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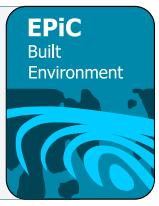

Comparison of Construction Scheduling Perspectives from General Contractors and Sub-Contractors: An Analysis of Current Tools and Practices

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Construction project managers are continually seeking to balance the limited resources of time and money. To do this, collaborative management is critical. Most importantly, communication is the key to collaborative management. One of the most important forms of communication is the creation of a project schedule. Information on the tools and practices used by industry can help improve these practices for managers. Likewise, decision makers in the industry should understand trends to see if they align with peers, or to find justification for differences. The objectives of this study are to determine the tools used to create a project schedule, who is creating the schedule, and how often the schedule is communicated. The study is a comparison of views from the perspectives of the general contractors and that of the subcontractors. Additionally, the study examines the perceptions of general and subcontractors to determine the causes of schedule delays. This study is a report of commercial contractors performing work in the United States that provides information on the tools and practices currently used in construction scheduling. This study is valuable for industry leaders and academics seeking information about scheduling tools, practices and perceptions that can be implemented into a company scheduling culture or used for instructional purposes.
Key Words: Construction Scheduling, Construction Project Management, General Contractor, Sub-Contractor, Schedule Delay

Introduction

Collaborative management is critical to balance the limited resources available during the construction process (Oglesby 1998). The project schedule is one of these critical collaboration tools. A manger may be well prepared to construct, but project success is not a matter of being able to construct the project, it is a matter of being able to communicate the plan to everyone else involved in the project (Newitt 2009). The schedule is a communication tool using graphs and numbers that show if the estimated decisions together achieve the workable purpose (McCarthy 2010). The construction schedule can be a valuable tool that can lead to the success or failure of a project. Understanding the practices used by construction managers to put together a schedule, as well as how that schedule is

used in the execution of project tasks can be helpful in improving project outcomes. Successful managers will want to learn from others in similar positions about the specific software used to manage schedules, how often project schedules are updated, and the type of analysis that helps in the planning of valuable resources like time and money. An analysis of the effectiveness of that communication is also helpful. This study tests that effectiveness by examining the perceptions of general contractors and subcontractors reporting on the causes of issues with the project schedule. This research reports on a study of commercial contractors working in the United States and provides information on the tools and practices currently used in construction scheduling. The study describes the perspectives of general contractors and subcontractors in relation to project schedules. Comparisons are made between the perceptions of how the scheduled is managed from the general contractors' and subcontractors' points of view. This research provides an overview of the current state of practice within construction scheduling industry.

Background

Some have observed that construction scheduling has moved back in time to the common bar chart (Wickwire 2000). With great scheduling tools available, it seems that the industry is slow to adopt these more sophisticated tools and practices (2000). Construction companies should, as a minimum, use the most basic of scheduling principles to prevent inefficiency and chaos (Williams 2010).

The use of the Critical Path Method (CPM) for an example, is one of the most widely accepted scheduling techniques (Hutchings 2004). Yet still it seems that some construction companies have not adopted the use of CPM software to help manage their projects. The majority of construction companies, however, do implement and use CPM or other scheduling methods and software (Liberatore et. al 2001). A study by Lieratore et. al in 2001 found that construction management professionals were more educated and experienced in scheduling than their business equals outside of construction. The study also found that the main scheduling tool used by general contractors was Primavera® (Primavera, Inc., Bala Cynwyd, Pa.). Microsoft Project® (Microsoft Corp., Redmond, Wash.) was also widely used. These studies are now more than 10 years old, it is evident that more recent information about the tools being used in the industry today is needed. Because construction is ever-changing and progressing, having more updated information about scheduling software can be valuable for industry and for those training future industry members.

