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Development of an Organizational Structure of the Department of Quality Control in Construction Companies

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Abstract. construction projects is characterized by the fact that each project has a privacy and requirement differs from each other, this makes it difficult to establish a fixed solutions for all the problems facing the implementation of the project, so the process of quality control over the implementation of the project and completing it within the specified duration, cost, and quality has become the dream of all the workers in this sector. In this research an organizational structure for the work of the department of quality control in construction companies was proposed. The proposed organizational structure is based on scientific sources related to the subject and the questionnaire which has been conducted with consultants and experts in the field of the implementation of construction projects, the proposed organizational structure was applied to a project which has a deviation between actual and planned completion rates. The proposed system has proven its effectiveness through showing positive and clear results by reducing deviation in project duration during a short period of time.

Keywords: quality control, organizational structure, construction projects.

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تطوير هيكل تنظيمي لقسم السيطرة النوعية في الشركات الإنشائية

الخلاصة

ان المشروع الإنشائي يتميز كون كل مشروع له خصوصية ومتطلبات تختلف عن الاخر, وهذا يجعل من الصعب وضع حلول ثابته لكل المشاكل التي يواجه تنفيذ المشروع لذ, فعملية السيطرة النوعية على تنفيذ المشروع وأكمال بالمدة والكلفة والنوعية المحددة له وحلم جميع العاملين في هذا القطاع. وفي هذا البحث فقد اقترح هيكل تنظيمي لعمل قسم السيطرة النوعية في الشركات الانشائية بالاعتماد على المصادر العلمية التي تناولت هذا الموضوع والاستبيان الذي اجري مع استشاريين وخبراء في مجال تنفيذ المشاريع الانشائية , وقد طبق النظام المقترح لعمل قسم السيطرة النوعية على مشروع ظهر فيه انحرافا بين نسب الانجاز الفعلية والمخططة. وكان النظام المقترح فعال حيث اعطى نتائج واضحة ايجابية من خلال خفض نسبة الانحراف الحاصل في المشروع خلال مدة قياسية .

Introduction

The role of quality control department is in most construction companies, it is responsible of determining the percentage of completion of projects in order to pay and documenting the stops for future demands while modern management gives the quality control department much larger role through monitoring and treatment of projects problems which gives the opportunity to complete projects within the required time, cost and quality. Quality control department has a vital and sensitive role in construction projects. [1]

Quality control for construction projects

For construction projects, quality control means making sure things are done according to the plans, specifications, and permit requirements. The days of easy federal money seem to be over, making it imperative that communities get the most out of their infrastructure projects. One of the best ways to assure good construction projects is to use an inspector. The first step an inspector should take is to become familiar with the plans, specification, and permit requirements and, equally important, to have some common sense. Quality control during all construction phases needs to be better, and the utility system needs to know what is being installed while the work is being done. On most construction jobs, the inspection is one of the last things to be done—if it gets done at all. [2]

Factors affecting construction project quality

Establishing project requirements at the project inception stage could affect the quality of completed project. As [3] mentioned that, quality of any construction project is meeting the requirements of the designer, constructor and regulatory agencies as well as the owner. Accordingly, a careful balance between the owner's requirements of the project costs and schedule, desired operating characteristics, materials of construction, etc. and the design professional's need for adequate time and budget to meet those requirements during the design process is essential. Owners balance their requirements against economic considerations and, in some cases, against chance of failure [4]. The design professional is obligated to protect public health and safety in the context of the final completed project. The constructor is responsible for the means, methods, techniques, sequences, and procedures of construction, as well as safety precautions and programs during the construction process [4; 5]. The completion of project in accordance with the project requirements could be assured by the

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quality of its construction. Project requirements are the key main factors influencing construction project quality. However, it can be influenced by many factors. According to a study by [6], management commitment and leadership in construction organizations could affect construction quality. It is because, the poor management practices directly and indirectly lead to decline of construction productivity and ultimately effect on project quality. In construction terms, cost, schedule, and possibly quality goals are established for each project. Project managers are rewarded on the basis of meeting these goals [7]. Further, the quality teams provide companies with the structured environment necessary for successfully implementing and continuously applying the quality in construction [6]. As [6] further stated, extent of teamwork of parties participating in the design phase was found to be the most important factor that affects quality teamwork among parties such as Structural Engineers, Electrical Engineers, Environmental Engineers, Civil Engineers, Architects, and owners is essential to reach the quality goals for design. Further, in the construction phase, extent of teamwork of parties participating in the construction process was found to be very important.

