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DEPARTMENT OF BUILDING TECHNOLOGY
(M.SC. CONSTRUCTION MANAGEMENT)

DISSERTATION

TOPIC: TIME PERFORMANCE OF PUBLIC BUILDING PROJECTS IN GHANA.

BY

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ABSTRACT

This study investigates the time performance of public building projects in Ghana. The aim is to improve the time performance of public building projects in the country.

The study adopted the quantitative research strategy and survey research method with the use of questionnaires and interview to seek Experts' Opinion on the projects duration estimation methods currently used in practice, the time performance of public building projects and relevant time-influencing factor within the Ghanaian construction environment.

The result of the research revealed the mean Time Performance Index (TPI) of public building projects in Ghana within the range 1.9035 to 2.7143. This suggests that on the average, public building projects takes between 1.9035 to 2.7143 times the original project duration to complete, an indication of poor project time performance. The research identified this poor TPI to be due to over-dependent on experience for the determination of project duration and lack of proper project planning. Also public building projects durations were mostly given by the client who will normally not have any scientific basis for it.

Thirty-five (35) significant construction time-influencing factors were established out of the 72 identified with the first six in the order of decreasing importance being Project Finance Method, Material (Prices/Availability/Supply/ Quality/Imports), Clients' Financial Ability, Completeness and Timeliness of Project Information, Variation Orders/ Additional Works (Magnitude, Timing, Interference Level) and Contractors' Financial Capability (Table 5.13).

It was recommended that scientific approach and proper project planning be adopted for the estimation of project durations and time control to improve time performance.

Keywords: Building Projects, Ghana, Public, Time-influencing Factors, Time Performance,.

EDICATION

I dedicate this research work to my Wife, Children and Parents.

ACKNOWLEDGEMENT

In conducting this study, I encountered many problems most of which were finance centered but by dint of hardwork, dedication and determination I have successfully completed it.

First and foremost I thank the almighty God who gives me life, strength, knowledge, protection and guidance through all the stages involved in this study till its successful completion.

I thank my Wife and Children for their love, care, encouragement, moral and spiritual support that gave me the determination and peaceful mind to be successful in this undertaking. May the good Lord continue to bless and protect them.

My profound gratitude goes to my parents for their immense contribution and commitment they made towards the success of this research work, most especially for their financial, moral and spiritual support that sail me through all difficulties. I am most grateful and may the Almighty God grant them long good health and reward them in manifold.

My appreciation goes to my Supervisors, Examiners and all Lecturers of the Dept. of Building Technology for their efforts and commitments, especially my main Supervisor Mr. B.K. Baiden for his timely consideration of issues that needed urgent address. I wish them the Lords guidance and protection so that they could continue the good work.

I also extend my appreciation to my Brother, Sisters and Brothers-in-law for the diverse ways that they contributed to ensure the success of this study. My gratitude goes to Mr. Philemon Beiden for his kind financial support. I wish them success in their various endeavors.

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CHAPTER ONE – INTRODUCTION

1.0 INTRODUCTION

This Chapter presents the introduction to the research. It contains the Background, Statement of Problem, Justification and Scope of this research work. The Chapter defines the Key Research Questions, Aim and Objectives and the Research Process.

The Chapter also contains the highlights of the Research Method and Design employed for this study. This includes a brief of the Research Strategy and Method, comprising Sampling and Data Collection and Data Analyses.

The Deliverables/ Expected Output and Research Outline/ Organization are also defined.

1.1 BACKGROUND

The construction industry is the sector that propels infrastructural development of a country. The biggest customer of the construction industry in most developing countries is the government (Okpala and Aniekwu, 1988).

In Nigeria the construction industry is of paramount importance for employment and economic growth. While in Nigeria Olaloku (1987) found that it contributed an average of 5% to the annual gross domestic product and average of about one-third of the total fixed capital investment, Kazie (1987) affirmed that construction expenditure accounts for about 50% of the Nigerian government's expenditure. In Malaysia, Wong (2003) concluded that the construction industry growth is generally influenced by three major factors, namely national economic growth, level of demand by the property sector and government spending. Master Builders Association of Malaysia (MBAM, 2003). reported that Gross Domestic Product (GDP) for construction in 2001 was 2.3 percent and 2002 growth in the construction was maintained at 2.3 percent which was supported mainly by higher government expenditure on infrastructure projects and household demand for residential property.

The construction industry contribution towards economic growth was also reported by many earlier studies. Chan and Kumaraswamy's (1996) study in Hong Kong indicated that about 5 percent of the country's GDP for 1994 was contributed by the construction industry while in Indonesia construction accounted for 5.5 percent of annual gross domestic product in 1993 (Kaming *et al.*, 1997). In Ghana the sector is one of the fastest growing in the economy and contributes significantly to the economic growth of the country. According to Ghana Statistical Service (2006 cited Ghana Budget Statement 2007), the sector accounted for nearly 8.1% of GDP in the year 2004, 8.4% of GDP in the year 2005 and 8.6% of GDP in the year 2006.

The industry however, faces many challenges including construction time overrun which translates into poor project time performance. Past researches on construction projects suggested that the common criteria for project success are generally considered to be cost, time and quality/performance (De Wit, 1988; Wright, 1997; Arditi and Gunaydin, 1997; Frimpong *et al.*, 2003; Williams, 2003; Luu *et al.*, 2003; Dissanayaka and Kumaraswamy,1999a & b). Of these, cost and time tend to be the most important and after considered as critical because of their direct economic implications if they are unnecessarily exceeded. Both Nkado (1995) and Chan and Kumaraswamy (1997) quoted NEDO Faster Building for Commerce published in 1988, which regarded completing projects on time as symbolic of an efficient construction industry. The Latham Report (Latham, 1994) suggested that timely delivery of projects is one of the paramount needs of clients of the construction industry.

According to Mbachu and Olaoye (1989), Nigerian construction industry today is bedeviled by the fact that almost all projects are completed after duration much longer than initially planned. This was buttressed by Odusami and Olusanya (2000) who concluded that projects executed in the Lagos metropolis experienced an average delay of 51% of planned duration for most projects.

The problem of project time performance is a global phenomenon. In Saudi Arabia, Assaf and Al-Hejji (2006) found that only 30% of construction projects were completed within the scheduled completion dates and that the average time overrun was between 10% and 30%. In Nigeria, Ajanlekoko (1987) observed that the performance of the construction industry in terms of time was poor. Odeyinka and Yusif (1997) have shown that 70% projects in Nigeria suffered delays in their execution. The situation is the some in Ghana where most public projects experiences construction time overrun. Tacey (2005) determines that, in respect of 291 contracts for Goods, Works and Services concluded between 1997 and 2002 which were reviewed, 55% of them suffered from delays in completion.

Nkado (1995) emphasis the significance of time influencing factors in the estimation of construction project duration. These construction time-influencing factors are country-specific. Also Elhag and Bousabaine (2002) in their study of factors affecting cost and duration of construction projects revealed that Construction Practitioners are aware of uncertainties, incompleteness and unknown circumstances of factors affecting duration of construction projects. The situation suggests the evaluation of the project duration estimation process as practiced in Ghana and identification of relevant construction time influencing factors to improve the time performance of public projects.

1.2 STATEMENT OF PROBLEM

The huge volume and complexity of projects in Ghana's construction sector pose a great challenge and provided a wealth of opportunities to various companies in the construction industry. However, construction time overrun is a major problem confronting the industry particularly, on public construction projects and it is mostly accompanied by cost overrun which is not suitable for a developing country. According to Aibinu and Jagboro (2002), cost overrun is one of the six effects of construction delay.

Poor time performance of public construction projects has a significant influence on the country's infrastructure growth. This can be attributed to a number of factors as enumerated by Nkado (1995) and Kumaraswamy and Chan (1998). The outcome effects are inefficient implementation, unsuccessful delivery and cost overrun of projects. Time performance of projects in Ghana needs to be improved to instill public confidence in the delivery.

