IMPACT OF UNPLANNED SCHEDULE COMPRESSION ON PROJECT COST

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ABSTRACT: The implementation of unplanned schedule compression is common in the construction environment. When necessary, contractors would need to select methods that also minimize the cost impact on the project. Unfortunately, a limited knowledge exists for determining the methods to be employed in mitigating these potential negative outcomes of higher project costs. This study investigates the frequency of local contractors having experience with unplanned schedule compression, the methods of unplanned schedule compression percentage of usage, and their impact on project costs. The research was based on interviews and questionnaire surveys with building contractors in Penang. An analysis based on numerical scale was conducted on the responses to obtain the average values of impact on project cost. From the analysis, it was concluded that majority of the respondents have experienced unplanned schedule compression. The most frequently used compression methods are working overtime, employing additional workers and using additional work-shift. The least frequently used methods are set-up crew and special material clean-up crew. Detail project planning, doing it right the first time and construction sequencing have the least impact on increasing project cost. Most contractors select their methods based on familiarity instead of carefully considering the impact on project costs.

Keywords – Unplanned schedule compression, schedule acceleration, project costs, building contractor.

1. Introduction

Schedule compression was defined as ‘a reduction from the normal experienced time or optional time typical for the type and size of project being planned within a given set of circumstances’ (CII, 1990). Unplanned schedule compression occurs when it is not anticipated and planned for before the commencement of the construction phase. It is a reactive approach which is caused by delay or project scope changes during the construction phase (Noyce and Hanna, 1998).

The necessity of implementing unplanned schedule compression is of paramount importance to the construction environment. For the interest of the project client, orders had been issued by the Public Work Department of Malaysia to contractors in order to accelerate the completion of certain projects (Chief, 2003). However, there is a tendency that project management to choose only methods that are familiar to them, instead of selecting methods that would minimize the cost and time impacts on the project. In most cases, they are inclined to resort to working overtime, use additional staff or additional shift, even though the overall impact of the methods is not clear. This paper determines the frequency of occurrence of unplanned schedule compression and the cost impact of different schedule compression methods on local construction projects.

2. Background

According to CII (1990), the primary reasons for compressing or accelerating the schedule of a construction project can be attributed to the following reasons:

a) To reduce total design-construct time from those considered normal;
b) To accelerate a schedule following owner's request; and
c) To recover lost time after falling behind schedule.

The necessity to implement unplanned schedule compression is very frequently found in current construction environment. In spite of whatever reason for schedule compression, the project integrity, as originally intended, must be maintained. In order to meet these requirements, normal construction procedures and manpower usages are altered in a way that generally leads to lower-than-normal productivity, thus creating less profit. When it is necessary to compress a construction schedule, project management is faced with selecting a method that minimizes the cost and time impacts on the project. The selected method must make effective use of resources, maintain the previously planned schedule and also preserve the activity sequence of the existing project plan. The determination of the most effective and economical way to achieve these requirements, in terms of labour productivity, is usually the most essential because project labour generally represents the most variable and largest percentage of the total project costs.

2.1 Concepts and Methods of Schedule Compression

Previous study has identified ninety four concepts and methods of compressing a schedule, which provides a practical and usable catalogue of concepts and methods used effectively for compressing a schedule in the construction industry (Noyce and Hanna, 1995). There is a need, to go beyond this by providing contractors with information about how to compress a schedule effectively by selecting the best concepts and methods that minimize the additional costs caused by schedule compression. Historical data and experience from other contractors, in both planned and unplanned schedule compression situations will become very significant and useful. The appropriate decision and methods of schedule compression selected by the contractor should be correlated closely to the given situations and constraints, which will minimize the potential of financial losses. The primary purpose of this study is to develop a better understanding on the impact of unplanned schedule compression on project productivity elements that would subsequently have impact on project costs. There are relatively few experimental studies that have directly measured the effects of compressed schedule period as compared to the traditional schedule period (Duchon and Smith, 1993). The majority of literature related to planned and unplanned schedule compression only evaluates the humanistic impacts of such action in terms of labour productivity. Schedule compression is commonly regarded as a time-cost trade-off problem, with the trade-off between the amount of compression and the consequent increase in direct costs due to schedule compression (CII, 1988). Therefore it is important to recognize the impact of unplanned schedule compression on project costs so that people can learn and change their current practice, if cost impact had never been assessed before.