The proposed organizational structure

In this research an organizational structure has been proposed in order to develop the work of quality control department. The information that has been used in developing the proposed organizational structure was gotten from literature review and open interviews with engineers and consultants who have experiments in executing construction projects.

In order to develop the work of quality control department and ensure work accuracy especially in large projects which involve working in several items in different places of the project at the same time, it was proposed to divide quality control department into three divisions as explained in figure (1). Table (1) shows the duties of each of the three divisions.

Fig 1.the proposed organizational structure

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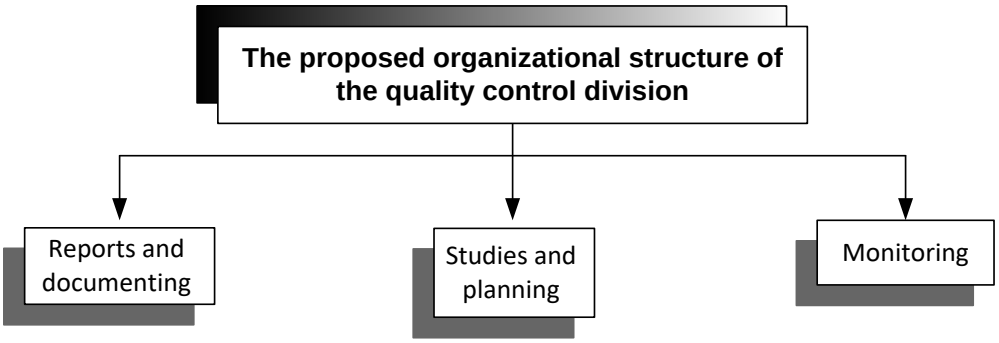

divisions	Duties
Reports and documenting	1. Create a form to follow up the work of the project. This form is changed according to the nature and size of the project. 2. Collecting forms of follow up the work to work every day from engineers at the site which contributes to save time engineers not to leave their positions especially when working in critical paragraphs which require the presence of Engineers. 3. Issuing a daily work progress reports after collecting them from site engineers 4. issue weekly progress reports 5. doing questionnaires when needed, and provide them to studies unite to analyze student the results
Studies and planning	1. monitoring the schedule of work progress and determine the percentage of completion 2. study and analysis of schedules of daily work progress 3. documenting and preserving of reports and meetings 4. studying and analyzing the recommendations of the Consultants 5. preparation of development and research studies 6. determining equipment that are needed the next day 7. Providing software programs that facilitate the work of reports and documenting 8. Creating a data base of information to be used in solving problems in the future.
Monitoring	1. Monitoring incoming and outgoing Email with the companies and the relevant authorities 2. preparing and arranging meetings and seminars 3. periodic meetings with the site engineers to discuss what has been achieved and the obstacles facing the workflow and the proposed plans for the next day

Table 1. duties of the department divisions

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Alqaherah-UR Bridge as a case study

The bridge consists of a main body, which connects the end of Jafar-Sadeq University Street, from the side of Alqaherah neighborhood with Ur neighborhood through Al-Jaish channel, In addition to four sub-approaches with vertical axes on the main axis, linking the directions of all traffic on the main body to Omar bin Al-Khattab and Imam Ali highways, which are parallel to Al-Jaish channel.

Total duration of the project = 390 days - duration of project contract (design + Execution).Total duration for the completion of key parts of the project = 307 days. Number of actual working days for completion of key project parts = 3009 days.

Applying the proposed organizational structure

The proposed organizational structure of the Department of quality control was applied in the company that executed the project. The Department of quality control consists of three Divisions as was been mentioned previously. The work of the three divisions is explained as the following:

1. studies and planning division

The main job of this division is organizing the work of the project; their duties can be summarized as the following:

a. Preparation of the planned time schedule of the project, which is the most complex studies, the most sensitive to changes in the field construction management. Planning time of construction projects overlap the four resources (4Ms: Man-Machine-Material-Money) which has a significant impact on the success of the planning process also the experience with the need to accommodate the planned potential of the implementing agency and the surrounding circumstances, whether internal or external .

b. In order to ensure the integrity of the work of Studies and Planning Division with other divisions in full control of the implementation of the project work; it was necessary to create an integrated information management system is closely linked to the timetable of the project, and included:

- Human Resources Management System
- warehouses and stores management system
- Fixed Assets System

The project was divided into 13 parts to facilitate preparing and monitoring of time schedules, each part was given a relative weight that was calculated from equation (1). Table (2) shows relative weights for all parts.

