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Development of A Framework For The Measurement Of Construction Works Progress In Ghana

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DECLARATION AND CERTIFICATION

I hereby declare that, this project report submitted towards the award of MPhil Construction Management is the result of my own work, except for the literature whose sources have been explicitly stated and that, this thesis has neither in whole nor in part been prescribed by another degree elsewhere to the best of my knowledge.

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ABSTRACT

Progress measurement is very important in project management. Progress management encompasses project monitoring and evaluation. Construction project progress is key information in the integrated project management systems as it provides the baseline for comparing what is planned and/or actual cost/work. Among the various kinds of as-built information collected on a project, the project progress rate is one of the critical indices that represent the project performance and progress state. The progress rate aids timely and accurate decision-making through the provision of basic information that can be applied to project planning and control as well as cost engineering. Despite the importance of the progress information, it has come to light that many a time construction professionals disagree on the assessment of the percentage completion of construction projects. This is as a result of the lack of pragmatic methodology. Some professionals prefer to use cost as a basis whilst others use time elapsed or the resource requirements. The lack of pragmatic methodology in measuring construction works objcetively necessitates this research work so as to eliminate the subjectivity from the process. The aim for the research is to propose a pragmatic procedure and framework for measuring construction progress. In order to achieve this aim, a number of objectives were set. Key among them is identification of barriers to the realization of accurate assessment of progress and critical factors that will help drive the process of realistic assessment of construction progress. Existing literature revealed that time, cost and quantity of work are key factors in progress determination. The main tools for the collection of data included questionnaires and interviews. The target population for the data collection included senior management of large building construction companies (D1) and senior consultants of quantity surveying firms. Statistical package for social scientists (SPSS V 20) was used to analyze data obtained. Descriptive statistics, relative importance index, Mann-Whitney U Test and mean ranks were the tools used. The study revealed that the three most critical factors that will help drive the process of accurate progress measurement are cost/budget, quantity (scope of works) and schedule (time) whiles the four major barriers to the process are dependency of supervisor opinion without hard data to back, different units of measurement of bills of quantity items, unspecified method of progress measurement in conditions of contracts and difficulty in getting uniform work breakdown structure. By way of recommendation, contractors and consultants are asked to allocate adequate resources to construction work planning.

Keywords: Construction Works, Progress Measurement, Cost, Time, Quantity

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DEDICATION

To God Almighty, my grand mum, and my inspiring son Benaiah Asare Jnr

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND TO THE RESEARCH

The construction industry in Ghana is one of the major industries significantly contributing to socio – economic development just as in other countries. In recent times, there has been significant growth of the Ghanaian construction industry. According to OBD (2011), the Ghanaian construction industry is picking up after a difficult period following the world economic crisis and in 2011 it contributed around 8 – 9% to the overall GDP of the Ghanaian economy. Despite this growth, the industry is facing a lot of challenges such as project delays (time overruns), delay payments, expenditure exceeding budget (cost overruns), inefficient progress management and inadequate/incorrect project information, (Frimpong et al., 2003). In addition, OBG (2011) also identifies high cost of construction materials and capital as problems facing the Ghanaian construction industry.

The construction industry is very complex in nature: it brings together many organizations, groups and individuals for initiating, directing, planning and controlling the project procurement and production. Controlling a construction project/contract is a continuous activity that starts with a successful tender and end with a satisfactory final account. Effective project/contract control, according to Calvert et al. (1995), entails a regular comparison of actual progress or performance against predetermined targets or requirements, followed by the initiation of appropriate actions to achieve or maintain the desired objectives. The proper focus and speed of construction (or the realization of capital project) cannot be economically attained by compulsion, but require careful and adequate planning and control.

Construction itself is a complex and risky venture which is affected by several variable factors that influence the smooth running of construction contracts or projects. It is for this reason that Calvert et al. (1995), stated that planning and organization provides the strategy and means for subsequent control and coordination and site management. This means a constant interchange of information, which in turn pre-supposes good communication system for the effective transmission of ideas, instructions, reports and details.

Under the ever-changing and highly competitive construction business environment, progress and performance measurement is a very critical issue for any type of construction organization including clients, architects, quantity surveyors, engineering firms and contractors, (Jung and Lee, 2010). It is in line with this that Halpin (2006) said, early detection of actual or potential time and/or cost overruns on a construction project (activities) are very important to project management. This will provide the project team an opportunity take corrective measures to enhance the chances of controlling such overruns or minimize the impact. Time and cost overruns reduce profits of project. It is for this reason that project managers, contractors, clients and consultants are perceptive to any deviation from the project plan. This according to Mani et al (2009) entreats project managers, contractors and consultants to design implement and maintain a systematic and detailing approach for progress monitoring to quickly find out, process and communicate any divergences between actual and planned progress/performance as early as possible.

Progress measurement is very important in project management. Progress measurement encompasses project monitoring and evaluation. Monitoring and/or evaluation is defined by Mani et al. (2009) as gathering, examining, recording and reporting information concerning key aspects of the project such as the budget, time, quality and quantity of work done.

The budget, time and quality of work are the main indicators for construction project progress and performance, (Jung and Kang, 2007). Also according to Rasdorf and Abudayyeh (1991); Jung and Gibson (1999), the integration of cost and schedule control systems are issues of great concern to practitioners and researchers. This implies that most efforts on the subject has been centered on budget, time and quality leaving out the quantity of work done and the correlation between budget, time, actual quantity of work done and quality of the works.

In furtherance of the above, studies on this subject has been targeted at data acquisition for the measurement of progress, Jung and Lee (2010), Mani et al. (2009) and El-Omari and Moselhi (2009). Also a research by Chin et al. (2006) proposed a framework that could be used to measure progress taking into accounts cost, the work and measurement method leaving out time which is a critical progress and performance indicator in construction project delivery. It is now clear that existing researches did not holistically consider all the critical factors to propose a more suitable and effective framework for measuring project progress hence the focus of this research to propose comprehensive framework that would be used to measure construction project progress. The framework will consider all the important project performance indicators with respect to measurement methods.

1.2 PROBLEM STATEMENT

Construction project progress is very important information in the integrated budget and schedule control as it provides the baseline for comparing what is planned and/or actual cost / work, (Jung and Kang, 2007). However, the methods, data and accuracy of the measured progress may vary due to the characteristics of the project i.e. the size, the type and nature and the location. Irrespective of these variations in methods and accuracy, progress information should be analyzed and maintained in a highly detailed simple form for the consumption of project stakeholders in relation to effective cost, time and task/work planning and control, Deng and Hung (1998), Rasdorf and Abudayyeh (1991) and Jung and Woo (2004) opined.

Construction project managers in recent times depend more on project management information systems for efficient management by collecting as – built information and using it for decision – making. Among the various kinds of as-built data collected on a project, according to Chin et al (2006), the project progress rate is one of the critical types of information that represent the project performance and progress state. The progress rate aids timely and accurate decisionmaking through the provision of basic information that can be applied to project planning and control as well as cost engineering. But progress measurement and management has not been quite effective, since it has not been based on objective criteria but rather on subjective judgment depending on the individuals experience and preference, (Lee, 1997). For instance, when a contractor or consultant says the project is 80% complete, what does it mean? That 80% of the works has been done? That 80% of the project time has been spent? That 80% of the problems have been solved? That 80% of the project budget has been spent? All or none of the above? For some , 80% means there is a progress payment for stating that the work is 80% complete, whether it is or not. This example shows the subjectivity of the existing progress measurement systems. It has also come to light that many a time construction professionals disagree on the assessment of the percentage completion of construction projects. This is as a result of the lack of a pragmatic methodology in that regard. Some professionals prefer to use cost as a basis whilst others use time elapsed or the resource requirements.

Concerning progress measurements and managements, Thomas and Mathews (1996) grouped the progress management into three categories by the progress measurement methods, namely estimated percentage complete, physical progress measurement and earned value. Flemming and Koppleman (1996) and CII (1987) grouped the methods of progress measurement at much more detailed level and suggested the use of different methods based on the project characteristics. Chin et al. (2006) also developed a progress measurement framework by considering the work and cost based on the measurement methods. One important element missing out in this framework is time. This clearly shows that the proposed framework did not consider time and the relationship between budget, time and the work in selection of measurement methods. It for this reasons that it has become very necessary to conduct a research into the subject; progress measurement taking into account the budget (cost), time (schedule) and the works (task) .

1.3 AIM OF THE RESEARCH

The aim of this research is to propose a framework for the determination of construction works progress in Ghana

1.4 OBJECTIVES OF THE RESEARCH

The objectives of this research are to:

a. Identify the methods currently in use in the construction industry to measure project progress.
b. Determine the critical factors that drive the process of progress measurement of construction projects.

c. Identify the critical barriers to the determination of realistic assessment of construction work progress.

d. Identify and document the processes and procedures adopted by relevant construction industry stakeholders in the measurement of construction work progress.

1.5 RESEARCH QUESTIONS

The purpose of this research is to propose an innovative procedure for the determination of construction project progress measurement and management in Ghana. It is also to propose a comprehensive progress measurement framework that could be used to measure actual project progress.

In line with the above the following research questions are posed:

1. What methods are being used to measure project progress?
2. What are the factors that affect/influence the measurement of construction progress?
3. What are the critical factors that drive the process of progress measurement?
4. What are the critical barriers to the realization of accurate assessment of construction project progress?
5. What is the relationship between the work (task), time (schedule) and budget (cost/payments)?

1.6 SIGNIFICANCE/JUSTIFICATION FOR THE RESEARCH

The importance of progress measurement and management cannot be over emphasized. For his own benefit, and to support the payment of his claims/certificates, the contractor needs to put in place a method of measuring his progress in relation the works, time and cost. Without this, neither the contractor nor the client will have any firm basis for judging how far the work has really progressed, whether the work is at the correct stage of completion or whether the project/work is likely to be completed on time/schedule. In addition without the knowledge of how far a project has progressed, control is almost impossible. Think of the uncertainty that will be involved if you are on a long car journey through wild country and you have no fuel gauge to give you information on the progress of your fuel tank towards being completely empty! This analogy demonstrates how importance progress measurement and management is to project stakeholders.

Despite the importance of progress information, little or no research appears to exist on the subject construction project progress measurement and management in Ghana, although there has been several researches on the causes and effects of project cost and time overruns, planning and control and variations. These researches attribute the major cause of project delay, cost overruns and variations to lack of adequate planning and controlling mechanisms, Aftab et al. (2011), Adu-Boateng (2011) and Oduro (2011). Calvert et al. (1995) also argued that planning and controlling depend largely on adequate and accurate information. This therefore makes construction project progress measurement very critical and important to project control so as to deliver the project within time and budget yet there is no research in this regard.

In addition, several models frameworks have been developed over the years to predict duration of projects and possible project cost overruns. Yes these models are helpful in budgeting and planning but do not help in project controlling. This therefore makes this research very important and necessary to aid project controlling so as to deliver project within budgets and time. This will also help project promoters in strategic business planning and decision making.

1.7 SCOPE OF THE RESEARCH

This research focused mainly on building works because projects are complex and contains several work sections and activities which makes its progress measurements challenging and worth researching.

The research at was limited to Activity and work section levels of building works. Also the research considered the essential parameters for progress measurements and management such as the work (task), time and cost.

1.8 RESEARCH METHODOLOGY

A detailed literature review was conducted to provide the researcher with background information on construction project progress measurement and management. This historical data will also assist in providing insight into current problems associated with project progress measurement and management.

The studies used a questionnaire survey, interview and case study projects to investigate construction experts' perspectives on progress measurement and management for primary data.

The results were analyzed using simple statistical tools such as frequencies, percentages and means as well as probabilities.

1.9 ORGANIZATION OF THE RESEARCH

This research was organized into five chapters as detailed below:

Chapter 1 – Introduction: - this deals with the background phase of the research by providing the aims & objectives, proposed methodology overview, scope and research outline.

Chapter 2 – Literature Review: - this will entails review of existing literature of the subject from professional journals, books, internet searches and from interviews with construction project experts. The Chapter two will essentially provide a review of the current state of the art in progress measurement and management.

Chapter 3 – Research Methodology: - It will discuss in details the methods used to carry out the research.

Chapter 4 – Data Analysis: - this Chapter will contain data collected from the questionnaires and historical projects as well as the analysis of the raw data collected.

Chapter 5 – Discussion of Findings, Conclusions and Recommendation: - it will discuss the findings from the analysis carried out in chapter 4 and develops conclusions and recommendations that are derived from the research and how the research objective are align with the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This Chapter deals with detailed review of existing important literature on the subject; "progress measurement of construction projects"

2.2 CONSTRUCTION PROJECTS

Construction is a process of putting together resources towards realization of infrastructure (Frimpong, 2007). It is the means by which real properties are usefully created in the built environment. Construction is not a single activity but a large scale multi activity. Construction therefore ought to be planned and controlled for the realization of projects. Construction project refers to any building and civil engineering works including simple one bedroom apartment to skyscrapers and complex suspended bridges (Adinyira, 2010).. These construction projects can be classified under two (2) main categories, namely:

1. Building construction
   a. Residential building construction
   b. Industrial construction
   c. Commercial building
   d. Institutional construction
2. Heavy civil engineering construction

Every construction project in whatever form will involve putting a team and other resources to initiate, plan, design, construct and maintain (Kwakye, 2008).

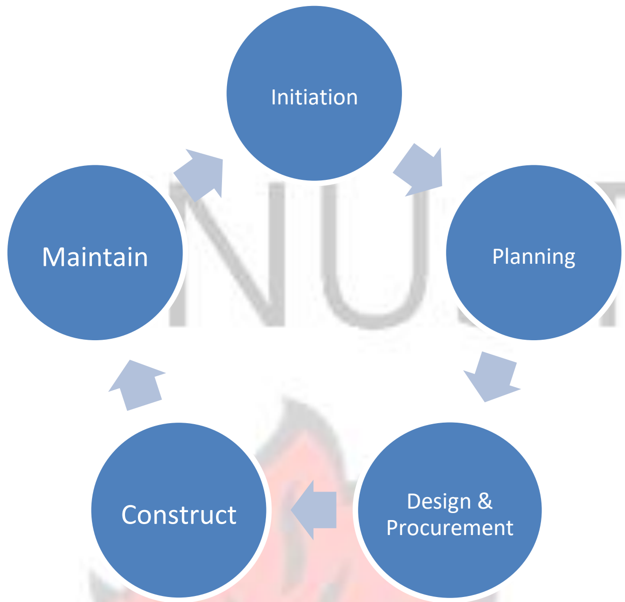

Figure 2.1: Construction Project Cycle

2.2.1 Building Project

Building projects, be it residential, industrial, commercial or institutional will requires a team of professionals to carry it through the process of initiation, planning, designing, construction and maintenance. This process can be classified as pre-contract and post-contract processes. According to Fugar (2010), by the traditional method of construction, the client and consultants are solely responsible for the pre-contract works which includes initiation, planning and design & procurement. Again Fugar (2010), Frederick and Jonathan (2001) argue that the contractor is solely responsible for the post-contract stage which includes the construction and commissioning of the project. But the contractor does so under the supervision of the consultants. This argument is being defeated as new forms of procurement methods involve the contractor from the precontract stage of a project. This is what is called integrated systems (Harris and McCaffer, 2001).

2.3 PROJECT PERFORMANCE / PROGRESS

Project progress managements during a project is to know how the project is faring so that early warning challenges that might hinder achieving project objectives can be identified so as to manage them as well as expectations.

Project progress and performance measurement is a very critical issue to any type of construction organization (be it clients, consultants and/or contractors) under the ever changing and highly competitive construction environment, Jung and Lee (2010) argued.

According to George (2013) project progress and performance measurement on the surface may seem easy to measure: just keep tract of the three key elements of the project such as time, cost and scope and it is done, but when it is deeply looked into it will be found that it is not simple at all. It is in line with this that Jung and Lee (2010) clearly stated that, the effort required in collecting and analyzing project performance data makes systematic management stressful. It is further argued that the methodologies and applications utilized in order to monitor project performance are getting complex and advance. However most of these methods are subjective to manipulations of the project supervisor/coordinators. Therefore when measuring project progress, specifically, when the project is going on, it is important to concentrate on the project objectives and performance against time and cost estimates, George (2013) opined.

