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Challenges of Construction Scheduling Practice in Ethiopian Construction Industry

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Abstract

Practice of construction scheduling includes tasks of developing, controlling, and communicating the schedule to the concerned parties. This study focuses on identifying the major challenges of construction scheduling practice in Ethiopia. Questionnaire survey was used to collected data from selected construction professionals and one hundred fifty-five valid responses were collected. The data was checked for construct validity and internal reliability. Exploratory factor analysis was conducted to identify challenges of construction scheduling practice. The factor analysis has resulted in four challenge affecting construction scheduling practice: (1) lack of top management commitment, (2) lack of scheduling knowledge and nature of construction projects, (3) lack of scheduling standards and (4) reliable resource scheduling in a resource constrained environment. One sample T-test was conducted to evaluate relative significance of the challenges, and reliable resource scheduling in a resource constrained environment was found to be the most challenging factor of construction scheduling practice. Developing countries' construction industry faces major uncertainties in the resource availability and quality aspect than developed countries. Hence, it is important to understand the operating environment and consider the situation to improve the construction scheduling practice.

Keywords: challenges; construction scheduling; Ethiopia; resource scheduling

1. Introduction

Construction projects are complex projects to perform due to the ever-changing project location, geography, stakeholders, manpower of different background and the complexity of the product itself. Effective planning is important to tackle difficulties arising out of these changing factors. Construction scheduling is the determination of the timing and sequence of operations in the project and their assembly to give the overall completion time (Mubarak, 2015). Appropriate construction schedules are tools for project monitoring and dispute resolution between client and contractors. Developing a robust construction project schedule is one of the major factors towards construction projects' success (Derbe et al., 2020). A project's start and end dates are usually determined in the planning stage before scheduling. However, scheduling is the detailed timing of each activity usually in a sequential manner. There are different types of project scheduling based on either technique of estimating activity duration or graphical representation of the schedules. However, Critical Path Method (CPM) is the most commonly used method for purposes of dispute resolutions in schedule delay analysis (PMI, 2016). This study is also limited to CPM scheduling. The critical path method of scheduling is a technique of identifying the critical path through CPM calculations, which is the longest path of the schedule network.

The provisions in conditions of contract require the contractor to submit a baseline schedule at the beginning of the project and continual updating during implementation (FIDIC, 2017). The Ethiopian conditions of contract for public construction works also requires for submission of update schedules otherwise the contractor will be penalized by an amount of money determined by the Engineer (FPPA, 2011). A baseline schedule refers to the starting reference schedule against which progress is compared while master schedule is the schedule from which all other schedules of concerned stakeholders is derived. Usually, the master schedule is developed by those many stakeholders jointly to accommodate the differing plans (Mubarak, 2015). To the broader extent, scheduling practice is not limited to the single task of developing schedule or determining the timing and sequence of project activities. It deals with schedule management which comprises schedule development and control. Moreover, communicating the different schedule versions and related documents, and involvement of stakeholders in activities of scheduling are also very important part of the scheduling practice. The construction scheduling practice in Ethiopia is facing many challenges. Those are mainly challenges from task of iterative resource scheduling, frequent and uncontrolled need for updating, absence of scheduling standards, unorganized culture of schedule communication and low commitment to perform accordingly. The purpose of this study is to identify challenge factors of the scheduling practice in the Ethiopian context.

Developing Schedule

Schedule developing is usually the initial production of the schedule based prior plans such project duration and work scope. Any modification of the schedule after developed are called schedule updating and in the Ethiopian industry context it is known by the name schedule revision. The most common method of scheduling is currently the CPM method. Other methods such the line of balance scheduling also exist for repetitive type of project activities such as high rise buildings and linear scheduling for linear projects such as road and railway (PMI, 2016). The scheduler determines the shortest possible duration which is the longest path in the schedule activity network. The basic procedures of scheduling are: defining activities, formulating the appropriate work breakdown structure, determining the schedule network, estimating activity durations and performing optimum allocation of resources. Mubarak (2015) adds further steps of inspecting and examining the schedule to look for omitted, incorrect, overlapping, and looping linkages. There are also other important subtasks of scheduling such as risk assessment of the schedule, constructability review and developing S-Curve for monitoring purpose. Defining activity is mainly scope definition in which what is to be delivered is clearly described. Activity definition is conversion of scope definition to specific activities and tasks required to complete a program or a project (AACE, 2011). Formulating the appropriate work breakdown structure is determining the right level of work package structure suited for purposes of scheduling and reporting (Ambriz & Landa, 2015). The schedule network is then determined based on dependencies between those activities in which predecessor and successor activities are also determined. In construction, most sequencing is displayed using commercially available scheduling software. Finally, the durations to accomplish each task of the schedule are estimated based on resource availability and/or constraints, working hours and productivity figures. The productivity can be manpower productivity or productivity of equipment.