Table (3) explains actual Duration needed for each part, start and finish dates which can be determined according to activities involved in each part and productivity of workers and equipment. The finish date of the last part of the project will be the finish date of the project.

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$$\text{Relative weight for each part} = \frac{\text{planned dutation}}{\text{planned total project dutation}} \text{ ……..(1)}$$

Table 2. relative weight of each part

Parts	Days of work	Relative weight
LOT1	157	5.22
LOT2L	167	5.55
LOT2R	167	5.55
LOT3L	364	12.10
LOT3R	388	12.89
LOT4L	167	5.55
LOT4R	167	5.55
LOT5	119	3.95
LOT6	182	6.05
LOT7	162	5.38
LOT8	167	5.55
LOT9	162	5.38
LOT10	196	6.51
LOT11	157	5.22
LOT12	125	4.15
LOT13	162	5.38
	∑3009	100.00

Table 3. start and finish dates

No.	LOT No.	Starting Date	Duration (days)	Finish Date
1	1	20/6/2005	134	31/10/2005
2	2L	13/1/2006	93	15/4/2006
3	2R	4/12/2005	109	22/3/2006
4	3L	13/1/2006	101	23/4/2006
5	3R	13/1/2006	99	21/4/2006
6	4L	4/12/2005	110	23/3/2006
7	4R	13/1/2006	92	14/4/2006
8	5	27/6/2005	113	17/10/2005
9	6	23/6/2005	143	12/11/2005
10	7	1/8/2005	233	21/3/2006
11	8	9/7/2005	134	19/11/2005
12	9	6/9/2005	215	8/4/2006
13	10	9/7/2005	149	4/12/2005
14	11	19/8/2005	243	18/4/2006
15	12	1/8/2005	110	18/11/2005
16	13	30/10/2005	144	22/3/2006

Determinants that affected the specified durations and start dates for the project parts are as follows:

a. The duration of implementing the project is very little (390 days only) as compared to the large design and the many details and difficult circumstance that cast a dark shadow on the implementation inevitably, thus, many activities have been reduced to minimal implementation time.
b. The start dates of implementing parts (LOTs) were identified on the basis of the conflicts existing in the site and considering the limited templates; with an emphasis on planning that

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takes into account the accumulation of experience achieved in executing parts in the latter part of the project.

c. Incidental or emergency conditions Which occur on site required starting with the six approaches in the middle part, Which led to linking the date of completion of approaches to the completion of the common axes between them and the central part of the bridge

The success of any system depends on two main factors: self-sufficiency and adequacy of employees working in; to ensure continuous sustain and feed it with the correct data to get accurate results.

2. Reports and Documenting Division

The main job of this division is to prepare reports and documenting the results. In order to apply quality control principles, Reports and documenting division duties were as follows:

a. Develop an information form filled daily by Executive engineers in the project as shown in figure (2) ,and then answers gathered in one report (project progress report) as in figure (3).

b. Prepare questionnaires to evaluate certain situations in the project. For example a delay was accrued in the arrival of reinforcing steel to the project so that an assessment of metal workshop as it is one of the important sections in the project – as the project is a concrete bridge- was needed.

Reports and documenting division prepared a questionnaire to be filled by engineers in order to evaluate the work of metal workshop. The questionnaire results were analyzed by Studies and Planning Division; and the questions on the questionnaire evaluating the work of the workshop rebar steel as the follows:

1- Do you have schedule contain the amount and the type of the rebar steel which should be used in the site? The result answer is in fig. (4).

2-what is the period which submit request for the rebar steel from the workshop rebar steel? The result answer is in fig.(5).

3-is the rebar steel arriving in time? The result answer is in fig.(6).

4-is the reason for the delay in providing you with a rebar steel delay work on your site? The result answer is in fig.(7).

5-is your submit request for the rebar steel from the workshop rebar steel contain provide rebar steel progressively or full amount? The result answer is in fig. (8).