CII (1990b) had divided the methods of schedule compression into different level of applicability:

a) Applicable to all phases of a project,
b) Engineering phase,
c) Contractual approach,
d) Scheduling,
e) Materials management,
f) Construction work management,
g) Field labour management, and
h) Start-up phase.

Each of the levels stated above has been found of value to reduce time or to help prevent loss of time by project managers at specific period. They have general and limited applications, which some will save cost while others will increase cost. They can be used as catalogue of ideas and techniques that comprise a checklist for management to consider when addressing the subject of schedule compression. Many of the ideas are simply good management practice in that they should be standard for management to include if applicable to the project at hand. Others are essentially "emergency" techniques to be considered only when the advantages of schedule compression outweigh the higher cost or other drawbacks associated with them.

3. Methodology

3.1 Research Design

A multi-method approach was used in this study where both quantitative and qualitative methods were applied. A multi-method approach has a potential of enriching and cross-validating research findings (Irumba and Rennie, 2004). Structured questionnaires and interviews were used to collect data from respondents.

3.2 Sampling and Respondent

The respondents of this study comprise contractors of G7, G6 and G5 'B-building' category in Penang, who have undertaken building construction projects and registered with the Construction Industry Development Board of Malaysia. There are currently a total of 240 contractors registered in that category.

From previous studies, a sample size of 30 is considered adequate for statistical analysis based on 15% response rate (Engineering Statistic, 2003; Mui et al, 2004). The studies also recommended a ratio of 1 interview for every 10 questionnaires as substantial backups. Based on that, the actual sample size derived for questionnaire and interview in this study were 142 and 4, respectively.

3.3 Questionnaire Design

Literature review was carried out in order to identify the existing methods of unplanned schedule compression that were considered effective and being practiced in the construction industry. Findings from literature review were used in the development of the pilot survey and interviews conducted in order to validate the methods initially found. Feedbacks from the pilot survey were then used to develop and fine-tune the questionnaire for the final survey.

The final questionnaire was divided into three sections, namely respondent background and information; methods applied and impact on project costs; and additional questions. The first section was used to collect information regarding the background of the respondents. In the second section, respondents were asked to provide whether they have experienced any form of unplanned schedule compression in their current and previous projects. This second section subsequently provided the rank of the most and least frequently used methods of unplanned schedule compression. The data were collected based on a numerical scale adopted from previous study (Noyce and Hanna, 1998). The scale for impact on project cost used was:

1 = significantly decreased;
2 = moderately decreased;
3 = no effect;
4 = moderately increased; and
5 = significantly increased;

if the specific methods of schedule compression were selected and applied. Data were collected using the form shown in Table 1.

3.4 Data Collection

The final questionnaires were distributed randomly to 142 construction contracting companies in Penang. A total of 26 questionnaires were returned, yielding a slightly higher response rate (18.3%) than expected (15.0%). 3 companies were willing to be interviewed.

4. Results and Discussion

From the 26 companies that have responded, 21 companies were from category G7, 2 companies from G6 and 3 companies from G5. The respondents have given their insights on unplanned schedule compression based on their experience involving in constructing several building projects. 92% of the respondents indicated that they have experienced some forms of unplanned schedule compression. Table 2 contains all the categories and methods identified and to be reviewed by the respondents. There are 5 categories, which are labour, material, construction method, equipment & tools, and organization. These categories contains project productivity elements that usually have impact on project costs.

Table 3 shows the overall popularity ranking of the methods based on the percentage of usage by respondents. It was found that working overtime (96%) was the most frequently applied method, followed by employ additional workers (92%) and use additional work shift (88%). Also from Table 3, special material clean-up crew (17%) was found to be the least frequently used methods. Use set-up crew (0%) was the only method that has not been tried or applied by the respondents. The percentage of usage ranged from 0% to 96%. All respondents have also stated in the questionnaire that methods were selected mostly based on familiarity only, and not by considering their impacts on project cost. Most respondents also claimed that they have no confidence in trying or using other methods.

