

THE ASSESSMENT OF THE CRITICAL PATH ANALYSIS IN CONSTRUCTION PROJECTS IN KITWE

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ABSTRACT-

The primary responsibility of any project manager is to balance and achieve the three key themes of a project, which are quality, cost and time. It is the latter that forms the pillar of this research. The aim of this research was to assess the use and implementation of the critical path method in construction projects. The study was conducted in Kitwe District and focused on the construction projects that are currently running and tried to find out whether CPM is implemented or used to improve on the completion of construction projects in a timely manner. The study considered among other factors the failure to complete projects on time, the knowledge and perceptions of Critical path method (CPM), its use in construction projects. The efficiency and effectiveness of using CPM. Studies undertaken have shown that most contractors fail to perform in the area of time completion for many reasons. The literature review showed that incompetence on the part of project managers, lack of using project software and a reliance on experience on the part of the project implementers lack of technical capacity to execute complex projects, also the lagging behind in information technology. Also, inadequate policy or regulatory frame work by government and quasi government agencies to monitor and control the adherence and use of project software that makes use of CPM. The study was conducted to also reveal

perspectives of the consultants, local contractors as well as on site project implementers view point regarding factors affecting Zambian contractors' project performance. A descriptive design research was conducted in this research 50 participants were approached using questionnaires. The data collected was both quantitative and qualitative in nature and was analyzed using SPSS package, to establish the results to the study. The study showed that, most Zambian contractor's knowledge and application of CPM is still not as sufficient in terms of implementation, as observed that 86% had knowledge about CPM and a 72% agreeing to the fact that using CPM had a positive result on the completion time of a project. They either did not have CPM software or use the manual method but relied more on experience and lack of management skills led to poor site and incorrect time estimates. Recommendations are being presented to the Contractors, Associations and Ministry of Works and Supply to amend or introduce the necessary legislature that would give most of these regulatory bodies enough access to the actual contractors, where need be provide training programs to local contractors on the importance of CPM.

I) INTRODUCTION

This paper sought to demonstrate the importance of using and applying the critical path method (CPM) in construction projects.

The Critical Path Method (CPM) or Critical Path Analysis, is a mathematically based algorithm for scheduling a set of project activities, according to Barron (2011). It is an important tool for effective project management. The CPM is a project modelling technique developed in the late 50s by Morgan R. Walker of Dupont and James E. Kelly Jr. of Remington Rand. Kelly and Walker related their memories of the development of CPM. The precursors of what came to be known as the critical Path were developed and put into practice by Dupont in the 1940s and contributed to the success of the Manhattan Projects. With the critical path method, one can better manage projects and anticipate timelines by finding which tasks and outlining the fastest way to the end of the project. Commonly used with all forms of projects, including construction, software development, research projects, product development, engineering, and plant maintenance, among others. Any project with interdependent activities can apply this method of scheduling. The essential technique for using the critical path method (CPM) is to construct a model for the project that enables the project manager satisfy all three project constraints especially the time factor. Rodriguez (2019) says that CPM is a popular scheduling technique in the construction industry due to its simplicity and effectiveness. It generates a graphical view of a project and calculates how much time and resources are required to complete each activity. It also determines critical activities requiring attention so that the project can be completed on time. A list of all activities required to complete the project also known as Work Breakdown Structure. The time that each activity will take to completion. The dependencies between the activities CPM calculates the longest path of

planned activities to the end of the project. Furthermore, Richman (2002) defines the critical path as the path through the network that takes the longest total time, and therefore determines the earliest possible time the project can be completed. There are a number of advantages of using critical path analysis which are; it allows for a comprehensive view of the entire project. Because of the sequential and concurrent relationships, time scheduling becomes very effective. Identifying the critical activities keeps the executive alert and in a state of preparedness, with alternative plans ready in case these are needed. Breaking down the project into smaller components permits better and closer control. White (2006) concludes to say that CPM plays more roles than the issue of time completion, it can also be used to monitor and evaluate project activities.

Bragadin (2016) noted in his publication on the scheduling assessment of construction projects that, several factors can contribute to the success of construction projects.

Critical path analysis offers economical and effective system of control based on the principle of management by exception i.e. need for corrective action arises only in exceptional situations and in most of other cases, performance is in conformity with the plans. Thirdly it is a dynamic tool of management that calls for constant review, a reformulation of the project design, the network, and finding the current path of relevance and optimum resources allocation.

Construction project management diverges from a typical project management role by demanding and incorporating extensive knowledge of the construction industry, a field filled with unique challenges. According to The Construction Management Association of America, construction PMs average around one hundred and twenty responsibilities, which means they have to be strategic and thoughtful about working in an environment impacted by constant change.

Planning may be the second of the Project Management Institute's five phases of project management, but construction project managers should start planning long before actual construction begins, and continue revising and developing plans until the project ends. The design, pre-construction, and procurement stages of a construction project each require extensive planning and each may need to be revised as the next stage unfolds. Anything can happen at a construction site. If you encounter unexpected environmental problems during the pre-construction phase, the design may need to change. Even slight adjustments can affect the overall plan and timeline. This remains true during the actual build. While you will be working with experienced professionals in electrical engineering, plumbing, scaffolding, and carpentry, they still need a focused direction to coordinate their efforts with each other. As earlier alluded to CPM is a deterministic tool that allows project managers explicitly estimate and control the time factor in a project. Project management can be defined as Richman (2002) a set of principles, methods and techniques that people use to effectively plan and control project work. Project management establishes a sound basis for effective planning, scheduling, resourcing, decision-making, controlling and planning. From the just given definition we can safely say that project management principles and techniques help complete projects on schedule, within budget, and in full accordance with project specifications. At the same time, they help achieve the other goals of the organization, such as productivity, quality and cost effectiveness. This draws us to the three central themes of project management which are cost, quality and time, it's the latter that the writer of this research will focused on, as Larry (2002) stresses the importance of project management today as he writes, that speed, quality and cost control are taking on increased significance in business, government and nonprofit sectors.

According to PMBOK, (2013) project management is defined as the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. Given the definitions and analysis of project management one thing that is important to note that finishing it on and in time is as important as doing it within the budgeted cost and according to the quality. Having said this, it brings us to the topic at hand that which the writer wishes to highlight that despite the knowledge and understanding how and why are most especially construction projects never finished on time world over and Zambia in particular. Having observed this the writer wishes to assess the effectiveness of the critical path analysis in construction projects as already alluded to this technique is a project management tool that helps calculate the longest time a project can take if it's used especially at the planning stage, how do most projects fail to finish on time. The writer did not dwell most on other factors like environmental forces or acts of nature that for sure will delay a project, but solely to stress the importance need application and use of CPM, in projects, for the completion of projects in and on time. This will in turn highlight the benefits or advantages of using CPM. When overseeing any project, a project manager can often feel overwhelmed by all the tasks that must be completed before reaching the end goal. Working with a team also involves outsourcing the work to members of that team, which can cause delays and take aspects of the project out of the project manager's hands. Project managers might also be responsible for reporting progress to managers and executives in the company, so the timeline estimates and associated tasks must be accurate.

Critical path method scheduling allows a project manager focus on the larger the picture instead of being slowed down by smaller details. By creating a specific schedule and working with those who will be responsible for completing each individual task along the way, it's easier to determine an accurate timeline and track what needs to be completed for

each step. A critical path chart, also called a diagram, puts all team members on the same path toward completion while clearly outlining who is responsible for what task.

Critical path methodology project management also becomes a tool of reference for monitoring progress and reporting on each task as it is completed. The project manager may need to adjust the resources allocated to a certain work package if it is taking longer than expected or potentially causing a delay. In order to be effective, project managers must continue to consult the critical path plan throughout the project to prevent delays and keep the work moving.

A. *Statement of the problem*

Critical path method intimidates most people because they find it complex and time consuming, the detailing of each task or activity that has to be done through the first activity to the last is a daunting task. Despite the advancement in technology in the creation of tools and techniques that help ease the cumbersome procedure of calculating the critical path of a project. The lack or improper use of these tools has contributed in some way to the incompleteness of projects on time world over especially in Africa and Zambia in particular. They believe that construction realities in the field should drive the schedule with this approach, however, efficiency generally suffers and ultimately the project completion time delayed. The effectiveness of using CPM in construction projects has not been as impressive, fundamentally because of the Zambian Authorities failure to establish a coherent institutional and policy framework. Performance is related to many variables and factors such as time, cost, quality, client satisfaction; productivity and safety. In addition, there are other different reasons affecting construction projects performance based on completion in Zambia such as poor management and leadership, inappropriate participants, poor relations and coordination. Furthermore, the

deliberate lack of use of the deterministic tools that help calculate and monitor the project period, such as CPM. This research will focus on the gap that is there through the non-application, misuse or blatant lack of use of CPM especially in the completion of projects on time.

B. *The general objective of the study*

The general objective of this study is assessing the use of the critical path in construction projects. The specific objectives were, to evaluate the perceptions of the Critical path method in construction projects, to assess the implementation of Critical path method in construction projects, to determine the effectiveness of Critical path method in construction projects and finally, to examine the efficiency of Critical path method in construction projects.

C. *Research questions*

The research centered on key questions which were, firstly how much does the industry know about CPM? Secondly to find out to what extent is the CPM utilized in construction projects? Thirdly, what are the effects of using Critical Path Method in construction projects? Fourthly, what are the perceptions of the efficiency of Critical Path Method projects?

D. *Significance of the study*

Project planning and management plays a vital role in the development of a nation and the world at large and Zambia is not left out. This study aims to generate information on the efficiency of project management and in particular the planning of the critical path method in projects. This study will also highlight the perceptions of project managers on the critical path method its adoption and effective use in the completion of projects on or before time without compromising the quality or cost. Importantly to also enable others to use CPM because it helps during pre-project planning,

awarding of sub-contracts, placing material orders; but it requires too much time to keep up to date on the chart as the job changes due to schedule changes.