6-your submit request for the rebar steel contain the size (12, 16,20,25,32 mm)? The result answer is in fig.(9).

7-which type of the rebar steel delay providing when you required the size (12, 16,20,25,32 mm)? The result answer in fig.(10).

According to questionnaire results the following actions were applied to avoid delay in material arrival:

- Preparing an information form to be filled by executive engineer a week before starting the work in that part of project as in figure(11) , so that the metal workshop provide the needed amount of reinforcing steel with specified specifications
- Prepare another information form as in figure (12) to determine other resources that are needed for the work. This form must be applied a week before start date working in the intended part of project.

Fig 2. A form to be filled daily by execution engineers

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Table of quality control											
Date: Lot No.:											
	Resources (materials)		Resources (Equipment)		Human Resources(No.)						
note	Quantity and unit	material	No.	equipment	worker	Skilled worker	foreman	Eng.	Activity description	Activity No.	Seq.
quality control	Eng.										

Fig 3. The daily progress report of the project

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daily progress report			Date:		
accumulated implementation rate	Completion rate of activities%	Weight 0f activity	Activities which are implemented and under implementation	Lot No.	Seq.
				LOT1	1
				LOT2L	2
				LOT2R	3
				LOT3R	4
				LOT3L	5
				LOT4R	6
				LOT4L	7
				LOT5	8
				LOT6	9
				LOT7	10
				LOT8	11
				LOT9	12
				LOT10	13
				LOT12	14
				LOT13	15
Σ			accumulated implementation rate for all lots		
			Percentage of site preparation works		
			Percentage of design works		
Σ					

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Fig. from (4-10) are the results and explained of the questionnaire

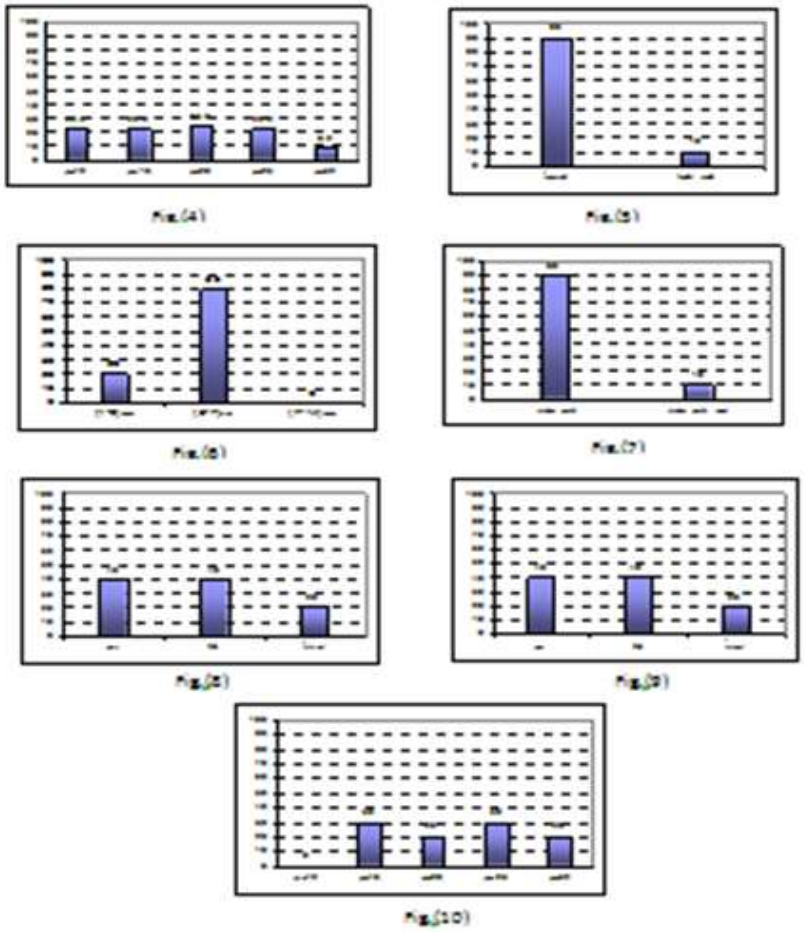

Fig 11 The daily need for rebar steel

Fig 12. Weekly request resource form

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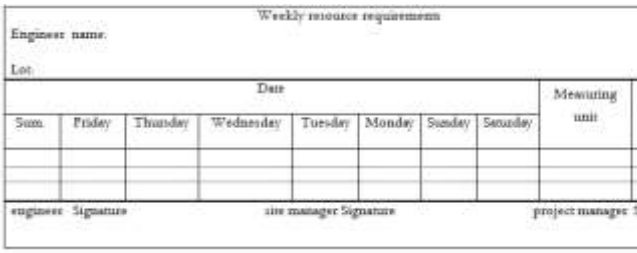
Report of the rebar workshop