Table 4 displays the methods that have been ranked according to their impact on increasing or reducing project cost by using the average response value. It is shown in Table 4 that five out of the top-ten methods come from construction method category, four from organization category and one from material category. From the analysis, the method ranked with the highest impact was detailed project planning, followed by get the work done right the first time and construction sequencing. Three methods that have the lowest impact on project cost were working overtime, employ additional workers and use additional work-shift. The standard deviations of the listed methods were mostly less than 1, which indicate good data consistency.

By comparing the chosen methods and their impact on project costs (Table 5), it is clearly shown that the top three most frequently used methods are also the three methods that have the highest impact on project cost. In other words, these methods were regarded as top choice by the respondents regardless of their negative impact (increase) on project cost. The results of this study have shown some similarity to a previous study (Noyce and Hanna, 1998), even though the respondents of their study were selected from electrical industry. Therefore, it is important for project manager to review and reconsider their choice of compressing project schedule so that impact on project cost is minimal.

Table 1. Form used for collecting data

	Unplanned Methods of Schedule Compression	Please tick your choice (v) below.						
		Have you used this method during unplanned schedule compression ?		If yes, what is the impact on project cost ? (Please refer to the scale)				
		Yes	No	1	2	3	4	5
A	**Labour**							
1	Working Overtime							
2	Employ Additional Workers							
3	Use Additional Work Shift							
4	Use Set-Up Crew							
5	Shift to Smaller Crew							
6	Use Special Crew for Variation Order Work							
B	**Material**							
1	Just-In-Time Delivery							
2	Special Material Handling Crew							
3	Special Material Clean-Up Crew							
4	Assign Material Coordinator							
5	Establish Clear Zone Area							
6	Deliver As Much Material As Practical							
7	Optimal Material Management for Critical Items							
C	**Construction Method**							
1	Schedule Task in Repetition							
2	More Detailed Subcontractor Schedule							
3	Get the Work Done Right the First Time							
4	Look for Short Cut in Process							
5	Alternate Construction Method (other than IBS)							
6	Construction Sequencing							
7	Use IBS / Prefabricated / Preassembled Components							
D	**Equipment And Tools**							
1	Develop Tool Management Programme							
2	Increase Inventory of Spare Parts & Tools							
3	Increase Equipment & Tools Maintenance							
4	Additional Plant							
E	**Organisation**							
1	Provide Employees with Incentives							
2	Staff Project with Most Efficient Crews							
3	Avoid Interruptions							
4	Proactive Schedule Management / Front-End Planning							
5	Participative Management							
6	Detailed Project Planning							
7	Reduction of Task Scope to Milestone Act							
8	Increase Supervisor/Worker Ratio							
9	Using Scheduling Techniques, e.g. CPM, PERT							
10	Include Weather Delays in Schedule							
11	Pre-Work Crew Briefing							
12	Monitor Absenteeism for Trends							
13	Subcontractors and Joint Venture							
14	Using Time-Cost Trade-Offs Analysis							
F	**Other methods, please specify**							
1								

Table 2. Categories for unplanned methods of schedule compression

	Unplanned Methods of Schedule Compression
	Labour
L1	Working overtime
L2	Employ additional workers
L3	Use additional work shift
L4	Use set-up crew
L5	Shift to smaller crew
L6	Use special crew for variation order work
	Material
M1	Just-in-time delivery
M2	Special material handling crew
M3	Special material clean-up crew
M4	Assign material coordinator
M5	Establish clear zone area
M6	Deliver as much material as practical
M7	Optimal material management for critical items
	Construction Method
C1	Schedule task in repetition
C2	More detailed subcontractor schedule
C3	Get the work done right the first time
C4	Look for short cut in process
C5	Alternate construction method (other than IBS)
C6	Construction sequencing
C7	Use IBS/Pre-fabricated/Pre-assembled
	Equipment And Tools
E1	Develop tool management programme
E2	Increase inventory of spare parts and tools
E3	Increase equipment and tools maintenance
E4	Additional plant
	Organisation
O1	Provide employees with incentives
O2	Staff project with most efficient crews
O3	Avoid interruptions
O4	Proactive schedule management / Front-end planning
O5	Participative management
O6	Detailed project planning
O7	Reduction of task scope to milestone act
O8	Increase supervisor/Worker ratio
O9	Using scheduling techniques, e.g. CPM, PERT
O10	Include weather delays in schedule
O11	Pre-work crew briefing
O12	Monitor absenteeism for trends
O13	Subcontractors and joint venture
O14	Using time-cost trade-offs analysis