2.3.1 Key Project Progress Indicators (KPPIs)

According to George (2013) Typical Key Project Progress Indicators (KPPIs) for any projects include;

a. Schedule (Time) compliance
b. Budget (cost) compliance

c. Number of Scope changes

d. Number of issue

e. Number of defects and

f. Stakeholders satisfaction

However for construction projects, the key project progress indicators (according to Jung and Lee, 2010) are

a. Cost

b. Schedule

c. Quantity (scope of work)

d. Value

e. Safety

f. Rework/defect

g. Productivity

h. Construction Techniques/methods

i. Cooperation's / harmony

Nevertheless, it can be seen that;

1. Safety, productivity, rework and construction methods and harmony are cost related.
2. Value, safety, rework / defects, construction methods, corporation are also schedule / time related whereas
3. Quantity is influenced by safety, defects / rework; and construction methods

It is therefore clear that Jung and Lee (2010) were right to have said that for construction projects, the major key project progress indicators are;

1. Cost
2. Schedule/Time and
3. Quantity (scope of work)

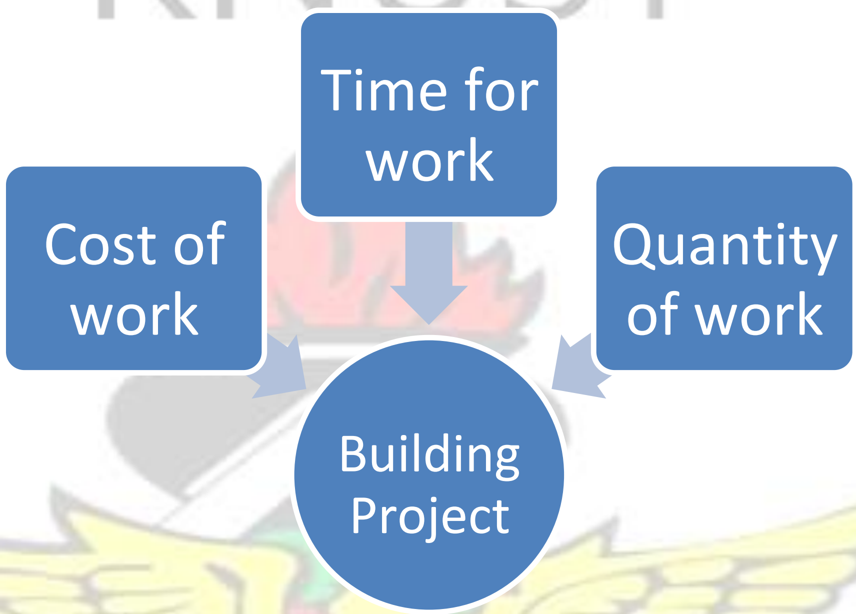

Figure 2: Key project progress indicators (KPPIs).

2.4 PROJECT PLANNING

Planning is most useful under conditions of uncertainty. The construction industry unlike other industries where most of its activities are carried out in the open and under very unpredictable conditions requires adequate planning in order to achieve project goals (Adinyira, 2010). According to Harris and McCaffer (2001), there are two main levels of construction project planning. These are;

- Strategic planning and
- Operational planning

Strategic Planning

Strategic planning deal with high level selection of overall project objectives, including the scope, procurement units, time-scale and financing options the strategic planning, for a project according to Harris and McCaffer (2001), results in broad outlines of what the project has to achieve and how it is to be undertaken.

Operational Planning

The operational planning process starts with the contractor deciding whether to bid or not to bid for the project (Manteau, 2008). The adage that "if you fail to plan, you are planning to fail" is very true of the construction industry.

This involves establishing a method statement for each activity in the project. It allows you to assess the project's resources requirements. The operational planning according to Manteau (2008) can be categorized under three main phases from the perspective of the contractor.

- Pre-Tender planning phase
- Pre-Contact planning phase
- Post Contract/contract planning

2.4.1. Pre-Tender planning phase

It involves all the activities that contractors embark on from the time that they were informed about the job (invited to tender) up to the time that he submits a bona fide tender for the projects. Calvert et al. (2001) said the objective of pre-tender planning includes the following:

1. To pool the company's past experience and the knowledge of its various departments and specialist.
2. To assist the estimating department by delegating certain tasks to other interested personnel's,
3. To eliminate certain controversy between estimator and supervisor on such matters as methods, output rates, preliminaries and on-cost /overheads,
4. To ensure a realistic tender by coordinating technical theory with current practice,
5. To improve the ratio of awards / tender submitted by reason of the increased attention to details and advantages of co-operation.

To achieve the objectives of pre-tender planning the following activities are undertaken (Manteau, 2008)

1. The decision to bid or cost
2. Site visit reports
3. Method statement/preliminary plan of works
4. Preparation of cost estimates
5. Estimate finance statement
6. Adjudication of the estimates
7. Report to management

2.4.2. Pre-Contract Planning

As soon as the contractor learns that he has been successful in winning a contract, he will have to start organizing and planning for the work that lies ahead. All activities undertaken by the contactors from the time the award is conveyed to him up to the time that he takes possession of the site, constitute the pre-contract planning phase of the contract, (Manteau, 2008)

At this stage of the project, the contractor is expected to contact the project manager for a full set of working drawings for his study and planning purposes. After the study of the drawings, a good contractor at this stage would place sub-contract orders, other materials arrange for plant and equipment, engage labour and prepare his schedule of operations and the general organization and programming of the works (Calvert et al., 2001).

All issues that were considered at the pre-tender phase must be analyzed further before work commences. As a result the following are subject to further analysis at this stage of planning (Manteau, 2008);

1. Site visit report
2. Method statement
3. Site organization structure
4. Schedule of site on-cost /overheads
5. Sub-contracting arrangements
6. Pre-tender programme
7. Estimate finance statement

The objective of pre-contract is for a smooth and successful project take off. Some of the activities to be undertaken at pre-contract stage planning include (Adinyira, 2010);

1. Pre-contract meeting
2. Registration of drawings
3. List/names of sub-contractors (Domestic & nominated)
4. List of suppliers (domestic & nominated)
5. Pre-contract method statements
6. Pre-contract master programme
7. Site logout planning
8. Requirement schedule
9. Checklist & requisition for starting new contract

2.4.3 Contract Planning Phase

This phase planning will commence immediately the contractor takes possession of the site. The first series of activities on the master programme would be put into effect, usually starting with mobilization activities (Manteau, 2008)

Adinyira (2010) argued that once the contractor has started work on site, planning will be required at regular intervals to find out when and how specific site activities are to be executed. These types of planning are usually termed as short-term planning and it is carried out every six weeks monthly, bi-monthly (forth night) weekly, or even daily basis. This involves monitoring the master programme and updating it, reporting progress and making sure that health and safety concerns of the project are catered for. Planning at this stage is carried out at a fairly detailed level to ensure that the contractor makes the best use of limited available resources.

2.5 PLANNING TECHNIQUES.

The most commonly used planning techniques in the construction industry are the bar charts or procedure bar chart and network diagrams (Manteau, 2008; Harris and McCaffer, 2001)

2.6. DOCUMENTS NEEDED FOR CONSTRUCTION PLANNING

The principal document needed for a successful planning includes (Manteau, 2008; Harris and McCaffer, 2001);

1. Method statement
2. Bills of quantity
3. drawings

2.7 PROJECT CONTROL

Controlling a construction project is a continuous activity which starts with a successful bid and ends with a satisfactory final account. Calvert et al. (2001) states that effective control involves a regular comparison of actual progress or performance against plan progress and the initiation of appropriate action to achieve or maintained the desired objections. This therefore places progress measurement and management in a very critical position regarding project control and completion.

Proper direction and speed of construction projects cannot economically be attained by compulsion but through the creation of conditions that will encourage self-control and promote team spirit which is so vital to an efficient and successful project delivery. This makes planning and organizing a vital strategy and means to subsequently control project progress. Calvert et al. (2001)

gave credence to this by saying that a constant interchange of information which in turn pre-supposes good communication system for the effective transmission of ideas, instructions and details .One importance of such information system is the project progress and performance. In furtherance, Adinyira (2010) stated that without control, it will take a longer time to complete the project and may probably be completed at a lower standards .This implies that effective control of construction activity will reduce the possibility of exceeding the time and financial forecast .To achieve effective project control, Adinyira (2010), argued that it is very important to set up a systematic procedure that can easily be appraised. This system could be the use of good/accurate progress measurement systems as stated by Aaron (2009), that progress measurement is a crucial component of effective project control.

In summary, Mubarak (2010) said, project control encompasses the following process:

1. Monitoring and work progress
2. Comparing it with the baseline schedule and budget – Evaluating the work progress
3. Identifying any nonconformities, finding out where it is occurring and the intensity, and examining them to ascertain the causes
4. Taking remedial action whenever and wherever necessary to bring the project back on schedule and within budget

Along with these four basic functions, another function of project control may be to help identify areas in which to improve work efficiency, to help accelerate the schedule, to help reduce cost, or to help the project in other ways. Project control in the context of this research involves both budget control and schedule control as well as quantity of woks. It can also include quality control and safety control,

2.8 PROGRESS MEASUREMENT AND MANAGEMENT

Progress measurement is a critical component of effective project control in the delivery of project Aaron (2009) stated. This means that, for any construction project to be delivered within time and budget at a specified quality, accurate progress measurement must be ensured. All projects deviate from the plan and all schedules change during the construction phase of any construction project. It is therefore important that, the project team must be aware of what is happening, so that they will be in a continual reactive mode to put the project on track in terms of time and budget, Aaron (2009) argued. Progress measurement is then defined by Reid (2008) as a method by which the defined scope of work can be quantified, such that each element can later be measured and aggregated with other element to provide a measure of how far the project has progressed. Progress in itself is defined in the Association of "Cost Engineering Terminology" booklet as "percentage completion as determined by physical or theoretical measurement" (ww.acet.com/progress). In essence, progress measurement is the process by which the status of completion of a project at any defined stage can be quantified against a target.

Generally after progress is measured, it must be managed to ensure the success of the project. However, progress measurement according to Bae (1989), is defined differently contingent on the aspect of cost engineering and schedule planning respectively. But in overall view, project progress management can be considered as the integration of cost and schedule, Lee (1997) argued. Base on the operational definition, construction project progress management in this research shall be defined as the measurement and analysis of the degree of progress based on measured actual work done, its budget and time allocated.

2.9 PROGRESS MEASUREMENT METHODS

Existing researches on progress management have suggested various progress measurement methods for use.

Thomas and Mathews (1996) identified three measuring methods namely:

1. Estimated percentage complete.
2. Physical progress measurement.
3. Earned value.

Construction industry institute-CII (1987), also proposed 6 methods of measuring construction work progress. They includes

1. Unit completed.
2. Incremental milestone.
3. Start/finish supervisor.
4. Opinion.
5. Cost ratio
6. Weighted or Equivalent units

A research by Fleming and Koppleman (1996), also came up with the following measuring methods;

1. Weighted Milestone
2. Fixed formulae by task
3. Percentage complete and milestone gates
4. Earned standard
5. Apportioned relationship to discrete work

6. Level of effort.

A more recent research undertaken by Chin et al. (2006) also developed the following methods for progress measurement;

1. Measure fixed quantity of single major item
2. Measure fixed quantities of many major items
3. Measure fixed quantities of all items
4. Check start/finish of work
5. Check milestone
6. Estimated percentage complete

Eldin (1989) established a computer application for the determination of construction work progress built on weighted milestones and earn value. Mani et al. (2009) also added flavour to the computer application by developing a 4 – dimensional augmented reality model for automating the progress measurement process. In addition, Choi (2003) claimed that the effectiveness and efficiency of measuring progress can be maximized through specifying major items that can represent the real work progress.

Even though the existing researches came up with several measurement methods for work progress, the progress management has not been based on objective criteria but based on the project manager's judgments and conveniences. Also Mani's 4D model will aid visual reporting but it will be very expensive and difficult to implement such system even in developed countries how much more in developing countries like Ghana where ICT know-how and application is very low in the construction industry.

2.9.1 Measuring of work progress

AACE (2014) and Mubarak (2010) agrees with the methods developed CII, (1987). Now looking at the methods developed by the other researchers, it is clear that AACE (2014) and Mubarak (2010) agree that the other methods proposed by other researchers are nothing new but just recycling of names. Let us now examine the methods in detail

2.9.1.1 Unit Complete

This progress measurement method is normally used for work packages that their scope can further be disintegrated into fairly standardized units of work such that each unit requires roughly the same level of effort to complete. This method estimates the percent complete or progress by dividing the units completed by the total units times hundred Progress=workdone/plan quantitiesx100% (AACE, 2014 and Mubarak, 2010).

The advantages of this method are:

1. It is objective and ideal for activity level progress measurement.
2. It is simple to compute
3. Appropriate for activities with small works and works that are, identical and repetitive in nature

The disadvantages include:

1. It is quantity bias to the neglect of cost and time
2. It cannot be used to compute work progress of a complete project and even work section due to varying unit of measurements.

In conclusion, this method's disadvantages far outweigh the advantages and it will only be ideal for simple activity level progress measurement.

2.9.1.2 Cost or Time Ratio or Resource Expenditure (Level of Effort)

Some construction activities do not have discrete deliverables, for instance, safety inspection, quality control and assurance and management type activities. This method is ideal for such activities. This method calculates work progress in two ways.

- Baseline or Budgeted method

$$Percent\ complet = \frac{\text{Budgeted cost to date or Baseline budgeted time to date}}{\text{project baseline cost budget or project baseline time}}$$

- Actual cost or time method

$$percentage\ complete = \frac{\text{reall cost or time to date}}{\text{Estimated cost or time at completion}}$$

The baseline method shows the percentage that ought to be attained at the time of measurement and reporting. The actual cost/time gives the actual percentage achieved at the time relative to cost or time (AACE, 2014 and Mubarak, 2010).

Advantages of this method are:

1. It is quick and simple to compute
2. It is objective
3. It can be apply to work sections and the entire project to large extent.

The disadvantages are:

1. This method is deceptive since using the two methods at a time will give you different progress rate. For instance, a construction management work scheduled for twelve (12)

months with a budget of GHS 90,000.00. After three(3) months, the expenditure /value achieved is GHS30,000.00.The progress record at the time will be:

a. Using cost ratio - percent complete $= \frac{30,000.00}{90,000.00} x100 = 33\%$

b. Using time ratio - $Percent\ complete = \frac{3}{12} x100 = 25\%$

The question here is which of the two represent true progress? For the quantity surveyor its will be the cost ratio and for the works study engineer, it will be the time. One project same information but different progress but the progress must be one.

2. It only considers one of the project objectives leaving behind other equally important project objectives or elements and therefore it will not give you the true progress of a project/activity.

To sum up, it will be said that despite the fact that this method provides basis for earned value analysis it fall short of a holistic progress measurement approach

2.9.1.3 Start – Finish Method

This method works best for small activities, work sections and projects, with no or short duration. The construction manager or coordinator may assign two or three levels for the activity or work section or the entire project. Not started will be 0%, progressing but not completed (an arbitrary amount) says 45 % or 60% and completed will be 100%. This method can be applied easily to the whole project progress measurement but it lends itself to subjectivity. It is simple to use this method at the activity level but experience and judgment will be required to apply it to the entire project. It is less objective (AACE, 2014 and Mubarak, 2010).

2.9.1.4 Judgment / Supervisor's opinion

This is the most biased method. This is mostly used where no other method will be appropriate to applied. Example is dewatering operation. In this method, the project participant who is handling a work package, he or she will purely determine the percentage complete of work done based on his or her judgment due to his experience. This method depends solely on the experience of the supervisor (AACE, 2014 and Mubarak, 2010). The only advantage is that it is quick and easy to use. The main disadvantage is it is totally biased.

2.9.1.5 Incremental Milestone

This is most appropriate method for complex or multistage activities. In other words it is used where the work package is one deliverable. The activities or project must be carried out in sequence so that the completion of incremental tasks can be observed. In this method each stage or step or section of a given activity or project is assigned a "weight" that is approximately equal to its percentage share of efforts in the task/activity or the project. This method seems simple but highly depends on past experience of the supervisor who assigned or estimates the weight or milestone. The method is subjective but convenient and great results could be achieved if the supervisor is well experience (ACCE, 2014 and Mubarak, 2010).