This study gave project managers, construction supervisors the insights into the critical path analysis, how it contributes to project efficiency, control and completion. The researcher endeavored to underline the importance of calculating CPM in all construction projects to determine the period for the project, in addition it will help in monitoring of the stages and completion of individual tasks during the project cycle. This study will further contribute to the body of knowledge in the critical path analysis and the success and completion of projects. This study will also help project managers ascertain the importance of using CPM in their construction projects as a management tool because it may be used as remedial action to take to bring a project back on course if it has diverted.

E. Conceptual framework

The study adopted a conceptual framework which focused on cost, time and quality factors complexity analysis. It is based on developments to the work of Hughes (1990) which emphasize that factors relating to cost, time and quality are crucially important to the successful completion of the projects. Hughes (1990) viewed business environment as an intermediate variable. He argued that changes in the environment effects the execution of the projects. The rationale for the argument is that a changing environment demands construction organizations to be responsive and dynamic. Cost, quality, planning tools, other techniques. Experience and knowledge of CPM are independent variables while successful completion of the projects is the dependent variable.

In the conceptual framework for this research, the project planning tools, other deterministic techniques, construction experience and knowledge of the critical path method (CPM), the experience

and the efficient use of the critical path method are the independent variables while the project success in completing in time is the dependent variable. While the intermediary variables are a good business environment, adequate monitoring and evaluation techniques. It should be should be stated that for a project to succeed a number of other success factors play an important role.

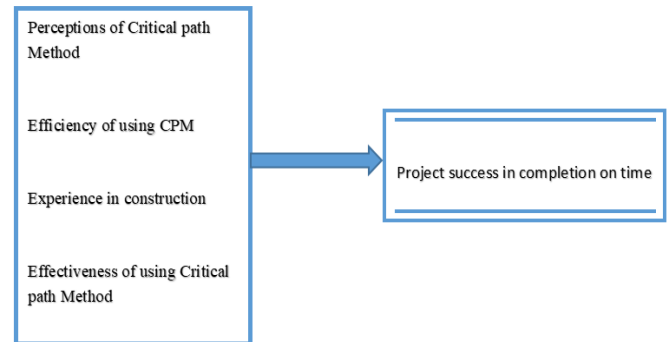


Figure 1.1 Conceptual framework.

Source: The researcher (2019)

II. LITERATURE REVIEW

A. Perceptions of CPM

According to Muhammed & Nurul (2010), scheduling is needed to show the relationship among activities and the whole project and demonstrates realistic cost and time estimates for each activity. Plan, coordination and control has an important role in achieving the goal. There are several techniques in the network planning that can be used. They observed in their research that the most widely used techniques of network planning are CPM and PERT techniques used for planning and implementation of projects, which shows the relationship between activities. The objective of this research was to arrange network planning on construction projects and to know the role of network planning in increasing the efficiency of time so that can be obtained the optimal project completion period. His research used descriptive method, where the data collected by direct observation to the company, interview, and

literature study. The result of this research is optimal time planning in project work. Based on the results of the research, it was concluded that the use of the both methods in scheduling of house construction project gives very significant effect on the completion time of the project, especially using CPM. They also noted that using CPM (Critical Path Method) method the project he used could complete the project with 131 days, while using the PERT (Program Evaluation Review and Technique) Method takes 136 days. Based on PERT calculation obtained. This means that the possibility of house construction project activities can be completed on time is high enough. While without using both methods the project completion time takes 173 days. So, using the CPM method, the company can save time up to 42 days and has time efficiency by using network planning.

Muhammed and Nurul (2010) made observations that help the writer of this research because the use and benefits of CPM scheduling are observed in the just cited research.

In general, techniques in project scheduling can be grouped into two methods, the Gant Chart and Network Planning. Network planning method is one of the management techniques that can be used to assist management in project planning and control. A project schedule network diagram is a graphical activity. There are two basic techniques used in network planning, the Critical Path Method (CPM) and Program Evaluation Review and Technique (PERT). CPM is a time-oriented method that leads to timing and time estimates are deterministic. While PERT is a time-oriented method that leads to the determination of the schedule and the time is probabilistic. This research used CPM as the deterministic tool because it is used to control the coordination of various activities in a job so that the project can be completed in time. This method also can help the company in planning, scheduling and supervising projects with more efficient time. So, the objective of his research was to find out how the scheduling of house

development project by using CPM and PERT method in relation to more efficient time.

Stelth & Roy (2009) in their journal on projects analysis through CPM, a technique for analyzing projects by determining the longest sequence of activities through a project network. They said that organisations today are also increasingly using virtual project management teams, in that they are procuring expertise and materials from all corners of the world. Hence CPM has become more complicated than earlier. The purpose of their study was to determine how to lean or cut or trim operations for any organization. They also wanted to find out the advantages and disadvantages of CPM and CCM and the impact of both on a project. Further to complement the two in conjunction for any project being implemented. Their study was conducted using secondary research method. They concluded that both CPM and CCPM were both valuable tools that any institution could use successfully to manage their projects. Also, that both techniques use a safety net to manage the uncertainty that arises in the process of completing a project. Despite these two researchers' efforts they fail to address the issues of implementation and effectiveness of using CPM.

Suhaidi & Ismal (2012) in their journal on the usage of CPM software in Malaysia noted that CPM is a well-known scheduling method is a necessary tool in middle and big construction projects. Their study investigated the utilization of CPM software amongst contractors and its relations towards their perceptions of project performance. The use of questionnaires to collect data from participants, and the results showed that Malaysian contractors have yet to fully adopt CPM software in their projects.

He further noted that scheduling the construction process is essential not only to ensure that projects can be completed profitably and on time,

but also that any delays can be evaluated in order to prove entitlement to time and cost. Their study concluded that Malaysian contractors needed to make more use of CPM software in their projects of they are to improve on efficiency and effectiveness.

Hammad & Radhlinah (2015) note that despite attention being paid to the development of planning and scheduling theory, it is unclear whether project stakeholders and practitioners have sufficient understanding about how it applies in practice. Such an observation works well with the writers' conceptual framework of this research in that it seeks to understand the relationship between the perceptions whether positive or negative to the use and implementation of CPM. Hammad & Radhlinah (2015) further observed that in competitive environments where construction and infrastructure projects are taking place planning and scheduling are vital to understanding project performance, this to mean that the three themes of project management are achieved or attained which are tie cost and quality.

Hammad & Radhlinah (2015) in their study conducted with the aim of assessing practitioners' perceptions of planning and scheduling theory and practice on construction projects in Oman. The overall findings of their research imply that practicing managers should implement new management strategies and foster knowledge based planning and scheduling concepts for more a more effective construction process

Okmen

(2014) notes that though CPM may have advantages he makes an observation to say that, In spite of its wide usage and popularity, CPM has some limitations and criticized features. The limitations of CPM are related to its deterministic calculation procedure, which is insufficient for modelling uncertainty. CPM is deterministic because of the invariable duration values assigned to activities in network calculations, as if these durations are known certainly and do not vary by

various risk factors. This deficiency may lead to inaccurate critical path identification and project duration measurement.

Okmen (2014) in this context, this study aims at proposing a method of the CPM network calculations (forward and backward pass calculations) with fuzzy sets. The activity durations are represented by special kinds of fuzzy sets called fuzzy numbers in this method, and accordingly the CPM forward and backward pass calculations are executed by fuzzy operations. The representation of activity durations by fuzzy numbers enables modelling the uncertainty effect. In construction projects, the duration of an activity cannot be proposed with certainty in advance. Okmen (2014) concluded that the findings show that CPM is applicable with fuzzy sets, and the developed method operates well for modelling the uncertainty in CPM network calculations. His conclusions are very encouraging in that they promote the use and implementation of CPM especially in construction projects.

B. Accessing the implementation of CPM.

Burger (2015) in his publication on construction management, said that 'while smaller construction jobs allow for spontaneous planning, bigger projects require construction project management'. The critical path method (CPM) is a tool that many project managers use, often with their construction management software, to help figure out the best steps to take to finish a job efficiently. This critical path method, otherwise known as critical path scheduling, is one of the most frequently used construction planning techniques.

Burger (2015) in his study was trying to create an easy way or chronological way of approaching projects as he stipulates four key steps in approaching a construction project, which are firstly 'breaking down every step or activity to be done, secondly use construction management software to organize the information. Thirdly calculate the CPM that helps and leads to the

project's completion. Finally building or constructing.'

The critical path is defined as the longest path that ultimately leads to the project's completion. Its drag is equal to its duration. Once the critical path is identified, construction project managers can start to calculate dependencies that is how tasks interact with each other and activity-based resource dependencies which is really just another way of saying where and how a construction company is spending their time and money on a project. Burger (2015). Also says that 'this is an area where enterprise resource planning software may come in, because large construction firms may want to use the critical path method for more than one intertwined project'. Burger (2015) concluded to say that the use of construction management software helps to figure out the best steps to take to finish a job efficiently. The calculation of CPM in projects according to Burger was concluded to increase efficiency in the execution of project completion time. He goes on to conclude that 'in as much as the CPM is incredibly common and a powerful tool to use across the construction industry, its strength lies in the accuracy of the data input'. The research makes an observation here that is very important which is that expertise coupled with some experience would be very helpful in the use of CPM software. CPM software is very necessary because it also helps in monitoring resource usage and is able to easily identify the stages of a project, through the noting of which tasks are being done when in parallel with other activities or tasks.

To better understand critical path project management, reviewing some examples of others' analyses can be helpful. A project manager can determine the best format for critical path analysis. Some use spreadsheets, while others create actual diagrams with arrows pointing to the specific tasks along the way. Reviewing examples in several formats can provide additional insights and options

for the best method based on the scope and needs of the project.