A portion of this study deals with determining who is responsible for schedule overruns. Perceptions of general contractors and subcontractors regarding who is responsible for schedule overruns is reported. A literature review of managers' perceptions about responsibility for schedule delays resulted in few significant works. Because some of the biggest lawsuits relating to construction are related to delay claims, this should be an area of increased focus in the industry and the classroom (Newitt 2009). A recent book *Construction Delays* discusses the responsibilities of delay (Trauner et al. 2017). The determination of responsibility was analyzed by a comparison to the contract. Additionally, communication through submittals, daily reports, meeting minutes, schedule updates, design drawings, estimates and other communication tools were used as contract-like documents that could help determine responsibility for project delays (2017). This book did not report on actual data about project delays but was rather instruction on how responsibility could be determined. Actual project data and comparisons like the ones found in the paper are needed to determine where improvements to project delays could be made. Multiple studies were found that identify factors leading to the delay of project schedules. They do not identify who is responsible for these delays. Larsen et al (2016) identified 26 factors leading to delays. Other works like Kazaz et al. (2012), Fugar et al. (2010), and Yang et al. (2010), either identified delays specific to an individual country or in the

example of Yang et al., delays specific to a portion of the construction process like the design phase. Once again, the gap in the literature is found when trying to determine who is responsible for the delays, or the opinions of managers as to whom is responsible. Future work should focus on compiling all the identified causes for schedule delays and determining the primary responsible parties for each factor.

Research Methodology

The research data represented in this paper resulted from a survey sent out to commercial contractors working in the United States. Surveys were collected from subcontractors (Subs) and general contractors (GCs). The survey was created by the principle researcher and given to a GC and a subcontractor to evaluate the questions. These interviews consisted of asking the survey questions as they were written and allowing the participants to ask clarifying questions. This led to the modification of survey questions and further interviews confirming the intent of the questions were clear. After a modification of survey questions based on the industry feedback, a finalized survey was then sent to commercial contractors through an online survey. Commercial companies fitting in the study demographics were targeted and an individualized survey was sent to managers within the construction company. In total, 62 subs and GCs participated in the survey. Survey data was collected, compiled, and analyzed the data and the findings are reported in this paper. Data was used to answer several research related questions. First, who is creating the project schedule and what type of input are they using from outside sources? Second, what scheduling software is being used by the contractors, and what software is being used by the sub-contractors. Third, how often is the project schedule discussed as a project team, how often is it updated, and how often are updates communicated? Fourth, what are the perceptions of GCs and Subs about the reasons for not meeting schedule deadlines? Many statistical tools were used for analysis of the data including grouping of demographic data, comparisons of means, analysis of variance, and box and whisker plots.

Boxplots provide information such as the median, interquartile range, outliers, and extremes. The median is demonstrated using a straight horizontal line. The box around the median gives the interquartile range with the bottom end showing the 25th percentile and the upper end depicting the 75th percentile. Fifty percent of responses are found within this interquartile. The median demonstrates the central tendency, while the box around it shows variability. If the line is not in the middle of the box, then the distribution is skewed. Vertical lines extend past the box, both above and below, demonstrating the largest and smallest values that are not considered outliers or extremes.

Research Findings

The survey was limited to GC's and Subs in the commercial construction sector of the industry. Of the 62 surveys administered, 40 surveys fit the limitations of the study. Limitations included performing the majority of their work in the United States, and having an average contract amount of at least 50,000 dollars. There were 23 GCs and 17 subcontractors who completed the survey and met study parameters. Respondents held multiple positions in construction industry from project engineers to executives. Nine respondents from the GCs were project executives, seven were project managers, two were project engineers, and five were project superintendents. For GCs, the average size contract ranged from under 1 Million to over 50 Million US dollars. The overall average contract size for all the projects was 10 million. Subcontractors average contract size ranged from 50,000 to over 1 Million, with an average contract amount of $150,000.

One purpose of the study was to find which tools are being used in construction scheduling, including specific software. The first question was given only to GCs who are primarily responsible for creating project construction schedules. Figure 1 shows the responses for the 23 contractors surveyed.