For instance, a contractor is to install 25 windows. Five windows that are yet to started are 0% complete. Seven Windows have their frames fixed. They are said to be 25% complete. Another five windows have been fixed. They are given 50% complete. Five additional windows are painted, considering them to be 75% complete. The last 3 windows have had the hardware installed. They are now 100% complete. Each window will follow through steps:

Table 2.1: Incremental Milestone

Task	Weight (%)	Cumulative Weight (%)	No. Units	% Complete Weight
Yet to started	0%	0%	5	4x0%/25 = 0.0
Fix window frames	25%	25%	7	7x 25%/25 = 0.096
Fix windows	25%	50%	5	5 x50%/25 = 0.120
Paint windows	25%	75%	5	5 x75%/25 = 0.120
Install hardware	25%	100%	3	3 x100%/25= 0.120
			25	Total = 0.456 = 45.6%

Source – Mubarak, 2010

2.9.1.6 Weighted or Equivalent Units completed

This method is a combination of unit complete with incremental milestone. It is used when the work package scope includes non-standardized units of work and or work tasks that overlap such that the other methods don't work well. This method also relies on past experience of the project manager to assigned weights (AACE, 2014 and Mubarak, 2010). This therefore suggest that irrespective of calculations involve, the fundamentals or the basics are subjective to the experience of the project manager. According to Mubarak, 2010 the method consists of the following steps:

1. Assign a weight to each sub activities / activities / work sections so that the total weight equal to 100%
2. Multiply the weight of each sub activities / activities / work sections by the quantity of the total sub activities / activities / work sections to arrive at the "equivalent weight" in units of each sub activities /activities / work sections.

3. Calculate the percentage complete or the progress of work for each sub activity / activity / work section by using one of the previous discussed methods.
4. Multiply the percentage complete of each sub activity / activity / work section by its equivalent weight to achieve "earned quantity"
5. Add the earned quantities for all the sub activities / activities / work sections and divide by the total quantity.

Now, one critical issue with this method is that it is very ideal for activity level progress measurement due its level of objectivity. However it's fundamental is very subjective and the subjectivity comes to play when you apply it to a work section or the entire project. This because the activities within a work section of a building project has different units of measurement. This therefore raises the question of what will be the total quantity of a work section for which you will divide the earned quantity with. For instance a work section like concrete works consists of the following major activities with different units of measurement by the SMM7:

a. Formwork m^2
b. Reinforcement tons(t)
c. In-situ concrete m^3

2.10 OVERVIEW OF THE METHODS

The question is which of the above methods is better? There is no straight forward answer as they all have their strength and weakness. According to Mubarak 2010, the method chosen will largely depend on what you are locking for and the data available. All of the above methods are suitable for activity level of progress measurement to some extent because they all contain some degree of subjectivity. Also they all contained some level of objectivity too with exception of the judgment / supervisor's opinion. However the objectivity is very limited due to the fact that the fundamental of all the method is on the experience of the project manager i.e. his judgment is required as the basis for the computation of the percent complete by the method.

In addition none of the above methods makes the attempt to integrate the key project performance/progress indicators/elements i.e. cost, time and quantity of work done (work scope). It is the absence of this integration that undermined the strength of the methods.

2.11 INTEGRATION OF COST, TIME AND WORK

Garold (2000) asserted that, experienced project managers are familiar with the problems of using partial information such as only cost or time to track the status of a project progress. For instance half of a project budget or cost may be expended by mid-point of the schedule duration but only 25% of the work may be accomplished. In fact monitoring only the cost or time would show that the project is progressing well. However upon completion of the project there would be likely cost or time overrun because the measurement of the work was not included in the project control systems. This therefore imposes on project managers to develop an integrated cost, time and work system that would provide meaningful feedback during the project rather than afterwards, Garold (2000) argued. The status/progress of the project can then be determined and corrective actions taken when corrections can be made at the least cost.

To enable project managers integrate these three (3) basic components or elements of a project objectively, they must appreciate the relationship that exist between them. These three components can be said to have a direct relationship i.e. very elastic to each other. This implies that once the quantity of work (scope) is altered positively (increased), the cost and the duration will responded positively (increase).

2.11.1 Earned Value Analysis Method

The main benefit of earned value analysis is that it improves predictability. It allows you to establish what has been completed against what has been planned and then use the level of performance/progress achieved to provide a more realistic assessment of where a project is heading in terms of cost and schedule (Javier, 2013).

The system tries to integrate the three basic components or elements of the project but it start on one element i.e. cost or time or work. This is used to determine the percent complete which is used to compute the earned value. Since the foundation is weak the whole process cannot be relied upon. The concern here is the computation of the percent complete and not the subsequent process or steps like the earned value, time variance, time performance index, value variance and value performance index. Once the basics (i.e. the percent complete) is corrected the integration would be well grounded (Garold, 2000 and Javier, 2013)

2.12 APPRAISAL OF EXISTING PROGRESS MEASUREMENT FRAMEWORK

Among existing researchers, it is only Chin et al. (2006) who developed a progress measurement framework. Although Jung and Lee (2010), Mani et al. (2009) and El-Omari and Moselhi (2009) are all proposing computer application and automating the progress measurement process, particularly data acquisition. However, these prepositions will be greatly enhanced if adequate and comprehensive progress measurement framework is developed to aid standardization for the computer application.

Chin et al. (2006), progress measurement framework has three-dimensional structure that integrated work breakdown structures, cost breakdown structures and measurement methods. The object of this framework is the work, cost and the measurement method. This framework was developed from a cost engineer's point of view. This framework will aid cost planning and control but will be of no help or use to a schedule planner. The framework is illustrated in the figure below;

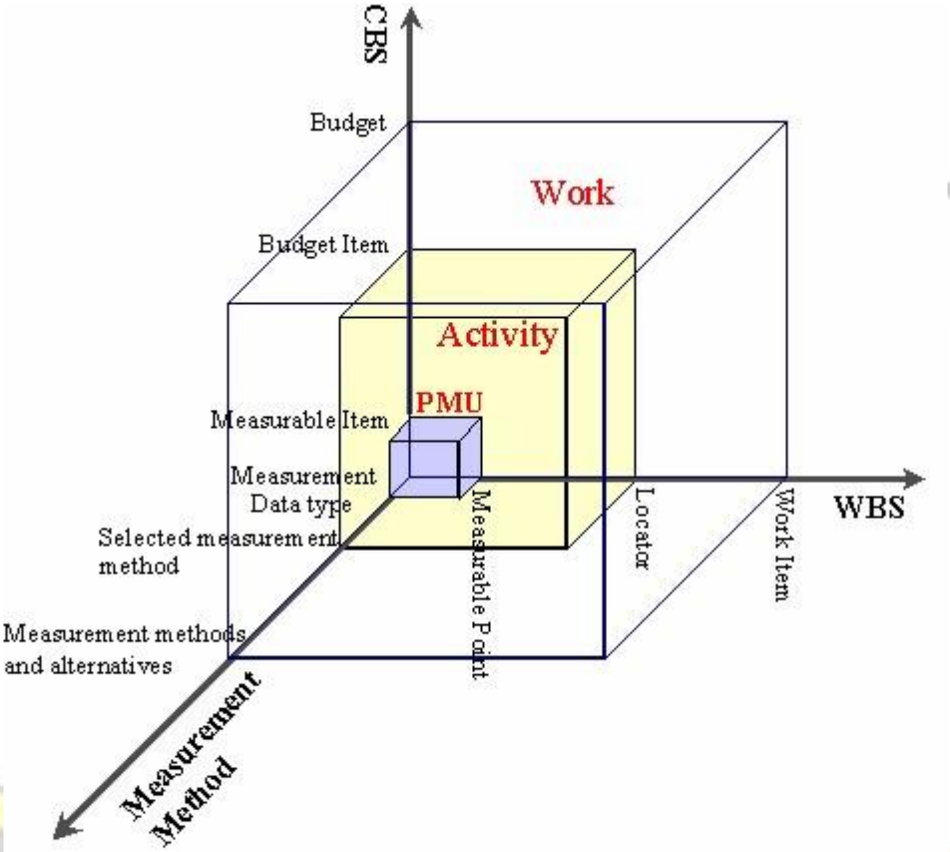

Figure 2.3: Existing Progress Measurement Framework (Adopted from Chin *et al*, 2006)

2.13 CONDITIONS OF CONTRACT PROVISION WITH RESPECT TO CONSTRUCTION PROJECT PROGRESS

Every construction contract is governed by a set of rules termed conditions of contract. This document anticipates problems likely to ensure on any project and make room for resolution. One of such areas is project progress. Let as now examine the provision in the various conditions of contract with regards to progress management.

2.13.1 PPA Conditions of Contract (For Medium Contracts)

Clause 31 of this condition advocate site meeting (management meeting) so as to discuss progress and corrective measures that need to be taken to ensure completion of the project on time and with budget. Clause 31.1 express provision is “The project manager shall arrange monthly meetings. The business of management meetings shall be to review the plan for remaining work and to deal with matters raised in accordance with the early warning procedures”.

2.13.2 FIDIC (1992 Edition) Conditions Contract

Clause 46 deals with progress management under the FIDIC. It discussed the procedure to be followed in managing the project if work rate or progress in the estimation of the consultant is to slow and will affect the project completion date. Clause 46.1 express provisions are “if for any reason, which does not entitle the contractor to an extension of time, the rate of progress of the works or any section at any time, in the opinion of the Engineer, too slow to comply with the Time for completion, the engineer shall so notify the contractor who shall thereupon take such steps as are necessary, subject to the consent of the engineer, to expedite progress so as to comply with the time of completion. The contractor shall not be entitled to any additional payment for taking such steps. If, as a result of any notice given by the engineer under this clause, the contractor considers that it is necessary to do any work at night or on locally recognized days of rest, he shall be entitled to seek the consent of the engineer so to do. Provided that if any steps taken by the contractor in meeting his obligation under this clause, involve the employer in additional supervision cost, such cost shall, after due consultation with the employer and the contractor, be determined by the engineer and shall be recoverable from the contractor by the employer from any monies due or become due to the contractor and the engineer shall notify the contractor accordingly, with a copy to the employer”.

2.13.3 PINK FORM conditions of Contract

In this condition of contract, progress management was also dealt with. Clause 17.3 states that "should the rate of the work or any part thereof be at any time in the opinion of the consultant too slow to ensure the completion of the works by the prescribed time the consultant shall so notify the contractor in writing and the contractor shall thereupon take steps as the contractor may think necessary and the consultant may approve to expedite progress so as to complete the works by the prescribed time."

One thing missing in all the three conditions of contracts regarding the provisions on progress management is the method by which the progress shall be measured by the consultant. Also they stated that the progress shall be in the opinion of the consultant. This contributes to the subjectivity of all the proposed measurement methods. Also, the emphasis in the above provision is on completion time. This makes the task and time very critical elements in the progress measurement. However, earlier studies focus on the task and cost.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

Literature on the available progress measurement methods and their weaknesses was reviewed under chapter two. The review helped in composition of important research questions. The research questions focused on the progress measurement methods used in Ghana, factors that influences the process and how these could be used to proposed innovative procedure for measuring construction project progress. The aim of the research was, therefore, to propose framework for the determination of construction works progress. The objectives, relevant to arriving at the research aim, were then constituted. This chapter therefore discusses the research methodology used in this research. It focuses on the design of the survey questionnaire sample sizing. The data analysis tools for the research are also discussed.

3.2 RESEARCH DESIGN

A quantitative strategy was adopted in this research due to the fact that quantitative research follows a deductive approach in relation to theory and is concerned with the design measurement and sampling (Naoum, 2002). The strategy employs the use of statistical techniques to identify facts in relation to the subject matter. Quantitative research is also objective in nature and based on testing a hypothesis or theory composed of variables that characterised the common data collection techniques used in quantitative research such as questionnaires, tests and existing databases (Naoum, 2002). Hard and reliable data are often collected in quantitative research and, therefore, emphasises on quantification. The samples collected are often large and representative. This means that quantitative research results can be generalised to a larger population within acceptable error limits (Millicent, 2009).

The question which this research sorts to explore was to find out the methods commonly used to measure progress in Ghana, the factors that influence the process, critical factors that will help drive the process as wells as the barriers to the realisation of accurate assessment of progress from the perspective of contractors and consultants. This then, would form a basis for appropriate procedure to be developed for measuring construction project progress in Ghana.

3.3 JUSTIFICATION OF RESEARCH DESIGN

Researchers gather data whenever they solicit an opinion of a person or group of people. In furtherance efforts are made to identify the dominant view within an identifiable group.

A survey research was considered to be more suitable for this study for the following reasons:

- It deals with gathering of data from a section of a population, simplifying the study results so as to forecast the behaviour of the population of interest;
- The survey instrument in the form of questionnaire will be structured to collect data from the targeted population in an orderly and impartial method; and
- It allows statistical data analysis and generalisation to a whole population, which makes them appropriate for construction management research.

3.4 SAMPLE SIZING

The aim of the sample was to obtained information regarding the targeted population by studying only a small aspect of the whole population, i.e. the sample size.

3.4.1 The Study Population

The selection of the respondents was limited to only the D1K1 Building Construction Companies and Consultants consisting solely of Quantity Surveyors in the Greater Accra region of Ghana. The decision of this class of building and civil engineering construction companies was taken against the back drop that they are well recognized companies with their offices fairly easy to be located and they are open to proper progress measurements and management due to the type and size of projects they undertake.

The choice to concentrate on the Greater Accra region alone was based on a list from the Association of Building and Civil Engineering Contractors of Ghana (ABCECG) as at April 2015 which indicated that 56% of D1K1 contractors are located in Greater Accra Region, 28% in Ashanti, Central, Western and Volta regions and 16% for the remaining regions. Information obtained from Ghana Institution of Surveyors (GhIS) indicate that 85% of quantity surveying firms in good standing are in Greater Accra region whiles the remaining 15% spread among Ashanti, Western, Bolgatanga and Wa. This also informed the choice of Greater Accra Region.

The choice of Quantity Surveyors as the only consultant was arrived after a preliminary survey among consultants as to who provides the team with progress information during which 95% of architects said they picked their progress information from the interim certificates raised by the project quantity surveyor. This clearly shows that it is the quantity surveyor's opinion that will be relevant to this research.

Other factors that made it difficult for the researcher to collect data from the other regions were time and financial constraints.

3.4.2 Method of Sampling

Probability sampling method was used in this research. In probability sampling, the choice as to whether a specific respondent is incorporated in the sample or not, is determined by chance only. The method enables each element or respondent to be selected randomly by chance.

An example of the probability sampling method is Purposive sampling was used in identifying the major respondents namely Contractors, and Consultants. This was as results of the fact that the researcher needed some particular class of respondents who had handled large volume of building construction projects and as such had good experience in progress measurements and management to respond to the questions in the questionnaires. Purposive sampling was also used in the selection of Contractors and consultants for this research. This lead to the selection of D1K1 contractors and

Quantity Surveying Consultants from the Greater Accra region because the researcher believed that they represent the targeted populations and will give practical and undoubted responses to the questions posed.

3.4.3 Sample Size

There are several approaches that are used in finding the sample size for any research work (Israel 1992). Among these approaches are:

1. Census for small populations,
2. Emulating a sample size of researches similar in nature,
3. Published tables, and
4. Lastly using formulas to compute the sample size.

For this research, item number one above was applied.

The targeted population sizes (N) for this research including the Consultants and D1 contractors was 28 and 43 respectively based on a list obtained from GhIS and ABCECG as indicated above. Due to the size of the targeted populations census was used to arrive at the sample sizes for the D1K1 contractors (n=43) and Consultants (n=28). The census approach helps eradicates sampling errors and makes available data on all elements in the population. In furtherance, the approach permits nearly the whole population to be appraised, in little population to accomplish a needed level of accuracy. In summary the targeted sample sizes for this research were 71in total.

