaining the normalcy of the data through Kolmogorov-Smirnov, if the sig of the variables is over 0/05, the data would be normal and if it be under 0/05, then the data would be non-normal. As a result, for studying the relationship between research variables, one can use correlation parametric test with regard to the distribution of the scores in both scales. In other words, with regard to the distribution of the scores, in both scales and their relevant micro-scales are normal. Here, we use parametric statistics methods in which Pierson test is applied as a parametric test for investigating the extent of the correlation of the variables.

3-1 Descriptive Findings

Before conducting the principal analyses, a number of preliminary analyses were done with the aim of coming to the primary insights in relation with the data. In this research, in total, the relationships among 3 variables have been studied within the suggested model. The descriptive findings pertinent to the average, standard deviation, and the highest and lowest triable scores on research variables are demonstrated in table (2) and the correlation matrix of the model's variables are demonstrated in table (3).

Table 2: The descriptive findings pertinent to the research variables for the entire triables:

The highest	The lowest	Standard deviation	average	Variables
31	5	8/28	26/14	Projects' performance
20	3	5/92	15/86	Costs
15	2	4/96	11/03	time

100N=

As it can be discerned by the content of the table (2), the average (and standard aviation) of the entire sample (that is, 100 individuals) in the projects' performance is 26/14 (8/28), costs 15/86 (5/92), time 11/03 (4/96).

Table 3: the matrix of the correlation of the model's variables:

3	2	1		
		1	Projects' performance	1
	1	0/86**	Costs	2
1	0/74**	0/84**	time	3

<0/01P**

The content of the table (3) demonstrates that the assumed notion of the relationship among variables is in accordance with the expected paths. This means that the entire relations on significance levels have had a significance of 0/01. These correlation analyses provide an insight into the relations between dual variables existing in the variables of the study. For the simultaneous of the notion of the assumed relations in the present research, the path-alteration method has been exerted.

3-2. the deductive analysis of the research variables

The method of earned value management (EVM) is one of the very important techniques which, in the last three decades, has been used for calculating the actual progress of the project and/or, in other words, for the comprehensive and unified management of the project.

Using (EVM) method, in technical projects, with the intention of assessing the performance of the projects and the results in progress and its impact on budget-planning of the projects, is completely observable. This requires assessing some of the main bases such as the costs of project completion and its termination date which, in this method, one first addressed the identification and approximation of the time and costs required for fulfilling the project. In this method, after having fulfilled the assessments mentioned above, one follows with the analysis of each of the indexes pertinent to the project's performance. Here, the time and costs assessed are analyzed and determined via particular parameters, tables, and formulas.



The first question of the research

What is the relationship between project management techniques in the surplus value management which consists of the source planning and technical costs in addition to the planning requirements?

In this research, the quotes or questions in the questionnaire, consisting of 21 questions, are considered as the observed variables, where these 21 questions for the indexes of costs (8 questions), time (9 questions), and performance (4 questions) as the lurking or latent variables.

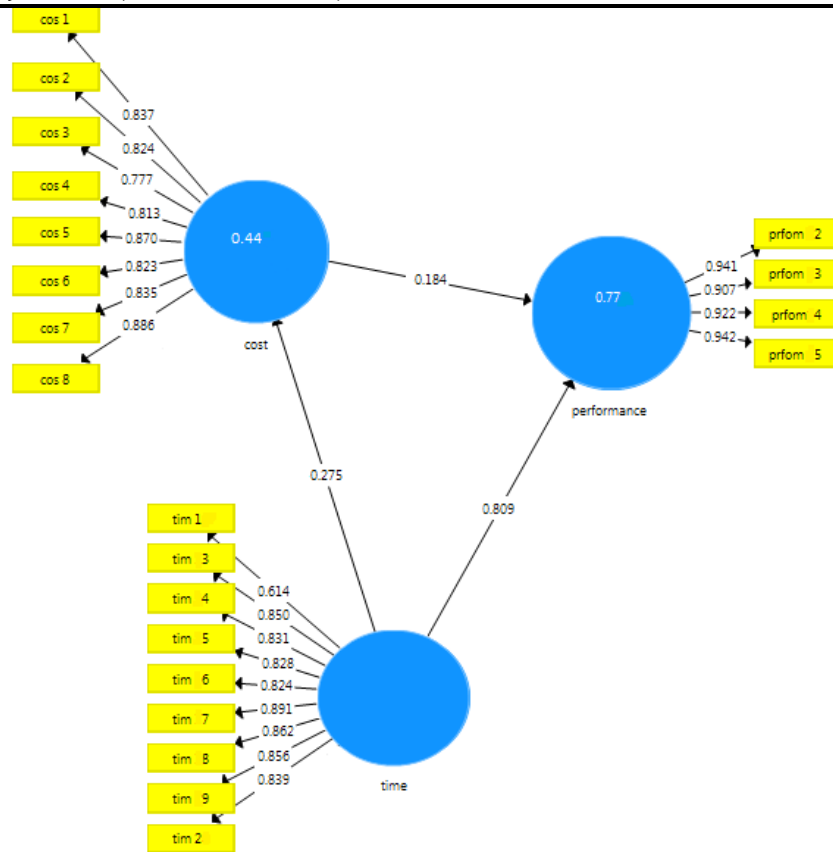


Figure 1: The output of pls software

The first question of the research was investigated on the model of structural equations. Considering the results of the study of relation between the independent and dependent constructs, by the use of the relevant co-efficient, one can address the significance of the impacts between the constructs of the first research question. In the present research, smart pls software is used. This software is compatible with the existence of certain conditions such as collinearity of the independent variables related to the lack of normalcy in the data, and the smallness of the volume of the sample.

In pls models, two models are put to test. The exterior model is equivalent to the measuring model and the interior model similar to the structural model in the models of structural equations. The interior model represents the load factors of the observed variables and the relationship between the latent or lurking variables of the research. The conceptual model put to test is presented in the figure and the numbers on the lines are the beta coefficient resulted from the regression equation between the variables which is the path coefficient and expresses the load factors are demonstrated the numbers within circles represent the amount of R2 of a mode whose predictive variables have entered that circle via an arrow.

For studying the amount of the significance of the path coefficient, it is required to demonstrate the amount of t in each path in which all paths have become significant at the level of 0/95.

Table4-results of t-test for research's variables

Significance level	t	Standard deviation	Average sample	Main sample	Variables
0/023	8/236	0/092	0/226	-0/219	time ← cost
0/018	6/237	0/072	0/208	-0/189	time ← performance
0/001	12/298	0/083	0/520	0/452	cost ← performance

As demonstrated in table (7), the amount of t of each path under study in the model is above the standard amount of the absolute value, that is, 92/5 and an evidence for the significant relationship between the research dimensions and the first question of it which is thus rendered valid.

The second research question

- What is the relationship between the earned value management system and its indexes in the improvement of the projects' performance?