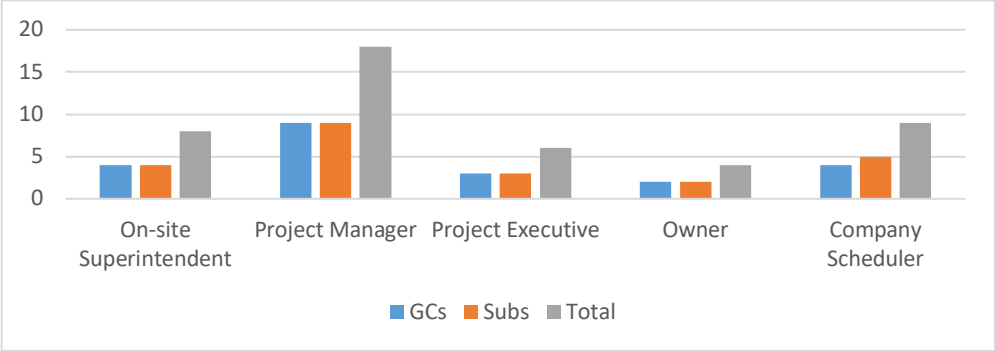


Figure 1. Who Creates the Schedule

Construction schedules were created by various people within the GC organization but for most companies that role was typically given to the project manager. Shown in Figure 1, schedules are also created by company schedulers, superintendents, or others. The size of the construction company and the type and size of the project are factors that influence who prepares the schedule.

When a schedule is created, improvements to the schedule can be made by getting input from subcontractors. According to those surveyed, there is a discrepancy in the amount of times the GCs are using subcontractor input to create the schedule and the percentage of the time subcontractors report being asked for input into the creation of the schedule. According to contractors they involve subcontractors in the creation of the schedule 70 percent of the time. Conversely, subcontractors reported they were included 56 percent of the time.

General contractors reported that they create 100 percent of the schedules for their projects. Subcontractors were asked if they created and managed a separate schedule from the main project schedule. Seventy percent of the subcontractors reported creating a separate schedule for their projects. There are multiple software tools available for the creation and management of schedules. The subjects of the study reported which tools they used on their projects (see figure 2).

There can be many advantages to having a project manager put together schedule. The project manager is the main point of contact for a project and has dealing with the day to day activities. They are more intimately involved in the details of the project. A company scheduler isn't always around for the day to day activities and may not have the detailed focus that may be needed. However, for some companies, it might make sense to have a company scheduler for efficiency in setting up the software, consistency in scheduling techniques, and management and tracking of resources at a company level. Similar arguments could be made about the use of a superintendent or project executives in the creation of the schedule.

