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Extension of Time Determination in Construction Projects in Nigeria: *The Critical Path Method*

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----------ABSTRACT----------

Project time and cost are important aspects of a construction contract. Efforts are made in this regard by operators and researchers to optimize the use of time and cost resources of projects. These efforts, which are aimed at reducing the overall production time and cost of construction works has recorded limited successes. It is also a common practice with contracting companies to call for extension of construction time and make claims for loss and expenses resulting from such extensions. This has in most cases, resulted to increase in the total project cost and delivery time of projects. It has in many cases led to protracted conflicts between the parties to the contract and the abrupt and untimely termination of projects. This paper is aimed at determining the appropriateness or otherwise of contractors' requests for extension of project activity time and the claims arising thereof with the aid of the Critical Path Method.

***KEYWORDS**: Critical Path Method, contractual claims, time and cost overruns*

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I. INTRODUCTION

Construction projects are engaged generally to add value to their environment and most importantly to provide solution to a given problem in a particular time and location with a clear time, budgetary and quality parameters. Therefore if the project is not delivered within the pre-determined time, budget and quality, its usefulness and value addition motive will no longer be total. One of the basic characteristic of a construction project is its novelty and ability to effect change. It is a step into the unknown, fraught with risks and uncertainties. The acyclic nature of construction projects makes it more complex to precisely determine the final time, cost and quality outcomes of the project plan. Techniques are therefore required by individuals who have the responsibility of managing construction contracts to impose personal and specific time, cost and quality restrictions on every project activity in order not to exceed the established project time, budgetary and quality boundaries.

II. LITERATURE REVIEW

Andawei(2001) and Davis(1974) in their separate arguments, contended that project cost and time can no longer afford to be open-ended and suggested that traditional steps should be taken to achieve the planned cost, time and performance requirements of the project. *Davis* (1974) further expressed concern over the difficulties faced by project team members in maintaining stable work programs, thus allowing project executors to completing their projects late with impotent perplexities as to whether the cause is from poor management of the design or from the contractor or both. *Spinner* (1997) in his opinion gave job complexity and technological innovations in the construction industry as some of the reasons that has made job coordination and resource allocation difficult. This trend, according to him, has made it imperative for the operators of the construction industry to adopt better planning techniques such as the Critical Path Method, a form of network scheduling technique, in the planning and scheduling of project resources.The Critical Path Method, which is for network scheduling techniques, which came to lime light in the 1950s as claimed by many authors, was borne out of the need to improve planning and evaluating status of projects(*Lockyer*,1981, *Lock*, 1996). According to *Harris and McCaffer* (1985), the birth of the critical path method-*CPM*, which is one of the network techniques, was mainly due to the inadequacies of the then existing planning techniques such as bar chart. One of the inadequacies of bar chart is in its inability to show the interrelationship between the various activities. As a result it could not determine to what extent the project duration would be affected if there is a delay in one or more of the project activities. Secondly, it was difficult to allocate resources adequately to project activities with the aid of the bar chart.

The introduction of the Critical Path Method in managing construction project is therefore to address these shortfalls. It helps in determining the effect activity delay has on the entire project duration and also plays a vital contributing role in the project resource allocation and scheduling, they concluded. *Akpan and Chizea(2013)* consider the network technique as a graphical method of presenting the work to be done in a form of arrow diagram to show the interrelationships that exist between the various activities that make up the work. According to them, the network therefore forms the basis of the Critical Path Method and statement of policy on how a given task should be done.

They grouped the CPM as network flow analysis or flow graph theory. Within this group, one has minimal and maximal flows and since the objective of the project network in general is that of finding the longest path through the network, maximal flow forms the cornerstone of the CPM. *Ford et al(1962)* were about the first to analyze the network scheduling(including the critical path method) by adopting the maximal flow technique. They hypothesized that there is a conservation of flow at each node of the network, i.e what flows into and out each node must be equal without any loss during the process of transformation. They also assumed that the flow capacities at each node to be indefinite. Since then, a lot of work has been carried out to find simpler models since the later involves a lot of variables to handle even for a small sized project.

Project delay and extension of time

The primary objective of any client is the successful completion of his project by the contractor on schedule, within the cost limit and meeting the performance requirements of the project. Consequently, the extension of the productive time of the project activities will not only increase the cost of materials, labor and plant but will also attract penalties on the part of erring party. A project is considered delayed when some or all the activities of the project cannot be completed according to planned work breakdown structure by the agency responsible for the execution of the project. This could be caused by late activity starting or poor resource planning, allocation, monitoring and control. It is a situation whereby the contractor fails to complete any of the project activities such that it will have a multiplier effect on the entire project time and budget. Demand for extension of project time, which results from activity delays are usually initiated by the contracting organization when one or more conditions listed under Clause 23 of the standard conditions of contract (*JCT 1963 edition*). It provides that upon it becoming reasonably apparent that the progress of the works is delayed, the contractor shall forthwith give written notice of the cause of the delay to the architect, and if in the opinion of the architect the completion of the works is likely to be or has been delayed beyond the date of completion stated in the appendix to the conditions of contract:

- By force majeure
- reason of inclement weather
- reason of civil commotion
- reason of architect's instruction issued under the contract
- reason of the contractor not having received in due time necessary instructions, drawings, details or levels from the architect.
- delay on the part of nominated sub-contractor or nominated supplier
- delay on the part of artists, tradesmen or others engaged by the employer

If extension of time is eventually granted to the contractor under any of the above circumstances, the following will happen.