No.:
Date:
Lot:

Rebar steel for the pile	Rebar steel for the column (ton)	Rebar steel for the pile cap (ton)	Rebar steel for the support wall(ton)	Rebar steel for the foundation (ton)	Diameter(mm)
					12
					16
					20
					25
					32

Engineer signature :



Weekly resource requirements

Engineer name:

Lot:

Date								Measuring unit
Sum	Friday	Thursday	Wednesday	Tuesday	Monday	Sunday	Saturday	

engineer Signature site manager Signature project manager

3. Monitoring division

The work of this Division is sensitive and important as it is related to project work progress within the planned schedule. Its work is based project work progress reports that are collected and compared with the planned schedule.

Analysis of reasons for the inability to achieve the planned completion ratio shows that 85% of delays (54% lack of commitment to the time schedule+31% lack of resources) are due to non-compliance to time schedule that was approved by senior management, as explained in table (4). Table (5) explains delays due to stops in project parts that have piles work.

The study and analysis of each part till 16/11/2005 as explained in table (6) and figure(13) , the finish date for the whole project can be at (3/7/2007) with (437)days delay.

Table (7) and figure (14) represent the completion of one part of the project analysis model.

Table 4. Reasons for delays in project parts up to 6/11/2005

Lot No.	Lack of commitment to the timetable	conflicts	Official holidays	Lack of resource	Referral of execution	Total delay duration	Time Weight for the lots	Work Duration in the lots	proportion of planned achievement up to 6/11/2005	
1	19	70	8			97	5.97%	154	100.00%	
2L	57		8	4		69	4.15%	93	92.20%	
2R.	71		8	2		81	4.73%	109	92.20%	
3L	23		2	58		83	4.24%	101	86.92%	
3R.	34		5	44		83	4.01%	99	89.74%	
4L	14			34		48	4.90%	110	44.93%	
4R.	6			34		40	4.10%	92	44.93%	
5	15		13	14		42	3.04%	113	100.00%	
6	28		13	8	30	79	6.38%	143	100.00%	
7	34		11	78		143	12.33%	233	92.59%	
8	25		9	30	30	64	3.97%	134	83.60%	
9	22		8	105		135	9.59%	215	92.59%	
10	39		10	5		54	6.64%	149	82.14%	
11	221					221	10.83%	243	91.08%	
12	67		13	10		90	4.90%	110	100.00%	
13	26		3			29	6.42%	144	34.58%	
Σ	53	4	7	31	4	98	100%			

Fig 13. The percentage of reasons for the delay in project parts

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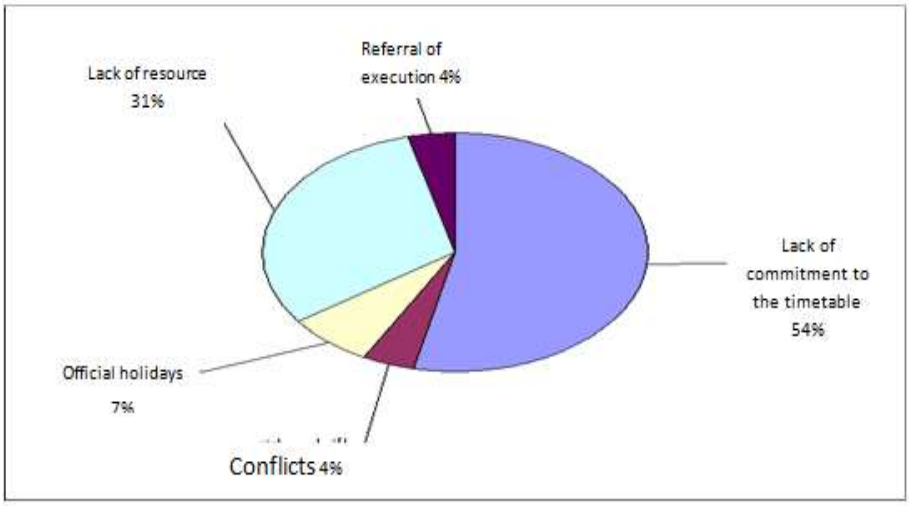