3.5 DATA COLLECTION

To achieve the objectives of the research, the research concentrated on contractors, and consultants in the construction industry. This was because these groups of respondents were those directly confronted with these issues as they occur in the industry.

3.5.1 Research Tool

The data for the study was obtained principally by questionnaires. Project participation through site and office visits and informal interviews were also used to collect the needed data on progress measurement on site and procedure of measuring progress.

3.5.2 Questionnaire Design

The questionnaire was developed based on the research objectives in order to gather an extensive collection of data as practicable as possible, from these contractors and consultants. Structured questionnaire was prepared and self-distributed to the numerous respondents. The questionnaire which is made up with 4 main categories of closed-ended questions was made to gather data on progress measurement. The first sets of questions were related to the profile of the respondent. This was designed to establish the background, expertise and experience of respondents. The second group of questions related to construction project progress measurement methods currently in use in Ghana. The third set has to do with the factors that influence or affect measurement of construction progress. The fourth deals with barriers to the realization of accurate assessment of construction progress and finally the processes and procedures adopted by firms to measure construction progress. Informal interviews, participatory and site visits were also used to obtain more definite data on the processes and procedures adopted by professionals to measure construction progress measurement

3.5.2.1 Questionnaire Structure

The questions were developed using the Likert scale. The respondents were requested to rank on:

- Scale of 1-5 the rate at which they use the available progress measurement methods, where 1= “never used”, 2= “seldom used”, 3= “sometimes”, 4= “frequently used” and 5= “always used”
- Scale of 1-5 their degree of agreement to barriers to the realization of accurate assessment of construction progress and the factors that will influence the progress measurements processes and procedure, where 1= “strongly disagree”, 2= “disagree”, 3= “not sure”, 4= “agree” and 5= “strongly agree”
- A scale of 1-3 how critical the factors can help drive the process of progress measurements, where 1= “not critical”, 2= “critical” and 3= “highly critical”.

On the processes and procedures adopted by relevant construction industry stakeholders to measure construction progress, they were asked 13 closed ended questions with options to choose from.

3.8 METHOD OF ANALYSES

The Software Package that was used to run the analysis was Statistical Package for Social Scientist (SPSS) version 20 as the research was more of quantitative in nature. The raw data from the answered questionnaires were imputed into Microsoft Excel Spread sheet. The entered data was imported to SPSS for setup and analysis. Results were exported to Microsoft Word for editing and write-up. Relevant information and tables were extracted and structured using

Microsoft Excel and final results were put in word for write-up.The statistical tools used were descriptive; mean scores and standard deviation, Relative Importance Index (RII), and MannWhitney U Test.

3.8.1 Descriptive Statistics

Mean score

The mean is used to determined central tendency. The high mean score for a factor would indicate that the factor under contemplation is significant (Hoe, The mean 2006). The Mean scores were obtained by the following formula:

$$\mu = \frac{\sum_{i=1}^{5} i.f_i}{\sum_{i=1}^{5} f_i}$$ (Begum et al., 2006)

$$\mu = \frac{\sum_{i=1}^{3} i.f_i}{\sum_{i=1}^{3} f_i}$$

Where, f = the frequency of score

and i = the factor concerned.

In this research, mean value of 3.0 and 2.0 is seen as significant where the likert scale has a maximum of score of 5 and 3 respectively.

Standard Deviation

Standard Deviation is the measure of spread of the numbers in a set of data from its mean value. In addition it can also be defined as a measure of changeability or instability in the given series of data. A standard deviation approaching to 0 shows that the data points tend to be very near to the mean (the other name for such standard deviation is expected value) of the set, whereas a very high standard deviation depicts that the data points are spread out over a wider range of values.

An important aspect of the standard deviation is that, unlike the variance, it is expressed in the same units as the data. In furtherance to stating the variability of a population, the standard deviation is mostly used to determine the confidence in statistical conclusions. This is calculated by the formula below:

$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

n = The number of data points

$\bar{x}$ = The mean of the x_i

x_i = Each of the values of the data

Adopted from www.statistic.about.com/od/formulas/ss/The-Standard-Deviation-F0rmula.htm

3.8.2 Relative Importance Index (RII)

Ranking as a comparison amongst given alternatives, within couples of alternatives, by cardinality of significance (first, second, third), or that score items one at a time using a common scale, and it also determines the importance/significance of that factor (Fowler and Floyd 1995). The Relative Importance Index (R.I.I) of determination of significance of factors was embraced for the reason that, Enshassi et al., (2007) emphasized that to analyze data on ordinal scale (e.g. Likert scale 1-5), the use of Importance Index is very appropriate. Variables with high significant effect could be observed through this method because unlike the mean that could be influence by extreme values (outliers), relative index weigh each variable in relation of the other variables.

3.8.3 The Mann-Whitney U Test

The Mann-Whitney U test is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. The analysis satisfied the assumptions of Mann-Whitney Test which states that the dependent variable should be measured at the ordinal or continuous level. The data is purely a 5-point ordinal scale explaining methods frequently used and level of agreement. The independent variable should consist of two categorical, independent groups. The independent variable that meets this criterion was group of respondent (2 groups: contractors and consultants). If the Mann-Whitney Test is observed to be significant, it means the two groups have different view on rating the variable, thus p-value<0.05. On the other hand, if P-value > 0.05 the two groups have the same view/ratings statistically.

3.9 CHALLENGES

Obtaining information for the study was very challenging because majority of the respondents contacted were very busy and cautious to make available information. The researcher went through hectic time in finding out offices of some contractors as well as consultants due to absence of directional signage and name plates to lead people to their office locations. Some of contact numbers provided were not in use making it impossible to reach some of them. Others too that were contacted through e-mail too never responded and some too the e-mail addresses were not correct. The researcher would have love to cover the whole Ghana but due to financial and time constrains he concentrated on Greater Accra

CHAPTER FOUR

DATA ANALYSIS, FINDINGS AND DISCUSSIONS

4.1 INTRODUCTION

The aim of this study is to proposed pragmatic and innovative procedure to measure on construction works progress. To realize the aim of this research, a method comprising of a literature review and a survey of relevant stakeholders to achieve the real insight into the subject matter. The survey results, analyses of the results and findings of the research are present in this chapter.

4.2 RESPONSE RATE

Twenty-eight (28) research tools were distributed to quantity surveying (QS) consultant firms with 26 were received in total indicating 92.86% response rate. Another forty-three (43) questionnaires were also dispensed to the D1K1 building construction companies and a 36 in all were retrieved representing 83.72% response rate. All these are represented and figure 4.1 below.

Total number of questionnaires issued: 71

Gross total response: 62

Overall response rate: = $\frac{62}{71}x100 = 87.32 \approx 87\%$

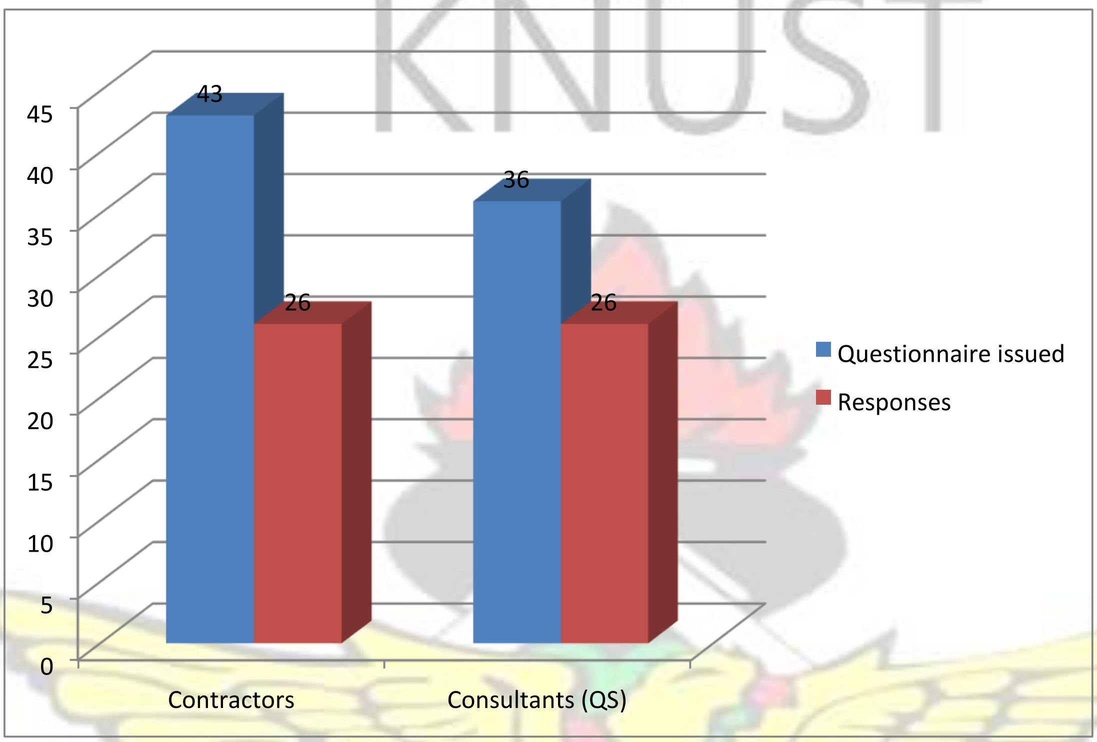

Figure 4.1: Response rate of the two groups of respondents

4.3 QUESTIONS RESPONSES

The responses to the questions were clearly answered as possible as the respondent can. The respondents were given ample time (i.e. between two to three weeks) to answer the questions and as such they were not under any pressure to rush through the questions. Discussions were also held with some of the respondents to obtain further information and reasons for their answers. We also visited some project sites and collected project information for the development of proposed progress measurement method.

4.4 SURVEY RESULTS

Questionnaires were sent to 71 firms, in the category of consultants and contractors. Out of this 62 responses were received for a response rate of 87%. This response rate is good as other researchers with rates less than this were considered adequate. The responses were further analyzed to:

- Determine the profile of respondents,
- Identify construction progress measurement methods currently in use in Ghana,
- Identify the factors that will affects the measurement of construction progress,
- Determine the critical factors that drive the process construction progress measurement,
- Identify the critical barriers to progress measurement and
- Document the process and procedures adopted by firms in measuring construction progress perspective of industry players.

4.5 DEMOGRAPHICS OF RESPONDENTS

These dealt with the respondents position, experience in the industry, whether the respondents have the requisite knowledge on the subject matter.

From table 4.1 below shows that 58.1% of respondents a contractors whiles 41.90% are consultants. This indicates that the respondents are involved in construction progress measurement and management. In addition, 53.01% and 43.50% of respondents are senior and management staffs respectively. This implies that majority of 96.70% of respondent are key staffs of their firm and plays a role in construction progress measurement and management. Also

43.50% of the respondents have adequate knowledge and 51.60% had advance knowledge. This means that 95.20% of the respondents are well vexed in the subject matter with only 4.8% that have intermediate knowledge on the construction progress measurement and management. This conforms to the information obtained about the position of the respondents in the firms. On experience, a whopping majority of 98.40% of the respondents had excess of 5-years of experience in the construction industry. It was important to find out the years of working experience of the respondents as well as their level of knowledge on the subject matter in order to be able to achieve applied and undoubted answers to the questions posed.

Table 4.1: Profile of Respondents

Variable	Category	Frequency	Percent
Category of respondents	Contractors	36	58.1
	Consultants	26	41.9
	Total	62	100.0
Position in firm	Senior staff	33	53.2
	Junior staff	2	3.2
	Management	27	43.5
	Total	62	100.0
Category of firm	Contractor-D1	36	58.1
	Consultant	26	41.9
	Total	62	100.0
Number of years firm has been in existence	1-5 years	1	1.6
	6-10 years	13	21.0
	11-15 years	12	19.4
	16-20 years	21	33.9
	Above 20 years	15	24.2
	Total	62	100.0

Level of knowledge regarding construction project progress measurement	Intermediate	3	4.8
	Adequate	27	43.5
	Advance	32	51.6
	Total	62	100.0

4.6 CONSTRUCTION PROGRESS MEASUREMENT METHODS

Using a descriptive statistics such as the mean and standard deviation and relative importance index (RII) as described in chapter three of this study a test on the response from the survey was carried out to find out the among the existing methods which ones are being used by the practitioners. This will help the researcher know the methods which practitioners are comfortable to use. This will also help know why many a times construction professionals disagree on the assessment of percentage completion of construction projects.

The table 4.2 below indicates that cost ratio method ranked first the most commonly used methods in Ghana with a mean of 4.84, standard deviation of 0.549 and RII of 96.8. It is followed by Judgment/Supervisor's opinion with a mean of 4.52, standard deviation of 0.954 and RII of 90.3. The third and fourth ranked commonly method used in Ghana are the Unit Complete method and time ratio. This information shows that the construction professionals depend mainly on only one element of a project to determine progress. This shows that the progress obtained shall be misleading because a small item may cost so much but its impact on time and quantity of work may be little or negligible. In addition, in case where the contractors pricing strategy is front or back load, the progress by this method may not reflect the true work done. Also this means that any claims like fluctuation or interest on delay payments may be captured in the progress compute. The second method, Supervisor's Opinion is purely subjective. And therefore there is way two independent opinions will be same.

Interestingly the third method is very objective for activity level measurement but cannot be used to measure a progress a work section let alone a whole project. The time ratio also has limitations similar to the cost ratio. It is also one of the important elements of construction project. This method is affected by inclimate Weather and extension of time. Here to an activity may take a longer time to carry it out but its impact of the project duration and cost may be little or negligible. This method used on a project along with cost ration with produce different percentage complete as illustrated in the literature review of this research.

A further statistical test was conducted on the data to find out how the two groups (i.e. contractors and consultants) of respondents within the study population rate the methods as to their frequency of use. From Table 4.3 it came to light that there are significant difference on how they rate unit complete method and supervisor's opinion method. Table 4.4 shows that contractors ranked high the unit complete method and the supervisor's opinion than the consultants with a mean rank of 35.58 and 37.86 as against the consultants mean rank of 25.85 and 22.69 respectively. This shows that the contractors depend mostly on these two methods than the consultants. However there is no significant difference on how they ranked the cost ratio method.

This information clearly shows that the methods used in measuring progress in Ghana are one the reasons why the professionals differ on the percentage complete of construction projects.

Table 4.2:Construction progress measurement Methods Currently in Use in Ghana

Methods	N	Sum	Mean	Std. Deviation	RII	Ranking
Cost ratio	62	300	4.84	0.549	96.8	1
Judgment or Supervisor's Opinion	62	280	4.52	0.954	90.3	2
Unit completed	62	246	3.97	0.829	79.4	3
Time ratio	62	221	3.56	1.140	71.3	4
Incremental milestone	62	198	3.19	1.006	63.9	5
Start – Finish	62	174	2.81	1.353	56.1	6
Weighted/Equivalent units completed	62	102	1.65	0.630	32.9	7
Eared value Analysis	62	99	1.60	0.858	31.9	8

Table 4.3: Construction Project Progress Methods -Test indices

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Unit completed	321	672	-2.251	0.024
Incremental milestone	177	843	-4.334	0.000
Start – Finish	368.5	1034.5	-1.459	0.145
Judgment or Supervisor's Opinion	239	590	-4.168	0.000
Cost ratio	455	806	-0.362	0.718
Time ratio	157	508	-4.597	0.000
Eared value Analysis	330	996	-2.227	0.026
Weighted/Equivalent units completed	354	705	-1.847	0.065

a. Grouping Variable: Category of respondents

Table 4.4: Construction Project Progress Methods -Ranks

	Category of respondents	N	Mean Rank	Sum of Ranks
Unit completed	Contractors	36	35.58	1281
	Consultants	26	25.85	672
	Total	62		
Incremental milestone	Contractors	36	23.42	843
	Consultants	26	42.69	1110
	Total	62		
Start – Finish	Contractors	36	28.74	1034.5
	Consultants	26	35.33	918.5
	Total	62		
Judgment or Supervisor's Opinion	Contractors	36	37.86	1363
	Consultants	26	22.69	590
	Total	62		
Cost ratio	Contractors	36	31.86	1147
	Consultants	26	31	806
	Total	62		
Time ratio	Contractors	36	40.14	1445
	Consultants	26	19.54	508
	Total	62		
Eared value Analysis	Contractors	36	27.67	996
	Consultants	26	36.81	957
	Total	62		
Weighted/Equivalent units completed	Contractors	36	34.67	1248
	Consultants	26	27.12	705
	Total	62		

4.7 FACTORS THAT INFLUENCE / AFFECT CONSTRUCTION PROGRESS MEASUREMENTS

Results from this section of the questionnaire will help us know relative important factors to consider when developing an innovative proposal for measuring construction progress. A statistical test results from Table 4.5 shows the factors that can influence the process of construction progress measurements. Schedule (Time) ranked first followed by quantity of work (scope of work), cost / budget and productivity level (labour and plant output) in that order. The results imply that these are the four major factors that respondents agree will impact on the process of construction progress measurement. This conforms to literature as can be seen in the literature review (Jung and Lee, 2010).