- The project duration would exceed the original completion date.
- There is likelihood for the employer to expect material and labor price fluctuations, particularly in developing economies.
- There is the possibility of increase in the indirect cost of the project resulting from increased duration.
- The employer would indemnify the contractor all loss and expense suffered as a result of the delay occasioned by the extension.

Procedurally, the architect is empowered by the conditions of contract to determine whether or not any of the above conditions highlighted under clause 23 would affect the regular progress of the affected project activity or the entire project duration.

Analytically, such determination would be open to erroneous judgment if time analysis of the affected activities and indeed the entire project were not carried out taking into account the free time available (total float) to the individual project activities. This picture can be clearer with the help of critical path method (CPM).

Time analysis of construction activities

Baguley(2003), Oxley and *Poskitt*(1980), *Lock*(1996) and *Lockyer*(1981) considered the critical path as the longest path through the network. They further noted that the critical path passes through the critical activities whose durations are equal to the difference between the preceding and succeeding event times. They argued that though, sub-critical activities can safely be allowed to take longer time than planned, it is important that the extended time does not exceed the spare time available (total float). Total float is therefore the total amount of time by which the activity can be extended or delayed and still not interfere with the project end date. Mathematically, total float is computed as:

$t_{float}=l_{finish}-e_{start}-d$

where:
t_{float} = Total float
$_{lfinish}$=Latest finish
e_{start}= Earliest start
d=Duration.

The cost implication of granting extension of time in construction works is the attendant inflation and fluctuation in prices of materials, labor, plants and other associated liabilities. The question now is that, are the delayed activities critical to the project completion? If yes, to what extent does the delay actually affects the entire project duration?
The adoption of network techniques, like the *Critical Path Method*(CPM) the various project activities can be easily analyzed to determine their criticality levels and to what extent can extension of time request that can be granted.

Case of a sample project

Using a10-activity sample project to demonstrates the applicability of networks in extension of time determination. The project details are as follows:

Table 1. Sample project network details

Activity code	Activity Duration(weeks)	Total Float	Activity Remark
1-2	4	4	sub-critical
1-3	6	0	critical
1-5	3	7	sub-critical
2-4	2	5	sub-critical
2-5	2	4	sub-critical
3-7	10	0	critical
4-6	3	3	sub-critical
5-6	4	4	sub-critical
6-7	2	2	sub-critical
7-8	4	0	critical

The project network shows that the project is billed to be completed at week 20. The project activity remark column shows that except activities 1-3, 3-7 and 7-8 all other activities are sub-critical. This implies that the project estimated duration will only change if the duration of activities 1-3, 3-7 and 7-8 are tampered with during the progress of the work. Assume that due to obvious reasons as listed under Clause 23 of the conditions of contract, the contractor could not commence work for activities 1-2 and 1-5 for 5weeks. The contractor subsequently requested for an extension of 5weeks each to meet up the lost time citing that it was the client's fault for not commencing these activities as scheduled.

In the above problem, the project team is required to determine firstly whether or not the extension of time is necessary. Secondly, the team will also determine whether the contractor should be granted the 5weeks per activity as requested. This can only be done easily with the aid of the CPM, one of the scheduling techniques. The analysis of the critical indices of the project as shown in table 1 above indicates that the affected activities 1-2 and 1-5 has float of 4weeks and 7weeks respectively. Under this situation, the project duration as planned would not be affected if these activities are not exceeded beyond their float periods. This implies that the 5weeks delay in take-off of these activities would slightly affect only activity 1-2 that has 4weeks as total

float. The network also shows that, activities 1-2 and 1-5 are parallel and are undertaken simultaneously. Therefore the request for 5weeks each activity is certainly unacceptable. The only consideration that can be given is the granting of 1week extension of time for activity 1-2 whose total float period has been exhausted by the delay.

Benefits of Critical Path Method application

The above case of a sample project has clearly shown in practical terms the usefulness of critical path method in determining the amount of time a project is expected to be extended if any of the conditions listed under clause 23 occurs. The project activity relationship as pictorized by the network diagram is able to show activities that are in parallel and those that are serial and the critical indices indicates which activities have float and those that are critical from the inception of the project. This information, which is provided only with the aid of *CPM*, in my view, is critical in assessing the genuineness of any demand for extension of time of any projects.

III. CONCLUSION

Construction projects are initiated to meet cost, duration and quality needs of clients. The project team is by these basic criteria required to implement and accomplish the project tasks on time and within the budget as specified in the project management plan. These seemingly perfect project conditions are often times unduly exceeded making the project team's work more challenging. The adoption of CPM, one of the network scheduling techniques would enable the project manager of determine justified request for extension of project time and claims arising thereof, thereby minimizing time and cost surprises.

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