The stages of the analysis of the second question consists of the following:

- Time-tabling the project's activities and resources allocation and leveling
- Drawing the project's baseline
- Updating (report collecting) for the project

Time-tabling the project's activities and resources allocation and leveling

In this process, the sequential order of the commencement of the project activities and also the amount of the resources required for fulfilling the project are determined. Scheduling or time-tabling, along with the time lengths assessed for the activities, enables us to draw the Gantt graph of the activities. With the use of the Microsoft software, it is possible to draw, as done in the following figure, one can insert the project's list of activities and their relevant account in addition to Gantt graph of them.



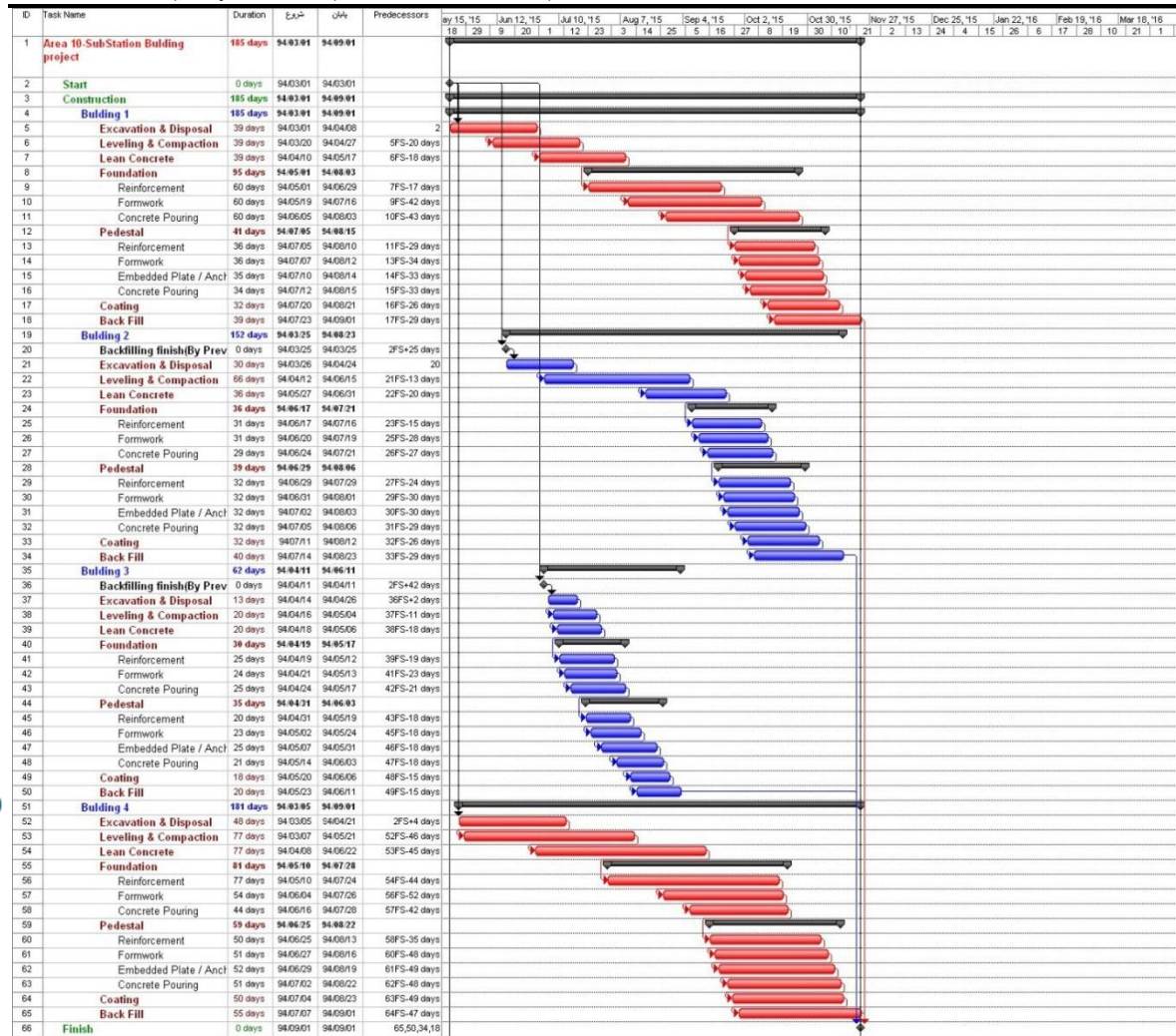


Figure 2: Gantt graph

With access to the limits of the project, scheduling or time-tabling, and the costs assessed for each activity, one can draw the baseline of the project. The date of the initiation of the project is 23rd of December, 2009, and, after the preliminary scheduling or time-tabling of the project, a baseline representing the primary plan is saved in the software so that after the updates and inserting the actual percentages be of use for making comparisons (the horizontal axis: the number of the activity/vertical axis: the time of the activity).