1.3 JUSTIFICATION FOR THE RESEARCH

The time performance of projects is an essential measure of its success. According to Aibinu and Jagboro (2002), construction time overrun results in cost overrun, Arbitration, Litigation, Total abandonment and disputes. These issues can be avoided if original project durations are not excessively exceeded, an indication of good project time performance.

Chan and Kumaraswamy (1997), emphasized that timely delivery of projects within budget and to the level of quality standard specified by the client is an index of successful project delivery. This implies that time performance of public projects is a major concern for governments (Clients).

The delivery times of public projects provide inputs into plans of other sectors of the economy. Time performance of public projects is therefore crucial for accelerated infrastructure development, hence economic growth particularly, for projects that are earmarked for commercial activities. This can only be achieved if public projects are efficiently managed to achieve good time performance in the country.

Studies by Okpala and Aniekwu (1988) in Nigeria and ,Nkado (1995) in the United Kingdom (UK) concluded that construction delays can be minimized. Efforts geared minimizing delays will translate into improving time performance of public construction project and results in cost savings for the country as a whole.

1.4 SCOPE OF STUDY

The scope of this research work is the Ministries, Departments and Agencies (MDAs) that are involved in the procurement of public construction projects. The study is further limited to the departments under the Ministry of Water Resource, Works and Housing (MWRWH) and the Ministry of Local Government, Environment and Rural Development. This includes the Public Works Department (PWD), Architectural and Engineering Services Limited (AESL), Department of Rural Housing (DRH) and Metropolitan, Municipal and District Assemblies (MMDAs) in the Greater Accra and Ashanti Regions. The target group will be the Engineers, Architects and Quantity Surveyors of the above mentioned departments as well as private consultants who render consultancy services on most of public building contracts and Contractors who are registered with the Ministry of Water, Works and Housing (MWRWH) within the work classification D1, since these are the category of contractors that are required to have qualified professional Engineers and Quantity Surveyors on their staff.

1.5 KEY RESEARCH QUESTIONS

The following were the key research questions:

1.0 Do public building projects in Ghana suffer time overrun?

2.0 What are the causes of time overrun on public building projects in Ghana?

1.6 AIM AND OBJECTIVES OF STUDY

1.6.1 AIM

The aim of this research work is to improve the time performance of public building construction projects in Ghana. This will have a positive turn on the rate of infrastructural development, hence accelerated economic growth of the country.

1.6.2 OBJECTIVES

The above aim will be realized through the following objectives:

1. To determine the Time Performance Index (TPI) of public building projects in Ghana as at March, 2008.
2. To evaluate the process of estimating duration of public building construction projects in Ghana.
3. To identify duration estimation methods currently applied to public building construction projects in Ghana.
4. To identify the relevant factors that influence the duration of public building projects in Ghana.
5. To make recommendations for improving the TPI of public building projects in Ghana.

1.7 RESEARCH PROCESS

Research process defines the overall approach to the study and the interconnectivity among the various stages of the research. The research process adopted for this study is as outlined in Fig. 1.1.

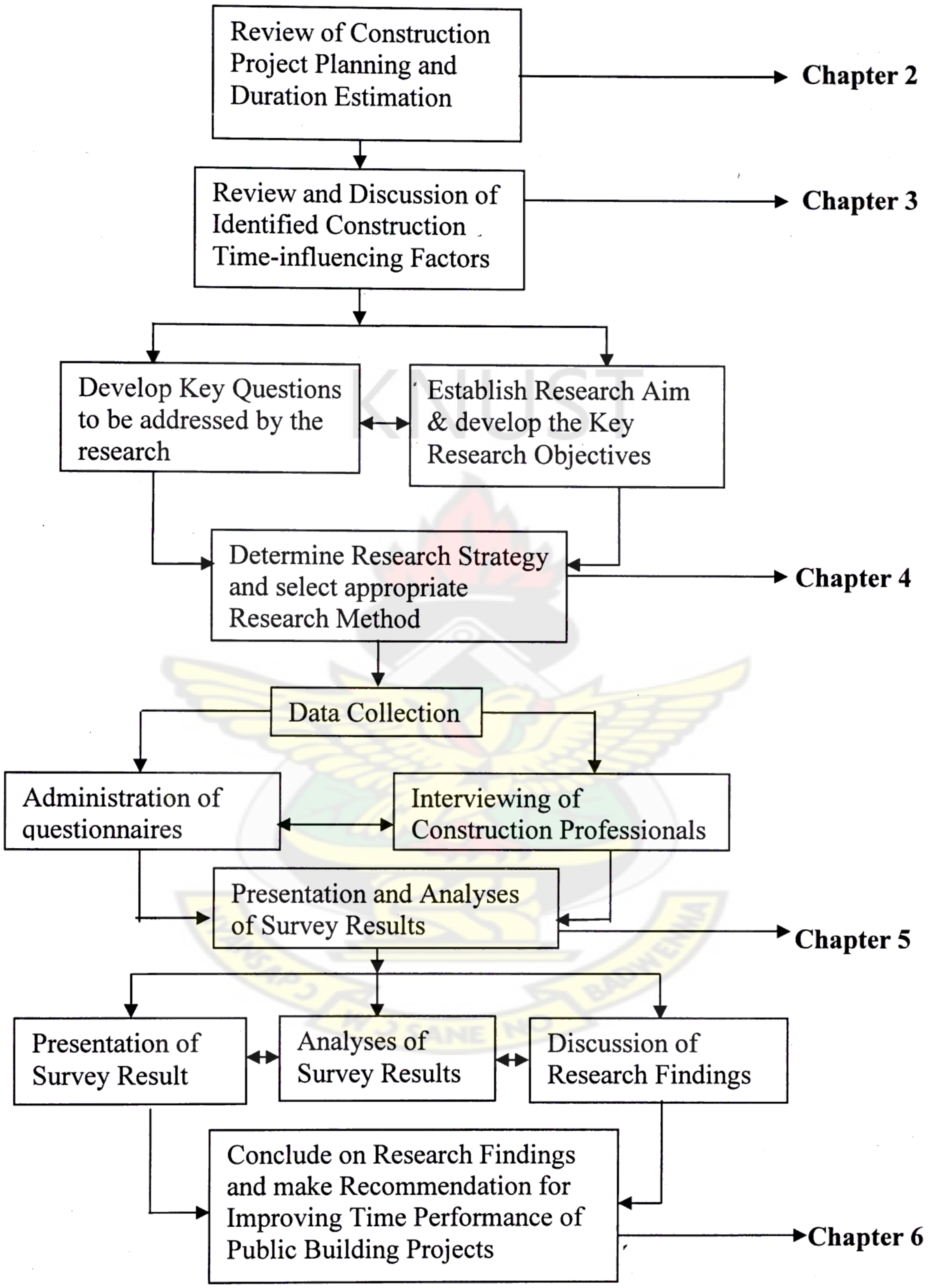

Fig. 1.1 Research Process

1.8 RESEARCH METHOD AND DESIGN

The research method and design for this study are as outlined below.

1.8.1 RESEARCH STRATEGY AND METHOD

This study adopted the quantitative research strategy which involves collection of numerical data, use of statistical tools for data analysis and making decisions based on figures. The study also adopted the survey research method for data collection with the use of questionnaires and interview.

1.8.2 SAMPLING AND DATA COLLECTION

In determining the sample space, the respondents were considered into Consultants and Contractors group. Engineers, Architects and Quantity Surveyors of the MDAs (Clients) were considered in the Consultant group since they constitute the in-house technical team that overseas construction projects and also provide consultancy services on some of the projects. The Kish formula (Kish 1965) was used to determine the sample size for the consultants but for the Contractors, the entire population was used because of the small size involved. Stratified sampling method was used to select respondents for the questionnaire and simple random sampling for the selection of the interviewees.