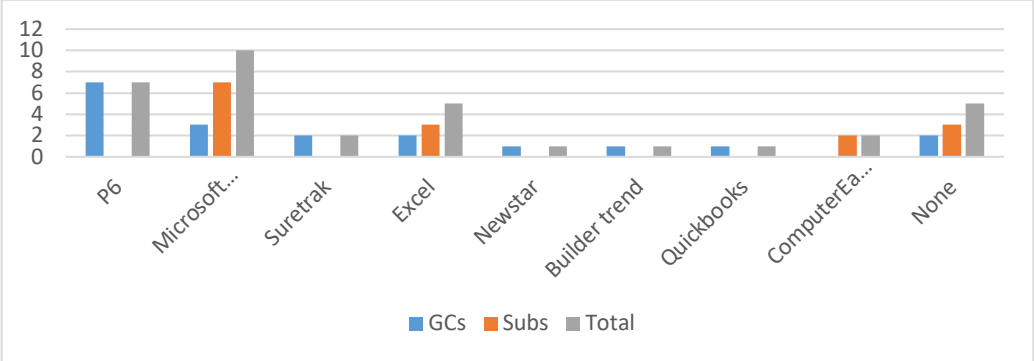


Figure 2. Construction Software Use

Overall, Microsoft Project was the software most used by all respondents. Commercial General Contractors reported that they primarily used Primavera's P6® (P6) to create and manage their projects followed by Microsoft Project® (Project). Discussions with GCs have led the authors to believe that many factors influence the software used for scheduling. Companies with smaller projects, and smaller companies in general, primarily use Microsoft Project. This is most likely due to the low cost of the software in comparison to the other CPM software. Additionally, subs may not feel the need to track resources or cost at a company level using a scheduling software. Project does not have the capability of tracking multiple schedules and compiling information at a compony or enterprise level, P6 does have this capability. One factor the authors found interesting was that in follow-up questions with the GCs in the study, it was found that the selection of the software to use was based on which software was being taught in the universities. Many contractors sited that P6 and Microsoft Project were being taught in the classroom which was a primary motivating factor for using that software in the field. Cost also played a role in their decision of which software to use. Microsoft Project was viewed as the least-cost option. Suretrak® was still used by a few GC's even though it is no longer updated or supported by the software creator. Still some were using what would be considered non-logic based or Critical Path Method (CPM) software, like Excel®, to create and manage their schedules. Future research is needed to understand the ties between the selection factors such as cost and project or company size with the specific software used by the company.

According to the subcontractors surveyed, over 90 percent of general contractors are discussing the project with the subs at least weekly. Table 1 shows the frequency of collaborations from the perspective of the GCs as well as from the perspective of the Subs. GCs and subs generally agree on how often the schedule is discussed. In fact, subs have the perception that the schedule is discussed more often than the GCs might realize. There are some surprising results shown here that for some projects the schedule is still rarely or never discussed. Overall this finding is favorable for construction mangers. They are discussing the schedule often, which is a recommended best practice for successful projects.

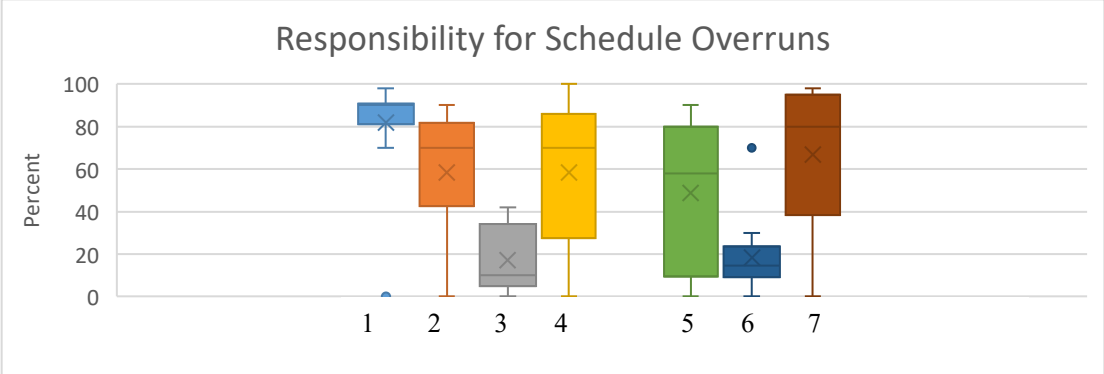
Table 1

Schedule Coordination and Updating

	How often do you (GC) discuss the project schedule with subcontractors?		How often does the GC discuss the schedule with you (sub)?		As a General Contractor, how often is the project schedule updated?		How often is an updated schedule communicated to you as a subcontractor?	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Monthly	-	-	-	-	4	20%	2	13
Weekly	13	65%	12	80%	14	70%	11	73%
Daily	3	15%	2	13%	-	-	-	-
Bi-monthly	1	5%	-	-	1	5%	-	-
Once	1	5%	1	7%	-	-	2	13
Never	1	5%	-	-	1	-	-	-
Bi-weekly	1	5%	-	-	-	-	-	-

In terms of schedule updates contractors reported that the schedule was updated on a weekly if not monthly basis. These updates were reportedly being shared with subcontractors at a similar time interval. Subcontractors reported receiving weekly updates 73 percent of the time and at least monthly updates 87 percent of the time. Table 1 gives a breakdown of how often the schedule was updated and then communicated to subcontractors.