All these factors influencing the amount of duration can't be exactly known that the task of determining duration is just an estimation based on experience. Optimizing resource allocation refers to the task of resource levelling based on constraints of availability, space constraint, priority of performing an activity and profitability aspect related to keeping workers and maintaining smooth employment. Resource breakdown structures (RBS) and resource calendars are often established for key resources such as tower cranes, excavators, backhoes, equipment operators, and specialized construction crews (PMI, 2016). AACE (2011) recommended practice describes the primary objective of schedule constructability review is to determine if the project schedule is accurate, logical and achievable. It is intended to disclose problems in the reasonableness of work sequence, completion of construction planning, coordination and interface among the various craft trades and engineering disciplines, adequacy of lead time for material and equipment procurement, site work restrictions and adequacy of site access (AACE, 2009). It has been

recommended that the schedule constructability review process should be implemented in "vertical slices" for each discipline or major feature of work.

Schedule Control – Monitoring Changes & Updating the Schedule

When a schedule no longer reflects the actual progress and changes in the work scope, it is important to update the schedule to actually represent the project condition. Schedule control involves monitoring effects of progress, delays and changes and updating the schedule (Keane & Caletka, 2015). It is for purpose of fair and realistic periodic comparison with actual performance (Mubarak, 2015). Communication throughout the project execution stage is required for key stakeholders to continuously have understanding and documentation of the different versions of the schedule. Understanding a schedule includes dates of major milestones, progress information, resource schedule and different assumptions in the schedule basis. The communication should be as early as possible in order to avoid delay of the schedule approval and early need for schedule updating. A communication made on modern technology platform is the ideal mechanism to automatically communicate schedules. Modern scheduling software packages such as MS Project and Primavera are equipped with those platforms. An ethically managed use of social media platforms can also be helpful.

Challenges of Construction Scheduling Practice

The critical path method of scheduling is a technique of identifying the critical path through CPM calculations, which is the longest path of the schedule network. CPM scheduling involves breaking down project activities, analyzing sequence of activities and optimizing resources allocations. Optimizing resource allocation is important to consider project constraints and make the schedule reflect actual conditions on the ground. Resource allocation and duration estimation are the most interrelated tasks of scheduling that they affect one another. The more resource constraints the longer the duration. The main challenge comes when optimizing duration and resource allocation in a schedule consisting of thousands of activities competing for resource where CPM software packages don't allow resource scheduling. It is also the most difficult challenge in construction scheduling because it affects the cost, order, and duration of projects (Tsegaye, 2019).

There are other challenges originating from lack of standardization of schedule deliverables. Most standard forms of don't provide sufficient requirements for developing and updating construction schedules (SCL, 2017). Absence of scheduling manual and standards for either uniform basis of duration estimation and resource allocation or the deliverables makes the scheduling very prone to wrong estimations based on individual subjectivity. Activities are usually in thousand numbers having complex logical relationships which also compete for resource, a multi-disciplinary environment in which it is crucial to explore interdependencies, manage the uncertainty of the information exchange (Li et al., 2006). A challenge originating from lack of awareness on the very necessity of a schedule and a good communication mechanism makes involvement of key stakeholders in tasks of periodic update, communication, and documentation of schedule to be practically challenging. Better planning results from the involvement of key team members facilitated by the project planner (AACE, 2020). Involvement of key stakeholders in the task of scheduling serves many purposes such as helping create a true representative schedule of the project, gaining a common understanding of the schedule for quick schedule approval process and schedule delay analysis. Lack of commitment from the contractor and the consultant to act on time and submitting formality purpose schedules have also been challenges in the scheduling practice of Ethiopia (Nigussie, 2015). Lack of commitment from the contractor and the consultant to act on time results in early delay of schedules necessitating early updating in short periods.