Self administered questionnaires and semi structured interview were the data collection methods employed in this research. Qualitative data was collected and converted to quantitative by assignment of weightings.

1.8.3 DATA ANALYSIS

The quantitative data analyses techniques was employed in this research in arriving at decision. The analyses are as outlined below.

1.8.3.1 Evaluation of Project Duration Estimation Methods

The project duration estimation methods currently employed on public building construction projects were evaluated on the basis of the percentage of responses received in respect of the questions and where possible the results were depicted in charts for pictorial view.

1.8.3.2 Time Performance Index

In this study the Time Performance Index (TPI) was used as an indicator to assess the construction time performance level of selected public building projects completed in Ghana as at March, 2008, where TPI is a ratio of actual contract duration to original contract duration.

1.8.3.3 Ranking of Identified Construction Time-influencing Factors

The identified time-influencing factors were ranked on the basis of their Relative Important Indices (RII) for both the Consultants and Contractors groups. The overall ranking was done on the basis of the weighted RIIs of the factors.

Consistency in the ranking by the two groups was ascertained using the Coefficient of Variation (CV) analysis and Spearman's Rank Correlation Coefficient (r_s) and further buttressed with hypothesis test on the strength of the decision made relative to the r_s value.

The factors were further subjected to significance testing using the Normal Test Statistics and buttressed with the *P-Values* to select the relevant factors to public building construction projects in Ghana.

1.9 DELIVERABLES /EXPECTED OUTPUT

The deliverables of this research are:

1. Contributors to inaccurate estimation of public building projects duration in Ghana.
2. Construction time influencing factor relevant to public building projects in Ghana.
3. Time performance of public building projects completed in Ghana as at March, 2008.

1.10 RESEARCH OUTLINE/ORGANIZATION

This research is organized in six chapters comprising Introduction, Project Planning and Duration Estimation, Construction Time-influencing Factors, Research Method and

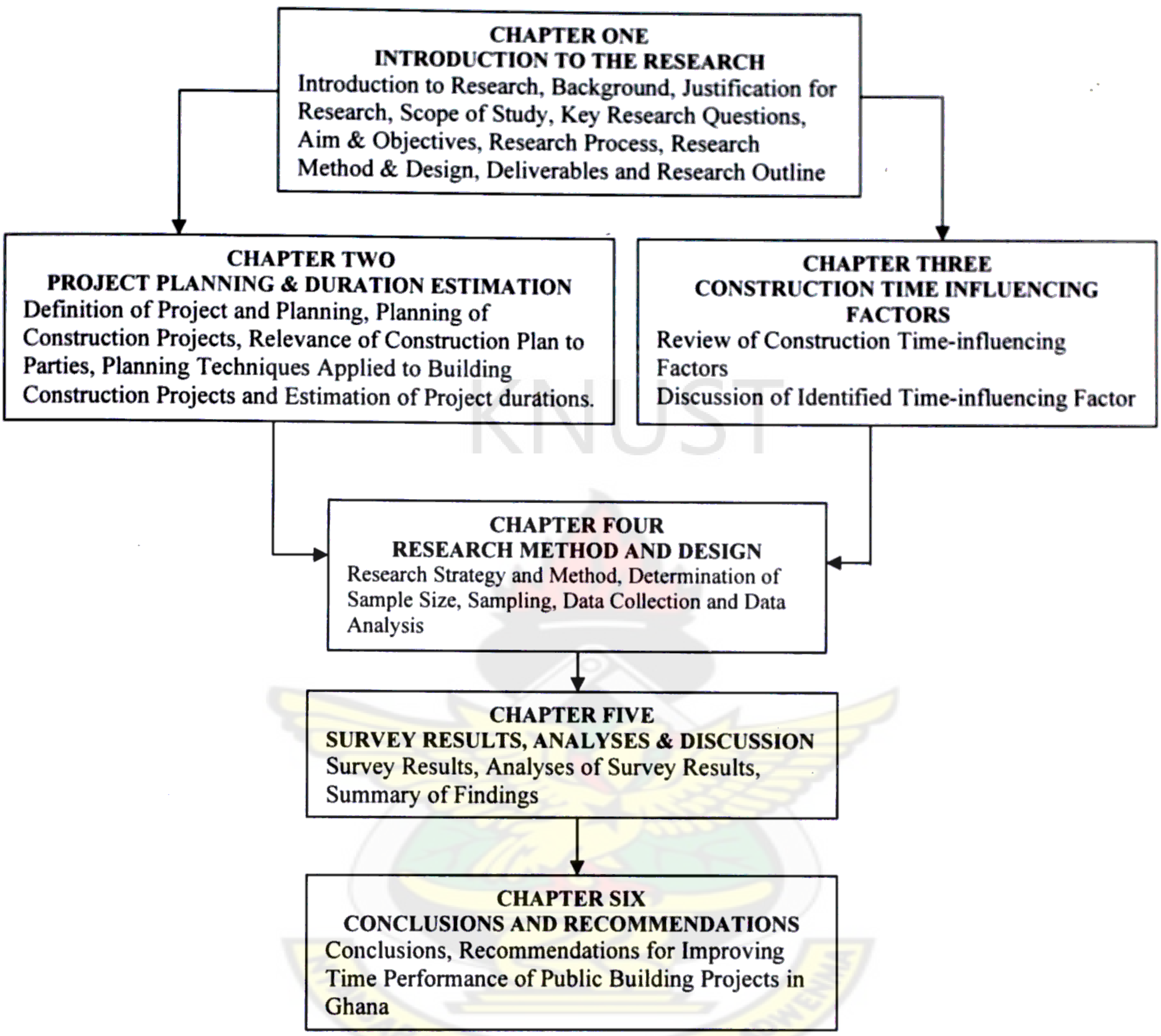

Fig. 1.2 Research Outline

Details of the research outline are as present below:

Chapter One – This presents the introduction to the research, the background, the justification for undertaking this research and scope of the research. The key questions for the research were posed leading to the statement of the aim and objectives. The

Chapter also contains a brief outline of the research process (details of this is contained in Chapter Four), the deliverables and the research outline.

Chapter Two – This Chapter reviews the project planning and duration estimation. It defines Project and Planning in the context of construction, Planning of Construction Projects, Planning Stages, Relevance of Construction Plans to Parties in the Construction Industry, Planning Techniques Applied to Building Construction Projects and Estimation of Project Duration.

Chapter Three – This Chapter reviews the Construction Time-influencing Factors and discusses the identified Time-influencing Factors.

Chapter Four – This Chapter presents the details of the Strategy and Method adopted for the research. The chapter also discusses the Determination of Sample Size, Data Collection and Data Analysis (details contained in Chapter Five).

Chapter Five – This Chapter presents the Survey Results, Analysis of Survey Results and Summary of Findings.

Chapter Six – This Chapter presents the Conclusions of the Study and the Recommendations for improving the time performance of public building projects in Ghana.

1.11 SUMMARY

Exploratory literature review on construction project time performance gives the background to this research. Poor time performance of projects was identified as the problem to be addressed by this study. The scope of the study is limited to the MDAs in the Greater Accra and Ashanti Regions. Improving time performance of public building projects was established as the aim of this research and this is to be achieved with five objectives. The research process was outlined to show the interrelation among the stages of the research. Quantitative research strategy and survey research method were decided to be adopted for the study. The study is organized in six chapters.

CHAPTER TWO – PROJECT PLANNING AND DURATION ESTIMATION

2.0 INTRODUCTION

Chapter one focused on the introduction to the research. It presents the Background, Justification for the research into time performance of public building projects in Ghana. This is a yardstick for measuring success of projects delivery in the construction industry. The chapter also defined the Scope of the research, Key Research Questions, Aim and Objectives, Research Process, Research Method and Design, Deliverables and the Research Outline. This chapter reviews construction project planning and duration estimation.