One important finding from the survey dealt with understanding the sources of schedule overruns. Multiple survey questions asked general contractors and subcontractors their perception on who was to blame for schedule overruns. Figure 3 provides a visual representation of the comparison in the form of a box and whiskers plot between the perceptions of these two groups. As one might predict, both groups blame the other group as the primary contributor to schedule overruns. Subcontractors felt that they were finishing their scope of work within the allotted time 87 percent of the time. They also felt that they finished on the original dates 62 percent of the time. When we compare that with the perception of the GC the number are close. GCs felt that durations and dates were on time 70 percent of the time. The biggest differences come from the cited source or reason for the delays in construction. From the perspective of the Subcontractors, they felt that they were to blame for only 19 percent of schedule delays. Subs felt that GCs were responsible for 62 percent of the delays. On the other hand, GCs felt that the subs were to blame for 51 percent of the delays, and that they were only responsible for 18 percent of schedule delays. Schedule delays cause undesirable outcomes for all the parties involved, and at times litigation is needed to sort out who is actually to blame for schedule delays. Understanding this dynamic between GCs and Subs is important to understand and discuss as it could lead to better scheduling practices.



1	2	3	4	5	6	7
As a subcontractor, what percent of time do you finish your scope of work within the allotted duration?	As a subcontractor, what percent of the time do finish your scopes of work on the originally scheduled dates?	From your perspective as a GC, what percent of the time are schedule overruns caused by the general contractor?	From your perspective as a subcontractor, what percent of the time are schedule overruns caused by the General Contractor of the project?	From your perspective as a GC, what percent of the time are schedule runs caused by the subcontractors?	What percentage of the time are schedule overruns caused by you as a subcontractor?	What percent of the time do your projects finish on the projected schedule deadline? (GC)
87%	**62%**	**18%**	**62%**	**51%**	**19%**	**70%**

Figure 3. GC and Sub Schedule Perceptions

Conclusions

With any project, a key contributor to project success is the project schedule. Significant time and energy should be put into good scheduling techniques as well as to provide training in software related to construction scheduling. Information on the types of construction scheduling software that are being used by subcontractors and general contractors is valuable for both industry and educational purposes. This paper showed that the main software used is Microsoft Project. P6 is also used, but primarily used more by the GCs. There is still other CPM software used and even non-CPM software used by commercial contractors. Common scheduling practices showed that a high percentage of GCs are discussing the project on at least a weekly basis (90 percent). Schedule updates are happening on at least a monthly basis for 90 percent of the contractors surveyed. Subs report that these updates are communicated to them at a similar rate. These percentages are sign that high levels of collaboration are happening between project stakeholders which has been shown to improve project success.

Subcontractors reported finishing their scope of work within the allotted time 87 percent of the time, and finishing on the original dates 62 percent of the time. From the perspective of the GCs projects finished on time 70 percent of the time. From the perspective of a subcontractor, 62 percent of the time schedule overruns are caused by the General Contractor. From the perspective of a GC, 51 percent of the time schedule runs are caused by the subcontractors. Subcontractors reported being at fault for overruns for 19 percent of the time. GC report being at fault 18 percent of the time. The differences in perspectives from GC and Subs indicate an atmosphere of blame within a construction project. GC and Subs do not agree on the causes of schedule delays. This can cause a problem in the

long term as litigation over causes of schedule delays is increasing. Project teams should account for delays as soon as they happen, and assign responsibility to all the parties involved.

This study contributes to the body of knowledge by providing industry leaders and academics valuable information about scheduling tools, practices and perceptions that can be implemented into a company scheduling culture. Future research will focus on more surveys collected nationally and internationally to get a better perspective of scheduling practices and perceptions. Additionally, work related to causes of specific scheduling delays and the most reasonable responsible group to avoid schedule delays is needed.

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