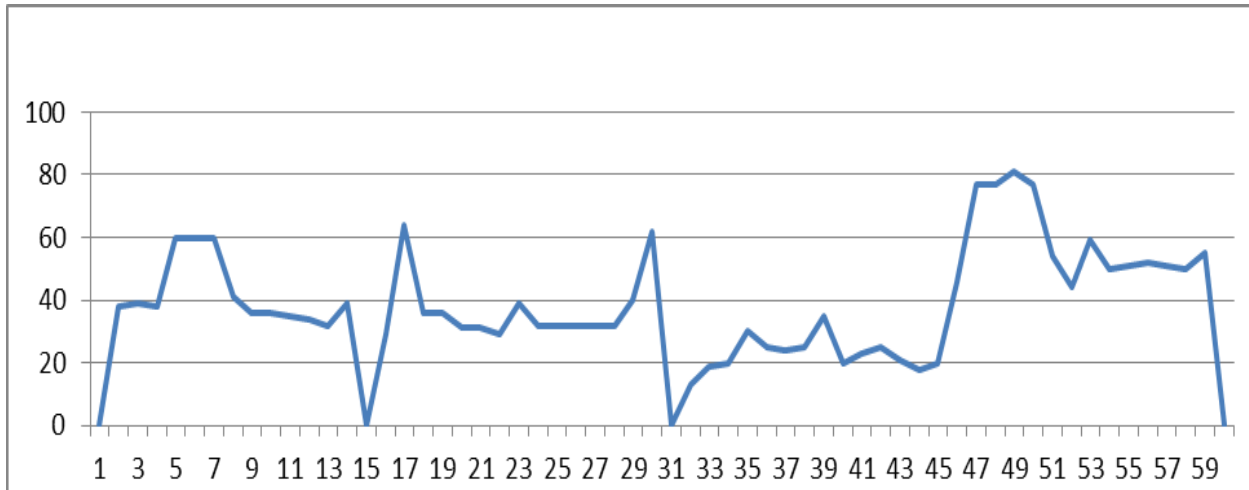


Figure 3: Project baseline

ID	Task Name	BCWS	BCWP	ACWP	CV%	SV%	EAC	VAC
1	Area 10-SubStation Building project	1,263,255,705.10	1,127,472,423.60	1,225,744,212.86	-9%	-11%	10,877,816,123.01	(872,108,913.41)
2	Start	0.00	0.00	0.00	0%	0%	0.00	0.00
3	Construction	1,263,255,705.10	1,127,472,423.60	1,225,744,212.86	-9%	-11%	10,877,816,123.01	(872,108,913.41)
4	Building 1	142,513,394.74	101,480,744.36	161,403,279.30	-59%	-29%	2,904,350,631.11	(2,761,869,886.75)
5	Excavation & Disposal	76,954,020.97	76,954,020.97	136,254,020.97	-77%	0%	136,254,020.97	(59,300,000.00)
6	Leveling & Compaction	19,862,599.85	3,768,801.00	3,972,519.97	-81%	-81%	20,936,259.85	(1,073,654.05)
7	Lean Concrete	38,801,918.08	12,484,095.38	13,159,911.35	-68%	-68%	69,391,019.28	(3,589,462.53)
8	Foundation	6,894,855.84	8,273,827.01	8,017,827.01	3%	20%	815,464,676.31	26,036,849.56
9	Reinforcement	6,894,855.84	8,273,827.01	8,017,827.01	3%	20%	400,891,390.40	12,800,000.00
10	Formwork	0.00	0.00	0.00	0%	0%	70,684,328.86	0.00
11	Concrete Pouring	0.00	0.00	0.00	0%	0%	357,145,840.61	0.00
12	Pedestal	0.00	0.00	0.00	0%	0%	617,587,886.31	0.00
13	Reinforcement	0.00	0.00	0.00	0%	0%	223,472,680.21	0.00
14	Formwork	0.00	0.00	0.00	0%	0%	91,674,180.21	0.00
15	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	116,946,558.63	0.00
16	Concrete Pouring	0.00	0.00	0.00	0%	0%	185,494,667.25	0.00
17	Coating	0.00	0.00	0.00	0%	0%	76,732,540.66	0.00
18	Back Fill	0.00	0.00	0.00	0%	0%	127,649,928.74	0.00
19	Building 2	108,525,200.77	35,703,744.43	35,234,021.45	1%	-67%	2,867,551,947.82	38,228,818.81
20	Backfilling finish(By Previous Subcontractor)	0.00	0.00	0.00	0%	0%	0.00	0.00
21	Excavation & Disposal	97,803,263.38	24,450,815.84	24,450,815.84	0%	-75%	97,803,263.38	0.00
22	Leveling & Compaction	10,721,837.40	11,282,928.58	10,763,206.61	4%	-5%	32,290,908.08	1,406,611.44
23	Lean Concrete	0.00	0.00	0.00	0%	0%	107,307,678.58	0.00
24	Foundation	0.00	0.00	0.00	0%	0%	1,347,313,786.85	0.00
25	Reinforcement	0.00	0.00	0.00	0%	0%	97,803,263.38	0.00
26	Formwork	0.00	0.00	0.00	0%	0%	112,375,286.79	0.00
27	Concrete Pouring	0.00	0.00	0.00	0%	0%	649,646,143.29	0.00
28	Pedestal	0.00	0.00	0.00	0%	0%	982,141,088.17	0.00
29	Reinforcement	0.00	0.00	0.00	0%	0%	326,628,043.26	0.00
30	Formwork	0.00	0.00	0.00	0%	0%	128,163,543.26	0.00
31	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	232,822,997.37	0.00
32	Concrete Pouring	0.00	0.00	0.00	0%	0%	294,526,924.27	0.00
33	Coating	0.00	0.00	0.00	0%	0%	131,515,981.92	0.00
34	Back Fill	0.00	0.00	0.00	0%	0%	208,001,430.21	0.00
35	Building 3	868,106,546.75	847,170,807.01	811,543,636.55	4%	-2%	2,879,052,146.13	126,391,825.31
36	Backfilling finish(By Previous Subcontractor)	0.00	0.00	0.00	0%	0%	0.00	0.00
37	Excavation & Disposal	80,848,879.71	56,594,215.80	56,594,215.80	0%	-30%	80,848,879.71	0.00
38	Leveling & Compaction	30,638,880.25	52,348,359.71	21,827,444.88	3%	-27%	34,882,875.62	1,162,765.85
39	Lean Concrete	87,263,040.98	69,143,171.94	64,066,230.03	6%	-22%	109,614,923.13	6,969,131.47
40	Foundation	637,295,136.31	668,124,444.03	637,295,136.31	5%	5%	1,331,613,936.12	64,426,793.69
41	Reinforcement	331,490,331.97	331,490,331.97	331,490,331.97	0%	0%	591,947,021.37	0.00
42	Formwork	58,069,241.65	58,069,241.65	58,069,241.65	0%	0%	116,138,483.31	0.00
43	Concrete Pouring	247,735,556.69	278,564,870.41	247,735,556.69	11%	12%	611,994,952.29	76,159,371.84
44	Pedestal	31,960,615.53	31,960,615.53	31,960,615.53	0%	0%	1,019,771,144.59	0.00
45	Reinforcement	0.00	0.00	0.00	0%	0%	319,506,155.29	0.00
46	Formwork	0.00	0.00	0.00	0%	0%	140,232,155.29	0.00
47	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	244,481,741.47	0.00
48	Concrete Pouring	0.00	0.00	0.00	0%	0%	315,471,092.64	0.00
49	Coating	0.00	0.00	0.00	0%	0%	140,169,674.35	0.00
50	Back Fill	0.00	0.00	0.00	0%	0%	215,894,646.90	0.00
51	Building 4	144,110,562.83	143,117,427.80	217,563,275.85	-52%	-4%	3,448,368,466.82	(3,304,250,839.02)
52	Excavation & Disposal	97,350,971.14	97,350,971.14	171,210,971.14	-76%	0%	171,210,971.14	(73,860,000.00)
53	Leveling & Compaction	18,935,183.53	19,499,896.47	18,823,548.01	3%	24%	24,829,611.53	749,469.02
54	Lean Concrete	27,824,428.17	26,266,260.19	27,423,756.41	-4%	-6%	89,475,815.39	(3,776,576.62)
55	Foundation	0.00	0.00	0.00	0%	0%	1,852,297,489.69	0.00
56	Reinforcement	0.00	0.00	0.00	0%	0%	499,115,510.65	0.00
57	Formwork	0.00	0.00	0.00	0%	0%	87,741,079.04	0.00
58	Concrete Pouring	0.00	0.00	0.00	0%	0%	465,440,819.99	0.00
59	Pedestal	0.00	0.00	0.00	0%	0%	143,163,982.72	0.00
60	Reinforcement	0.00	0.00	0.00	0%	0%	274,373,181.63	0.00
61	Formwork	0.00	0.00	0.00	0%	0%	105,139,981.63	0.00
62	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	151,660,003.74	0.00
63	Concrete Pouring	0.00	0.00	0.00	0%	0%	211,980,735.71	0.00
64	Coating	0.00	0.00	0.00	0%	0%	99,346,613.25	0.00
65	Back Fill	0.00	0.00	0.00	0%	0%	164,963,003.27	0.00
66	Finish	0.00	0.00	0.00	0%	0%	0.00	0.00

Figure 4: updating the project

With regard to the updating date (22nd of October, 2016), it can be observed that 6 years after its commencement, the project has been completed at about 75% in which there are deviations in comparison with the extent of progress expected to make; this is addressed further in what follows:

The extent of the actual progress made is 25% while it is expected to be 90%. The amount of the actual cost is equal to ACWP = (3,524,958,752) while it was expected to be BCWP = (4,968,42,631).