This comprises definition of project and planning in the context of construction, planning of construction projects, planning stages, relevance of construction plan to parties in the construction industry and planning techniques applied to building construction projects. The chapter also discusses the estimation of project duration. This comprises pre-tender activities such as site investigation; method statement and programming to give an insight into the scientific approach to project duration estimation. The chapter concluded with a summary of the discussions.

2.1 PROJECT AND PLANNING

2.1.1 PROJECT

Pyron (1999) defined project as a collection of activities or tasks designed to achieve a specific but temporary goal of the organization with specific performance requirement and subject to time and cost constraints.

According to Wideman (1995), project is a process or undertaking that encompasses an entire set of activity having a definable starting point and well defined objectives the delivery of which signal the completion of the project. He continues that projects are usually required to be accomplished within limited recourses.

In accordance with Baker and Baker (1992), projects is a unique venture with a beginning and an end, undertaken by people to meet established goals within defined constraints of time, resources, and quality.

According to Rosenau (1988), project is an organized undertaking utilizing human and physical resources, done once, to accomplish a specific goal, which is normally defined by a Triple Constraint. The constraints being time, cost and quality.

In the context of construction, project can be defined as a collection of construction activities in a chronological order to produce a specific construction product that will meet a specific performance requirement and constructed within a predetermined technical specifications, time and cost constraint.

2.1.2 PLANNING

Planning can be defined as the process of anticipating future occurrences and problems, explaining their probable impact and determining policies, goals, objectives and strategies to solve the problem. In other words, planning is the process of setting goals, developing strategies and outlining tasks and schedules to accomplish the goals.

In accordance with Cooke and Williams (2004), without planning it is difficult to envisage the successful conclusion of any project or the effective control of time, money or resources. Planning is also essential in order to deal with construction risks and devise safe working methods. This is true through all stages of the process from inception through the design, tendering, construction to commissioning stages of a project.

According to Cooke and Williams (2004), the reasons for planning may be summarized as:

- To aid contract control
- To establish realistic standards
- To monitor performance in terms of output, time and money
- To keep the plan under constant review and take action when necessary to correct the situation

2.2 PLANNING OF CONSTRUCTION PROJECTS

Construction projects commences with planning. According to Harris and McCaffer (2006), there are two main levels of planning associated with construction projects. These are strategic and operational planning.

2.2.1 STRATEGIC PLANNING

Strategic planning deals with the high level selection of overall project objectives, including the scope, procurement routes, time-scale and financing options (Harris and

McCaffer 2006). They continue that strategic planning for a project results in broad outlines of what the project has to achieve and how it is to be undertaken.

2.2.2 OPERATIONAL PLANNING

Operational planning allows a more detail look at the project's resource requirement that is not obvious at the strategic level (Harris and McCaffer 2006). Example of operational plans includes a tender plan, feasibility plan, and construction plan.

Planning at both strategic and operational levels for construction project requires various tools and techniques as will be discussed later in this chapter.

2.3 PLANNING STAGES

According to Cooke and Williams (2004), there are three main planning stages involved at operational planning level. These are;

i) Pre-tender Planning Stage ii) Pre-contract Planning Stage and

iii) Contract Planning Stage

2.3.1 PRE-TENDER PLANNING STAGE

The pre-tender planning stage is the first stage in the planning process of a construction product. At this stage contractors engage in activities that will enable them prepare and submit a competitive tender for a proposed construction product. This process is referred to as pre-tender planning.

Pre-tender planning may be defined as the contractor's planning considerations during the preparation of an estimate and its conversion into a commercial bid (Cooke and Williams 2004). The pre-tender planning process ends at tender submission.

Pre-tender planning is crucial to the overall construction process for the following reasons:

- To establish a realistic contract period on which the tender may be based
- To identify economically suitablé construction methods
- To assess method-related items which affect the bid price
- To aid the build-up of contract preliminaries and plant expenditure
- To aid the tendering process
- In some cases, to comply with tender requirements

2.3.2 PRE-CONTRACT PLANNING STAGE

The pre-contract planning stage is next to the pre-tender planning stage in the planning process of a construction product. It commences immediately after notification of acceptance of tender and ends at signing of contract (Cooke and Williams 2004). This is the case for projects based on traditional competitive tender but there may be differences in procedure where other procurement arrangements are used.

At this stage, contractors engaged in pre-contact planning activities. Pre-contract planning therefore involves all the activities carried-out immediately after notification of acceptance of tender up to the commencement of work on site (Cooke and Williams 2004). Basically, pre-contract planning is the process of developing the pre-tender programme into contract master programme which shows the main construction operations and it is mainly used by Clients to monitor the overall progress of the construction work.

According to Cooke and Williams (2004), pre-contract planning is carried out for the following reasons:

- To provide a broad outline plan or strategy for the project
- To comply with contract conditions
- To establish the construction sequence on which the master programme will be based
- To identify key project dates
- To highlight key information requirements
- To enable the assessment of contract budgets and cumulative value forecasts
- To schedule key dates with respect to key material and subcontractor requirements

2.3.3 CONTRACT PLANNING STAGE

Contract planning stage is next to the pre-contract planning stage and it is the final stage in the planning process of construction product. It is the stage where the actual execution of the construction work is planned.

Contract planning involves all the activities carried out immediate after signing of contract up to the total delivery of the construction product (Cooke and Williams 2004).

Basically, it involves the development of the master programme to further breakdown every activity into details.

Reasons for pre-contract planning are:

- To monitor the master programme – monthly, weekly and daily
- To plan site operations in detail in the short term
- To optimized and review resources
- To keep the project under review and report on variances

For the purpose of this research, the focus will be on the pre-tender planning. Pre-tender planning commences with invitation for tenders and ends at tender submission as illustrated in Fig. 2.1.