Table 5. Interruptions in work due to lack of piles excavators

The percentage of stops due to lack of piles excavators in the lots where piles are implemented up to 27/12/2008

Lot No.	Starting date	Num. of working days until the preparation of disclosure	Interruptions due to lack of piles excavators	The percentage of interruptions
3L	01/09/2008	113	97	85.84%
3R	01/09/2008	113	48	42.48%
4L	11/10/2008	77	51	66.23%
4R	11/10/2008	77	51	66.23%
11	29/11/2008	28	23	82.14%
		370	408	

Table 6. Actual and planned completion dates for projec

Lot No.	The planned date of completion.	Estimated date of actual achievement
1	31/10/2005	21/5/2006
2L	15/4/2006	2/9/2006
2R	22/5/2006	19/9/2006
3L	23/4/2006	3/7/2007
3R	21/4/2006	17/3/2007
4L	23/5/2006	21/7/2006
4R	2006/4/14	21/7/2006
5	17/10/2003	25/2006
6	12/11/2005	6/6/2006
7	21/5/2006	25/10/2006
8	19/11/2005	4/4/2006
9	6/4/2006	27/6/2006
10	4/12/2003	18/1/2006
11	18/4/2006	does not start in the work on it
12	18/11/2005	21/1/2007
13	22/5/2006	2/8/2006

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Table 7. the completion of one of project parts of analysis model

LOT 1

Achievement analysis until 2005 11 16

Ratio the actual to the planning	No actual days accumulated	No. of days as planning	The time weight for effective	Description of activity	No of activity
0.00	2	4	6.35%	Clean the site settled and planning	1.1
3.91	43	11	17.46%	Excavation of the natural ground level to the required depth	1.2
2.21	31	14	22.22%	Material processing and implementation of a layer of gravel mixed	1.3
1.33	12	9	14.29%	Pour weak concrete under the foundation	1.4
1.52	32	21	33.33%	Execution rebar for the foundation	1.5
1.25	5	4	6.35%	Pour concrete for the foundation	1.6
0.00	0	25	0.00%	Addition on rebar for the supportive walls	1.7
0.00	0	3	0.00%	Measurement templates for the supportive walls	1.8
0.00	0	3	0.00%	Pour concrete for the supportive walls	1.9
0.00	0	15	0.00%	Casting insulating material on material	1.10
0.00	0	24	0.00%	insulation by chemical engineering	1.11
0.00	0	19	0.00%	Materials preparation and Addition of a layer of gravel mixture to the stairs	1.12
1.98		157	63	sum	

No. of the days as planning for the other activity lot (1.7+1.12)=94 days

No. of the days as expect as productive =187 days

The date of actual achievement expected 6-21-05-2006 2005 11 16+187 days

•Note

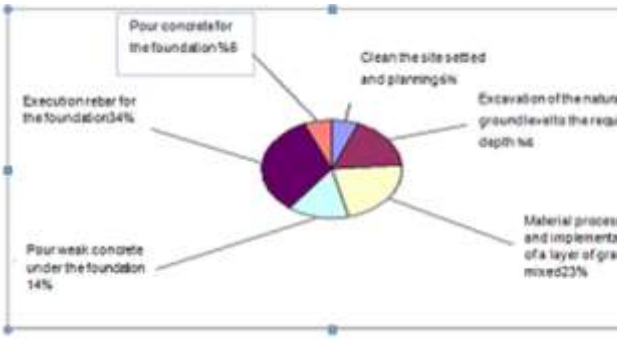
-The time weight for effective=(No .of days as planning for the activity/sum No .of days as planning for the activities which there work in it(1.1-1.6))

-Ratio the actual to the planning =No .of days as planning/No .actual days accumulated

-sum No .of days as planning for the activities which there work in it from1.1to 1.6 = 63

-No. of the days as expect as productive =Ratio the actual to the planning x No. of the days as planning for the other activity lot (1.7-1.12)

Fig 14. percentage of completion of one of project parts analysis model



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When comparing the planned achievement ratios with that are actually achieved, the proportion of the deficit in the implementation of time schedule stand out clearly, as explained in table (8).