The research further seek to seek to find out among these factors can help drive the process of progress measurement of construction projects. The results as shown in table 4.6 indicates that the most critical factor from first to fourth respectively are cost/budget, quantity (scope of work), Schedule (time) and productivity level.

One interesting fact from Table 4.7 is that whiles the respondents ranked schedule (time) first as the most influential they ranked cost/budget first as the most critical factors to help drive the process of construction progress measurement. But the most important fact is that they are all in the first three under the two tests. The following are the first three factors considered influential and critical to drive the process of progress measurement by the indicate in table 4.5

1. Cost/budget,
2. Quantity (scope of work) and
3. Schedule.

Table 4.8 clearly indicates that there is no major difference in how the two group of respondents' rate the quantity factor. However their views vary on the other two critical factors i.e. cost/ budget and schedule (time). The contractors rank the two very high as compared to the consultants. Table 4.9 shows a mean rank of 35.42 and 33.78 for schedule and budget/cost respectively in favour of contractors as against the consultants mean rank of 26.08 and 26.35. This shows that contractors believe more in the two factors as compared to consultants however they share same opinion on the quantity factor. Table 4.10 and 4.11 also carries similar information. This also implies that the ability to measure construction project progress is dependent on one's ability to integrate these elements of the project objectively.

Table 4.5: Level of Agreement on influential factors

Factors	N	Sum	Mean	Std. Deviation	RII	Ranking
Schedule (time)	62	300	4.84	0.413	96.8	1
Quantity (scope of work)	62	300	4.84	0.413	96.8	2
Cost / Budget	62	297	4.79	0.449	95.8	3
Productivity Level (labour and Plant output)	62	256	4.13	0.713	82.6	4
Rework/defects	62	236	3.81	0.721	76.1	5
Safety	62	172	2.77	1.031	55.5	6
Construction techniques/methods	62	171	2.76	0.935	55.2	7
Value	62	155	2.5	0.825	50.0	8
Cooperation/Harmony	62	142	2.29	1.03	45.8	9

6: Critical factors to help drive the process of construction progress measurement

Factors	N	Sum	Mean	Std. Deviation	RII	Ranking
Cost / Budget	62	178	2.87	0.338	95.7	1
Quantity (scope of work)	62	178	2.87	0.383	95.7	2
Schedule (time)	62	173	2.79	0.41	93.0	3
Productivity Level (labour and Plant output)	62	122	1.97	0.478	65.6	4
Rework/defects	62	113	1.82	0.497	60.8	5
Construction techniques/methods	62	88	1.42	0.56	47.3	6
Safety	62	79	1.27	0.485	42.5	7
Cooperation/Harmony	62	79	1.27	0.548	42.5	8
Value	62	75	1.21	0.449	40.3	9

Table 4.7: Factors that Influences/Affect Measurement of Construction Project Process

	Level of Agreement				Critical			
	Mean	Std. Deviation	RII	Ranking	Mean	Std. Deviation	RII	Ranking
Quantity (scope of work)	4.84	0.413	96.8	1	2.87	0.383	95.7	2
Schedule (time)	4.84	0.413	96.8	2	2.79	0.410	93.0	3
Cost / Budget	4.79	0.449	95.8	3	2.87	0.338	95.7	1
Productivity Level (labour and Plant output)	4.13	0.713	82.6	4	1.97	0.478	65.6	4
Rework/defects	3.81	0.721	76.1	5	1.82	0.497	60.8	5
Safety	2.77	1.031	55.5	6	1.27	0.485	42.5	7
Construction techniques/methods	2.76	0.935	55.2	7	1.42	0.560	47.3	6
Value	2.5	0.825	50.0	8	1.21	0.449	40.3	9
Cooperation/Harmony	2.29	1.030	45.8	9	1.27	0.548	42.5	8

Table 4.

Table 4.8: Critical factors to help drive the process of construction progress measurement - Test Indices

Factors	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2tailed)
Cost / Budget	386	737	-2.014	0.044
Schedule (time)	327	678	-2.852	0.004
Quantity (scope of work)	467.5	818.5	-0.013	0.99
Safety	290.5	641.5	-3.332	0.001
Value	373	724	-1.977	0.048
Rework/defects	393.5	744.5	-1.365	0.172
Productivity Level (labour and Plant output)	378	729	-1.758	0.079
Construction techniques/methods	420	1086	-0.804	0.421
Cooperation/Harmony	436.5	1102.5	-0.617	0.537

9: Critical factors to help drive the process of construction progress measurement –Ranks

	Category of respondents	N	Mean Rank	Sum of Ranks
Cost / Budget	Contractors	36	33.78	1216
	Consultants	26	28.35	737
	Total	62		
Schedule (time)	Contractors	36	35.42	1275
	Consultants	26	26.08	678
	Total	62		
Quantity (scope of work)	Contractors	36	31.51	1134.5
	Consultants	26	31.48	818.5
	Total	62		
Safety	Contractors	36	36.43	1311.5
	Consultants	26	24.67	641.5
	Total	62		
Value	Contractors	36	34.14	1229
	Consultants	26	27.85	724
	Total	62		
Rework/defects	Contractors	36	33.57	1208.5
	Consultants	26	28.63	744.5
	Total	62		
Productivity Level (labour and Plant output)	Contractors	36	34	1224
	Consultants	26	28.04	729
	Total	62		
Construction techniques/methods	Contractors	36	30.17	1086
	Consultants	26	33.35	867
	Total	62		
Cooperation/Harmony	Contractors	36	30.63 32.71	1102.5
	Consultants	26		850.5
	Total	62		

Table 4.

Table 4.10: Level of Agreement on influential factors - Test Indices

Factors	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Cost / Budget	374	725	-1.956	0.050
Schedule (time)	336.5	687.5	-3.070	0.002
Quantity (scope of work)	402	753	-1.541	0.123
Safety	151	502	-4.729	0.000
Value	178	529	-4.517	0.000
Rework/defects	418	769	-0.975	0.329
Productivity Level (labour and Plant output)	240	591	-3.597	0.000
Construction techniques/methods	278	944	-2.930	0.003
Cooperation/Harmony	345	1011	-1.839	0.066

a. Grouping Variable: Category of respondents

11: Level of Agreement on influential factors –Ranks

	Category of respondents	N	Mean Rank	Sum of Ranks
Cost / Budget	Contractors	36	34.11	1228
	Consultants	26	27.88	725
	Total	62		
Schedule (time)	Contractors	36	35.15	1265.5
	Consultants	26	26.44	687.5
	Total	62		
Quantity (scope of work)	Contractors	36	33.33	1200
	Consultants	26	28.96	753
	Total	62		
Safety	Contractors	36	40.31	1451
	Consultants	26	19.31	502
	Total	62		
Value	Contractors	36	39.56	1424
	Consultants	26	20.35	529
	Total	62		
Rework/defects	Contractors	36	32.89	1184
	Consultants	26	29.58	769
	Total	62		
Productivity Level (labour and Plant output)	Contractors	36	37.83	1362
	Consultants	26	22.73	591
	Total	62		
Construction techniques/methods	Contractors	36	26.22	944
	Consultants	26	38.81	1009
	Total	62		
Cooperation/Harmony	Contractors	36	28.08 36.23	1011
	Consultants	26		942
	Total	62		

Table 4.

4.8 CRITICAL BARRIERS TO ACCURATE PROGRESS MEASUREMENT.

In order to developed innovative procedure for measuring construction progress one needs to identify the critical barrier to the process. From interaction with practitioners and literature sixteen barriers were identify for the study. Table 4.12 shows that all the barriers are critical except claims, inclimate weather and delays and disruptions since they have a mean score less than 3.0. The data was further analyzed with the standard deviation and relative important index and it came to light that the first four critical barriers to the realization of accurate construction progress measurement are:

1. Dependency of supervisor opinion without hard data to back,
2. Different units of measurement of bills of quantity items,
3. Unspecified method of progress measurement in conditions of contracts and
4. Difficulty in getting uniform work breakdown structure.

The view is that once these critical barriers been identified then we can address them appropriately. A point worth noting is that literature has it that the major barrier to accurate construction progress measure is difficulty in integrating the major elements such as cost, time and scope of work but the respondent ranked this barrier seventh. However these factors are acknowledged in Table 4.12 as the critical factors that will help drive the process of accurate construction progress measurement.

Therefore if we can eliminate the above four barriers then we shall be heading towards the integration of the elements.

Table 4.13 and 4.14 clearly indicates that there is no major difference in the response of the respondent regarding the first four barriers stated above. This shows that both contractors and consultants share the same opinion on these barriers.

12: Barriers to accurate progress measurement

Barriers	N	Sum	Mean	Std. Deviation	RII	Ranking
Dependence on the opinion of supervisors without hard data to back	60	294	4.90	0.303	98.0	1
Different units of measurement of bill items	60	288	4.80	0.546	96.0	2
Unspecified method of progress measurement in conditions of contract	60	288	4.80	0.514	96.0	3
Difficulty in getting uniform work breakdown structure	60	280	4.67	0.510	93.3	4
Time constrains	60	261	4.35	0.732	87.0	5
Data gathering	60	246	4.10	0.543	82.0	6
Difficulty in integrating cost, time and scope of work	60	241	4.02	0.892	80.3	7
Variations	60	231	3.85	0.659	77.0	8
Inadequate pre-contract planning	60	223	3.72	0.804	74.3	9
Inadequate method statement	60	212	3.53	0.812	70.7	10
Extension of time	60	196	3.27	0.710	65.3	11
Using time data only in computing progress	60	195	3.25	0.751	65.0	12
Using cost data only in computing progress	60	195	3.25	0.751	65.0	13
Claims	60	171	2.85	0.954	57.0	14
Delays and disruptions	60	160	2.67	1.052	53.3	15

Table 4.

Inclimate weather	60	156	2.60	0.827	52.0	16

Table 4.13: Barriers to accurate progress measurement -Test Indices

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2tailed)
Time constrains	99	424	-5.597	0.000
Data gathering	360	685	-1.536	0.124
Different units of measurement of bill items	421.5	1051.5	-0.406	0.684
Using time data only in computing progress	297.5	622.5	-2.281	0.023
Using cost data only in computing progress	281	606	-2.550	0.011
Difficulty in getting uniform work breakdown structure	429.5	754.5	-0.148	0.882
Unspecified method of progress measurement in conditions of contract	374.5	699.5	-1.523	0.128
Inadequate pre-contract planning	220	545	-3.791	0.000
Dependence on the opinion of supervisors without hard data to back	422.5	747.5	-0.433	0.665
Inadequate method statement	172	497	-4.709	0.000
Variations	332	657	-2.198	0.028
Claims	140	770	-4.740	0.000
Difficulty in integrating cost, time and scope of work	135	765	-4.864	0.000

Inclimate weather	237	562	-3.268	0.001
Extension of time	430.5	1060.5	-0.119	0.905
Delays and disruptions	329.5	959.5	-1.702	0.089

a. Grouping Variable: Category of respondents

14: Barriers to accurate progress measurement –Ranks

	Category of respondents	N	Mean Rank	Sum of Ranks
Time constrains	Contractors	35	40.17	1406
	Consultants	25	16.96	424
	Total	60		
Data gathering	Contractors	35	32.71	1145
	Consultants	25	27.4	685
	Total	60		
Different units of measurement of bill items	Contractors	35	30.04	1051.5
	Consultants	25	31.14	778.5
	Total	60		
Using time data only in computing progress	Contractors	35	34.5	1207.5
	Consultants	25	24.9	622.5
	Total	60		
Using cost data only in computing progress	Contractors	35	34.97	1224
	Consultants	25	24.24	606
	Total	60		
Difficulty in getting uniform work breakdown structure	Contractors	35	30.73	1075.5
	Consultants	25	30.18	754.5
	Total	60		

Table 4.

Unspecified method of progress measurement in conditions of contract	Contractors	35	32.3	1130.5
	Consultants	25	27.98	699.5
	Total	60		
Inadequate pre-contract planning	Contractors	35	36.71	1285
	Consultants	25	21.8	545
	Total	60		
Dependence on the opinion of supervisors without hard data to back	Contractors	35	30.93 29.9	1082.5
				747.5
	Consultants	25		
	Total	60		
Inadequate method statement	Contractors	35	38.09	1333
	Consultants	25	19.88	497
	Total	60		
Variations	Contractors	35	33.51	1173
	Consultants	25	26.28	657
	Total	60		
Claims	Contractors	35	22	770
	Consultants	25	42.4	1060
	Total	60		
Difficulty in integrating cost, time and scope of work	Contractors	35	21.86 42.6	765
	Consultants	25		1065
	Total	60		
Inclimate weather	Contractors	35	36.23	1268
	Consultants	25	22.48	562
	Total	60		
Extension of time	Contractors	35	30.3	1060.5
	Consultants	25	30.78	769.5
	Total	60		

	Contractors	35	27.41	959.5
Delays and disruptions	Consultants	25	34.82	870.5
	Total	60		

4.9 PROCESSES AND PROCEDURES ADOPTED BY FIRMS IN GHANA IN MEASURING CONSTRUCTION PROGRESS

Over here we try to document the processes and procedure adopted by construction firms and consultants in determining progress of work done. The Table 4.15 below shows that programmes of works mainly prepared by the quantity surveyor (QS) with a handful of 14.8% being done by the project manager (PM). About 21% of firms depend of a team of QS and PM to prepare the programme of works. None of them has a scheduler in their firm. The people involved have a good qualification as majority has a minimum qualification first degree with experience in excess of five (5) years. 68 % of firms have on work programmes and update and 100% claim to carry out progress update. Vast majority of 65% carries out the update monthly and 26% carries it out fortnightly. These updates are carried out by QS and PM on dedicated scheduler involved.it is this same class of professionals who determines the progress of work. This can therefore explained the reason why the cost ratio method is the most commonly used method followed by
Supervisor's opinion in Ghana. This also explained why most at times the consultant and the contractor differ in the percentage complete. This is confirmed in the table 4.15 below as only 16% percent frequently has their percentage complete agreed in the last five years. Although the respondents have it that management of their firms attach importance to progress measurement and management but that cannot be true as none of the firms has scheduler.

In short the existing the process and procedure is that:

a. Prepare a programme of work
b. Measure work done
c. Cost the works done and
d. Express the work done as a ratio of the contract sum

e. This is mainly done monthly

Alternatively they used the supervisor's opinion which depends on the experience of the supervisor. This second procedure is not scientific at all. On interesting thing is that Table 4.16 and 4.17 reveals that the two group have different opinion on the processes and procedures.