On the basis of the cost performance index, one can deduce that out of each 100 hours of the consumed labor in the project, only 72 hours of it have been effective. On the basis of the timing performance index, too, one can deduce that in order to meet the objectives of the project, for each 72 hours of the consumed labor, one has to plan for 100 hours. In the figure number (), the information relevant to the BCWS, BCWP, ACWP of the progress made in the project at the date of its updating are demonstrated. Since the index has attributed to itself a critical proportion, a number been 0/5 and 0/9.

The third research question

- What is the relationship between the earned value management system and its indexes in the improvement of the performance and time of the projects?

The stages involved in the analysis of the second question of the research:

- Time-tabling the project's activities and resources allocation and leveling
- Drawing the project's baseline
- Updating (report collecting) for the project
- Analyzing the project's status up to its updating date (the primary report collection)
- Corrective measures and the second updating of the project

Time-tabling the project's activities and resources allocation and leveling

In this process, the sequential order of the commencement of the project activities and also the amount of the resources required for fulfilling the project are determined. Scheduling or time-tabling, along with the time lengths assessed for the activities, enables us to draw the Gantt graph of the activities. With the use of the Microsoft software, it is possible to draw, as done in the following figure, one can insert the project's list of activities and their relevant account in addition to Gantt graph of them.



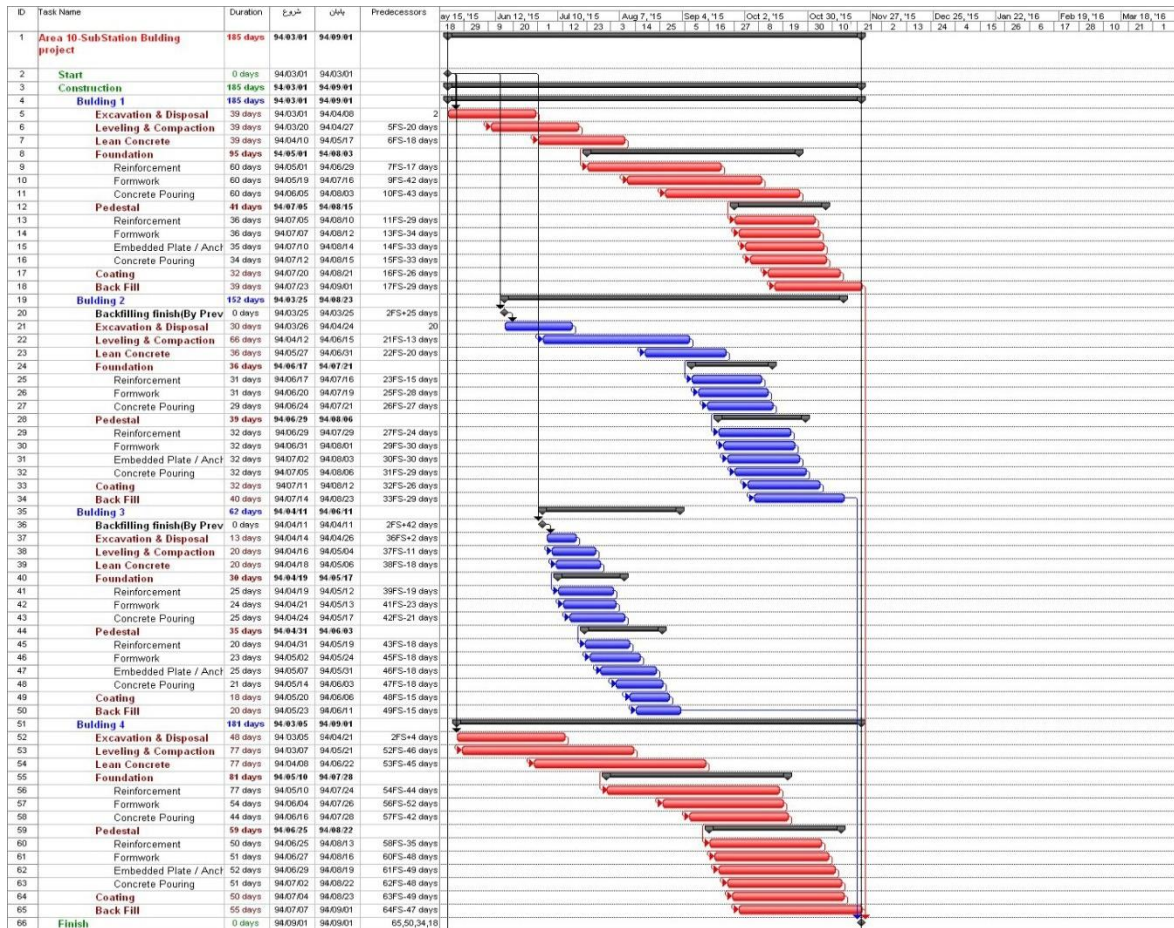


Figure 5: Gantt graph for project costs

With access to the limits of the project, scheduling or time-tabling, and the costs assessed for each activity, one can draw the baseline of the project. The date of the initiation of the project is 23rd of December, 2009, and, after the preliminary scheduling or time-tabling of the project, a baseline representing the primary plan is saved in the software so that after the updates and inserting the actual percentages be of use for making comparisons (the horizontal axis: the number of the activity/vertical axis: the time of the activity).