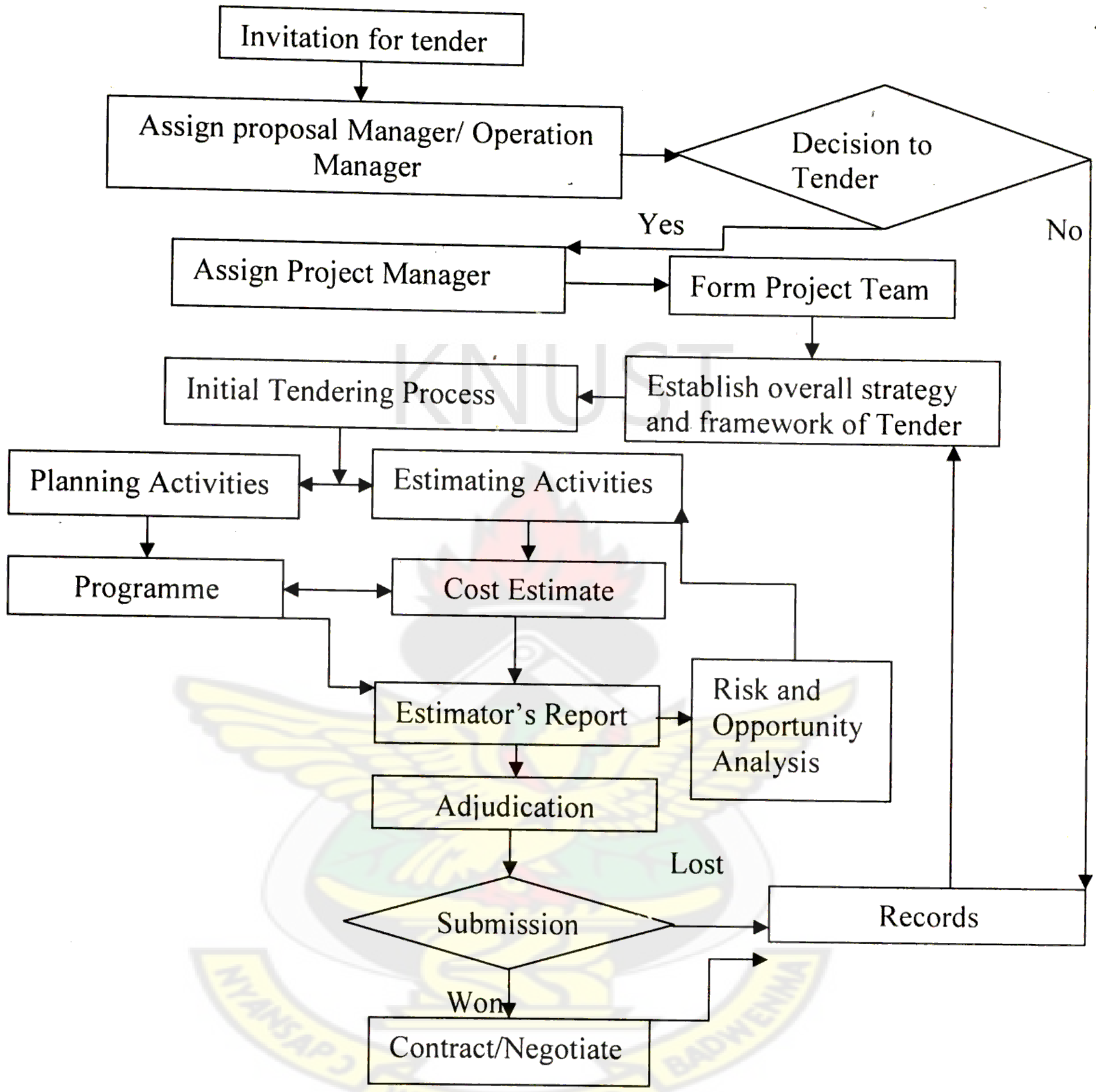

Fig. 2.1 Flow Chat Illustrating Estimation Process

**Source: Modern Construction Management, 6th Edition, by Harris, F. and McCaffer R., (2006).

At this stage, contractors perform two main tasks namely:

(i) Estimation of project cost

(ii) Estimation of project duration

These two tasks are performed concurrently to enable the translation of planning results data into cost. However, for the purpose of this research work only estimation of project duration will be discussed.

2.4 RELEVANCE OF CONSTRUCTION PLANS TO PARTIES IN THE CONSTRUCTION INDUSTRY

There are three main parties in the construction industry namely: Client (Employer), Consultant (Designer) and Contractor.

The type of plan required by each of the above parties depends on the role that the organization plays in the construction process.

2.4.1 CLIENT / EMPLOYER

The Client organization is the one who desired for the construction product and eventually pays for it. The organization is therefore always interested in the overall project plan commencing with the acquisition of the land up to the productive use of the facility. Primarily, the client organization needs the project plan to predetermine the times of cash out flow for which he has to make provision and provide guidance for overall strategic decision on the project's management. Also, the Clients need the project plan to decide a time of procuring plant items in which case the procurement times and the overall project duration are the key factors in such decisions.

2.4.2 CONSULTANT(S) / DESIGNER(S)

The consultant is the party employed by the clients to represent their interest and is assigned the responsibility of supervision and overall management of the project to successful completion. The consultant therefore provides the client with the project plan on which the client makes his decisions. However, being the supervisor or project manager, the consultant also depends on the project plans for the management of its own resources, and the overall construction process to achieve a construction product that meets the time, cost and performance requirement.

2.4.1 CONTRACTOR(S)

The contractor is the party responsible for the delivery of the physical construction product and is responsible to the client.

The contractor is the party that put in the greatest effort in the planning process because they believe that a well planned, carefully monitored and controlled contract reflects directly in the profitability of the contract, hence the company's success. The contractor plans at two stages; these are the estimation stage and the production stage.

Crudely it can be described that estimating evaluates the use of resources in terms of cost and planning evaluates the use of resources in terms of times put together (Harris and McCaffer 2006).

2.5 PLANNING TECHNIQUES APPLIED TO BUILDING CONSTRUCTION PROJECTS

Planning techniques are tools use for the presentation of construction programmes. Construction programme of work presents construction activities in their sequence of execution, with their associated duration and resource requirements (Harris and McCaffer 2006). The aggregation of the duration of the activities taking into account sequence, laps and delays between activities, gives the overall scientific project duration. The available scientific techniques mostly used for construction planning are:

1. Bar charts and Linked bar charts
2. Network Analysis
   a) Activity-on-the-Arrow (Arrow diagram)
   b) Activity-on-the-node (Precedence diagram)
3. Project Evaluation Review techniques (PERT)
4. Line of balance (for repetitive works)
5. Space- time diagrams.

2.5.1 BAR CHARTS AND LINKED BAR CHARTS

These are graphical representations of work programmes. They depict activities and their respective duration which is represented by horizontal bars drawn in proportion to the duration of the respective activities on a time scale starting from the respective start dates of the activities. On this chart, the time deference between the start of the first activity (bar) and the end of the last activity (bar) gives the overall scientific project duration. The level of detail of activities depends on the use.

Bar chart has the following advantages:

i. Easiest to understand and use

ii. Easy to construct

iii. Simplicity

iv. Linked bar charts has the added advantage of effects of delays easily seen

However, bar charts have the following disadvantages:

i) The start time of activities is arbitral

The major drawbacks relates to the construction of the bar chart for large and complex project with many activities, if the chart is produced manually, that is constructed on paper and not as a by-product of a computer system, then the bar charts is;

ii) Limited in size (say 30 to 100 activities)

iii) Not easy to update or schedule

Thus its main limitation is the inability to manipulate the bar-chart data.

This means, for large and complex contracts, the bar chart has the tendency of not being able to be updated and will fairly soon be out of date, discredited and disregarded.

Moreover, the usefulness of bar charts can not be over emphasized.

1. As progress control chart. This is achieved by superimposition of a second bar (in different shading) on the lower section the main bar (showing the planned time) to indicate progress for each activity. This enables calculation of percentage completion of each activity by relating the progress bar to the

plan bar at any particular time indicated by plumb line on the programme. In the case of linked bar charts the effect of delays in any activity are easily seen.

2. Calculation of resources required for the project. This is done by constructing resource aggregation charts along the programme showing the various resource requirements of the individual activities which are then summed-up to determine the total resource and the peak resource requirements of the project. This is further useful for estimating the work content in terms of labour hours or machine-hours, hence for the choice of economic construction method for the purpose of cost control.

3. Useful means of communication between Engineers and foremen, particularly by colour coding the activities e.g. Blue for carpenters, yellow for masons.

2.5.2 NETWORK ANALYSIS TECHNIQUES (NAT)

According to Lucey (2002), network analysis is a generic term for a family of related techniques developed to aid management to plan and control projects. The objective of network analysis is to locate the activities that must be kept to time, managed to ensure the most effective use of resources and look for ways for reducing the total project time (Curwin and Slater 2000).

This is a planning technique that lends itself to computer application; hence enables easy manipulation. With this planning technique planning data is held in computer files that are linked logically to define the relationship between the individual work activities. Change in activity duration and activity resource can easily be made Harris and McCaffer (2006). Also, change can be made in the logical relationship between activities and the consequences recalculated and represented. The steps to produce and process a network plan are more clearly defined, self-contained and offer a more rigorous approach to planning of complex operations.

According to Harris and McCaffer (2006), the steps are;

1) Listing the activities in a chronological order
2) Producing a network showing the logical relationship between activities.
3) Assessing the duration of each activity, producing a schedule, and determining the start or finish time of each activity as the floats available.
4) Assessing the resources required.