To define critical path, a project manager can look at the overall timeline for a project and then break that timeline out into specific tasks. Those tasks become the milestones along the path to completion of the project, which can be assigned to other members of the team involved. A project manager is responsible for overseeing the timeline and making sure that each task is on target for completion by the required end date.

White (2006) noted in his publication on CPM and construction contracts that, the Critical Path Method, in common with other planning tools seeks to simulate technologically related events and activities. One of the assumptions of the Critical Path Method states that there will be unlimited resources available enabling every task to commence at its earliest possible starting time. This rarely happens in practice. For some time, heuristic algorithms have been available for the resolution of resourcing conflicts. At the construction site level, critical path schedules are often generated from a known resource availability which dictates the network logic. The networks so produced are different from networks which model the technological relationships and then make adjustments for resource constraints. It was hoped that a resource-based network would be more rational than an activity-based network. However, there is no guarantee that the resource-based network will provide the most efficient solution. Developments in the combinatorial mathematics of scheduling enable the degree of in efficiency to be measured. At the construction site level, these issues tend to be irrelevant, however, if the Critical Path Method is being used to justify or disprove a construction claim, then distortions can be introduced. White (2006) affirms the fact that using CPM especially in the planning stage of a project is very helpful.

Karaca & Onargan (2007) in their article on the application on CPM in workflow schema of marble processing plants, observed that the critical path method (CPM) is a widely applied technique in large-scale industrial project planning and control. Based on a detailed review of the current literature, no references have been found referring to the use of the CPM in marble processing plants and other industrial mineral plants. In this regard, this study proposes a new application area of CPM and suggests the implementation details of mineral processing workflows with particular emphasis on marble production facilities. In the study, the CPM is applied to marble processing plants for selecting an applicable production process and for determining the workflow schema in order to optimize the cost of operation and to effectively manage time. As a consequence of this analysis, a new production plan is proposed for medium-scale marble processing plants. A suitable marble processing plant has been built and taken into operation in accordance with the proposed plant plan. It has been observed that this plant has a higher production rate at a preferable capacity when compared to three other plants studied as a part of this research. Karaca & Onargan (2007) conclude that using CPM increases production hence agreeing with the fact that it is a necessary tool that improves efficiency.

White (2006) in his publication on the implementation of CPM in construction projects noted that the Critical Path Method, in common with other planning tools seeks to simulate technologically related events and activities. One of the assumptions of the Critical Path Method states that there will be unlimited resources available enabling every task to commence at its earliest possible starting time. This rarely happens in practice. For some time, heuristic algorithms have been available for the resolution of resourcing conflicts. At the construction site level, critical path schedules are often generated from a known

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Keller (2004) observed in his research that focused on discussing the results of a third survey that compared how different sizes and different types of companies use CPM, and compared the results with past data. The comparisons that were made between how different companies and individuals involved in different types of construction use CPM. A surprising finding of this third study was that companies relied on specialists for CPM just as much now as they did in 1974 even though fewer companies found it requires excessive work to implement. He also observed that dependency on specialists might be for different two main reasons in now than in 1974. In the last 30 years, technology has greatly improved along with knowledge about CPM. The apparent need for specialists was initially needed because of the lack of knowledge of CPM and because application at the time was such a labor-intensive process. In 2003, more people are aware of CPM and software has made application much easier. CPM has also developed more uses and applications over the years.

One of his concerns when it came to the application or use was in the area of the use of precedence

diagramming instead of arrow diagramming. It was almost impossible to find scheduling software that supported the use of arrow diagrams. Some schedulers claim precedence diagramming is detrimental to scheduling because it is easily manipulated and the logic of the schedule is not as apparent as it is with arrow diagramming.

It has been observed that the future of CPM application appears hopeful in that it provides more uses than earlier established. The development of new uses and applications of CPM since its inception in the late 1950's has been overwhelming. Technology has been one of the greatest enablers of these new functions and as technology continues to improve, it is almost certain CPM will find new uses. In his conclusion Keller (2004) said that, 'the results from this study indicate the top 400 contractors are pleased with CPM. Of those that use CPM, most felt it is a valid management tool and some claimed it improves communication among the workforce. CPM is not just the current trend in scheduling as demonstrated by the fact that most of the companies asked feel CPM ranges from moderately to very important to the present and future success of the company'. Furthermore, the study indicates companies will encounter more benefits from CPM application the more project and top management believe in its usefulness.

Aliyu (2012) observed that traditional techniques of decision-making have hindered the technical efficiency of most professionals and executors of the public project in many developing countries such as Nigeria. The use of Gantt chart in project planning has continued to increase as a source of last resort in spite of its severe limitations for ineffective project management and delivery. CPM has gained widespread commendation and acceptance in the developed countries. This technique is yet to gain any appreciable acceptance for implementation of public projects in Nigeria. Professionals and executors of public projects in Nigeria have remained conscientiously to the Gantt chart. In order to address this problem of project

planning, the CPM was applied to "construction of a complex building at Federal University of Technology." This paper describes a specific case study with real data and an application. The results show the effectiveness of the CPM in, planning, scheduling, and organizing, coordinating, managing, and controlling of project time and cost. The study concluded by arguing that, CPM is not difficult to apply and when applied it improves inter-departmental communications, gives clear definition of responsibilities and minimizes the occurrence of crisis management. This research affirms the writers' purpose of study in that it concludes the importance of using CPM.

Okononwo & Mbachu (2015) noted that the critical objectives of construction industries nowadays are to complete a project within a stipulated time, scope and budget through process standardization and efficient use of resources, provided by project management techniques such as Programme Evaluation and Review Techniques, Critical Path Method, Cost Benefit Analysis etc. But still most of the construction companies face poor client satisfaction due to non-completion of the work as per the required standard and specification. Since the development of the Six Sigma in 1980s in manufacturing industry, its popularity as a process improvement method has significantly grown. However, the adoption of this concept is quite new in some construction industry. The aim of this project is to compare Six Sigma method with other Project Management Techniques and investigate the acceptability of its implementation within small and medium scale construction companies. The research in this project made efforts to establish complete analysis of 59 retrieved well developed instruments with data from major professionals in the construction industry. The research concluded that there is no doubt about the positive effects of the implementation of Six Sigma in the construction industry. Particularly, Six Sigma can provide a broader quality concept, detailed performance

measurement, coordinated and repeatable process/performance improvement.

Agyei (2015) said that completing a project on time and within budget is not an easy task. Project planning and scheduling plays a central role in predicting both the time and cost aspects of a project. This study is aimed at finding trade-off between the cost and minimum expected time that will be required to complete the building project. The data on the cost and duration of activities involved were obtained Angel Estates and Construction Ltd., a construction company based in Ashanti region, Ghana. Both critical path method (CPM) and project evaluation and review technique (PERT) were used for the analysis. The activities underwent crashing of both the time and cost using linear programming, this paved way for the determination of critical path. Further analysis revealed that the shortest possible time for the completion of the analyzed building project is 40 days instead of the expected duration of 79 days. This means that through proper scheduling of activities, the expected completion time was reduced by 39 days.

Metanxas & Deffner (2013) concluded that CPA is based on the fact that the planning and the implementation of a Place Marketing Plan is a strategic process, characterized by specific phases, actions and evaluation methods, which are fitted and controlled in specific time horizon. In this context, it can guarantee, to a great degree, the successful implementation of place marketing thus providing to it the character of a project, during the progress and the completion of which there will be no randomness, procrastination and important omissions or errors. However, in this study it is suggested that CPA's successful development is related to the capacity of EMG and local decision makers to implement it. In fact, this is the contribution of the study to the existing rich literature. The adoption of CPA has an innovative

and pioneering character in Place Marketing process, supporting directly the effective contribution to the economic development of the region that applies it. Of course, the whole proposal of CPA has a main limitation. The model of CPA does not take into account any of the contingencies of a political, social, institutional and economic nature which affect strategic planning or, for what sake, policy making in real life.

Ngomi (2017), recommended to the Local contractors, their association and Ministry of Works and Supply to, provide training programs to facilitate skills and professional development transfer to local contractors, also establish cooperative schemes for the local contractors to access loans, equipment and raw materials.

Chilongo (2017), Information Communications University in her publication on an Investigation into the factors affecting project performance among contractors in Lusaka. In her publication she wanted to identify the factors that contribute to projects delayed and not completing them on time. She used the observation method in collecting her information through interviews and focused group discussions. One of the factors that she identified was the need for contractors to minimize waste through project implementation in order to improve their performance, and that there should be more interest when it comes to conformance of the three themes of project management which are cost quality and time. Chilongo (2017) observed that there two types of delay in a construction project and these are excusable delays such as unforeseen events; these are normally beyond the contractor's control. While non-excusable delays are those that are caused by factors beyond the contractor's reasonable control and not to the contractors' fault or negligence. She provides the basis for the high importance attached to the use of CPM of scheduling for approving or disapproving the extension of time or prolongation of a project. She recommended that the performance problem is

costly and often results in disputes. From this citation, the writer denotes the importance of applying and implementing the CPM in construction projects to improve on the performance and achievement of project objectives.

C. Determining the effectiveness of CPM in construction projects.

Mubarak (2015) in his book, *Construction Project Scheduling and Control* 3rd edition, noted that to ensure contractor's proper planning for timely finish, the easy prediction and calculating the cash flow, there was need to use CPM. Furthermore, he stated that CPM serves as an effective project monitoring tool, as well as a tool to evaluate the effect of change, that may occur during a project, it is also used to verify delay claims by the contractor. He further observed that other parties involved in the project may also need a CPM schedule, such as the designer, project management consultant, and financial (lending) institution. The need for a CPM schedule varies with several factors. In general, it increases with the increase in size and complexity of the project.