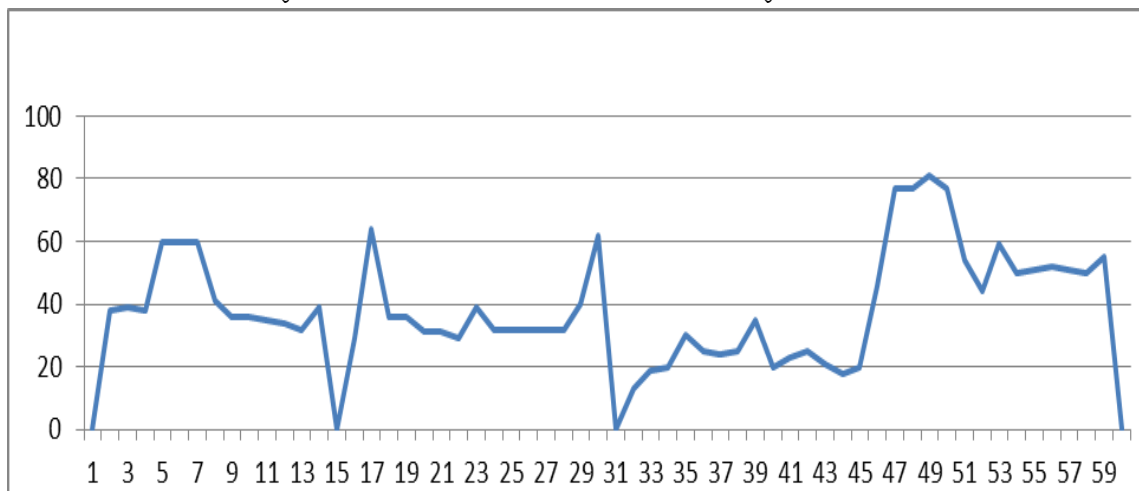


Figure 6: project baseline

ID	Task Name	BCWS	BCWP	ACWP	CV%	SV%	EAC	VAC
1	Area 10-SubStation Building project	1,263,255,705.10 TL	1,127,472,423.60 TL	1,225,744,212.86 TL	-9%	-11%	10,677,816,123.01 TL	(872,108,913.41 TL)
2	Start	0.00 TL	0.00 TL	0.00 TL	0%	0%	0.00 TL	0.00 TL
3	Construction	1,263,255,705.10 TL	1,127,472,423.60 TL	1,225,744,212.86 TL	-9%	-11%	10,677,816,123.01 TL	(872,108,913.41 TL)
4	Building 1	142,513,194.74 TL	101,460,744.36 TL	161,403,279.30 TL	-59%	-29%	2,904,330,631.11 TL	3,041,817,436.77 TL
5	Excavation & Disposal	76,954,020.97 TL	76,954,020.97 TL	136,254,020.97 TL	-77%	0%	136,254,020.97 TL	(59,300,000.00 TL)
6	Leveling & Compaction	19,862,599.85 TL	3,768,801.00 TL	3,972,519.97 TL	-5%	-81%	20,936,253.89 TL	(1,073,654.05 TL)
7	Lean Concrete	38,601,918.08 TL	12,484,095.30 TL	13,156,911.36 TL	-5%	-88%	69,351,018.26 TL	(3,556,462.53 TL)
8	Foundation	6,894,855.84 TL	8,273,827.01 TL	8,017,827.01 TL	3%	20%	815,464,476.31 TL	26,036,845.56 TL
9	Reinforcement	6,894,855.84 TL	8,273,827.01 TL	8,017,827.01 TL	3%	20%	400,691,350.40 TL	12,800,000.00 TL
10	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	70,864,326.86 TL	0.00 TL
11	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	357,145,840.61 TL	0.00 TL
12	Pedestal	0.00 TL	0.00 TL	0.00 TL	0%	0%	617,587,986.31 TL	0.00 TL
13	Reinforcement	0.00 TL	0.00 TL	0.00 TL	0%	0%	223,472,680.21 TL	0.00 TL
14	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	91,674,180.21 TL	0.00 TL
15	Embedded Plats / Anchor Bolt	0.00 TL	0.00 TL	0.00 TL	0%	0%	115,945,558.63 TL	0.00 TL
16	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	185,494,667.25 TL	0.00 TL
17	Coating	0.00 TL	0.00 TL	0.00 TL	0%	0%	76,732,540.68 TL	0.00 TL
18	Back Fill	0.00 TL	0.00 TL	0.00 TL	0%	0%	127,649,926.74 TL	0.00 TL
19	Building 2	108,525,206.77 TL	35,763,744.43 TL	35,234,021.45 TL	1%	-67%	2,667,551,497.82 TL	38,228,818.81 TL
20	Backfilling finish(By Previous Subcontractor)	0.00 TL	0.00 TL	0.00 TL	0%	0%	0.00 TL	0.00 TL
21	Excavation & Disposal	97,803,263.38 TL	24,450,815.84 TL	24,450,815.84 TL	0%	-75%	97,803,263.38 TL	0.00 TL
22	Leveling & Compaction	10,721,937.40 TL	11,252,928.56 TL	10,783,205.61 TL	4%	5%	32,290,906.09 TL	1,406,611.44 TL
23	Foundation	0.00 TL	0.00 TL	0.00 TL	0%	0%	107,307,676.58 TL	0.00 TL
24	Reinforcement	0.00 TL	0.00 TL	0.00 TL	0%	0%	585,292,356.77 TL	0.00 TL
25	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	112,375,286.74 TL	0.00 TL
26	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	649,646,143.23 TL	0.00 TL
27	Pedestal	0.00 TL	0.00 TL	0.00 TL	0%	0%	982,141,508.17 TL	0.00 TL
28	Reinforcement	0.00 TL	0.00 TL	0.00 TL	0%	0%	326,626,043.26 TL	0.00 TL
29	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	128,163,543.26 TL	0.00 TL
30	Embedded Plats / Anchor Bolt	0.00 TL	0.00 TL	0.00 TL	0%	0%	232,822,997.37 TL	0.00 TL
31	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	294,526,924.27 TL	0.00 TL
32	Coating	0.00 TL	0.00 TL	0.00 TL	0%	0%	131,515,581.92 TL	0.00 TL