Table 3. Popularity ranking based on percentage of usage

		Unplanned Methods of Schedule Compression	% of usage
1	L1	Working overtime	96
2	L2	Employ additional workers	92
3	L3	Use additional work shift	88
4	O6	Detailed project planning	79
5	C3	Get the work done right the first time	79
6	C6	Construction sequencing	75
7	M6	Deliver as much material as practical	71
8	E3	Increase equipment and tools maintenance	71
9	O9	Using scheduling techniques, e.g. CPM, PERT	71
10	C2	More detailed subcontractor schedule	67
11	C4	Look for short cut in process	67
12	C5	Alternate construction method (other than IBS)	67
13	O2	Staff project with most efficient crews	67
14	O3	Avoid interruptions	67
15	O11	Pre-work crew briefing	67
16	C7	Use IBS/Pre-fabricated/Pre-assembled	63
17	E1	Develop tool management programme	63
18	E2	Increase inventory of spare parts and tools	63
19	C1	Schedule task in repetition	58
20	O1	Provide employees with incentives	58
21	O5	Participative management	58
22	E4	Additional plant	54
23	O4	Proactive schedule management / Front-end planning	54
24	O8	Increase supervisor/Worker ratio	54
25	M1	Just-in-time delivery	50
26	O7	Reduction of task scope to milestone act	50
27	O10	Include weather delays in schedule	50
28	M7	Optimal material management for critical items	46
29	O13	Subcontractors and joint venture	46
30	L6	Use special crew for variation order work	42
31	M2	Special material handling crew	42
32	M4	Assign material coordinator	42
33	M5	Establish clear zone area	42
34	O12	Monitor absenteeism for trends	42
35	O14	Using time-cost trade-offs analysis	38
36	L5	Shift to smaller crew	25
37	M3	Special material clean-up crew	17
38	L4	Use set-up crew	0

Table 4. Ranking according to impact on project cost

		Unplanned Methods of Schedule Compression	Impact on Project Cost	
			Average	Std. deviation
1	O6	Detailed project planning	2.00	0.67
2	C3	Get the work done right the first time	2.26	0.56
3	C6	Construction sequencing	2.33	0.59
4	O5	Participative management	2.36	0.63
5	M2	Special material handling crew	2.50	0.53
6	C1	Schedule task in repetition	2.57	0.51
7	C4	Look for short cut in process	2.69	0.79
8	O9	Using scheduling techniques, e.g. CPM, PERT	2.71	0.59
9	C2	More detailed subcontractor schedule	2.75	0.45
10	O7	Reduction of task scope to milestone act	2.75	0.45
11	O4	Proactive schedule management / Front-end planning	2.77	0.44
12	O14	Using time-cost trade-offs analysis	2.78	0.44
13	O3	Avoid interruptions	2.81	0.40
14	O11	Pre-work crew briefing	2.88	0.34
15	O12	Monitor absenteeism for trends	2.90	0.32
16	M1	Just-in-time delivery	2.92	0.67
17	O10	Include weather delays in schedule	2.92	0.29
18	E1	Develop tool management programme	2.93	0.26
19	M5	Establish clear zone area	3.00	0.00
20	M4	Assign material coordinator	3.10	0.57
21	C5	Alternate construction method (other than IBS)	3.13	0.81
22	L5	Shift to smaller crew	3.17	0.41
23	M7	Optimal material management for critical items	3.18	0.40
24	M3	Special material clean-up crew	3.25	0.50
25	E3	Increase equipment and tools maintenance	3.29	0.69
26	O13	Subcontractors and joint venture	3.36	0.50
27	C7	Use IBS/Pre-fabricated/Pre-assembled	3.40	1.06
28	E2	Increase inventory of spare parts and tools	3.40	0.51
29	O2	Staff project with most efficient crews	3.50	0.52
30	M6	Deliver as much material as practical	3.53	0.51
31	O8	Increase supervisor/Worker ratio	3.69	0.63
32	E4	Additional plant	3.77	0.73
33	O1	Provide employees with incentives	4.00	0.00
34	L6	Use special crew for variation order work	4.00	0.67
35	L3	Use additional work shift	4.05	0.67
36	L2	Employ additional workers	4.50	0.51
37	L1	Working overtime	4.57	0.51
38	L4	Use set-up crew	-	-