Table 4.15: The Process and Procedure Adopted by Firms in Measuring Construction Progress

Variable	Categories	Frequency	Percent
Who prepares programmes of work for any construction project	Quantity surveyors	31	50.8
	Project manager	9	14.8
	Project engineer	2	3.3
	Team (QS, PE & PM)	4	6.6
	QS & PM	13	21.3
	PM & PE	2	3.3
	Total	61	100.0
Qualification of the person (s) who prepares programmes of work	First degree	38	61.3
	Masters	24	38.7
	Total	62	100.0
The experience level of the person who prepares project programmes of work	Less than 5 years	4	6.5
	5-10 years	25	40.3
	11-15 years	22	35.5
	Above 15 years	11	17.7
	Total	62	100.0
Firm has company policy on construction project programming and update	Yes	42	67.7
	No	20	32.3
	Total	62	100.0
Firm carry out construction progress update	Yes	62	100.0

What intervals do you carry out programmes update	Weekly	6	9.7
	Every two weeks	16	25.8
	Monthly	40	64.5
	Total	62	100.0
Who carries out the update	Quantity surveyors	30	48.4
	Project manager 18 29.0 Project engineer 1 1.6		
	Team (QS, PE & PM)	9	14.5
	QS & PM	3	4.8
	PM & PE	1	1.6
	Total	62	100.0
Determines the progress of work in firm	Quantity surveyors	31	50.0
	Project manager	18	29.0
	Team (QS, PE & PM)	4	6.5
	QS & PM	5	8.1
	PM & PE	4	6.5
	Total	62	100.0
How often you measure progress	Daily	2 6	3.2
	Weekly	5	9.7
	Every two weeks		8.1
	Monthly	49	79.0
	Total	62	100.0
Level of importance top management attached to progress measurements	Important	30	48.4
	Very important Not	29	46.8
	sure	3	4.8
	Total	62	100.0
Extent progress assessment agrees with that of consultants/contractors in last five years	Seldom agrees	18	29.0
	Sometimes agrees	34	54.8
	Frequently agrees	10	16.1
	Total	62	100.0

Opinion is the relationship between cost, time and work	Directly proportional to one another Independent of one another	61 1	98.4 1.6
	Total	62	100.0

Table 4.16: The process and procedure adopted by firm in measuring construction progress – Test Indices

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2tailed)
Who prepares programmes of work for any construction project	139	490	-4.982	0.000
Qualification of the person (s) who prepares programmes of work	280	631	-3.178	0.001
The experience level of the person who prepares project programmes of work	313.5	664.5	-2.344	0.019
Firm has company policy on construction project programming and update	108	774	-6.342	0.000
Firm carry out construction	468	819	0.000	1.000
What intervals do you carry out programmes update	210	876	-4.357	0.000
Who carries out the update	120.5	471.5	-5.348	0.000
Determines the progress of work in firm	145	496	-4.999	0.000
How often you measure progress	326	992	-2.850	0.004

Level of importance top management attached to progress measurements	452.5	1118.5	-0.250	0.803
Extent progress assessment agrees with that of consultants/contractors in last five years	288	954	-2.859	0.004
Opinion is the relationship between cost, time and work	455	806	-0.850	0.395

a. Grouping Variable: Category of respondents

Table 4.17: The process and procedure adopted by firm in measuring construction progressRanks

	Category of respondents	N	Mean Rank	Sum of Ranks
Who prepares programmes of work for any construction project	Contractors	35	40.03	1401
	Consultants	26	18.85	490
	Total	61		
Qualification of the person (s) who prepares programmes of work	Contractors	36	36.72	1322
	Consultants	26	24.27	631
	Total	62		
The experience level of the person who prepares project programmes of work	Contractors	36	35.79	1288.5
	Consultants	26	25.56	664.5
	Total	62		
Firm has company policy on construction project programming and update	Contractors	36	21.5	774
	Consultants	26	45.35	1179
	Total	62		
Firm carry out construction	Contractors	36	31.5	1134
	Consultants	26	31.5	819
	Total	62		
What intervals do you carry out programmes update	Contractors	36	24.33	876
	Consultants	26	41.42	1077
	Total	62		
Who carries out the update	Contractors	36	41.15	1481.5
	Consultants	26	18.13	471.5
	Total	62		
Determines the progress of work in firm	Contractors	36	40.47	1457
	Consultants	26	19.08	496

	Total	62		
How often you measure progress	Contractors	36	27.56 36.96	992
	Consultants	26		961
	Total	62		
Level of importance top management attached to progress measurements	Contractors	36	31.07	1118.5
	Consultants	26	32.1	834.5
	Total	62		
Extent progress assessment agrees with that of consultants/contractors in last five years	Contractors	36	26.5	954
	Consultants	26	38.42	999
	Total	62		
Opinion is the relationship between cost, time and work	Contractors	36	31.86	1147
	Consultants	26	31	806
	Total	62		

4.10 PROPOSED PROGRESS MEASUREMENT METHOD

To enable us develop a measurement method we need to look at the framework that will form the basis of the new method. From the study it was found out that the following are the critical barriers to achieving an accurate method of progress measurement.

1. Dependency of supervisor opinion without hard data to back,
2. Different units of measurement of bills of quantity items,
3. Unspecified method of progress measurement in conditions of contracts and
4. Difficulty in getting uniform work breakdown structure.

This therefore suggests that any framework and method developed must first overcome these barriers.

Another issue discovered from the literature and the study is that the most significant factors that when focus is placed on them can help us developed accurate measurement methods are:

1. Cost/budget,
2. Quantity (scope of work) and

3. Schedule.

Our focus is to try and integrate these factors as objectively as possible so as to eliminate subjectivity from the process.

4.10.1 The Progress Measurement Framework

The framework below takes into account a progress measurement method that considers the work itself, its cost and time for carrying out the work. For the work, the framework looks at the work breakdown structure which will form the basis of construction work programming. It has the project as the umbrella task, break down to work sections and then to activities level. The cost or budget breakdown structure also takes into account cost of the whole project, the cost of the various work sections and the cost of activities within the work section. In the same vain the frame work did look at time breakdown structure. The time and the work form the basis of the construction programme of work. The time allotted for the activities also affects the cost of the work. The cost and time are also influenced by the quantity of work (scope of work) to be done.

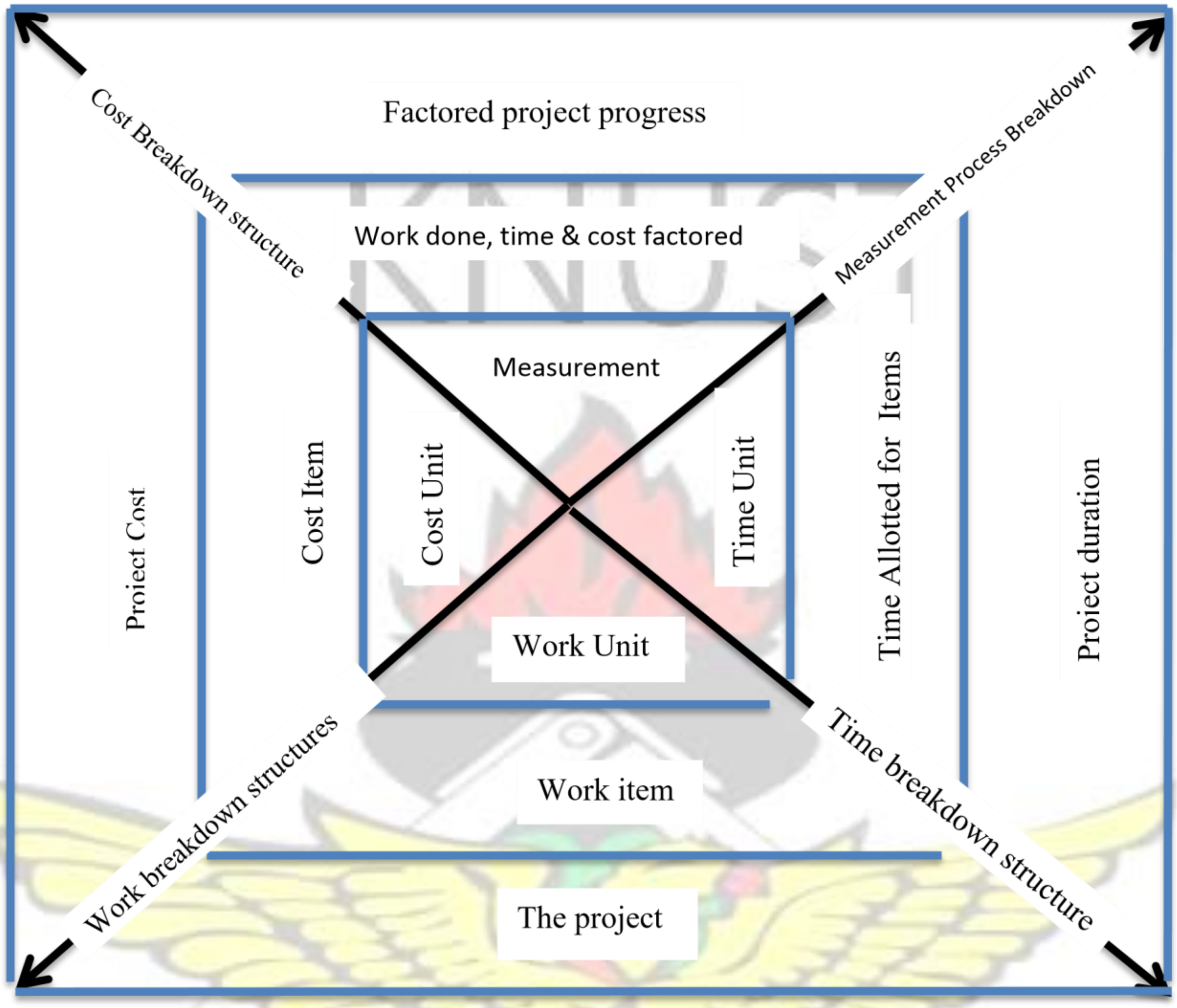

Figure 4.2: Proposed Progress measurement framework

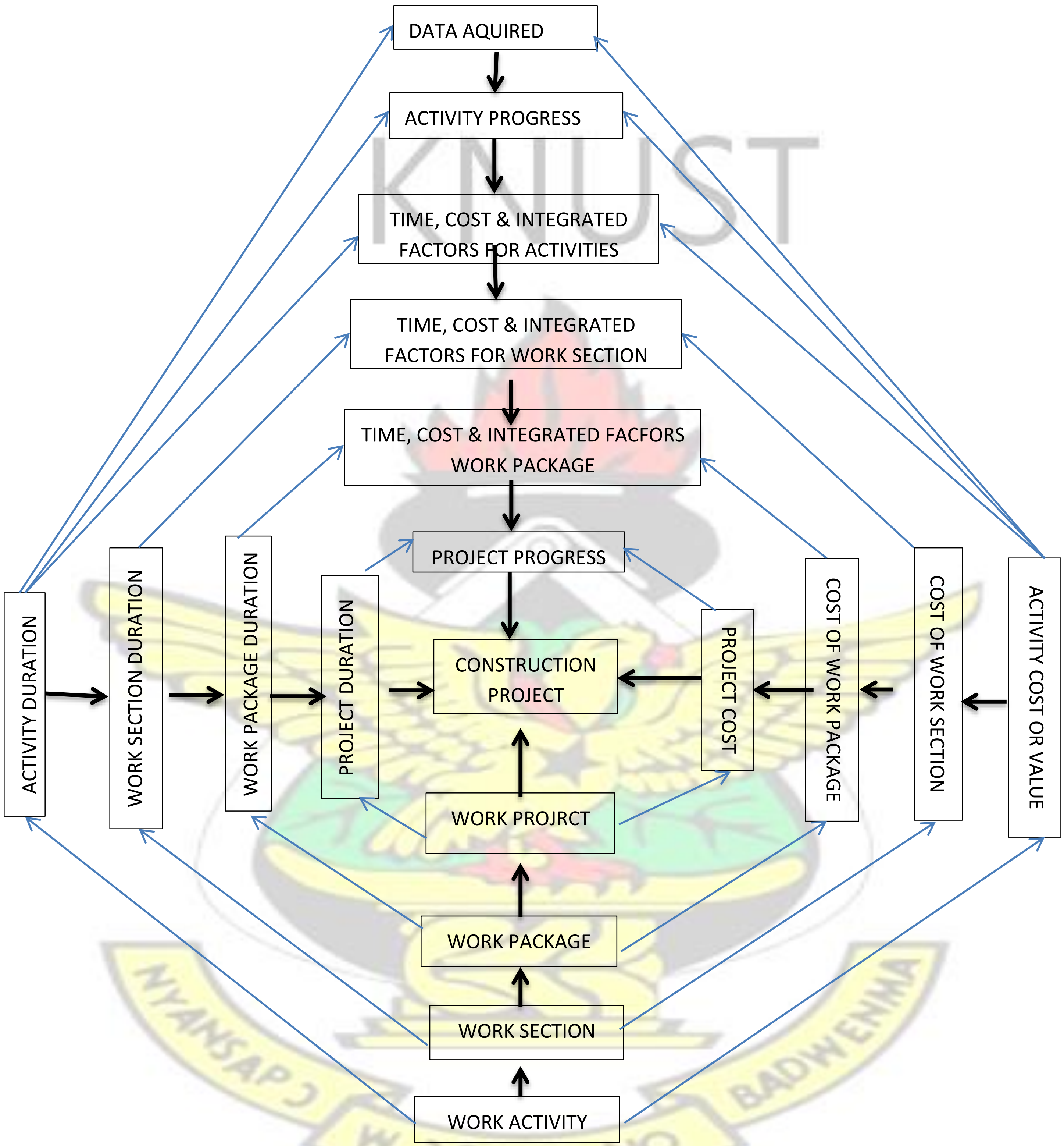

Figure 4.3: Flow Diagram of Proposed Progress measurement framework

4.10.2 The Proposed progress Measurement Method – The Integrated Factor Method

Now that we have determined the framework to measure progress, we can proceed to develop and proposed a new innovative method for determining the percentage complete of construction works.

The assumptions:

- That the scope of the work is well defined and will not be varied
- That the project pricing is consistent
- That the time allotted to an activity is adequate and will not be varied
- That activities that are running concurrently assumed to evenly share the time and one must be completed before the other. For instance if three activities will run concurrently on the programme for three weeks, the assumption is that each one will take one week to complete and will run one after the other.

4.10.2.1 Other Factors and the Way Forward

Construction projects cannot be completed without variations, claims, fluctuations, extension of time etc. These factors affect the accuracy of the progress measurement. The question is how we can overcome these factors in the new proposed method of determining percentage complete for a construction projects. First of all variations will affect the scope of work as well as time and cost. So what needs to be done is that any moment variations are introduce on a projects, we must assess its impact on the cost and time (project duration) and accordingly review the project cost and the project duration. This will now be used to determine the various factors for the progress measurement.

Claims such as fluctuation can be determined under the various work or trade sections of the bills of quantities and can therefore be proportionally distributed to the various activities under the work or trade section. This will only affect the total cost but will not affect the cost factors for the progress determination. Some claims can only be made at the end of the project. These ones will not affect the proposed method. The other claims emanating variations will be taken care of the same way as variations. Extension of time will also be treated as the case is in variations.

4.10.2.2 Data Required

The proposed method tries to eliminate subjectivity from the process of determining the progress of work. This method place premium on objectivity and as such depends on the following data:

- Project priced bills of quantities - the plan quantities and the cost of the activities
- The programme of work – project duration and time allotted for carrying out the activities
- Measured quantities of works done as at a specified date.

4.10.2.3 The Process and Procedure – Integrated Factor Method

The following steps must be followed in using the proposed method:

1. Establish the cost factors for each activity using the priced bills of quantities. This is achieved by dividing each activity cost by the total work section cost or project. Cf= $\frac{cost\ of\ activity}{project\ or\ work\ section\ cost}$. The total of the factors must not exceed one (1). This uses ratio and probability principle.
2. Establish the time ratio for each activity using the programme of work. These are done by dividing the time of each activity by the work section or project duration and add the time ratios to get the total time ratio. i.e. Tr = $\frac{Time\ for\ an\ activity}{Project\ or\ work\ section\ duraion}$
3. Determine the time factors for each activity by dividing the time ratio by the total time ratio. Time Factor (Tf) = $\frac{Time\ ratio\ for\ activity}{Total\ Time\ ratio}$. The total time factor must be one (1).

4. Determine the co-efficient for each activity i.e. $Ce = cost\ factor\ x\ time\ factor$. Sum the Co-efficient of the various activities to obtain the total co-efficient
5. Determine the integrated progress factor for each activity using the co-efficient. i.e. $I^f = \frac{Ce\ for\ an\ activity}{Total\ Ce}$
6. Using the unit complete method to establish quantity progress for each activity. i.e.