Several organizations now have a process and examination that leads to certification in project scheduling. The most prominent ones are: The International's Planning & Scheduling Professional (PSP), The PMI's Scheduling Professional (PMI-SP) Usually, an applicant for certification in project scheduling has to fulfill certain conditions; Achieve minimum education requirements, achieve minimum experience requirements, pass the certification examination, submit application and pay fees. Mubarak (2015) stated that such certification is important in showing the qualifications of the scheduler, particularly to a potential employer. A certification from a reputable organization. The writer of this research commended Mubarak for this final conclusion in that it would really help the construction industry and government to easily monitor and control projects.

According to Zalnu and Rahu (2014) of Malaysia the challenge of completing construction projects within estimated time frame is the biggest concern amongst the practitioners. Several approaches and tools are still being created to enhance the management of the construction projects. There publication paper identified commonly used techniques and software packages of time management together with their effectiveness level in large construction projects of Malaysia. Data was gathered through survey technique amongst the practitioners involved in handling large construction projects. Relative Importance Index calculation was employed to assess the level of effectiveness for time management techniques and software packages adopted in the construction project. The results highlighted that most common and effective time management technique and software Package are CPM and Microsoft Project respectively. Although, this technique and software package in almost every project is applied, but still the industry practitioners fail in achieving effective time management. Hence, this study recommends that further investigation be carried out in uncovering the related issue which hindrance in achieving the benefits of these in construction projects.

Ogero (2014) in his report on the influence of project management information on project performance in the construction industry noted that it's almost impossible to talk about performance without talking about CPM, furthermore he observes that construction projects are commonly acknowledged as successful when they are completed on time, within budget, and in accordance with specifications and to stakeholders' satisfaction. Many of the projects exceed the original cost; get cancelled prior to completion, while others fail on terms of the delivered functionality. While large amounts of time and resources are dedicated to selecting and designing projects, it remains of paramount importance that

projects be adequately managed in organizations if they are to achieve their performance objectives. The purpose of the study was to establish the influence of Project Management Information System on project performance in the construction industry; a case of Nairobi County, Kenya. The Objectives of this study were to determine the influence of: the system, quality information, the system user and the system use on performance of construction projects. Descriptive survey was used this enabled the researcher obtain the opinions of project managers in their natural setting and it is also good for management decision making. Ogero (2014) his research also found out that the use of the system to generate quality information needed by the user (project manager) to perform project tasks helped the project managers perform their tasks in a more professional manner thus increasing the performance of the project. It was therefore concluded that the use of Project Management Information System helped in the improving performance of project while respecting the projects constraints of time, budget and quality specification while meeting the project objectives. Future studies could evaluate performance from the client's perspective, that is, evaluate if the impacts of the Project Management Information System on project outcomes provide an adequate solution to the client's problem, bring true advantages to the organization in terms of quality of product/services offered, greater output volume, quicker delivery, and better strategic positioning, and provide tangible benefits such as increased sales and revenues. Despite the research conducted the little mention of CPM in trying to monitor performance of a project is not satisfactory enough hence the writer of this project sees a gap in this research and ascertains it in this report.

Goodrum (2014) in his publication says that steel construction activities are often undertaken in an environment with limited climate control. Both hot and cold temperatures can physically and

psychologically affect construction workers, thus decreasing their productivity. Temperature and humidity are two factors that constantly exert forces on workers and influence their performance and efficiency. Previous studies have established a relationship between labor productivity and temperature and humidity. This research is built on the existing body of knowledge and develops a framework of integrating building information modeling with a lower level critical path method (CPM) schedule to simulate the overall impact of temperature and humidity on a healthcare facility's structural steel installation project in terms of total man hours required to build the project. This research effort utilized historical weather data of four cities across the U.S., with each city having workable seasons year-round and conducted a baseline assessment to test if various project starting dates and locations could significantly impact the project's schedule performance. It was found that both varied project start dates and locations can significantly contribute to the difference in the man hours required to build the model project and that the project start date and location can have an interaction effect. This study contributes to the overall body of knowledge by providing a framework that can help practitioners better understand the overall impact of a productivity influencing factor at a project level, in order to facilitate better decision making. Goodrum (2014) concludes in his research that this research provides a framework of integrating BIM and CPM schedules to simulate the temperature and humidity impact on productivity at a project level. The research effort took a model project as a test model and selected four project locations in the U.S. and their last 50 years of historical weather data to demonstrate the applicability of the framework. The demonstration of the statistical analyses of the simulated results shows how the simulation results can be exploited to generate knowledge for decision making. Since this study took a specific model project and four project locations, the results of the

study cannot be directly applied to a different project. Therefore, the external validity of the statistics might be limited. However, the external validity of the developed framework is still preserved. The readers should direct their attention to the framework, because the concept can be generalized to any project. In addition, the BIM-based framework can have a broader use, such as simulating overtime and craft density's effect on labor productivity at the project level. Goodrum (2014) research does not fully focus on the impact of CPM but rather the integration of CPM and BIM. Aboubaker and Ismail (2018) in their journal on the effects of delays in road construction projects in Libya observed that construction delays have become endemic in Libya. It was imperative to create awareness of the extent to which such delays can adversely affect project delivery, especially with regard to road construction projects. It is clear that the Libyan road construction industry also faces the issue of not being able to complete projects within the allocated time. This paper identifies the effects of road construction delays, evaluates these through a questionnaire, and assesses them using an empirical method. A detailed review of related literature produced the secondary data, while the primary data was obtained via structured questionnaire which targeted the road construction projects owners, consultants and contractors. In order to fill the literature gap and address the problems of the construction industry in Libya, this study aims to measure the effects of delays, such as time overrun, cost overrun, litigation and project abandonment, on construction projects. Descriptive statistics were used to analyze the data received from the questionnaires. The findings of their study revealed that the major outcomes of road construction project schedule overruns in Tripoli, Libya included cost overruns, time extensions, disputes, loss of profit, breaches of contract, poor quality of work and company's bad reputation. The study makes a contribution to knowledge of the subject

of the outcomes of road construction project schedule overruns in Tripoli. It is found that delays in road construction projects widely lead to cost overrun, time overrun, litigation and disputes. The findings of the study also provided significant insights into the construction industry, which will help it formulate strategies in order to avoid delays and their consequences. The most important effects identified were time overrun, cost overrun and obstruction of economic and country development.

Aboubaker and Ismail (2018) noted that as the country struggles to recover from the conflict of 2011 with two different governing powers, international oil companies are partially resuming operations in the country. However, the Libyan oil industry has to face new challenges, such as security issues, a deregulated market, a vulnerable legal framework and lack of a central governing power. In such a business environment, an effective project management framework is of paramount importance for a quick recovery. Such a framework will help to avoid delays in projects, and identify the factors which cause these, and their possible consequences Kusakcı et al., (2017). Hence, the aim of this paper is to identify the outcomes of construction delays in road projects in Tripoli, Libya.

Infrastructure development plays a vital role in improving the overall development and progress of any country. However, delays in construction projects have negative impacts, such as time and cost overrun, litigation and abandonment of the project. The most adverse impact is that it gives a bad impression to foreign investors, which ultimately leads to a downturn in national development. According to Sweis et al. (2008), delays often occur due to poor project management related to project owners, contractors and consultants. In addition, general conditions including weather, the law and order situation, and deteriorating economic conditions will cause delays in the completion of projects. Hence, there is a dire

need to measure the effect of such delays on construction projects in Tripoli.

The effects of delays are a result of factors which are not identified and resolved. Numerous factors can result in cost and time overruns in various types of projects, and client satisfaction will decrease if the cost of a project or schedule exceeds the planned budget.

Matipa and Zulu (2000) observed that their winds of change sweeping through Southern Africa in terms of construction, the Zambian Construction Industry is experiencing obsolescence of the old construction corporation, the eruption of information technology, globalisation, new and intense competition, changing societal and customer expectations. Technological developments, financial constraints, restructuring and mergers, new philosophies and government intervention have hit the industry.

The paper concludes by stressing that it is of strategic importance that the Zambian construction industry anticipate the need to review their business models to proactively create advantage. As the seventh national development agenda unfolds, the issues of sustainability in construction industry come to the fore. Sustainable development refers to 'development, which meets the needs of the present without compromising the ability of future generations to meet their own needs'. Due to reliance on external suppliers of construction inputs, construction business has not been economically sustainable. Local suppliers face hardships in meeting customer demand for material The Post, (2002).

It is said that a key driver of transformation of the construction industry to achieving competitiveness is innovation. They identified innovation as technological, organizational, and process or product related. Technological innovation is that which utilises new knowledge or techniques to provide better quality, improved efficiency and cost effective. Technological change is creating new

possibilities for design, planning, production, delivery, marketing and ancillary service of products. Organisational innovation could foster change of the relationship between behaviours, attitudes and values. New types of organisation, new forms of contract and procurement could become evident. Process innovations could increase efficiency that is the application of project software in the planning stage of the project so as to determine when exactly a project will start and finish. While product innovations could enhance quality and result in superior products. Innovation in the supply chain can help improve site productivity through improved material flow and materials management. Reduction of cost through application of agile and lean construction practices and benchmarking best practices are also innovative ways of achieving a competitive advantage Shakantu and Talukhaba, (2002). The improvement of processes should not just concentrate on the final product but should encompass the whole construction process from initial planning to, management to technology and construction.

Until recently, construction projects in Zambia have mainly been managed in the traditional general contractor approach with the client approaching consultants to produce the design of the proposed works and supervise the construction phase while actual works of the design into the finished product was carried out by the contractor. Most projects were either parastatal or government funded. As global drivers of change sweep through the country, a previously content construction industry is faced by financial, technical, cultural and performance related demands for change. The paper has highlighted the major drivers of this change and the implications for the Zambian construction industry. Clearly, collaborative leadership, intellectual capital and knowledge baselines will require a systemic change effort. Fundamental technological transformations tightly integrating customers, supply chains and partnerships on one hand and an e-commerce revolution coupled with paradigmatic

business process re-engineering on the other will be inevitable.