There are basically two types of network analysis both of which employs critical path analysis to determine the critical activities and for the manipulation of overall project duration. These are;

i) Activity-on-the-arrow (Arrow diagram)
ii) Activity-on-the-node (Precedence diagram)

Network techniques are particularly applicable to "one off" projects, hence its considerable use for many construction projects.

For small and simple projects with few activities, networks can be constructed and manipulated manually. For large and complex projects with a lot of activities, computer application saves time in the analysis, re-analysis and updating. This particularly applies when optimization of cost and or resource allocation is being undertaken.

However, according to Osley and Poskitt (1986) network analysis has the following advantages over the bar chart:

1. Clear presentation of inter-relationship between all operations/ activities.
2. Critical activities can be identified delays can be easily addressed, through crushing whiles with bar chart; many activities will be unnecessarily crushed.
3. Ease of familiarization with progress of work in the event of anyone taking over a partially complete project.
4. It allows for careful understanding of sequence of operations which leads to closer project understanding.
5. Planning, analyzing and scheduling are separated with the use of network analysis which allows for concentration on the planning aspect.

2.5.2.1 Activity-on-the-arrow

An arrow diagram consists of activities and events. An activity is an operation or process (Osley and Poskitt 1986). All activities start and finish at an event, which is a point in time and may be the junction of two or more activities.

Activities take time whereas events do not, and one activity cannot be stated until all the activities leading to its proceeding event are completed (Osley and Poskitt 1986).

Activities are represented by arrows and the sequence of the arrows represents the sequence of activities; events are normally represented by circles or rectangles (Osley and Poskitt 1986).

Arrow diagrams sometimes employs what is called dummy activities (activities without duration) to either make the sequence clear (maintain correct logic) or to arrive at a unique numbering system (unique identification of activities). In building projects, many activities overlap therefore network analysis offer an efficient planning tool.

Producing a Schedule

Scheduling is the process of determining the actual time period during which the activities are planned to take place. Production of a schedule by network analysis requires duration or time analysis. The time required for each activity needs to be estimated with the use of method statement.

Having determine the duration and sequenced of all the activities from the method statement, a logical network is then drawn comprising circles (denoting a events) indicating start and finish of activities. These circles are normally partitioned into 3 parts (a part each for event number, latest event time and earliest event time) and are then connected with arrows (denoting activities).

The events are then numbered in a logical sequence to allow for identification. The duration and resource requirement of individual activities are also indicated respectively on top and bottom of the corresponding arrows.

At this stage, a process literally referred to as forward and backward pass is performed to establish the earliest event time (through forward pass) and latest event time (through backward pass) of each of the activities. This then allows for the determination of the critical activities and the calculation of floats.

The critical activities are those activities that satisfy the following conditions:

i) The Earliest Event Time and the Latest Event Time of the proceeding event are equal.

ii) The Earliest Event Time and the Latest Event Time of the succeeding events are equal.

iii) Addition of the Activity Duration to the Earliest Event Time of the proceeding event gives the Earliest Event Time of the succeeding event.

The path traced by the critical activities is the critical path.

According to Harris and McCaffer (2006), floats are spare time available for each activity within which the activity can be delayed without affecting the start time of a succeeding event. According to Osley and Poskitt (1986), there are four types of floats namely the Total Float, Free Flat, Independent Flat and Interfering Float.

Total Float is the total amount of time by which the activity could be extended or delayed without interfering with the project-end date (Harris and McCaffer 2006). Free float is the amount of time by which an activity could be extend or delayed without interfering with the succeeding activity(ies) (Harris and McCaffer 2006). Interfering float is the amount of total float shared by the succeeding activity(ies) (Harris and McCaffer 2006). Independent float is the amount of spare time available which can be used without affecting any succeeding activity and which can not be affected by any preceding activity (Osley and Poskit 1986).

Assessing Resources

In estimating the duration of an activity, the resources required for that activity will have to be considered. The resource can be written alongside each arrow in the network. The first and widely used resource assessment method is the Resource Aggregation Chart. The chart is produced for every resource say labour (Carpenters, Steel Benders, Masons etc.) and plants. Beyond the use of aggregation chart is Resource Allocations. These are the time-limited problem (completion of project by a specified date) and resource-limited problem (completion of project within limited resource).

Resource Allocation

Resource allocation is concerned with scheduling activities and their resources within predetermined constraints. Normally, networks are drawn on the assumption that resources are always available.

However, in real situation resources are limited, so must be allocated to satisfy the constraints. This then results in the manipulation of the network without preference for critical activities. The manipulation comes in two forms namely resource leveling and resource smoothing.

Resource leveling is the process of ensuring that available resource is not exceeded, in which case the project duration may well be influenced by insufficient resources.

Resource smoothing (time-limited resource consideration) is done when the project duration is of prime importance. First time analysis will be done to provide the minimum time possible for project completion. If the minimum time is established as the time limit, adjustments in the timing of any activity that may affect resource requirements must be undertaken within the float available. Critical path analysis is useful in these circumstances as it highlights those activities which must be examined for the project duration not to be exceeded. The aim will be to reduce the time required for those activities which will result in least cost overrun.

2.5.2.2 Precedence Diagram

Precedence diagram (Activity-on-the-node) follows the same principle and procedures as the arrow diagram earlier discussed. The differences in the application are as follows:

i. Rectangles are used to represent activities instead of arrows as in the case of arrow diagram

ii. Every activity has four time schedules as earliest start time, earliest finish time; latest finish time and latest start time whereas arrow diagram has only two time schedules i.e Earliest Event time and latest Event time.

iii. Because of the more time schedules, the techniques can be used to model several relationships unlike the arrow diagram that only shows start-to-finish relation. The most useful of these relationships are (1) start-to-start (SS), (ii) Finish-to-start (FS), (iii) Finish-to-finish (FF) and (iv) Start-to-finish (SF). These times are also determined through the forward and backward passes.

Apart from the above differences, precedence diagram employs the same principles and procedures as with arrow diagram for its analysis. Forwards and backward pass are done taking into account leads and lags to establish the four times of each activity. This then helps in the determination of the critical activities, hence the overall project duration. Crushing is similarly done to achieve shorter project duration.

The same principles as in the case of arrow diagram is employed in the Scheduling, Resource Aggregation and Resource Allocation.

2.5.3 PROGRAMME EVALUATION AND REVIEW TECHNIQUE (PERT)

This technique can be viewed as an extension to arrow diagrams as it has its bases as arrow diagram. Unlike the arrow diagram and the precedence diagram which assume that information employed in programme is reasonably accurate, PERT presents a more pragmatic technique that takes into account uncertainties associated with programming information. Cost and time overruns are uncommon in construction. In this regard, PERT addresses such uncertainties by making use of three time values for each activity duration referred to as:

(1) Opmistic duration (do) - Minimum duration of an activity if everything goes on well.

(2) Most likely duration (dm) - Duration based on analysis of previous projects, planner's experience and judgment.

(3) Pessimistic duration (dp) - Maximum time if everything goes wrong.

PERT is a probabilistic approach to estimation project duration which allow for uncertainties in project duration to be addressed.

Key activity parameters used for PERT analysis are:

1. Expected Duration de= (d0 + 4dm + dp)/6
2. Standard Deviation (θ_{de}) = (d_p-d_o)/6
3. Variance of expected duration (V_{de}) = $[(dp\text{-}do)/6]^2$

The expected duration reflects the activity duration in arrow diagram to precedence diagrams. PERT diagram is just the normal arrow diagram with additional information on variance. In determining project duration and critical activities the normal forward to background pass is performed.