Using critical path method (CPM) scheduling as an effective tool requires a serious commitment from upper management to adopt and use the schedule throughout the project (Mubarak, 2015). The

unrealistic task of schedule crushing that top managements of contractors impose during schedule updating and their low responsiveness to produced schedules are also potential challenges in the scheduling practice. Moreover, there is a lack of knowledge of, and understanding about, the significance of applications of project planning and scheduling theory in construction projects (AlNasseri, 2015). Lack of technical knowhow and weak legal frameworks were also identified in the scheduling practice (Omer, 2016). Failure to update work programs, failure to define project deliverables, failure of the contract to show defined project deliverables, failure to use appropriate method of programming, failure to use realistic work breakdown structures, failure to use realistic project link are challenges in the scheduling practice of Ethiopian road construction projects (Nigussie, 2015). Finally, project Schedule Management in construction involves complex challenges mainly due to the magnitude of stakeholders involved such as the owner, prime contractor, subcontractors, vendors, material suppliers, end users, regulatory agencies (PMI, 2016).

2. Research Methodology

The study used a quantitative research approach of collecting and analyzing sample survey data from selected construction professionals. A 5-point Likert scale questionnaire survey were used to collect professionals' perception by using Google form. Based on pilot survey, the survey questionnaire was improved for clarity, inclusiveness, and freedom to respond. Final respondents were primarily selected based on their work experience and closeness of their expertise to the study topic, and one hundred fifty-five complete responses were collected. . Construction professionals working in client (22.58%), contractor (50.32%), and consultant (27.1%), organizations were involved in the survey. The data was evaluated for normality and reliability. Coefficients of Cronbach's Alpha were determined to measure internal consistency of the data. Summary of the respondents' profile is provided in Table 1 below.

Table 1: Respondent Profile

Parameters	Number	Percent
Experience of Respondents		
0-2 year	9	6
3-5 year	19	12
6-9 year	69	45
10-15 years	46	29
>15 years	12	8
Respondents' Job Position		
Top Managements, Directors	12	8
Project Managers, Resident Engineers, Coordinators	46	29
Contract Admins, Construction Engineers, Project Engineers	69	45
Office Engineers, Site Engineers	19	12
Junior Office Engineers	9	6

Factor analysis was used to reduce the variables of scheduling practice to a smaller number based on their relationship. Very correlated challenge variables were merged together to form one common challenge factor in which a total of four challenge factors were identified. Mean values of those factors from factor analysis were compared by one sample T-test to evaluate their significance.

Validity in quantitative research refers to the extent to which a test measures what it is supposed to measure, it is the extent to which differences found with a measuring instrument reflect true differences among those being tested (Kothari, 2004). Reliability is the extent to which measurements are

repeatable – when different persons perform the measurements, on different occasions, under different conditions, with supposedly alternative instruments which measure the same thing (Drost, 2004).

Sürücü & Maslakçı (2020) identified that use of the wrong scale is the primary reason for low reliability coefficient that researchers should prefer to use scales whose validity and reliability have already been tested. Using Likert scale data for this study is appropriate as the respondent ranks his perception on level of the challenge. The authors also recommended increasing sample size is the best way to increase the Cronbach's alpha coefficient of reliability. Sample size of this study is large in this aspect. Cronbach's alpha method was applied to determine coefficient of internal consistency (0.725), $P<0.001$. Sürücü & Maslakçı (2020) state a Cronbach's alpha value of 0.6 to 0.7 is acceptable and a greater value up to 0.9 is favorable, 0.95 and above indicates some expressions found in the measuring instruments are the same and do not have any distinctive features meaning there are more expressions in the measuring instrument than necessary. Cronbach's alpha coefficient of 0.725 was obtained from SPSS V-26 software.

3. Results and Discussion

A common requirement to conduct factor analysis is that ratio of sample size to number of variables should be at least 5. The ratio in this case is 155/10 giving a value of 15.5. Spearman's correlation coefficient of up to 0.4 significant to 0.01 were obtained between variables. The principal component analysis and the varimax orthogonal rotation were employed. Kaiser-Meyer-Olkin Measure of Sampling Adequacy of 0.700 was obtained. The null hypothesis for Bartlett's Test of Sphericity was rejected that the correlation matrix was significantly different ($P<0.001$) from unit matrix. Eigen value of at least 1.00 was used to retain factors. Four factors were extracted out of the ten variables and 65% of the variance was explained by the factors. Average explained variances (AVE) of factors ranging from 0.498 to 0.682 were obtained for the construct validity.