Kabila and Mumba (2009) in their journal Cost escalation and schedule delays in road construction projects in Zambia, noted that the 'wealth of any nation is gauged by its performance in infrastructure provision through its construction industry. The construction industry is large, volatile, and requires tremendous capital outlays. For developing economies, road construction constitutes a major component of the construction industry. This means that much of the national budget on infrastructure development is channeled to road construction projects. The aim of the study reported in their paper was to identify causes and effects of cost escalation and schedule delays in road construction projects. Using a detailed literature review, structured interviews and questionnaire surveys, the results of the study confirmed the prevalence of cost escalation and schedule delays in road construction projects in Zambia. Their study established that bad or inclement weather due to heavy rains and floods, scope changes, environmental protection and mitigation costs, schedule delay, strikes, technical challenges, inflation and local government pressures were the major causes of cost escalation in Zambia's road construction projects. On the other hand, delayed payments, financial processes and difficulties on the part of contractors and clients, contract modification, economic problems, materials procurement, changes in drawings, staffing problems, equipment unavailability, poor supervision, construction mistakes, and poor coordination on site, changes in specifications and labor disputes and strikes were found to be the major causes of schedule delays in road construction projects. Finally, the appropriate project management practices are thus required to curb the causes and effects of cost escalation and schedule delays in road construction projects, such as project scheduling of individual tasks. The

allocation of labor and resources to the individual tasks has been known to help reduce construction delays.

Goksu (2012) in his presentation on the implementation of CPM and PERT that because of the growing effects of the globalization in various business environments, the manufacturing industry is expected to be effective and yet efficient. According to this, in planning, scheduling and controlling a project, which is a combination of various activities, project management techniques (PERT and CPM) are used. He asked the research question; is how will the implementation of CPM and PERT influence the effectiveness and efficiency of furniture company "Dallas"? The answer to this question is relevant in order to point out the importance of those methods in reducing the project completion time and costs. The data are taken from the furniture company "Dallas" and it will be combined with literature reviews. The research study is fueled by the following objectives: First is to determine the activities that are involved in the manufacturing process in selected company. Second is to demonstrate the benefits, as well as the drawbacks that those methods might create in the organization. And third is to demonstrate the influence of CPM and PERT in the entire furniture industry and its competitiveness. Implications of this research paper are evaluation of the project completion time and control of the resources, in order to see that the project is completed within the planned time and cost by using mentioned methods. At the end of the study, the result is expected to help all the individuals as well as the companies to understand more the concept of CPM and PERT methods in reducing the project completion time and costs. He made comparisons about the two techniques instead of focusing on one, which the researcher of this research focuses on.

Aliyu (2012) notes that, 'traditional techniques of decision-making have hindered the technical efficiency of most professionals and executors of

the public project in many developing countries such as Nigeria. The use of Gantt chart in project planning has continued to increase as a source of last resort in spite of its severe limitations for ineffective project management and delivery. CPM has gained widespread commendation and acceptance in the developed countries. This technique is yet to gain any appreciable acceptance for implementation of public projects in Nigeria. Professionals and executors of public projects in Nigeria have remained conscientiously to the Gantt chart. In order to address this problem of project planning, the CPM was applied to “construction of a complex building at Federal University of Technology, the source of data was purely secondary. A visit was conducted to the project site, and physical contact was made with the project manager on site. A program chart was provided in his paper he describes a specific case study with real data and an application.’ His findings show the effectiveness of the CPM in, planning, scheduling, and organizing, coordinating, managing, and controlling of project time and cost. The study concludes by arguing that, CPM is not difficult to apply and when applied it improves inter-departmental communications, gives clear definition of responsibilities and minimizes the occurrence of crisis management.

D. Examining the efficiency of CPM in construction projects

Soe (2018) in his publication on the critical path analysis programming method without networking noted that, project scheduling is an important task in project management which monitors the project duration, resource utilization and affects the benefit of project for all kinds of project such as construction, IT, renewable energy, product design and manufacturing etc. Among many methods for project management, critical path method (CPM) is one of the better-known planning and control techniques in project scheduling. In this study, CPM-based computerized program was developed

together with modeling of step by step calculations of parameters of interest such as earliest starts and finishes, slack and float times of project activities resulting in determination of critical path for the project. He observed the advantage of computer implementation of CPM using MATLAB in this study is that unlike conventional method, it eliminates necessity to conventionally draw network diagram to perform critical path analysis.

Soew (2017), there are two commonly used methods to find the minimum completion time for a project scheduling. These methods are Critical Path Method (CPM) and Program Evaluation Review Technique (PERT). In CPM, a network diagram, which is Activity on Node (AON), is drawn and the slack time for every activity is calculated such that the project’s critical path could be found. It is important that the critical path can suggest the shortest possible completion time. On the other hand, PERT concerns on uncertainty and risk in a project. It has three-time estimates, which are optimistic, pessimistic and most likely, and all the time estimates mentioned follows the beta distribution. Besides, the probability in completing the project within certain duration is calculated by using the standard normal distribution. As the risk cannot be avoided in a project, it is important to keep track on any changes and to minimize the completion time for a project. Both of the methods are used to calculate the shortest possible completion time, slack and critical path. The difference between these methods is CPM has only one determined time estimate, while PERT has three-time estimates, which shows the uncertainty in the duration of an activity in a project. For illustration, the data used for the construction of a three-room house was studied. The results show that the minimum completion time for the project is 44 days with a success probability 0.91. In conclusion, CPM and PERT are practical tool in the project scheduling. His conclusions are helpful to

this research in that they affirm the importance of using CPM in construction projects.

Wail (2010) from the University of Waterloo in Canada, noted to say that project managers today rely on scheduling tools based on the Critical Path Method (CPM) to determine the overall project duration and the activities' float times. He further noted to say that such data provides important information about the degree of flexibility with respect to the project schedule as well as the critical and noncritical activities, which leads to greater efficiency in planning and control of projects. While CPM has been useful for scheduling construction projects, years of practice and research have highlighted a number of serious drawbacks that limit its use as a decision support tool. The traditional representation of CPM lacks the ability to clearly record and represent detailed as-built information such as slow/fast progress and complete representation of work interruptions caused by the various parties involved. In addition, CPM is based on two unrealistic assumptions: that the project deadline is not restricted and that resources are unlimited. With CPM, therefore, the most cost-effective corrective actions needed in order to recover delays and overruns cannot be determined. His research was based on the view that many of the drawbacks of CPM stemmed from the rough level of detail at which progress data is represented and analyzed, where activities' durations are considered as continuous blocks of time. To overcome CPM drawbacks, this research presents a new Critical Path Segments (CPS) mechanism, with its mathematical formulation, that offers a finer level of granularity by decomposing the duration of each activity into separate time segments. The CPS mechanism addresses the problems with CPM in three innovative way.

Ahmad Maidamisa (2013) from University of technology of Malaysia in his article noted that traditional techniques of decision-making have hindered the technical efficiency of most

professionals and executors of the public projects in many developing countries such as Nigeria. The use of Gantt chart in project planning has continued to increase as a source of last resort in spite of its severe limitations for ineffective project management and delivery. He observed that CPM has gained widespread commendation and acceptance in the developed countries. This technique is yet to gain any appreciable acceptance for implementation of public projects in Nigeria. Professionals and executors of public projects in Nigeria have remained conscientiously to the Gantt chart. In order to address this problem of project planning, the CPM was applied to "construction of a complex building at Federal University of Technology." This paper describes a specific case study with real data and an application. The results show the effectiveness of the CPM in, planning, scheduling, and organizing, coordinating, managing, and controlling of project time and cost. His study concluded by arguing that, CPM is not difficult to apply and when applied it improves inter-departmental communications, gives clear definition of responsibilities and minimizes the occurrence of crisis management.

The general results of his research showed that the project was delayed and the project was executed at a staggering cost, because CPM plan was used. CPM is a technique of planning; scheduling and controlling projects time and cost by recording their interdependence in a diagrammatic form that enables each fundamental problem involved to be tackled separately Kothari (2003). This research work applied CPM Method on the project. The following results were noted, if all activities are carried out at their normal time, the building would be completed in forty-one weeks. On the other hand, if each and every activity is executed at its crash time, then, the complex building will be completed in thirty-two weeks. There is a substantial saving in project time and cost to the tune of nine weeks that is 22 per cent of time and forty- seven million; six hundred and eighty

thousand Naira, which represents 25.36 percent of the cost.

Elaiwi (2018) observed in his publication that according to the scientific developments in all sectors around the world, there is needs of using the technique of operation research and its implementation that help the manufacturers to draw their work policy and making future planning to achieve their goals. However, the complexity of industrial projects comprises a lot of activities, which needs to be controlled and scheduled in scientific ways, in according with the availabilities of equipment's and efforts of manufacturer. In his research his goal was to reduce the completion time and cost of constructing a yacht by using critical bath method and pert techniques. Results showed that the efficiency of using scientific critical path method and pert reduce the time of yacht construction. Also, the receiving and distribution of raw materials leads to minimize the completion job. Therefore, making training programs to the manufacturer employees to process the job in perfect performance. From this cited research it's important to not the results found which highlight the efficiency of using CPM in a project, this finding agrees with the researchers view point that using CPM in construction projects has a positive bearing on the completion time.