   Activity progress (Ap) = $\frac{measured\ quantity\ of\ work\ done\ for\ an\ activity}{The\ total\ plan\ quantity\ from\ the\ BoQ}\ x\ 100$
7. Apply the integrated progress factor for each activity to the activity quantity progress and sum them to obtain the project progress P = $Ap\ x\ I^f$

It is worth noting that u can obtain time or cost factored progress by applying time or cost factors to the quantity progress and sum them up.

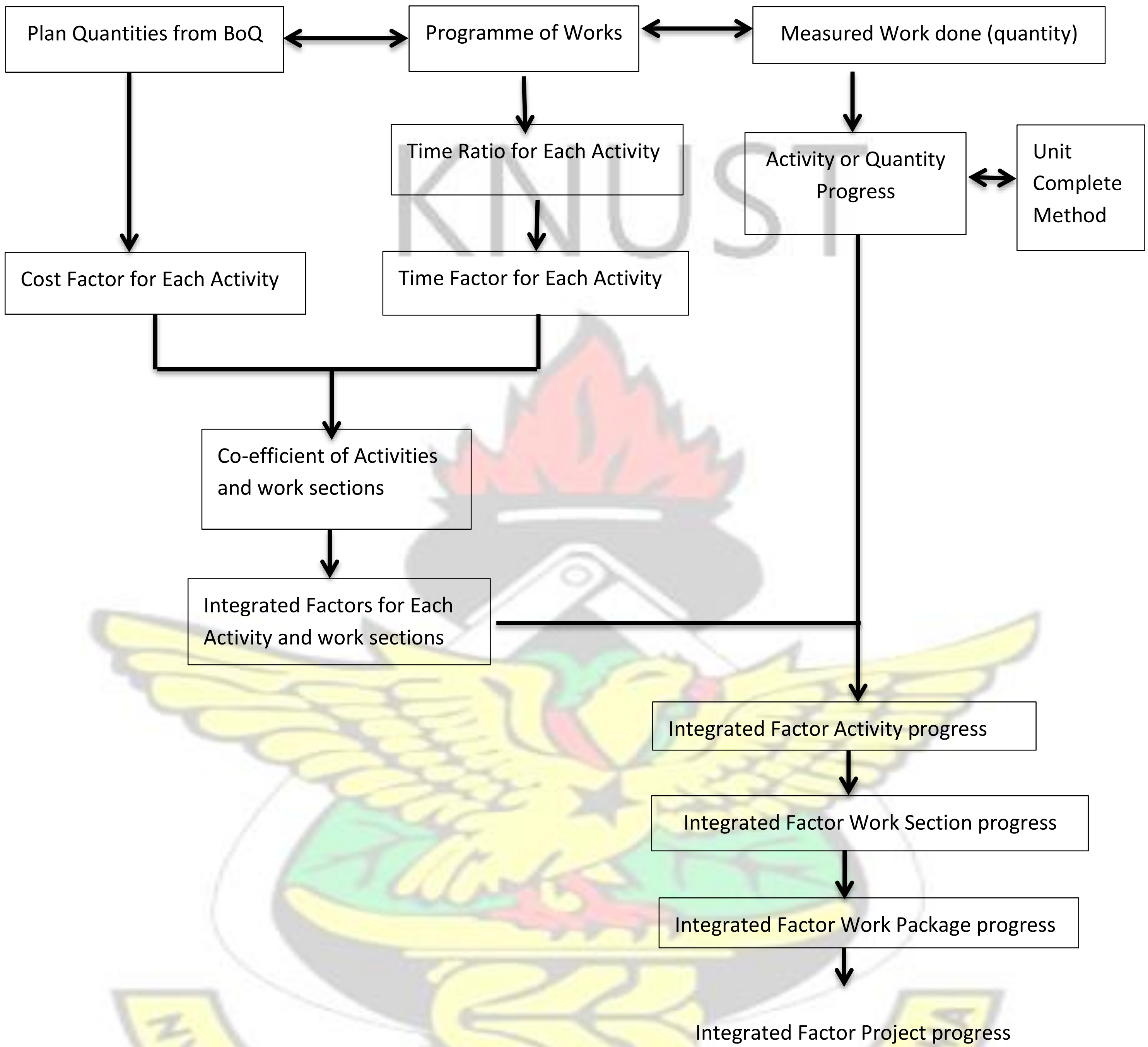

Figure 4.4: Processes and Procedures Flow Diagram of the Proposed progress measurement method (Integrated factor method).

4.10.2.4 Application of the proposed method

For the purpose of this study, the researcher obtains information on a Proposed Construction and Completion of CGCB Bank Branch at Sogakope for the application of the proposed method. We obtained the priced bills of quantities for the project, the project programme of works and the measured work done as at the end of the third week. The researcher considers the substructure as a work section for the application of the integrated factor method. The total cost of the work section is GH₵61,757.60 and the duration is 24 Days. Below is the application:

Table 4.18: Activity Progress Using Unit Complete Method

Activities	Planned Qty	Units	Complet Qty	Units	Activity progress (%
Mobilization to site	Item	Sum	Item	Sum	100.00
Site clearance/reduce level exc	2500	m2	2500	m2	100.00
Excavation of pits	8	m3	8	m3	100.00
Excavation of trenches	30	m3	30	m3	100.00
Backfilling	17	m3	8	m3	47.06
Disposal	21	m3	0	m3	-
Blinding	25	m2	25	m2	100.00
Foundation concrete	11	m3	11	m3	100.00
Column bases	6	m3	6	m3	100.00
Floor bed	33	m3	0	m3	-
ramps/steps	2	m3	0	m3	-
Columns	2	m3	0	m3	-
Concrete walls	8	m3	2	m3	25.00
reinforcement rods in:					
column bases	395	Kg	395	Kg	100.00
colunms	499	kg	499	kg	100.00
walls	595	Kg	198	Kg	33.28
Formwork to:					
colunms	58	m2	29	m2	50.00
walls	60	m2	20	m2	33.33
edges of beds	60	m	0	m	-
edges of risers	36	m	0	m	-
Block Wall	135	m2	135	m2	100.00
DPM	275	m2	0	m2	-
HCF	33	m3	0	m3	-

Table 4.19: Cost Factor

Activities	Budget (GH¢)	Cost factor	QTY Progress	Factored Progress (%)
Mobilization to site	23,000.00	0.37	100.00	37.24
Site clearance/reduce level exc	5,750.00	0.09	100.00	9.31
Excavation of pits	120.00	0.00	100.00	0.19
Excavation of trenches	390.00	0.01	100.00	0.63
Backfilling	102.00	0.00	47.06	0.08
Disposal	315.00	0.01	-	-
Blinding	300.00	0.00	100.00	0.49
Foundation concrete	2,860.00	0.05	100.00	4.63
Column bases	1,920.00	0.03	100.00	3.11
Floor bed	8,580.00	0.14	-	-
ramps/steps	520.00	0.01	-	-
Columns	640.00	0.01	-	-
Concrete walls	2,560.00	0.04	25.00	1.04
reinforcement rods in:		-		-
column bases	1,145.50	0.02	100.00	1.85
colunms	1,447.10	0.02	100.00	2.34
walls	1,725.00	0.03	33.28	0.93
Formwork to:		-		-
colunms	870.00	0.01	50.00	0.70
walls	1,500.00	0.02	33.33	0.81
edges of beds	300.00	0.00	-	-
edges of risers	108.00	0.00	-	-
Block Wall	5,130.00	0.08	100.00	8.31
DPM	825.00	0.01	-	-
HCF	1,650.00	0.03	-	-
Total	**61,757.60**	**1.00**		**71.67**

Table 4.20: Time factor

Activities	**Time (Days)**	**Time Ratio**	**Time factor**	**Qty Progress (%)**	**Factored Progress(%)**
Mobilization to site	6	0.25	0.13	100.00	13.19
Site clearance/reduce level exc	1	0.02	0.01	100.00	1.10
Excavation of pits	1	0.04	0.02	100.00	2.20
Excavation of trenches	4	0.17	0.09	100.00	8.79
Backfilling	2	0.08	0.04	47.06	2.07
Disposal	1	0.04	0.02	-	-
Blinding	1	0.02	0.01	100.00	1.10
Foundation concrete	4	0.17	0.09	100.00	8.79
Column bases	3	0.13	0.07	100.00	6.59
Floor bed	3	0.13	0.07	-	-
ramps/steps	1	0.02	0.01	-	-
Columns	1	0.04	0.02	-	-
Concrete walls	1	0.02	0.01	25.00	0.27
reinforcement rods in:		-	-		-
column bases	1	0.04	0.02	100.00	2.20
colunms	1	0.04	0.02	100.00	2.20
walls	2	0.08	0.04	33.28	1.46
Formwork to:		-	-		-
colunms	5	0.21	0.11	50.00	5.49
walls	3	0.13	0.07	33.33	2.20
edges of beds	1	0.02	0.01	-	-
edges of risers	0	-	-	-	-
Block Wall	2	0.08	0.04	100.00	4.40
DPM	1	0.04	0.02	-	-
HCF	3	0.13	0.07	-	-
Total		**1.90**	**1.00**		**62.05**
Duration of substructure	**24**				

Table 4.21: Integrated factor method of Percentage complete

Activities	Activity progress (%)	Cost factor	Time factor	Co-efficient	Integrated Factor	Integrated Factored Progress (%)
Mobilization to site	100.00	0.37	0.13	0.04911	0.629	62.89
Site clearance/reduce level exc	100.00	0.09	0.01	0.00102	0.013	1.31
Excavation of pits	100.00	0.00	0.02	0.00004	0.001	0.05
Excavation of trenches	100.00	0.01	0.09	0.00056	0.007	0.71
Backfilling	47.06	0.00	0.04	0.00007	0.001	0.04
Disposal	-	0.01	0.02	0.00011	0.001	-
Blinding	100.00	0.00	0.01	0.00005	0.001	0.07
Foundation concrete	100.00	0.05	0.09	0.00407	0.052	5.21
Column bases	100.00	0.03	0.07	0.00205	0.026	2.63
Floor bed	-	0.14	0.07	0.00916	0.117	-
ramps/steps	-	0.01	0.01	0.00009	0.001	-
Columns	-	0.01	0.02	0.00023	0.003	-
Concrete walls	25.00	0.04	0.01	0.00046	0.006	0.15
reinforcement rods in:		-		0.00000	0.000	-
column bases	100.00	0.02	0.02	0.00041	0.005	0.52
colunms	100.00	0.02	0.02	0.00051	0.007	0.66
walls	33.28	0.03	0.04	0.00123	0.016	0.52
Formwork to:		-		0.00000	0.000	-
colunms	50.00	0.01	0.11	0.00155	0.020	0.99
walls	33.33	0.02	0.07	0.00160	0.021	0.68
edges of beds	-	0.00	0.01	0.00005	0.001	-
edges of risers	-	0.00	-	0.00000	0.000	-
Block Wall	100.00	0.08	0.04	0.00365	0.047	4.68
DPM	-	0.01	0.02	0.00029	0.004	-
HCF	-	0.03	0.07	0.00176	0.023	-
Total		**1.00**	**1.00**	**0.07809**	**1.000**	**81.12**

From the Table 4.18 we determine the progress for each activity using the bill quantities as against the measure quantities. This is the unit complete method. This cannot be applied to the whole project or a work section due to varying unit of measurement. But this provides the basis to determine the overall progress as seen in Table 4.19 to Table 4.21. Using the cost factor alone the overall progress is estimated to be 71.67% as shown in Table 4.19.Time factor alone also gave us 62.05% from Table 4.20. This difference was seen in literature and it is one of the inadequacies of using only on project elements in determining construction progress. It must be said that using the integrated method will go a long way to help eliminate this problem.

Table 4.21 where the integrated factor was applied gave 81.12 % progress of work done. This seems to be realistic.

4.11 MATHEMATICAL REPRESENTATION OF THE PROPOSED FRAMEWORK AND METHOD

The processes and procedure in the proposed progress measurement framework and methods can be sum up mathematically as shown below:

$$P_t = \sum_{i=0}^{t} (I_f x A p)$$

Where P_t = Project Progress at t time

t = time of measuring progress i

= project or activity start time

I_f = Integrated factors for each activity

A_p = Activity or quantity progress

The integrated factor for each activity is also obtained by:

$$I_f = \frac{C_e A}{TC_e}$$

Where C_eA = Co-efficient of an activity

TC_e = Total Co-efficient

The Co-efficient of an activity calculated by:

$$CeA = Cost\ factor\ of\ Activity\ A\ x\ time\ factor\ of\ activity\ A$$

4.12 VALIDATION OF FRAMEWORK AND METHOD BY EXPERTS

The framework and method was submitted to the three experts for their input and validation. The experts were three project managers, three construction managers and three consulting quantity surveyors. The project manager and the construction manager were from six different construction firms whereby the quantity surveyors were from three different consultancy firms.

They assessed a progress for substructure works at three different stages using their own methods after which we applied the proposed method so as to compare the results and comment on the proposed method and framework– integrated factor method. After the exercise the results were revealing. The results clearly display the subjectivity in the existing methods as well as the objectivity in the proposed method. The results are shown in the Table 4.22 below.

Table 4.22: Validation Results Substructure Section

Stages of the work	% of work done using existing methods									% of Work done using Integrated Factor Method								
	PM			CM			QS			PM			CM			QS		
	PM1	PM2	PM3	CM1	CM2	CM3	QS1	QS2	QS3	PM1	PM2	PM3	CM1	CM2	CM3	QS1	QS2	QS3
Up to Casting of foundation concrete	15	20	25	20	30	25	10	20	15	27	27	28	28	29	28	28	27	28
Up to Erecting of Footing walls	60	50	45	50	60	45	45	55	50	63	63	65	64	66	64	65	63	64
Up to Hardcore filling	98	97	90	95	98	85	80	90	85	93	94	96	95	95	94	93	95	94

The experts remarked that the objectivity of the proposed method is great. They agree that once the scope of work is well defined from the inception of the project the method will provide great results and relief for project stakeholders in determining construction work progress. They also agree that the assumptions for the framework and method are sound and grounded in principle of all things being equal.

However they were of the view that the method is a little difficult to work with because:

1. It requires detailed works and proper planning as it requires that the work breakdown must be in line with the bills of quantities so as to harmonize cost and time.
2. Once the work is varied, almost all the factors must be recalculated.

In all they concluded that this method is pragmatic, innovative and an improvement over existing methods.

4.13 LIMITATION OF THE FRAMEWORK AND THE METHOD

The main limitation of the proposed framework and method is that it assumes the scope of work will not be varied. However, once the project is varied then the project cost and duration must be reviewed as well as the factors for the progress determination. This therefore shows that the method will be slightly difficult to use for projects where the scope is not well define.

4.14 CONCLUSION

The findings from the quantitative analysis of this research have been present in this chapter under the following headings in relation to the research objectives:

- Progress measurement methods currently in use in Ghana,
- Factors that affects the process of progress measurement,

- Critical factors that will help drive the process of progress measurement
- Barriers to the realization of accurate assessment of progress and
- Process and procedures adopted by Ghanaian firms.

Results were presented on respondents perceptions on construction progress measurement and management. Finally a construction progress measurement framework and method is proposed.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The findings of the research from the analysis, conclusions and appropriate recommendations are presented in this chapter. The aim of the research is to propose or develop a pragmatic and innovative process and procedure for assessing the percentage complete of a construction project. Based on the aim a series of objectives were set and addressed.

5.2 SUMMARY OF FINDINGS

The highlights of the research findings obtained from the data analysis in relation to the objectives of the study are:

5.2.1 Construction Progress Measurement Methods

The study has identified the most commonly used progress measurement method in the construction industry of Ghana from the perspective of relevant construction industry stakeholders. The study identified the following as the first four commonly used method in

Ghana in descending order are:

1. cost ratio method
2. Judgment/Supervisor's opinion
3. Unit Complete and
4. Time ratio method

This information shows that the construction professionals depend mainly on only one element of a project to determine progress. This shows that the progress obtained shall be misleading because a small item may cost so much but its impact on time and quantity of work may be little or negligible. In addition, in case where the contractors pricing strategy is front or back load, the progress by this method may not reflect the true work done.