One sample T-test was performed to evaluate the significance of the challenge factors of the scheduling practice that shows the level of the challenges. Weighted average of the response scores of the factors were calculated to be 3.79, 3.70, 3.40 and 3.85. The one sample T-test was conducted against hypothetical mean value of 4 to evaluate how significantly the mean scores differ from each other. The T-test is conducted against high challenge factor of scheduling practice scale of 4 based on numbering given to the Likert scale responses. Mengistu & Mahesh (2022; 2020) used one sample T-test to evaluate the relative significance of mean scores of ordinal data on manpower development factors and challenge factors in the Ethiopian construction industry. The null hypothesis was rejected for Factor-1, Factor-2 & Factor-3 that there was a significant difference ($P<0.001$) between mean of the factors and high challenge scale level of the practice. For Factor-4 there was no evidence to reject the null hypothesis ($P=0.056$) that we failed to reject it. Therefore, there was no significant difference ($P<0.056$) between mean of this factor and high challenge scale level of the practice. The alternative hypothesis that the difference between mean of the factor and value of 4 is zero, is accepted which means it is closer to 4. For the other three factors with lower mean values of 3.79, 3.70 and 3.40, the difference between mean value of factors and value of 4 is different from zero ($P<0.001$). The mean values of these factors were significantly different from the test value of 4 ($P<0.001$). The T-test was also conducted against test value of 3 and the difference for all the factors was significant ($P<0.001$). Therefore, challenge values of all the factors are far from value of 3 as tested against value 4.

Low responsiveness of contractors' top management (Factor-1), Lack of technical knowledge and skill of scheduling (Factor-2), Lack of Scheduling Standards (Factor-3) were moderately challenging factors of construction scheduling with similar significance. Factor-4 which was 'task of iteration in a resource constrained environment' was found to be the most challenging factor in Ethiopian construction scheduling practice. The results are summarized in Table 2.

Table 2: Factor Analysis result- Challenges of construction scheduling practice

Extracted components. (Challenges)	Variables	Factor Group				Significance (One Sample T-test, Test Value=4)
		C1	C2	C3	C4	
C1 (Mean=3.79)	Top management of contractor imposes unrealistic task of schedule crushing during schedule updating.	.811				0.000
	Low responsiveness of contractor's top management to developed schedules.	.733				
	The practically difficult joint involvement of key stakeholders in task of periodic update of a schedule.	.632				
C2 (Mean=3.70)	Lack of knowledge and understanding on theories of project planning and scheduling		.739			0.000
	A challenge to the accuracy of a schedule arising from task of estimation of activity duration.		.739			
	Large number of construction work's activities (in thousands) of construction projects having a complex logical relationship which also compete for resource.		.635			
	Main parties consider the purpose of a schedule a formality purpose.		.484			
C3 (Mean=3.40)	Construction specifications don't specify sufficient schedule requirements.			.816		0.000
	Absence of national scheduling standards			.776		
C4 (Mean=3.85)	Optimum schedule output requires many iterations in a resource constrained environment.				.826	0.056
Percentage of Explained Variance		19.89	18.67	14.63	12.29	
Percentage of Cumulative Explained Variance		**65.48**				

C1: *Lack of top management commitment,* ***C2:*** *Lack of scheduling knowledge and nature of construction projects,* ***C3:*** *Lack of Scheduling Standards, and* ***C4:*** *Reliable resource scheduling in a resource constrained environment*

Lack of top management commitment

Lack of commitment from the contractor and from the consultant to act on time, contractors submitting program that they do not implement, giving no attention to schedule to its preparation and timely submission than its formality purpose (Nigussie, 2015). Contractor's top managements usually don't respond to their schedules by not allowing financial requirements, material supplies and manpower accordingly. They also tend to respond late that floats are consumed or the project's critical path is affected. (Nigussie, 2015) added that programs submitted are not realistic or they are already delayed. Top managements also impose task of unrealistic schedule crushing on the scheduling staff for submission purposes despite they know they are not implementing at least some part of that schedule. According to FIDIC (2017) the Engineer shall Review the initial programme and each revised programme submitted by the contractor and may give a notice to the contractor stating the extent to which it does not comply with the contract or ceases to reflect actual progress or is otherwise inconsistent with

the Contractor's obligations. Consultants should not approve such unrealistic programs. They should implement penalty terms like withholding an amount stated in the SCC from the next payment certificate(FPPA, 2011). Eighty eight percent of respondents in this study agreed that strict implementation of penalties on a party responsible for a delay can influence to improve the scheduling practice of construction organizations. The low responsiveness of contractors' top managements can also possibly be improved with implementation of penalties in case of identified delay responsibility.