Fugar and Agyakwah-ah, (2010), from the Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

This study investigated the causes of delay of building construction projects in Ghana to determine the most important according to the key project participants; clients, consultants, and contractors. Having noted some of the factors they were categorised into nine major groups. The list of delay causes was subjected to a questionnaire survey for the identification of the most important causes of delay. The relative importance of the individual causes and the groups were calculated and ranked by their relative importance index. The

overall results of the study indicated that the respondents generally agreed that financial group factors ranked highest among the major factors causing delay in construction projects in Ghana. The financial group factors were delay in honoring payment certificates, difficulty in accessing credit and fluctuation in prices. Materials group factors are second followed by scheduling and controlling factors. Their main objective of the study was to identify the major causes of delays of building construction projects in Ghana using an opinion survey. The primary aim was to identify the perceptions of the three main parties regarding the causes of delays and to suggest possible ways of eradicating or minimizing them.

Mohamed (2015) of Sudan from the University Tunku Abdul Rahman, in his dissertation on a study of project delay in Sudan construction industry, noted that 'the construction industry in Sudan is an important sector due to its enormous contribution to the country's economic development. However due to the geographical, political, social and financial situation of the country, many construction projects are prone to delay. These delay factors could only be avoided by first identifying the factors and their sources. The main aim of his paper was to find out the main causes of delay in Building construction projects in Sudan.

The results that were obtained by indicated that the top major causes of delay were; fluctuation of prices of construction materials, shortage of materials, inaccurate time estimation, and errors during construction. In addition, the top major effects of delay were; Cost overrun, acceleration of losses, time overrun, lack of appropriate use of basic project planning software. The researcher observed that this too had the reason of inaccurate time estimation that can only arise when PERT and CPM are not properly used and implemented in the very initial phase of planning. It was found that the lack of use of these tools also contributed to project delays. He also wanted the study on delay to help

stakeholders to be able to pin point exactly where the delay is from or what causes the delay.

According to Tembo and Chiponde (2015) in their publication on the risks that may occur in construction they said that 'construction projects are risk prone and as a consequence projects may have quality shortfalls, disputes, time and cost overruns. Realizing that huge sums are spent by the government in providing infrastructure, the research focused on assessing the feasibility of reducing risks on infrastructure projects through integrated risk management'. To achieve this, secondary data was obtained from an extensive literature review while primary data was through the use of a questionnaire survey to consultants and contractors. This revealed that the management of risks in the Zambian Construction Industry on projects is hugely hampered by the over-reliance on the traditional method of procurement in which teams are segregated resulting in adversarial relations. Hence, the reduction of risks on projects cannot be effectively achieved traditionally due to fragmentation of the parties involved. There is needed to change the traditional approach to construction projects as it does not encourage integration of project parties in order to reduce poor performance of infrastructure projects. It is for this reason that integrated risk management, which encourages team work, from inception project to completion, should be adopted to enhance management of risks. An integrated approach enhances communication, and builds relationships that aid collaboration resulting in reduced project risks.

They observed that at the briefing stage of any project which is often the early stage in the construction process, the client's requirements are written down in a formal document. This gives a fixed reference point for the subsequent design of the building. At the design and procurement stage the architect will produce the architectural design, and the engineers will produce the engineering

design according to the client's requirements from the briefing stage. Based on the traditional procurement approach the key participants in a building project are the client/financier, contractors, and designers consisting of architects, engineers (structural, civil and service engineers) and quantity surveyors these form a temporary organization to undertake the project.

It is therefore recommended that the industry adopts Integrated Risk Management and its principles such as mutual trust and respect, sharing of risks, early involvement of key participants, and sharing of experiences and knowledge in risk management. From this literature the writer notes that for any construction project integrated approaches to any construction especially in the initial phase of planning will be of most help because everyone will be fully aware of what to do when to do it and easily control the activities of a project through the application of CPM.

Zulu and Muleya (2018) in their journal on 'A student perspective of ethics in the Zambian construction industry the importance of ethical considerations in the construction industry is acknowledged. This is particularly the case that the industry plays a significant part in a nation's development. The Zambian construction industry has seen an increase in activity due, in part, to massive infrastructure development programmes adopted by successive governments, increase in foreign direct investment and housing development. The Zambian construction industry, like any other, is not immune to unethical behaviour. Their study aimed to investigate students' perception of the prevalence of unethical practices in the Zambian construction industry and how that affected project performance. A review of literature demonstrated that a number of contextual factors including location can influence the perception of unethical practices. A focus on Zambia was therefore considered necessary.

III) RESEARCH METHODOLOGY

A. *Research design*

The research design appropriate for this research was descriptive design. Descriptive design describes, explains and interprets conditions of the present. The implication being that descriptive research examines a phenomenon that is occurring at a specific place and time. A descriptive research investigated conditions, practices, differences or relations, structures, opinions held, and trends that are evident. This design does not establish the cause and effect relation postulated by McMillan and Schumacher (2010). When investigating a new area scientist use descriptive methods to identify the factors that exist and to identify the relationships that exist among the factors.

According to Lans & Van der Voordt (2002) one of the characteristics of descriptive research is that it is a factual registration and is no quest for an explanation why reality shows itself in a particular way. Descriptive research does not aim at forming hypotheses or develop theories, rather it has objectively and neutrality imbedded in it. Descriptive research is simply about describing the reality at a particular time.

This research design was appropriate for this research as it allowed describing the effect of using and implementing the critical path method in projects so as to maintain the time factor in the completion of projects. This approach will further provide an accurate description of what is currently obtaining in most projects as the time factor is involved.

B. *Study site*

The research site for the study was restricted to Kitwe district. The study targeted construction projects both Brownfield and Greenfield projects, institutions that are directly connected to projects that are taking place on the Copperbelt, Kitwe district.

The target population for the study are construction projects happening on the Copperbelt, Kitwe in particular. The inclusion criteria are construction projects that will include, roads infrastructure. The study population will include project managers, project supervisor's and project team members. Inclusion of Kitwe based institutions such as, ZDA (Zambia development Agency), RDA (Road Development Agency), EIZ (Engineering institute of Zambia) and NCC (National Council for Construction).

The sample size was 50 subjects from the selected construction projects, the questionnaires were broken down into three (3) of fifteen will be given to the project managers and senior personnel on site at the projects. A set of twenty will be given to supervisors, coordinators and project foramen. The remaining fifteen will be given to the project implementers or the general workers doing the actual work. The remaining five were distributed to regulating institutions, such as ZDA, EIZ and NCC

The target population is a group of objects from which samples are taken for measurement. According to Cooper and Schindler (2003) sampling is the process of selecting a predetermined number of subjects from a defined population as a representative of that population. Basically, to say that sampling is the process in which a representative part of the population is picked for the purpose of determining the characteristics and parameters of the entire population. This research will use the random sampling technique.

Description	Number of respondents
Institutions	5
Project managers	10
Project supervisors	20
Project implementers	15

Table 3.1 Distribution of Questionnaires. The researcher (2019)

The research will use questionnaires as the data collection tools. The questionnaire will be self-administered. The questionnaire will have an introductory letter from the university and a consent form informing the respondents on issues of confidentiality, findings, dissemination and data storage.

The questionnaire had four sections; section A will gather background information about the respondents. Section B will collect educational information. Section C will access the implementation of CPM in construction projects. While section D will determine the effectiveness of using the critical path method in construction projects and finally section E will find out what the perceptions of the efficiency of CPM in construction projects are.

According to Drost. (2011) instrument validity is concerned with the meaningfulness of the research components, meaning that it is concerned with whether the questions are measuring what they are intended to measure. The research used content validity through approaching professionals in research and the research supervisor before it is used. Hence the test questions were matched to the content of the subject which is the effectiveness of using CPM in projects.

According to Drost, (2011) reliability is the extent to which measurements are repeatable when different persons perform the measurement, on different occasions and under different conditions. Reliability is basically the consistency of measurement. To ensure reliability of the questionnaire, the writer tested the instrument on a project in progress, within the area. This process offered the writer a chance to make changes to the questionnaire.

Data collected was put into excel and Statistical Package for Social Sciences (SPSS) application for analysis. The data collected through open ended

questions will be analyzed using narrative and thematic approach using STATA software. Analyzing using thematic areas allowed the researcher to identify, analyze and report patterns within the data

The researcher was limited by finances to conduct in depth interviews and with participants to the questionnaire to gather more qualitative data. The scope of this paper was limited to the set research objectives due to time constraints. The writer would have liked to increase the sample size, but due to time finances and the limited projects within the study area.

The very nature of every research especially a social research is that it entails that many issues should be taken into consideration, especially in the manner in which the research is conducted. These include how the researcher ensured quality and integrity of the research, how the researcher sought informed consent from the participants, how the respect, confidentiality and anonymity of the research participants and finally how the researcher ensured that participants participated in the study voluntarily.

According to Jackson (2002) she observes that there three basic ethical principles relevant to research involving human subjects and include respect for persons, beneficence and justice.

For the sake of this study the researcher ensured that the subjects received full disclosure of the nature of the research, risks, benefits and opportunities with an extended arm to ask questions. The writer of this research made sure that the names of the participants were not written on the questionnaires to protect the anonymity and confidentiality of the participants. Secondly the writer of this research sought informed consent from the participants so as to make sure that they voluntarily participate in the research.

IV) RESULTS AND FINDINGS

The objective of this research was to have a better understanding of the elements that contribute to the impact of CPM on project performance. The study results are discussed in terms of the objectives and their direct and indirect effects of CPM on project performance.

A. *Questionnaire response rate*

This study had a sample size of 50 participants and 46 responses were obtained representing a 92% turnout, 8% of the questionnaires were rejected and according to Babbie (2002) any response of more than 50% from participants or respondents is adequate for analysis.