After determining the overall project duration because of contingency events could result in time-overrun during the execution/production storage, project duration is further negotiated. It is very essential that the potential to deliver the project within the negotiated period is clearly appreciated or assessed. This assessment is a measure of the risk associated with the programmed project schedule and provides useful information for the project manager who needs to negotiate the project delivery date. The extra period negotiated provides the float to cater for contingency situation. Estimation of the risk can be done by utilizing the variance information. This is done by assuming that all the activities are statistically independent. The difference between the Target Period (the negotiated period) and the Expected Project Duration (EPD) is expresses in units of standard deviations in order to make use of the area undér Normal Distribution Curve to compute the risk.

EPD = Sum of expected duration for all activities on the critical path i.e. critical activities.

V = overall variance of the project is the sum of the variances of all activities on the critical part.

i.e. EPD = $\sum de$

V = $\sum V_{de}$

Z = $(TD - EPD) / \sqrt{V}$ i.e. $TD = Z \times \sqrt{V} + EPD$

Where Z = z – score from normal distribution table

TD = Target Duration

If Z = 1.414

It implies that $P (Z \leq 1.141) = 0.92$

This means there is a 92% chance of completing the project within the negotiated period. The higher the percentage the lower the schedule risk associated with the planned project and vice versa. In practice a working probability of 95% is considered reasonable. So if TD is required, it can be determined from:

$TD = Z \times \sqrt{V} + EPD.$

The same analysis can be done to determine the risk associated with completion of individual activities. In this case;

TD = Latest Event Time of the activities (LET)

EPD = Earliest Event Times of the activity (EET)

Expected Activity Duration (EAP) = de

V_{de} = Activity Variance.

Hence, $Z = (LET - EET) / V_{de}$

This means all activities on the critical path will have Z = 0, equivalent probability of 0.5 (P – value). Simply, it means all the activities on the critical path have 50% chance of getting out of schedule and present a higher risk to the overall project schedule compares to activities of greater Z – values.

According to Harris and McCaffer (2006), the main advantage of PERT is in establishing the schedule risk associated with the planned programme. This reduces the incidence of categorical statement of project duration starting or ending on a specific date because life is full of uncertainties.

The three types of time estimates used in PERT are as represented on the bell-shaped named distribution curve.

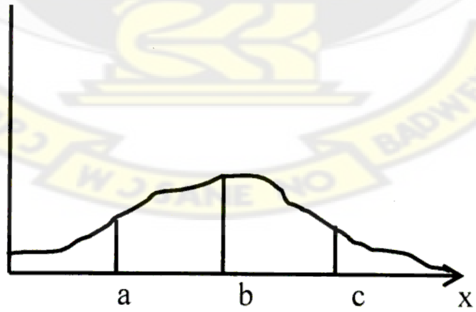

Figure 2.2 Illustration of Optimistic, Most Likely and Pessimistic durations

(o-a) – Most optimistic estimate

(o-b) – Most likely estimate

(o-c) – Pessimistic estimate

Uses of PERT

Just like the other network analysis techniques, PERT is useful for the following:

i) Computation of overall project duration

ii) Identification of critical activities

In addition to the above, PERT has a unique usefulness of;

iii) Assessing the risk of truly completion for activities and overall project in order to facilitate project schedule control.

So far the planning techniques discussed are those commonly used by the construction professionals for the scientific estimation of building construction projects durations.

2.5.4 OTHER PLANNING TECHNIQUES

Other planning techniques are the Line of Balance and Space Time Diagram. Line of Balance is used for repetitions works which is not a common feature of building projects. Space time diagram is also only useful for estimation of duration of road construction projects. These planning techniques will not be discussed in details because they are not relevant to the topic under consideration.

2.6 ESTIMATION OF PROJECT DURATION

The basic characteristics and purpose of project duration estimation are unique for the various phases of the building production process. Construction project duration is very crucial for the successful execution of construction projects and it is one of the two major tasks performed at the pre-tender stage. Contractors are mostly concerned with the estimation of project duration as part of the requirements for tenders. Astute contractors carry out this task of project duration estimation with due diligence as it reflects strongly on the profitability of the project. The process of construction project duration estimation commences with pre-tender planning.

Activities involved at the pre-tender planning stage can be broadly classified into three namely;

i) Site Visit / Investigation

ii) Methodology (Method Statement)

iii) Programming

2.6.1 SITE VISIT / INVESTIGATION

Site visit is an activity performed by Contractors (Tenderers) to enable them acquaints themselves with the conditions at a proposed construction site and to satisfy themselves with the content of a tender document. Contractors usually visit the proposed project site to make observations and in some cases conduct tests to confirm information contained in the tender document to enable them submit realistic quotation.

In civil engineering works, it is a normal practice for the Promoter's Engineer to arrange a site visit which gives the estimators and planners an opportunity to study the site with the design personnel on hand to answer queries. However, in building works site visit may not be formally arranged but nevertheless most contractors arrange one in their own interest.

Generally, site investigation reveals ground information, economic and market conditions, location and relates information and personnel availability. These are normally presented in site visit report, prepared by a team of the estimator and planner. According to Harris and McCaffer (2006), this report contains such information as:

- Description of the site
- Position of existing services
- Description of ground conditions
- Assessment of the availability of labour
- Problems relating to the security of the site
- Description of access to the site
- Topographical details of the site
- Description of any demolition works or temporary works to adjoining buildings
- Description of facilities available for the disposal of spoil
- Any other information that is necessary for the preparation of the tender and execution of the works such as the local market condition.

2.6.2 METHOD STATEMENT

Method Statement (Methodology) is defined as a description of how the work will be executed with details of the type of labour and plant required and a pre-tender programme (Harris and McCaffer 2006). According to Cooke and Williams (2004), the preparation of method statements forms an essential part of the contractor's planning process as these underpin the programme and explains how the work is to be undertaken.

Cooke and Williams (2004) categorized method statements into three distinct formats namely:

- The tender method statement
- The construction or work method statement
- The safety method statement

However, for the purpose of this research work, only the construction or work method statement was discussed.

During the preparation of method statement alternative methods of construction are considered together with alternative sequences of execution, differing rates of construct and alternative site layouts are considered. It requires information from site visit report to determine the most economic method of executing individual activities resulting in the determination of activity durations and sequence of activities. This information then provides inputs for the pre-tender programme.

According to Cooke and Williams (2004), there are two formats for presenting method statements namely the tabular format and the written or prose format.

The tabular format is probably simple and easier to read but there is a space restriction on content. The prose format gets over this problem of space restriction and provided it is well laid out, can be both useful and comprehensive.

The sections of a typical Method Statement include but not limited to:

- Description of activity/operation

- Quantity of activity/operation
- Sequence of activity/operation
- Resource requirement (plant and labour)
- Resource output rates
- Activity/operation duration

2.6.3 PROGRAMMING

Information on the methodology is then translated onto the pre-tender programme, a process literally referred to as pre-tender programming. The pre-tender programme shows the sequence of all the main activities, the individual activity durations and the overall project duration. From the pre-tender programme approximations of the labour and plant resources can be estimated. In some cases, the methodology is further refined or modified and the changes also transferred onto the pre-tender programme to give a modified or refined activity and overall project duration. This means the preparation of a pre-tender programme is not a one-time activity but subject to continual refinement and modification as both the estimator and planner become more and more aware of the implications of the project details.

The product of the pre-tender planning is the pre-tender programmes which details out the activities to be performed under the project, sequence of the activities, duration of individual activities, start and finish times of individual activities and the overall project duration.

2.7 SUMMARY

The Chapter reviewed the general concept of project planning and duration estimation as applied to construction. Strategic Planning and Operational Planning were identified and discussed as the two main levels in planning of construction projects. Pre-tender Planning, Pre-contract Planning and Contract Planning Stages were also identified and discussed as the three main planning stages encountered with construction projects. The Bar Charts and Linked Bar Charts, Network Analysis (Activity on the Arrow and Precedence Diagram) and PERT were identified and discussed as the planning techniques applied in construction for the determination of duration building projects. More so the review also revealed Site Visit/Investigation Report, Method Statement and Programming as the main activities involved in project duration estimation.