Lack of scheduling knowledge and project nature

It was found in this study that the scheduler's lack of technical knowledge & skill of scheduling is another challenge of the construction scheduling. There is a lack of knowledge of, and understanding about, the significance of applications of project planning and scheduling theory in construction projects (Al Nasseri & Aulin, 2016). It is unusual to show plant & equipment supplies dates as a milestone. Large respondent number in the questionnaire survey (51%) responded the type of software package used for scheduling is Microsoft excel which means that it is not suitable for showing milestones, automatic updating of schedule, calculating of the completion date. It can also be that the scheduler is not concerned about these requirements due to lack of the knowhow and importance of those scheduling concepts. This study leaves investigation of this dimension for future research. It is also unusual to show the critical path schedules on separate sheet while submitting schedules. The practice of demonstrating the critical path was found below good and unsatisfactory in terms of giving the necessary information for delay claim analysis.

Lack of scheduling standards

Construction scheduling and its management has been a challenging task because most standard forms of contract contain inadequate requirements for generating an Accepted Programme and/or keeping it up to date that parties should reach a clear agreement on the type of programming software, construction method statement, time of draft programme submission, mechanisms of approval, updating and documenting (SCL, 2017). Absence of national scheduling standards in Ethiopia was found to be another challenge of construction scheduling. National scheduling standard for uniform scheduling practice which can serve as a manual, guide or a minimum scheduling requirement by which schedules can be checked against and approved for acceptance is important. In the absence of such documents, there is also no way that construction owners can set minimum requirements of a schedule while preparing contract agreements at the outset. Culture of using the PMBOK (PMI, 2016) guide is also rare that absence of such national scheduling standard documents brings a challenge to the construction scheduling. A project team needs to prepare schedule related standards or criteria at project level that will be shared with counterparts at departments, field site offices, and subcontractors (Nam, 2016), despite this is not an implemented practice in Ethiopia.

Reliable resource scheduling in a resource constrained environment

Reliable resource scheduling in a resource constrained environment was found to be the most challenging factor in the Ethiopian construction industry. The critical path method of scheduling assumes there are unlimited resources for project execution. In practice, resources are limited and scheduling without considering resource constraints gives unreliable schedule (Kastor & Sirakoulis, 2009). Resources such as manpower and construction materials can be in limited supply that the optimum resource allocation between resource dependent activities should be made so that the completion date is minimized. This is also related to the technical skill and the type of software package used for scheduling. Software packages allowing automatic manipulation such as MS project and primavera are better for this purpose. In Ethiopia, the application of scheduling software is poor that makes task of resource optimization difficult. There is a high probability that unreliable schedules are prepared. Large number of respondents (77%) responded iteration in a resource constrained environment as high and moderate challenge to scheduling. The T-test also showed the challenge as the most significant.

4. Conclusion

Four challenges of construction scheduling practice were identified in the context of Ethiopian construction industry: (1) lack of top management commitment, (2) lack of scheduling knowledge and nature of construction projects, (3) lack of scheduling standards and (4) reliable resource scheduling in a resource constrained environment. Reliable resource scheduling in a resource constrained environment was found the most challenging factor. This study is helpful to construction stakeholders intending to improve their scheduling and monitoring practice. Government should prepare scheduling standards that specify schedule deliverable requirements and assist in tasks of estimations during scheduling. Stakeholders in general should work towards increasing their staff's scheduling knowledge and commitment of top management to monitor projects, i.e., trainings on reliable resource scheduling. A proper resource scheduling can be very helpful to monitor projects by follow up of the supplies. Follow up of resource supplies is an early project control mechanism before execution. However, resource scheduling needs a good knowledge and skill of scheduling. Stakeholders should give attention to resource scheduling in which resource constraints are considered. Constraints of resource availability, cost related to cash flow and productivity should be considered in resource scheduling. As the task of resource scheduling in a resource constrained environment is by itself challenging, schedule automation is important in which schedulers can get the opportunity to observe effects of changes in the schedule as a result of change in resource allocation once the schedule is developed. Stakeholders should also increase knowledge of scheduling software packages with regard to updating schedules accurately and easily no matter how frequent it is. A reliable project schedule is also very important for the monitoring to be realistic and controllable. Client and consultant organizations should always check for reliability of resource scheduled and compatibility with the activity schedule. The study recommends further studies towards developing construction scheduling standard and accurate schedule updating.

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