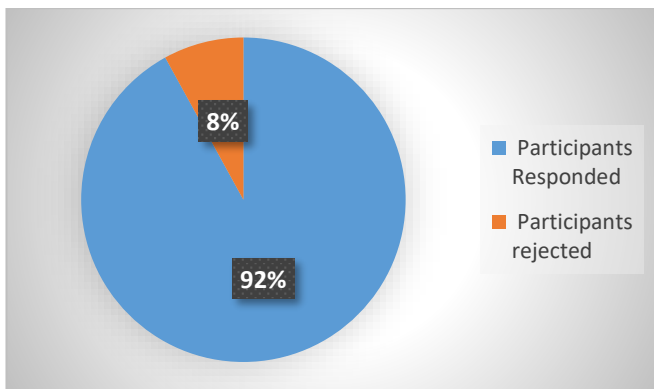


Figure 4.1 Participants response. The researcher (2019)

The research distributed all 50 questionnaires and managed to recollect a total of 46, of these 46; 39 were male 85% while 7 were female 15%. This representation or gender distribution is not healthy for development and the writer would in future like to see more women in the construction industry.

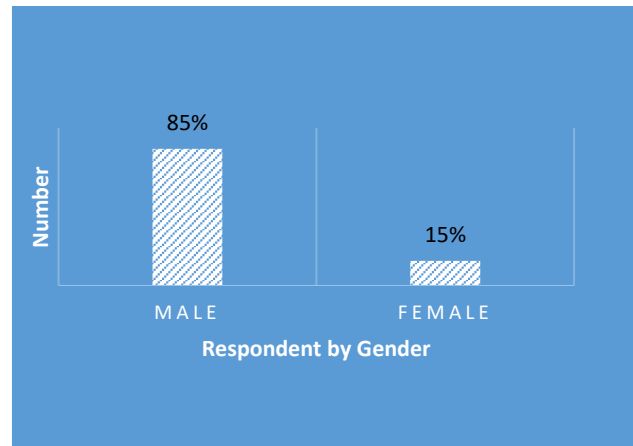


Figure 4.2 Participants by gender. The researcher (2019)

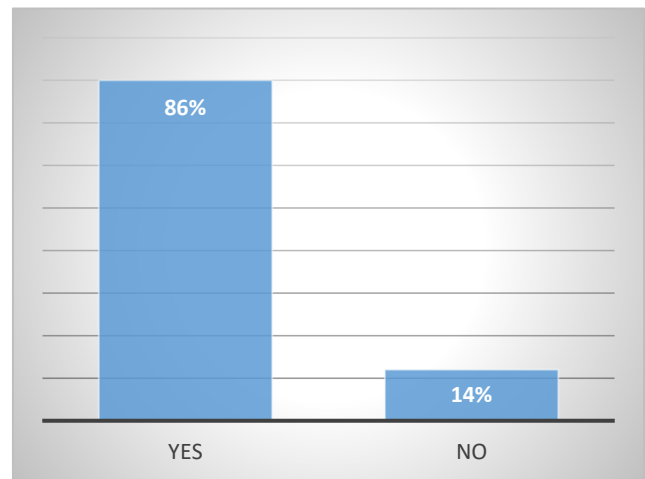


Figure 4.4 Knowledge of CPM. The researcher (2019)

From the participants responses it was observed that 86% of them knew what CPM is and only 14% did not which is a good response

B. *Assessing the implementation of CPM in construction projects.*

It is much easier to use or apply something one understands, out of the 46 participants 44 representing a 95% understanding of CPM expressed understanding of CPM, and this is a very good sign for the researcher, because it shows most participants in construction are conversant of CPM. Only 2 participants representing a 5% turnout of the

total participants did not understand what CPM is this though a very small percentage was worrying for the researcher because in the construction industry such an observation is not healthy in this day and age.

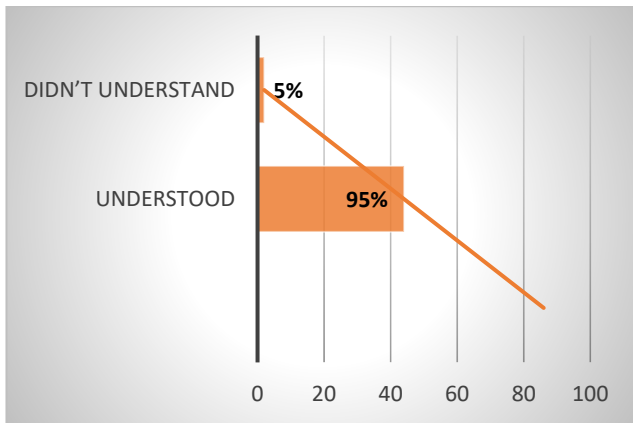


Figure 4.5 Understanding of CPM. The researcher (2019)

C. Which project software does your organization use to calculate CPM?

From the type of software used it was observed that 50% of the participants are more familiar with and use Microsoft project in their planning, 17% used Smart sheet, 30% were not sure this could be attributed to the fact that the project implementers were more concerned with doing the actual work than knowing which type of software is used, 3% just did not know this was due to the fact that they had not been to college or have any basic construction knowledge

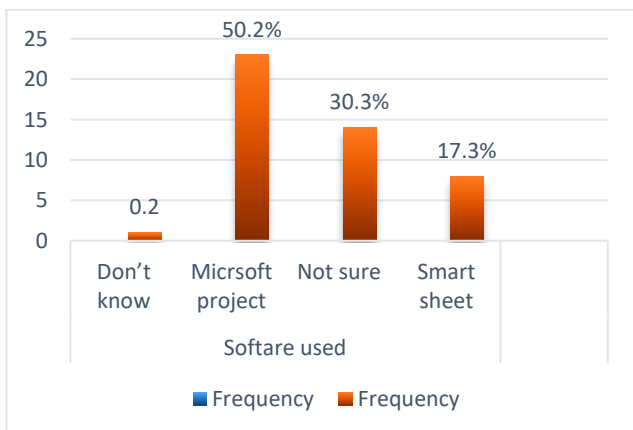


Figure 4.6 Type of software used. The researcher (2019)

D. Does the use of CPM in project planning increase the efficiency of completion of the project?

Project management has at least five key phases and of these planning in the initiation stage is one of the first, a project includes the initiation of the idea the planning the allocation of resources and the implementation. If the planning of a project takes longer than usual then the starting and finishing will also be delayed. In the efficiency on completion at least 72% agreed that using CPM either through software or manually enabled the completion of projects to be done on or before time. The other 28% disagreed not entirely due to the fact that CPM does not improve efficiency but mostly because they were not sure whether their supervisors used it or not.

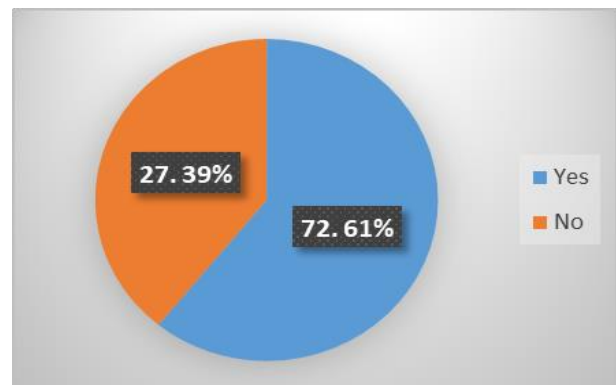


Figure 4.7 Usage versus completion. The researcher (2019)

E. Does the CPM software you use help reduce the calculating time for determining the project finishing date?

Using CPM as a deterministic tool to determine the duration of a project is paramount for any project. After asking participants if the use of CPM software in the determining of the project duration reduced the calculating time. It was found that 92% of all the participants agreed and said yes to the fact that it did reduce the calculating time, and only 8% of the participants said no. This result shows the

importance and need for using CPM as a deterministic tool. This was against the use of the manual method of calculating CPM, which is a very long and difficult task

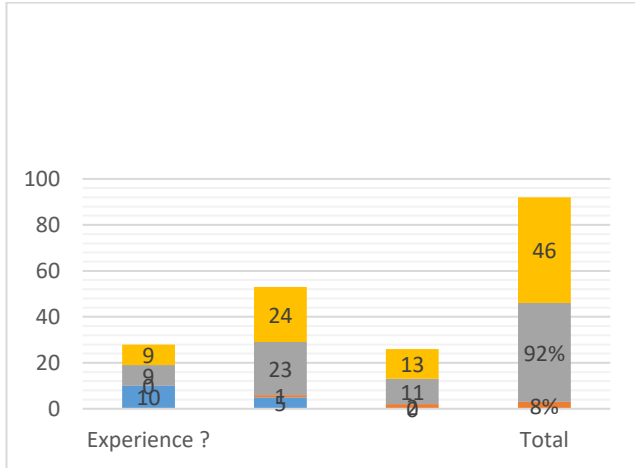


Figure 4.8 Reduction of time. The researcher (2019)

F. Would you agree that using project software in calculating CPM helps finish projects on time?

The usage of CPM software in project planning is technically meant to help in the efficient completion of construction projects. A question was given to the participants whether using CPM software in the planning stage specially to determine the duration +of the project. Of the 46 participants 78% agreed that using the software did have a contribution towards the efficient completion of projects and 22% disagreed. The use of other methods may be used such as PERT and other manual approaches, and the manual calculation of CPM which takes a lot of time and very cumbersome. This question ascertained the importance of using the software for calculating CPM especially in the planning stage

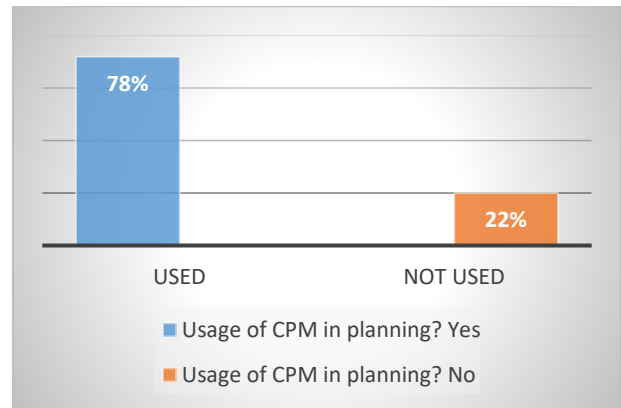


Figure 4.9 Use of CPM in planning. The researcher (2019)

G. Are you able to compare expected results versus actual of the project using CPM?

One of the many uses and advantages of using CPM by contractors in the construction industry their planning is having the capability of knowing how to easily monitor the tasks or activities of the project when participants were asked if CPM was able to help them compare expected results to the actual results 61% of the participants said yes it does and 37% said no and 2% said they were not sure. These results showed that using CPM is advantageous in helping monitors supervisors and owners of the project asses the progress being made and compare what was planned to what has been made.