When calculating the deficit ratio for the period from 28/9/2005 until 02/12/2006 and representing it in a diagram as in Figure (15), three parts can be characterized, as follows:

1. The first part represents an increase in the deficit ratio which ends at 26.93%.
2. The second part in which the curve flattens indicating the control of the deficit and stabilizes the rate between (26.34-26.05%).
3. The third part, which has a decrease in the deficit ratio to 12.69%, representing a recovery of nearly 14.24%, a healthy sign of the increase in daily productivity rates which is explained in the table (9).

Table 8. comparison between planned and actual completion percentage

Description	Planned percentage	Actual	Deficit percentage
1. planned Percentage of completion without stops	84.7	74.21	10.49
2. planned Percentage of completion with stops (including stops that were Officially installed including conflicts and public holidays and events)	83.78		9.57
3. planned percentage of completion with stops that include a lack of resources and referral implementation and conflicts, public holidays and events (for the purposes of quality control	82.61		8.4

Table 9. Detection of deficit ratios in the implementation of time schedule

Date of report	Proportion of planned achievement	The proportion of actual achievement	Deficit ratio	Disparities of Deficit ratios	Assessment deficit ratio
9/28/2005	44.91	34.42	10.48		
05/10/2005	47.27	35.9	11.37	0.89	Increase the d
12/10/2005	49.79	36.72	13.07	1.7	Increase the d
20/10/2005	53.7	37.33	16.37	3.3	Increase the d
27/10/2005	58.28	39.2	19.08	2.71	Increase the d
02/11/2005	61.6	40.23	21.37	2.29	Increase the d
16/11/2005	70.23	44.18	26.05	4.68	Increase the d
25/11/2005	74.91	47.98	26.93	0.88	Increase the d
03/12/2005	77.11	50.44	26.67	-0.26	decrease the r
16/12/2005	80.6	54.26	26.34	-0.33	decrease the r
28/12/2005	82.12	59.81	22.31	-4.03	decrease the r
14/01/2006	83.54	63.71	19.83	-2.48	decrease the r
26/01/2006	84.2	67.32	16.88	-2.95	decrease the r
07/02/2006	84.6	71.91	12.69	-4.19	decrease the r

*Note

-Deficit ratio=The proportion of the planned-The proportion of the actual
-Disparity by deficit =previous deficit ratio-present deficit ratio

Fig 15. deficit progression ratio between 5/9/2005 and 26/1/2006

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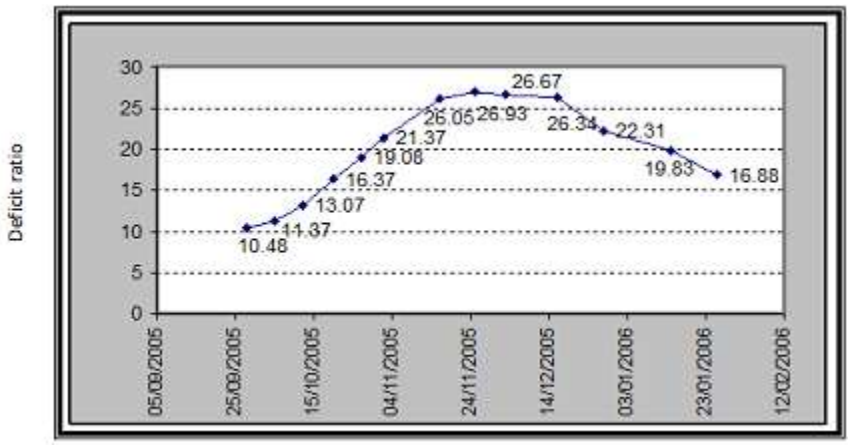

Conclusion

1- The proposed organizational structure of quality control department, which has been applied to a project (as case study) has proven its effectiveness by monitoring the decline in the deficit of the project completion rates.

2- In order to make the proposed organizational structure more effective, it is advised the existence of an operations research specialist or a construction management specialist in each division of the quality control department.

3- The problems and the solution that have been developed to solve them can be collected to develop an expert system for construction companies to facilitate the work in projects implementation. It can save time and expenses through the benefit of using the expert system in the engineering consulting when facing such problems in the future.

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