33	Back Fill	0.00 TL	0.00 TL	0.00 TL	0%	0%	206,001,430.21 TL	0.00 TL
34	Building 3	868,196,546.75 TL	847,170,107.81 TL	811,543,636.51 TL	4%	-2%	2,875,052,145.13 TL	126,391,825.31 TL
35	Backfilling finish(By Previous Subcontractor)	0.00 TL	0.00 TL	0.00 TL	0%	0%	0.00 TL	0.00 TL
36	Excavation & Disposal	80,848,879.71 TL	56,594,215.80 TL	56,594,215.80 TL	0%	-30%	80,848,879.71 TL	0.00 TL
37	Leveling & Compaction	30,639,880.25 TL	22,348,359.71 TL	21,627,444.88 TL	3%	-27%	34,882,975.62 TL	1,162,765.85 TL
38	Foundation	67,263,040.95 TL	69,143,171.94 TL	64,066,230.03 TL	0%	-22%	108,914,923.13 TL	6,969,131.47 TL
39	Lean Concrete	637,295,130.31 TL	668,124,444.03 TL	637,295,130.31 TL	5%	5%	1,331,813,935.12 TL	64,426,793.69 TL
40	Reinforcement	331,490,331.97 TL	331,490,331.97 TL	331,490,331.97 TL	0%	0%	591,947,021.37 TL	0.00 TL
41	Formwork	58,069,241.65 TL	58,069,241.65 TL	58,069,241.65 TL	0%	0%	116,138,483.31 TL	0.00 TL
42	Concrete Pouring	247,735,556.69 TL	279,564,870.41 TL	247,735,556.69 TL	11%	12%	611,994,952.29 TL	76,159,371.84 TL
43	Pedestal	31,960,615.53 TL	31,960,615.53 TL	31,960,615.53 TL	0%	0%	1,015,771,144.59 TL	0.00 TL
44	Reinforcement	31,960,615.53 TL	31,960,615.53 TL	31,960,615.53 TL	0%	0%	319,806,155.29 TL	0.00 TL
45	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	140,232,155.29 TL	0.00 TL
46	Embedded Plats / Anchor Bolt	0.00 TL	0.00 TL	0.00 TL	0%	0%	244,461,741.47 TL	0.00 TL
47	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	315,471,092.54 TL	0.00 TL
48	Coating	0.00 TL	0.00 TL	0.00 TL	0%	0%	140,169,674.35 TL	0.00 TL
49	Back Fill	0.00 TL	0.00 TL	0.00 TL	0%	0%	215,894,646.90 TL	0.00 TL
50	Building 4	144,110,562.83 TL	143,117,127.80 TL	217,563,275.55 TL	-52%	-1%	3,448,368,406.82 TL	3,304,257,839.03 TL
51	Excavation & Disposal	97,350,971.14 TL	97,350,971.14 TL	171,210,971.14 TL	-76%	0%	171,210,971.14 TL	(73,860,000.00 TL)
52	Leveling & Compaction	18,935,163.53 TL	19,499,896.47 TL	18,920,548.01 TL	3%	3%	24,829,811.53 TL	749,469.02 TL
53	Lean Concrete	27,824,428.17 TL	26,266,260.13 TL	27,423,756.41 TL	-4%	-6%	89,475,815.39 TL	(3,776,576.62 TL)
54	Foundation	0.00 TL	0.00 TL	0.00 TL	0%	0%	1,052,297,405.69 TL	0.00 TL
55	Reinforcement	0.00 TL	0.00 TL	0.00 TL	0%	0%	499,115,510.66 TL	0.00 TL
56	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	87,741,079.04 TL	0.00 TL
57	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	465,440,819.99 TL	0.00 TL
58	Pedestal	0.00 TL	0.00 TL	0.00 TL	0%	0%	743,163,992.72 TL	0.00 TL
59	Reinforcement	0.00 TL	0.00 TL	0.00 TL	0%	0%	274,373,181.63 TL	0.00 TL
60	Formwork	0.00 TL	0.00 TL	0.00 TL	0%	0%	106,139,981.63 TL	0.00 TL
61	Embedded Plats / Anchor Bolt	0.00 TL	0.00 TL	0.00 TL	0%	0%	151,660,003.74 TL	0.00 TL
62	Concrete Pouring	0.00 TL	0.00 TL	0.00 TL	0%	0%	211,990,735.71 TL	0.00 TL
63	Coating	0.00 TL	0.00 TL	0.00 TL	0%	0%	99,346,613.25 TL	0.00 TL
64	Back Fill	0.00 TL	0.00 TL	0.00 TL	0%	0%	164,963,003.27 TL	0.00 TL
65	Finish	0.00 TL	0.00 TL	0.00 TL	0%	0%	0.00 TL	0.00 TL