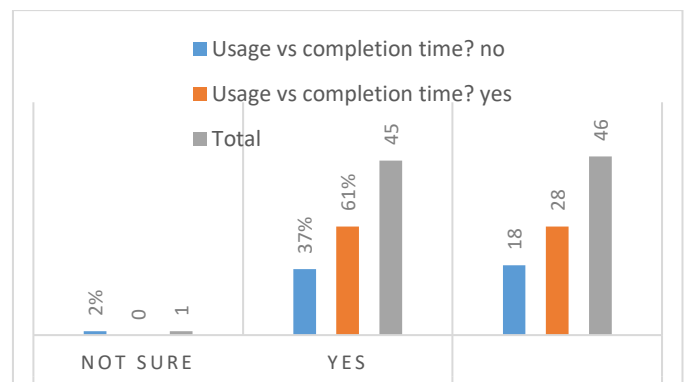


Figure 4.10 Expected results vs realities. The researcher (2019)

V) DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

A. Discussions

The findings on the research have shown that the critical path method has been underutilized by the construction industry. The study reached a total of 46 participants with a 92% turnout that revealed just how much project managers need to apply CPM in the construction industry.

The levels of perception of CPM generally in the construction industry in Zambia, Kitwe in particular was a very good out of the 46 participants 44 representing a 95 percent understanding of CPM expressed understanding of CPM, and this is a very good sign for the researcher, because it shows most participants in construction are conversant with CPM. Only 2 participants representing a 5 percent turnout of the total participants did not understand what CPM is. The literature that was reviewed from Okmen (2014), established that the procedures involved in listing all the activities that are to take place in a project has contributed to the negative perception CPM has received. This research therefore submits that the knowledge and use of CPM in the construction industry will directly impact on the completion time of the projects. The research also shows that despite the very good percentage of people having knowledge of CPM there needs to be a deliberate policy to close the remaining 5 percent so that all persons directly involved in a project have the necessary knowledge about CPM. The research also established that most engineers and artisans have enough knowledge about CPM. The research further established that the knowledge of CPM was not the main problem but its use and implementation.

The conclusion based on this objective the research established that the perception or knowledge of CPM are very high and good but the implementers or planners of projects are not doing their part to the fullest.

The data collected was analysed to establish the levels of usage and implementation of CPM in the main construction companies in Kitwe. The results showed that Using CPM as a deterministic tool to determine the duration of a project is paramount for any project. After asking participants if the use of CPM software in the determining of the project duration reduced the calculating time. It was found that 92% of all the participants agreed and said yes to the fact that it did reduce the calculating time, and only 8% of the participants said no. The results further showed that, the usage of CPM software in project planning is technically meant to help in the efficient completion of construction projects. A question was given to the participants whether using CPM software in the planning stage especially to determine the duration of the project. Of the 46 participants 78% agreed that using the software did have a contribution towards the efficient completion of projects and 22% disagreed. The literature that reviewed from Deacon and *9. (2015) in their study on the use of CPM in construction projects in South Africa concluded that construction companies needed to improve on the use of CPM in their planning. A project is said to be a success if it achieves the three constraints of cost quality and time. The findings of the research concluded that implementing CPM had a positive influence on the time constraint of project management. Further literature from Metanxas & Deffner (2013) concluded that CPM is based on the fact that the planning and the implementation of a Place Marketing Plan is a strategic process, characterised by specific phases, actions and evaluation methods, which are fitted and controlled in specific time horizon. In this context, it can guarantee, to a great degree, the successful implementation of place marketing thus providing to it the character of a project, during the progress and the completion of which there will be no randomness, procrastination and important omissions or errors. This research also established that the type of software used for implementation

also had a bearing on how to use CPM as observed from the findings, from the type of software used it was observed that 50% of the participants are more familiar with and use Microsoft project in their planning, 17% used Smart sheet, 30% were not sure this could be attributed to the fact that the project implementers were more concerned with doing the actual work than knowing which type of software is used, 3% just did not know this was due to the fact that they had not been to college or have any basic construction knowledge. The variations in the type of software used has to be narrowed down to two or three for the industry for easy monitoring and evaluation of the projects.

The research found that after asking participants if the use of CPM software in the determining of the project duration reduced the calculating time. It was found that 92% of all the participants agreed and said yes to the fact that it did reduce the calculating time, and only 8% of the participants said no. This result shows the importance and need for using CPM as a deterministic tool. The researcher observed from the literature reviewed from Mohamed. I.B. (2015) that the reason of inaccurate time estimation that can only arise when PERT and CPM are not properly used and implemented in the very initial phase of planning. Further literature according to Willett. (2011) in his research report he states that inasmuch as CPM helps these management tools greatly improve the systematic execution of projects. Although widely used, these tools do not guarantee that neither a project individual tasks nor the overall project will be finished on schedule, but properly used and implemented will make sure a project is finished on time.

The research established that using CPM whether as a planning tool or monitoring tool has always improved and closed projects efficiently. Of the total participants 61% of them attributed that projects success in terms of time completion was achieved and 39% could not attributed the success in time completion to the use of CPM. The research

further established that most project implementers recommended the use of CPM in planning.

The research further found out that attainment of the time constraint in project management is an achievement of a goal, if the planning of a project takes longer than usual then the starting and finishing will also be delayed. In the efficiency on completion at least 72% agreed that using CPM either through software or manually enabled the completion of projects to be done on or before time. The other 28% disagreed, the percentage of participants showed that effectiveness can be achieved. Goksu (2012) asked the research question, on how will the implementation of CPM and PERT influence the effectiveness and efficiency of production in the company. The use of CPM in planning of projects makes it possible to fulfil all the three project constraints of time cost and quality. The research established the relationship between the actual time and the planned time, one of the benefits of using CPM is its ability to help project managers compare the calculated time to with the actual time. 74 % of the participants said yes to the ease in being able to compare planned time to actual time 26% of the participants were not sure whether or not CPM was able to be used to compare the two times.

Furthermore, the research established the relationship between expected results and the actual realities on the ground.

This research concludes that using CPM in planning worked well towards effectiveness, when participants were asked if CPM was able to help them compare expected results to the actual results 61% of the participants said yes it does and 37% said no and 2% said they were not sure. These results showed that using CPM is advantageous in helping monitors supervisors and owners of the project assess the progress being made and compare what was planned to what has been made of the actual project.

Conclusions

The aim of this research was to assess the use of the critical path in construction projects. More specifically one of the specific objectives was to determine the usage of the critical path in construction projects. The other objective was to assess the efficiency of using the critical path and finally the other objective was to relate the effectiveness of using the critical path in the achievement of project goals.

Following the conclusions of previous similar researches that using the critical path in projects should continue and improve so that the success of all if not most constructions are completed efficiently and effectively.

Improvements in the usage and awareness of the critical path was noted to increase when it is integrated in the initial planning of the whole project. The results have shown the importance and need for using CPM as a deterministic tool in projects.

Project implementers and owners, especially of large, complex projects, should demand that project schedules identify the critical path and that ancillary construction activities such as procurement and resource management, are conducted with the critical path in mind.

The other advantages of using the Critical Path Method is that it increases visibility by allowing everyone on the project to understand how the individual tasks fit together and how they affect the overall project's duration. By dividing a large project into a series of smaller tasks, management and oversight are easier, and delays (critical or non-critical) are readily identifiable. However, the critical tasks will need to be supervised with more attention than others to fully realize the increased efficiency and cost controls that the Critical Path Method provides, it is this advantage that makes CPM the best too, because from it project managers are able to monitor projects easier by following the accomplished tasks.

A further benefit of CPM is that it helps the project manager to identify the least length of time needed to complete the project. Where one needs to run an accelerated project, it helps one to identify which project steps one should accelerate to complete the project within the set time.

Recommendations

The following recommendations were made:

- a. To the institutions that are directly or indirectly associated with construction contractors, and these are the recommendations the writer made;
- b. That they should find a common policy that enables them have enough access to the projects apart from the regulatory role that most of them had.
- c. Government should come up with a deliberate policy to enable contractors provide enough evidence on competency and software usage when it comes to CPM.
- d. The key institution should also improve their monitoring and control measures through the extensive application of CPM.
- e. Provide training programs to facilitate skills and professional development transfer to local contractors.
- f. National Council for Construction (NCC) is a statutory body set up under the National Council for Construction Act No. 13 of 2003 under the Laws of Zambia. Under this law, NCC is charged with the responsibility of providing for the promotion, development, training and regulation of the Construction Industry in Zambia.
- g. To reduce on project delays which can be costly for owners who are eager to begin generating revenue from the new infrastructures. Many owners should request a detailed CPM schedule at least 30 to 45 days before the project begins, so that they can monitor the actual pace of work. Preferably government and other related institutions.

VI) ACKNOWLEDGMENT

The participation of Project Managers, Project implementers and planners made this paper collect the data that has been analyzed and I must thank them for leaving their busy schedules to provide their knowledge and I must thank them for leaving their triple constraints of time, cost and quality. I wish also to acknowledge the input of my supervisors, Mr. Kelvin Chibomba and Mr. Kaela Kamweneshe for their patience, criticisms, encouragement and constant guidance rendered to me through the whole process

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