The second method, Supervisor's Opinion is purely subjective. And therefore there is way two independent opinions will be same. Interestingly the third method is very objective for activity level measurement but cannot be used to measure a progress a work section let alone a whole project. The time ratio also has limitations similar to the cost ratio. The contractors favour the judgment/supervisor's opinion than the consultants.

5.2.2 Factors That Influence / Affect Construction Progress Measurements

The results from the research show the factors that can influence the process of construction progress measurements. These first four factors in order of importance are:

1. Schedule (Time)
2. quantity of work (scope of work),
3. cost / budget and
4. productivity level (labour and plant output)

This conforms to literature as can be seen in the literature review (Jung and Lee, 2010).

The study further seeks that apart from these factors influencing the process of progress measurements, which of them will be very critical to derivation of accurate progress assessment method or procedure. It came to light that the most three critical factors that will help in the realization of accurate progress assessment are as follows:

1. Cost/budget,
2. Quantity (scope of work) and

3. Schedule.

This implies that the ability to measure construction project progress is dependent on one's ability to integrate these elements of the project objectively.

5.2.3 Critical Barriers to Accurate Progress Measurement.

The study revealed that the following are barriers to the realization of accurate progress measurement:

1. Dependence on the opinion of supervisors without hard data to back
2. Different units of measurement of bill items
3. Unspecified method of progress measurement in conditions of contract
4. Difficulty in getting uniform work breakdown structure
5. Time constrains
6. Data gathering
7. Difficulty in integrating cost, time and scope of work
8. Variations
9. Inadequate pre-contract planning
10. Inadequate method statement
11. Extension of time
12. Using time data only in computing progress
13. Using cost data only in computing progress

However the four most critical barriers to the realization of accurate construction progress measurement are:

1. Dependency of supervisor opinion without hard data to back,
2. Different units of measurement of bills of quantity items,

3. Unspecified method of progress measurement in conditions of contracts and
4. Difficulty in getting uniform work breakdown structure.

Therefore once these barriers can be eliminated then headway can be made in realizing accurate progress measurement.

5.2.4 Processes and Procedures Adopted By Firms in Ghana in Measuring Construction Progress

It can be seen from the research that construction professional are making all efforts within their means to assess progress. Whiles they claim management attached importance to progress measurement and management none of them have a scheduler in their set up. Most of them depend largely of the quantity surveyors and project management to determine the progress of work. From the research it can be said that the process and procedure adopted by firms in determining progress of work in Ghana are as follows:

a. Prepare a programme of work
b. Measure work done
c. Cost the works done and
d. Express the work done as a ratio of the contract sum
e. This is mainly done monthly

Alternatively they used the supervisor's opinion which depends largely on the experience of the supervisor

5.2.5 Proposed Progress Measurement Method

From the findings of the research in relation to the objectives the study progress measurement framework and method were proposed. Below are the details:

5.2.5.1 The progress measurement framework

The framework below takes into account a progress measurement method that considers the work itself, its cost and time for carrying out the work. For the work, the framework looks at the work breakdown structure which will form the basis of construction work programming. It has the project as the umbrella task, break down to work sections and then to activities level.

The cost or budget breakdown structure also takes into account cost of the whole project, the cost of the various work sections and the cost of activities within the work section. In the same vain the frame work did look at time breakdown structure. The time and the work form the basis of the construction programme of work. The time allotted for the activities also affects the cost of the work. The cost and time are also influence by the quantity of work (scope of work) to be done. See pages 57 – 58 for the Proposed Progress measurement framework

5.2.5.2 The Proposed Progress Measurement Method – The Integrated Factor Method

The following are the assumptions for the proposed method:

1. That the scope of the work is well defined and will not be varied
2. That the project pricing is consistent
3. That the time allotted to an activity is adequate and will not be varied
4. That activities that are running concurrently assumed to evenly share the time and one must be completed before the other. For instance if three activities will run concurrently on the programme for three weeks, the assumption is that each one will take one week to complete and will run one after the other.

Data Required

The proposed method tries to eliminate subjectivity from the process of determining the progress of work. This method place premium on objectivity and as such depends on the following data:

- Project priced bills of quantities - the plan quantities and the cost of the activities
- The programme of work – project duration and time allotted for carrying out the activities
- Measured quantities of works done as at a specified date.

The Process and Procedure – Integrated Factor Method

The steps to be followed in using the proposed method can be seen in pages 62 – 68 including application. The process and procedures of the proposed method is sum up mathematically with the formula below:

$$P_t = \sum_{i=0}^{t} (I_f x Ap)$$

Where P_t = Project Progress at t time

t = time of measuring progress i

= project or activity start time

I_f = Integrated factors for each activity

A_p = Activity or quantity progress

5.3 CONCLUSION

The study set out series of objectives and an aim in the areas stated below and findings on them has been presented.

- Progress methods currently in use in Ghana,
- Factors that affects the process of progress measurement,
- Critical factors that will help drive the process of progress measurement
- Barriers to the realization of accurate assessment of progress and

- Process and procedures adopted by Ghanaian firms.

Finally a construction progress measurement framework and method is proposed.

5.4 RECOMMENDATIONS

In order to promote the use of the proposed progress measurement method on construction projects in Ghana the following recommendations has been suggested:

1. Senior management must attached honest seriousness to progress measurement and management issues. Firms must begin to employ schedulers to handle progress measurements and management issues in the firm.
2. In order to help the construction industry, consultants must amend the appropriate clauses in the conditions of contract by specifying the method as the method to measure progress on the project. This will eliminate the subjectivity allow by conditions of contract in determining work progress.
3. Project planning must be given adequate attention. Issues like the scope of works must be well defined before commencement of the contract so as to limited variations.
4. Adequate resources must be allocated to construction works programming. This must be done by a team made up of quantity surveyors, project managers and engineers. Progress measurement must be carried out weekly so as to detect any deviation from the plan progress as early as possible.
5. Work beak down structure must be in consonants with the bills of quantity and the construction programme of work.
6. In order to ensure adequate knowledge on proposed method, it is advised that the KNUST Department of Building Technology as well as other organizations such as GIOC, ABCECG and GhIS must provide in service training for their members on the subject

matter through workshops and conferences so as to promote the proposed method. In addition, the Building Technology must include the progress measurement in the planning and control course so as to equip the students with the knowledge on the proposed progress measurement framework and method.

7. Finally, construction organizations should also provide progress measurement and management training for the project management team to enhance their knowledge on the processes and procedures for assessing construction progress.

5.5 LIMITATIONS OF THE STUDY

a. The research ought to have taken all building construction firms into account but because of unavailability of dependable data on small and medium size building construction firms, only large building construction companies with the highest technical and financial classifications were considered.
b. Also the research should have covered all the ten geographical regions of Ghana but since most of the organizations are centered in Greater Accra Region, the study concentrated on contractors and consultants in this region
c. Structural Engineering and Architectural Firms were excluded from the survey because they depend on the quantity surveyor for progress determination.

5.6 RECOMMENDATIONS FOR FUTURE STUDIES

It is suggested that further studies should conducted on:

1. Assessing the perceptions of Clients on progress measurement and performance indicators in Ghana
2. Assessing the impact of variations and other factors on construction progress measurement.

3. The impact of sub-contractors performance on progress measurement and management
4. Assessing the Culture of the construction industry in Ghana in relation to Progress Management practices.

5.7 IMPLICATIONS OF STUDY FOR THE CONSTRUCTION INDUSTRY

1. The outcome of the study will allow construction industry stakeholders including building construction companies and consultants to enhance their knowledge and skills in construction progress measurement and management through the implementation of the measures suggested for the implementation the proposed method.

2. The results will help eliminate the subjectivity in assessing construction progress and would improve project performance and have a positive impact on the construction industry and the national economy.

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APPENDIX A

QUESTIONNAIRE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF BUILDING TECHNOLOGY

QUESTIONAIRE

Master Francis T. Asare is an MPhil student at the Department of Building Technology of Kwame Nkrumah University of Science and Technology (KNUST).

It has come to light that many a time construction professionals disagree on the assessment of the percentage completion of construction projects. This is as a result of the lack of a pragmatic methodology in that regard. Some professionals prefer to use cost as a basis whilst others use time elapsed or the resource requirements.

The purpose of this survey is to help develop an innovative procedure for progress measurement and assessment of construction projects. It is in partial fulfillment for the Award of MPhil. (Building Technology) course at Kwame Nkrumah University of Science and Technology (KNUST)

The research is purely an academic exercise and your views and responses will be treated with utmost confidentiality. We expect you to spend at most fifteen (15) minutes of your precious time in answering the set of questions below.

Please take time off your busy schedule and respond to the following:

Section A – Profile of Respondent.

1. Name of respondent (optional)……………………………………………………………..

2. Position in firm
   a) Senior staff [ ]
   b) Junior staff [ ]
   c) Management [ ]

3. Name of firm (optional)…………………………………………………………………………

4. Category of firm
   a) Contractor – D1 [ ] b) Consultant [ ]

   c) Others (please specify)…………………………………………………………

5. How long has this firm been in existence?

a) 1 – 5 years [ ]

b) 6 – 10 years [ ]

c) 11 - 15 years [ ]

d) 16 – 20 years [ ]

e) Above 20 years [ ]

6. What is the level of your knowledge regarding construction project progress measurement?

a) Basic [ ]

b) Intermediate [ ]

c) Adequate [ ]

d) Advance [ ]

SECTION B – CONSTRUCTION PROJECT PROGRESS MEASUREMENT METHODS USED IN GHANA

7. On a scale of 1 – 5 rank the rate at which you use the following methods to measure construction project progress.

1 –Never used, 2 – Seldom used,
3 – Sometimes, 4 - Frequently used 5 – Always used

Methods	**1**	**2**	**3**	**4**	**5**
Unit completed [1]					
Incremental milestone [2]					
Start – Finish [3]					
Judgment or Supervisor's Opinion [4]					
Cost ratio [5]					
Time ratio [6]					

Eared value Analysis [7]					
Weighted/Equivalent units completed [8]					
Others (please specify) …… ………………………………………………………………………………………………					

Notes of the methods for clarification

1. *Considering quantities completed vis-à-vis what is outstanding and the overall quantities to be installed*
2. *Each step or stage or activity is assigned a "weight" in sequence of operation. The weight is approximately equal to its percentage share of efforts in the task/activity or the entire project*
3. *The project manager or the supervisor assigns two or three for the activity of work sections or the entire project e.g. not started 0%, started but not finished (arbitrary) say 45% or 55% and finished 100%.*
4. *Assessment purely by the judgment (opinion) of the project manager or the supervisor.*
5. *The ratio of the value achieved or the expenditure to date to the contract sum or plan budget*
6. *The ratio of time elapsed to the contract period*
7. *Using any of the methods described above to establish the percentage complete to I ntegrate cost and time.*
8. *This method involves the following five steps:*
    1. *Assign a weight to each sub activities/activities/work sections so that the total weight equal to 100%*
    2. *Multiply the weight of each sub activities/activities/work sections by the quantity of the total sub activities/activities/work sections. This is the "equivalent weight" in units of each sub activities/activities/work sections.*
    3. *Determine the percent complete for each sub activity/activity/work section by using one of the previous discussed methods.*
    4. *Multiply the percent complete of each sub activity/activity/work section by its equivalent weight. The result is the "earned quantity"*
    5. *Add the earned quantities for all the sub activities/activities/work sections and divide by the total quantity.*

SECTION C – FACTORS THAT INFLUENCES/AFFECT MEASUREMENT OF CONSTRUCTION PROJECT PROGRESS

8. Kindly state on the scale of 1 – 5 your level of agreement to the following as factors that will influence/affect measurement of construction project progress.

1 – Strongly disagree 2 – Disagree

3 – Not sure 4 – Agree 5 – Strongly agree

Factors	1	2	3	4	5

1. Cost / Budget					
2. Schedule (time)					
3. Quantity (scope of work)					
4. Safety					
5. Value					
6. Rework/defects					
7. Productivity Level (labour and Plant output)					
8. Construction techniques/methods					
9. Cooperation/Harmony					
10. Others (please specify) …… …… ………………………………………………………………………………………					

9. On a scale of 1 –3 indicate how critical the following factors can help drive the process of progress measurement of construction project.

1 – Not critical 2 – critical 3 – highly critical

Factors	1	2	3
1. Cost / Budget			
2. Schedule (time)			
3. Quantity (scope of work)			
4. Safety			
5. Value			
6. Rework/defects			

7. Productivity Level (labour and Plant output)			
8. Construction techniques/methods			
9. Cooperation/Harmony			
10. Others (please specify) ……… ……… ………………………………………………………………………			

SECTION D – BARRIERS TO PROGRESS MEASUREMENT

10. The following barriers militate against the realization of accurate assessment of construction of project progress. On the scale of 1 – 5 indicate your level of agreement or otherwise to these barriers.

1 – Strongly disagree 2 – Disagree
3 – Not sure 4 – Agree 5 – Strongly agree

Barriers	1	2	3	4	5
Time constrains					
Data gathering					
Different units of measurement of bill items					
Using time data only in computing progress					
Using cost data only in computing progress					
Difficulty in getting uniform work breakdown structure					
Unspecified method of progress measurement in conditions of contract					
Inadequate pre-contract planning					
Dependence on the opinion of supervisors without hard data to back					
Inadequate method statement					
Variations					
Claims					
Difficulty in integrating cost, time and scope of work					
Inclement weather					
Extension of time					
Delays and disruptions					
Others (please specify) ……......................................					

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SECTION E – THE PROCESS AND PROCEDURE ADOPTED BY FIRMS IN MEASURING CONSTRUCTION PROGRESS

11. Please who prepares your programmes of work for any construction project?

a) Quantity Surveyor(QS) [ ]
b) Project Manager(PM) [ ]
c) Project Engineer(PE) [ ]
d) Scheduler (S) [ ]
e) Team (QS, PE & PM) [ ]

12. What is the qualification of the person(s) who prepares your project programmes of work?

a) Diploma
b) First Degree
c) Masters
d) Others (Please specify)………………...
……………...

13. What is the experience level of the person(s) who prepares your project programmes of work?

a) Less than 5 years [ ]
b) 5 – 10 years [ ]
c) 11 – 15 years [ ]
d) Above 15 years [ ]

14. Does your firm have company policy on construction project programming and update?

a) Yes [ ]
b) No [ ]

15. Does your firm carry out construction programme update?

a) Yes [ ]
b) No [ ]

16. If yes, at what intervals do you carry out programmes update?

a) Daily [ ]
b) Weekly [ ]
c) Every two weeks [ ]
d) Monthly [ ]
e) Others (Please specify)………………...

17. If yes, who carries out the update?

a) Quantity Surveyor(QS) [ ]
b) Project Manager(PM) [ ]
c) Project Engineer(PE) [ ]
d) Scheduler (S) [ ]
e) Team (QS, PE & PM) [ ]

18. If your company has a scheduler, what are his\her qualifications?

a) Diploma
b) First Degree
c) Masters
d) Others (Please specify)………………...

19. Who determines the progress of work in your firm?

a) Quantity Surveyor(QS) [ ]
b) Project Manager(PM) [ ]
c) Project Engineer(PE) [ ]
d) Scheduler (S) [ ]
e) Team (QS, PE & PM) [ ]
f) Others (Please specify)………………...

20. How often do you measure progress?

a) Daily [ ]
b) Weekly [ ]
c) Every two weeks [ ]
d) Monthly [ ]
e) Others (Please specify)………………...

21. What data (if any) do you pick from site to determine progress of work ?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………………….........

22. What level of importance does top management attached to progress measurements?

a) Not important [ ]
b) Important [ ]
c) Very important [ ]
d) Not sure [ ]

23. To what extent do your progress assessment agrees with that of the consultants/contractors in the last five (5)?

a) Never agrees [ ]
b) Seldom agrees [ ]
c) Sometimes agrees [ ]
d) Frequently agrees [ ]
e) Always agrees [ ]

24. What in your opinion is the relationship between cost, time and work?

a) Directly proportional to one another [ ]
b) Inversely proportional to one another [ ]
c) Independent of one another [ ]

APPENDIX B: BILLS OF QUANTITIES
APPENDIX C: PROGRAMME OF WORKS