Table 5. Relating methods of schedule compression to their impact on project cost

Unplanned Methods of Schedule Compression			% of usage	Impact on Project Cost Average
1	L1	Working overtime	96	4.57
2	L2	Employ additional workers	92	4.50
3	L3	Use additional work shift	88	4.05
4	O6	Detailed project planning	79	2.00
5	C3	Get the work done right the first time	79	2.26
6	C6	Construction sequencing	75	2.33
7	O9	Using scheduling techniques, e.g. CPM, PERT	71	2.71
8	E3	Increase equipment and tools maintenance	71	3.29
9	M6	Deliver as much material as practical	71	3.53
10	C4	Look for short cut in process	67	2.69
11	C2	More detailed subcontractor schedule	67	2.75
12	O3	Avoid interruptions	67	2.81
13	O11	Pre-work crew briefing	67	2.88
14	C5	Alternate construction method (other than IBS)	67	3.13
15	O2	Staff project with most efficient crews	67	3.50
16	E1	Develop tool management programme	63	2.93
17	C7	Use IBS/Pre-fabricated/Pre-assembled	63	3.40
18	E2	Increase inventory of spare parts and tools	63	3.40
19	O5	Participative management	58	2.36
20	C1	Schedule task in repetition	58	2.57
21	O1	Provide employees with incentives	58	4.00
22	O4	Proactive schedule management / Front-end planning	54	2.77
23	O8	Increase supervisor/Worker ratio	54	3.69
24	E4	Additional plant	54	3.77
25	O7	Reduction of task scope to milestone act	50	2.75
26	M1	Just-in-time delivery	50	2.92
27	O10	Include weather delays in schedule	50	2.92
28	M7	Optimal material management for critical items	46	3.18
29	O13	Subcontractors and joint venture	46	3.36
30	M2	Special material handling crew	42	2.50
31	O12	Monitor absenteeism for trends	42	2.90
32	M5	Establish clear zone area	42	3.00
33	M4	Assign material coordinator	42	3.10
34	L6	Use special crew for variation order work	42	4.00
35	O14	Using time-cost trade-offs analysis	38	2.78
36	L5	Shift to smaller crew	25	3.17
37	M3	Special material clean-up crew	17	3.25
38	L4	Use set-up crew	0	-

5. Conclusions

In conclusion, it was found that except for use set-up crew method, all thirty seven methods of unplanned schedule compression presented in the questionnaire survey were identified as applicable methodologies in the local construction industry. 92% of the respondents indicated that they had experience some forms of unplanned schedule compression.

Methods that have lowest impact on project cost from this study were detailed project planning, followed by get work done right the first time and construction sequencing. However, their percentages of usage were only between 42% and 79%. Methods that have the

highest impact on project cost were working overtime, followed by employ additional workers and use additional work-shift. The most frequently used methods were working overtime, followed by employ additional workers and use additional work-shift. It was found that despite being the three most popular methods in reducing project time, they have actually caused project costs to increase from a moderate to significant amount.

Since the respondents indicated their knowledge of the negative impacts of working overtime, employing additional workers and use additional work-shift, some curiosities remain unanswered for the reasons of the high percentage of usage plus the little resistance to implementation. Even though a few contractors may believe that they will be able to recover these additional costs at the end of a project, if the constructor were aware of other methods that have a more positive impact on project costs, these 'more effective' methods should have been made as their first choice.

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