Figure 7: updating the costs

With regard to the updating date (22nd of October, 2016), it can be observed that 6 years after its commencement, the project has been completed at about 75% in which there are deviations in comparison with the extent of progress expected to make; this is addressed further in what follows:

The extent of the actual progress made is 25% while it is expected to be 90%. The amount of the actual cost is equal to ACWP = (3.524.958.752) while it was expected to be BCWP = (4.968.42.631).

On the basis of the cost performance index, one can deduce that out of each 100 hours of the consumed labor in the project, only 72 hours of it have been effective. On the basis of the timing performance index, too, one can deduce that in order to meet the objectives of the project, for each 72 hours of the consumed labor, one has to plan for 100 hours. In the figure number (), the information relevant to the BCWS, BCWP, ACWP of the progress made in the project at the date of its updating are demonstrated. Since the index has attributed to itself a critical proportion, a number been 0/5 and 0/9.

Updating (report collecting) the project

The date of the project's update was 22nd of July, 2016 whose results are presented in what follows:

(horizontal axis: the number of the activity/the vertical axis: costs)

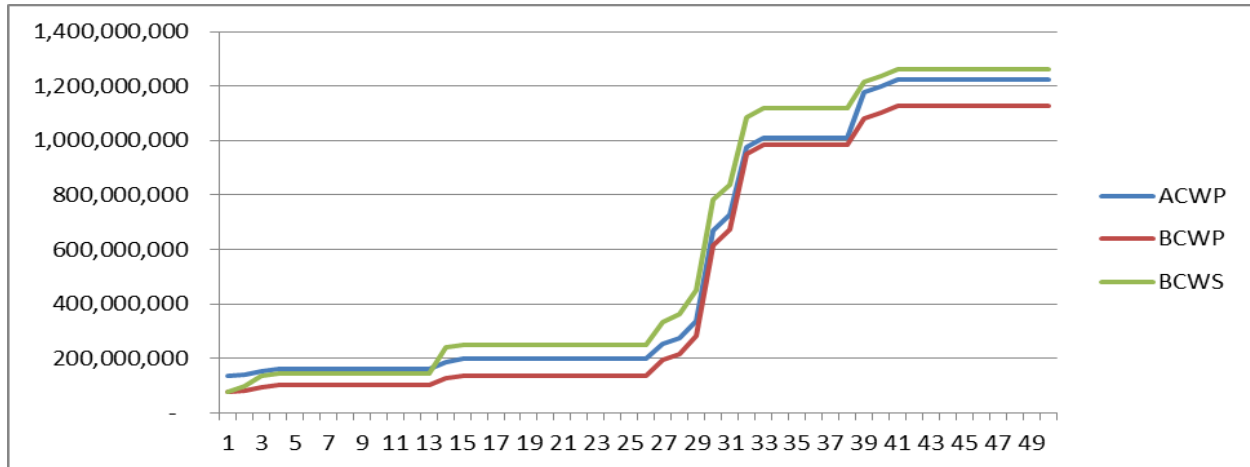


Figure 8: updating (report collecting) the project

ID	Task Name	BCWS	BCWP	ACWP	CV%	SV%	EAC	VAC
1	Area 10.SubStation Building project	1,263,255,705.10	1,127,472,423.66	1,225,744,212.86	-9%	-11%	10,877,816,123.01	(872,168,913.41)
2	Start	0.00	0.00	0.00	0%	0%	0.00	0.00
3	Construction	1,263,255,705.10	1,127,472,423.66	1,225,744,212.86	-9%	-11%	10,877,816,123.01	(872,168,913.41)
4	Building 1	142,513,394.74	101,480,744.36	161,403,279.30	-59%	-29%	2,904,350,631.11	(3,556,462.53)
5	Excavation & Disposal	76,954,020.97	76,954,020.97	136,254,020.97	-77%	0%	136,254,020.97	(59,300,000.00)
6	Leveling & Compaction	19,862,599.85	3,768,801.00	3,972,519.97	-5%	-81%	20,936,253.89	(1,073,654.05)
7	Lean Concrete	38,801,918.08	12,484,095.38	13,158,911.35	-5%	-68%	69,351,019.28	(3,556,462.53)
8	Foundation	6,894,855.84	8,273,827.01	8,017,827.01	3%	20%	815,464,670.31	26,036,849.56
9	Reinforcement	6,894,855.84	8,273,827.01	8,017,827.01	3%	20%	400,891,350.40	12,800,000.00
10	Formwork	0.00	0.00	0.00	0%	0%	70,664,328.88	0.00
11	Concrete Pouring	0.00	0.00	0.00	0%	0%	357,145,840.61	0.00
12	Pedestal	0.00	0.00	0.00	0%	0%	617,587,086.31	0.00
13	Reinforcement	0.00	0.00	0.00	0%	0%	223,472,880.21	0.00
14	Formwork	0.00	0.00	0.00	0%	0%	91,674,180.21	0.00
15	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	116,345,559.63	0.00
16	Concrete Pouring	0.00	0.00	0.00	0%	0%	185,494,667.28	0.00
17	Coating	0.00	0.00	0.00	0%	0%	76,732,540.66	0.00
18	Back Fill	0.00	0.00	0.00	0%	0%	127,649,928.74	0.00
19	Building 2	108,525,200.77	35,763,744.43	35,234,021.45	1%	-67%	2,867,551,947.82	38,228,818.81
20	Backfilling finish(By Previous Subcontractor)	0.00	0.00	0.00	0%	0%	0.00	0.00
21	Excavation & Disposal	97,803,263.38	24,450,815.84	24,450,815.84	0%	-75%	97,803,263.38	0.00
22	Leveling & Compaction	10,721,937.40	11,252,820.58	10,763,205.61	4%	5%	32,290,908.00	1,405,611.44
23	Lean Concrete	0.00	0.00	0.00	0%	0%	107,307,678.58	0.00
24	Foundation	0.00	0.00	0.00	0%	0%	1,347,313,786.85	0.00
25	Reinforcement	0.00	0.00	0.00	0%	0%	585,292,356.77	0.00
26	Formwork	0.00	0.00	0.00	0%	0%	112,375,286.79	0.00
27	Concrete Pouring	0.00	0.00	0.00	0%	0%	649,646,143.29	0.00
28	Pedestal	0.00	0.00	0.00	0%	0%	982,141,580.17	0.00
29	Reinforcement	0.00	0.00	0.00	0%	0%	326,628,043.26	0.00
30	Formwork	0.00	0.00	0.00	0%	0%	126,163,543.26	0.00
31	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	232,822,997.37	0.00
32	Concrete Pouring	0.00	0.00	0.00	0%	0%	294,626,924.27	0.00
33	Coating	0.00	0.00	0.00	0%	0%	131,615,581.92	0.00
34	Back Fill	0.00	0.00	0.00	0%	0%	206,001,430.21	0.00
35	Building 3	868,166,546.75	847,170,807.01	811,543,636.55	4%	-2%	2,879,852,145.13	126,391,825.31
36	Backfilling finish(By Previous Subcontractor)	0.00	0.00	0.00	0%	0%	0.00	0.00
37	Excavation & Disposal	80,848,879.71	56,594,215.80	56,594,215.80	0%	-30%	80,848,879.71	0.00
38	Leveling & Compaction	30,638,880.25	22,348,359.71	21,627,444.88	3%	-27%	34,882,975.62	1,162,765.85
39	Lean Concrete	87,363,040.95	68,143,171.94	64,086,230.03	6%	-22%	109,514,923.13	6,969,131.47
40	Foundation	637,295,136.31	648,174,444.03	637,295,136.31	5%	5%	1,331,413,835.12	64,426,793.69
41	Reinforcement	331,490,331.97	331,490,331.97	331,490,331.97	0%	0%	591,947,021.37	0.00
42	Formwork	58,069,241.65	58,069,241.65	58,069,241.65	0%	0%	116,138,483.31	0.00
43	Concrete Pouring	247,735,556.69	278,564,870.41	247,735,556.69	11%	12%	611,994,952.29	76,159,371.84
44	Pedestal	31,960,615.53	31,960,615.53	31,960,615.53	0%	0%	1,019,771,144.59	0.00
45	Reinforcement	31,960,615.53	31,960,615.53	31,960,615.53	0%	0%	319,606,155.29	0.00
46	Formwork	0.00	0.00	0.00	0%	0%	140,232,155.29	0.00
47	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	244,461,741.47	0.00
48	Concrete Pouring	0.00	0.00	0.00	0%	0%	315,471,092.54	0.00
49	Coating	0.00	0.00	0.00	0%	0%	140,169,674.35	0.00
50	Back Fill	0.00	0.00	0.00	0%	0%	215,884,646.90	0.00
51	Building 4	144,110,562.83	143,117,127.80	217,563,275.55	-52%	-1%	3,448,368,406.82	(3,556,462.53)
52	Excavation & Disposal	97,350,971.14	97,350,971.14	171,210,971.14	-76%	0%	171,210,971.14	(73,860,000.00)
53	Leveling & Compaction	18,935,163.53	19,499,896.47	18,928,548.01	3%	3%	24,929,611.53	749,469.02
54	Lean Concrete	27,824,420.17	26,268,260.19	27,423,756.41	-4%	-6%	89,475,815.39	(3,776,576.62)
55	Foundation	0.00	0.00	0.00	0%	0%	1,052,297,409.69	0.00
56	Reinforcement	0.00	0.00	0.00	0%	0%	499,115,510.68	0.00
57	Formwork	0.00	0.00	0.00	0%	0%	87,741,079.04	0.00
58	Concrete Pouring	0.00	0.00	0.00	0%	0%	465,440,819.99	0.00
59	Pedestal	0.00	0.00	0.00	0%	0%	743,163,982.72	0.00
60	Reinforcement	0.00	0.00	0.00	0%	0%	274,373,181.63	0.00
61	Formwork	0.00	0.00	0.00	0%	0%	105,139,981.63	0.00
62	Embedded Plate / Anchor Bolt	0.00	0.00	0.00	0%	0%	151,660,003.74	0.00
63	Concrete Pouring	0.00	0.00	0.00	0%	0%	211,990,735.71	0.00
64	Coating	0.00	0.00	0.00	0%	0%	99,346,613.25	0.00
65	Back Fill	0.00	0.00	0.00	0%	0%	164,963,003.27	0.00
66	Finish	0.00	0.00	0.00	0%	0%	0.00	0.00

Figure 9: temporal update

Project managers are responsible for managing the costs of a project. If the project management plan says that the organized analysis of the deviation and prediction are needed; they necessitate the use of earned value management for covering the aforesaid issue.



5. Conclusion

When project managers are in their own comfort zone and no problem leads them towards change, they, too, like others find a proper excuse for running things exactly the way they already are. This is a clear and typical example of a change management. The problem does not lie in the use or lack of use of the earned value management. The problem lies in the project's cost control. The employer asks the project managers to control the costs of their project. They usually do not ask how, yet there is a standard called the earned value management. Whenever they are in need of controlling the costs in their project, they will also need using earned value management and there is no excuse in tools cannot be rendered acceptable. Such tools as OpenPPM, MSP, and the like are available. No business manager would refrain from controlling project's costs; since they are the main beneficiaries of the project and the project managers are liable and it would be their problem. Generally, the customers of any given project desire to see the project finished in the shortest time. Yet, it cannot be the justification to using the fast tracking method by itself. Depending of the type of the project and the experiences of the project team and the expected results this technique may not amount to a good choice. In a project that should go through a temporal line that cannot be shortened, using this technique would only end in disruption and, consequently, failure. This is while if this technique is applied effectively by means of a thorough study of the project can become a helpful tool in reaction to the changes of conditions and market demands. In addition, the uni-factorial system is considered as the best method for performing a fast tracking project. For answering these research questions, firstly, certain questions should be designed on the basis of the indexes of time and cost in the system of earned value management and then, by an estimation gained through the relationship between the aforesaid system and performance, we would be able to come to a clear and convincing answer. Thus, the questions are arranged and ordered on the basis of Likert scale, and distributed among 100 individuals of the high-ranking managers involved in the project. What was resulted as the output of that questionnaire demonstrates the meaningful relationship between the constructs of question one (cost, time, and performance). Six years since its beginning, about 75% of it was completed¹ which suggests the advancement of it from the plan) which equals 90% at the end of the sixth year) .%75 The index of the cost performance has increased from 50% to 70% and also the index of time performance (planning) has attributed to itself the approximated number of 0/26 which is undesirable and caused the dissatisfaction of the project managers.

What became clear by the results gained from these questions was the necessity of using this system in projects' management with the aim of attaining the maximum degree of performance in time and cost dimensions. What was certified in the present research was the necessity of applying the earned value management system at all work stages especially in petrochemical projects where its necessary application became evident and specified. With the results gained from the variables of the earned value management system, it became clear how one can exploit this new system as a convenient tool for assessing projects' performance especially with regard



to the construction projects. In addition, with the identification of the effective dimension on the indexes of time and cost and their relationship with project performance, we managed to come to a proper assessment of the project's performance. The results of this research were in line with that of Adib et al (2012); Soltan'Panah, Farooghi and Abdi (2012); Jadid Gili and Arooji (2013); Shah'Husseini and Fathi (2013); Malekiyan et al (2014); and Muslemi Naeeni et al (2014) and Krikhov et al (2016). The earned value technique an important technique for analyzing project performance which enables one to do a more precise measuring of both performance and progress of a project.

Suggestion drawn from the research

Despite the importance of the earned value management system as a valuable methodology in analyzing and controlling the project performance of Ahwaz urban train system, research conducted with the aim of developing and designing a unified approach for controlling project's performance through this methodology have been very limited. In the projects (CPI, SPI) were used. For gaining reassurance of the main conditions for using these graphs being met, the relevant tests were run. One must keep in mind that regardless of the statistical distribution of the data, the presented methodology in this research can be applied in general for bringing the project performance under control via the indexes of the earned value.

The methodology for the best methodical choice is to estimate the cost and time of the project being completed. In this method, the best way for estimating the costs of the completion of the project is attained and its performative index was used for estimating the time of the project's completion. With the use of the scientific example, various existing methods in the area of time and cost estimation of the project were compared with one another and the best method with the lowest deviation from the actually observed amounts were selected.

The model presented here is completely practical and can be used whenever time and cost of the project have been defined in an indeterminate and fuzzy manger from the very beginning.

The present research can prepare the ground for the expansion of the fuzzy model of earned value in a way that other parameters of this technique would be put to study and, if possible, turned into fuzzy numbers; as an example, one can calculate the actual progress percentage of the activities through other methods and then study the feasibility of them becoming fuzzy.

With each research the path to other research is paved and the necessity of further research felt:

- Controlling projects' costs with the use of the earned value management method
- Classification and analysis of projects' performance in controlling the project and the earned value management
- The acquisition of the management of the value project: the improvement of the prediction capacity from the planned value
- The comparison of the methods of control in various projects with the use of the earned value management method
- Studying a fuzzy method for the earned value management
- Studying the applications of the system of the earned value management in each of the contractual systems of the country



- Studying the feasibility of the application of the earned value as a criterion for the financial statement being paid to the contractor in each of the conventional payment methods in the country

Sources:

1. Adib, A.; Salah'shoor. G.; Solooki. S. (2012) Presenting a New Index in the Management of the Earned Value with the Aim of Controlling Project Cost, the International Conference of Project Management
2. Jadid Gili, M.; and Orooji, A. (2014). Controlling the Projects' Costs with the Use of the Earned Value Method (EVM), the 29th International Power Conference, Tehran
3. Zakayi, M. (2005), the Handbook of Project Management, Tehran: Adineh
4. Soltan'Panah, H.; Farooghi, H.; and Abdi. R (2012). Presenting a Method for Calculating the Earned Value under Risky Conditions in a Fuzzy Environment. The scientific-research periodical of the Industrial Management Studies. 10 (26), 139-156
5. Shah'Husseini, V.; Fathi S.M.R; and Amiri, A. (2012), The Deficiency of the Earned Value Management in Project Control, the third international conference of construction industry, Tehran, the Institute of Construction Industry Research and Development
6. Feizi, M. (2005). The Standard Application of PMBOK for Assessing the Performance of Project Managers, the second international conference of project management
7. Noori, S. (2003), the Principles of Planning and Project Management, Tehran: Science and Industry University of Iran
8. [HunterO Howard, RichardFitzgerald,DeweyBarlow\(2014\), Improved cost monitoring and control through the Earned Value Management System, journal homepage: www.elsevier.com/locate/actaastro.](http://www.elsevier.com/locate/actaastro)
9. Project Management Institute, A Guide to the Project Management Body of Knowledge, fourth Edition, Project Management Institute. Inc, Pennsylvania, USA, 2008
10. Project Management Institute; "A Guide to the Project Management Body of Knowledge"; 3rd ed., USA, PMI, 2004.
11. Martin, Paula & Karen Tate; "Getting Started in Project Management"; USA, John Wiley & Sons, 2001.
12. [Moslemi Naeni ,Leila. Shahram Shadrokh, Amir Salehipour\(2014\), A fuzzy approach for the earned value management, International Journal of Project Management 12 \(2014\) 547–568.](#)
13. [Zhonga. Shuheng, Xin Wanga\(2011\), Improvement and application of earned value analysis in coal project management, Procedia Engineering 26 \(2011\) 1983 – 1989](#)