CHAPTER THREE – CONSTRUCTION TIME INFLUENCING FACTORS

3.0 INTRODUCTION

Chapter two reviewed the concept of project planning and project duration estimation. The chapter concluded the Strategic Planning and Operational Planning were main levels in the planning of construction projects. Pre-tender Planning, Pre-contract Planning and Contract Planning Stages three main planning stages encountered with construction projects. Also Site Visit/Investigation Report, Method Statement and Programming were identified as the main activities involved in project duration estimation. However earlier researches identified some construction time-influencing factors that often determine actual project durations.

This chapter focuses on the review and discussion of identified construction time-influencing factors. These factors will be subjected to significance test in Chapter Five to select those relevant to public building projects in Ghana.

The concludes with the number of identified construction time-influencing factors.

3.1 REVIEW OF CONSTRUCTION-TIME INFLUENCING FACTORS

Ogunlana *et al.* (1996) study in Thailand and Kaming *et al.* (1997) study in Indonesia found that the blame for most project delays were laid on the contractors. Abd. Majid and McCaffer (1998) conducted a literature survey on causes of project delay where they claimed that 50 percent of the delays can be categorized as non-excusable delays for which the contractors were responsible. A study by Kumaraswamy and Chan (1998) indicated that six common significant factors for both building works and civil engineering projects were poor site management and supervision, low speed of decision making involving all project teams, client initiated variations, necessary variations of works and inadequate contractor experience. Among causes of project delay in Lebanon identified by Mezher and Tawil (1998) were cash problems during construction, design changes by owners and availability of shop drawings. Al-Momani (2000) conducted a survey on 130 public projects and found delays occurred in 106 out of 130 projects surveyed due to poor designs, change orders, weather, site conditions, late delivery, economic conditions and increases in quantity. Elinwa and Joshua (2001) study in Nigeria revealed that the mode of financing and payment for completed works, improper planning and under estimation of project duration were among important factors causing delays. A study by Frimpong *et al.* (2003) on groundwater projects in Ghana indicated that 33 out of 47 projects were delayed where among the most significant delay factors were finance related and poor contract management.

In this section the study of Nkado (1995) and Elhag and Boussabaine (2002) were reviewed as follows:

3.1.1 NKADO'S STUDY

Construction Time-influencing Factors: The Contractor's Perspective

According to Nkado (1995), although construction time is just a part of life cycle duration of a project, it is increasingly important for several reasons. The construction period is the time frame within which all the resources for the project are integrated to produce a construction product. More so, construction time is one of the yardsticks for evaluating the success of a construction project.

Nkado (1995) identified six categories of construction time-influencing factors through the review of previous researches. The factors were as follows:

Factors Pertinent to Clients

- Financial ability/ Financial arrangement for the project
- Previous working relationships
- Project Category (Public/ Private)
- Priority on construction time
- Specified Sequence of Completion
- Possible changes to initial design.

Factors Pertinent to Consultants

- Completeness and timeliness of project information;
- Buildability of design
- Provision for ease of communication
- Previous working relationship

- Priority on construction time

Factors Pertinent to Contractors

- Availability of suitable management team given firm's current workload
- Programming construction work
- Previous performance of site management team
- Number of Sub-contractors

Factors Pertinent to Contract Form

- Suitability of project time
- Use of standard form of contract

Factors Pertinent to Project Conditions

- Function or end use (Office, Residential, Industrial)
- Complexity
- Location

External Factors

- Weather, Regulations, Statutory undertakes (Water, Gas etc.)

3.1.2 ELHAG AND BOUSSABAINE'S STUDY

Factors Affecting Cost and Duration of Construction Projects

Elhag and Boussabaine (2002) also identified Sixty-seven (67) construction time-influencing factors under six(6) characteristics as follows:

Client Characteristics

- Type of Client (Public/ Private/ Developer)
- Financial ability/ payment records
- Project finance method/ Appropriate funding in place on time
- Partnering arrangements
- Priority on construction time/ deadline requirements
- Experience on procuring construction work
- Client requirement on quality
- Certainty of project brief

Consultant and Design Characteristics

- Completeness and Timeliness of project information(Design, Drawings, Specifications)
- Buildability of design

- Working relationship with Client/ Contractors/ other design team Consultants (Previous/ Present)
- Variation orders and additional works (Magnitude, timing, interference level)
- Quality of design and specification
- Inspection, Testing and Approval of completed works (toughness/ requirements)
- Submission of early proposal for costing and cost planning
- Absence of alterations and late changes to design (no " design- as –we- go" on site philosophy)

Contractors Characteristics, Firm's Ability and Site Management

- Management team (suitability, experience and performance)
- Management labour relationships and confidence in workforce
- Financial Capability
- Experience on similar projects
- Current workload
- Level of communication within the contractor's organization
- Estimation methods and cost techniques (accuracy and reliability)
- Planning capability and level of resource deployment/ utilisation/ optimisation

- Productivity effects (Managerial, Organisational, labour, Technology)
- Percentage of main contractor's direct work and percentage of sub-contractor's work
- Number of sub-contractors
- Mark-up policies and percentage (general and project wise) (special or normal conditions applied)
- Record of payments of Sub-contractors
- Previous claim records i.e. assessment of " low tender"- " high claims" performance
- Present claims (size and quantity)
- Accidents on-site record
- Bond/ warranty arrangements
- CDM regulation awareness

Project Characteristics

- Type/ function (residential, commercial, industrial, office)
- Size/ gross floor area
- Height/ number of stories

- Number of basement levels
- Level of certainty of soil conditions
- Complexity
- Type of structure (steel, concrete, brick, timber, masonry)
- Location (region/ rural; urban) (intercity/ outskirts)
- Site Conditions/ Site topography
- Construction method/ technology
- Type of foundations (pile/raft/ pad etc.)
- Off-site prefabrication
- Type of cladding and external wall (brick, double glass)
- Access to site
- Intensity and complexity of building services
- Phasing requirements (areas to be handed over first or initial non-availability)
- Quality of finishing

Contract Procedure and Procurement Method

- Type of contract/ use of standard form of contract

- Tender selection method (open, selected, negotiated, single or two-stage)
- Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)
- Method of procurement (traditional, design and build, project management etc.)
- Spread of risk between construction parties(client/consultants/contractors)
- Claims and dispute resolution methods (litigation/ arbitration/others)
- Interviewing of selected prospective contractors

External Factors and Market Characteristics

- Material prices/ availability/ supply/ quality/ imports
- Labour costs/ availability/ supply/ performance/ productivity
- Plant costs/ availability/ supply/ condition/ performance
- Weather conditions
- Government regulations/ policies (health and safety, fire, CDM etc)
- Level of competition and level of construction activities
- Number of bidders on competitive projects
- Interest rate/ inflation rate
- Stability of market conditions

A review of international literature reveals a consensus between Nkado (1995) and Elhag and Boussabaine (2002) on the identified factors and their category. Most of the factors are similar and listed under six categories. In the same vein, Chan and Kumarraswamy (1995 and 2002) identified factors affecting construction duration under four headings. These factors are also similar to those determined by Nkado (1995) and Elhag and Boussabaine (2002) under six headings.

3.1.3 DISCUSSION OF IDENTIFIED TIME-INFLUENCING FACTORS

The above factors were put together as discussed below for further review and ranking to reflect the Ghanaian situation:

Client Characteristics

In the construction industry, the Client(s) is the body responsible for the overall implementation of the project including giving the designer a brief of the project, approving the cost, dictates the form of contract, timing and payment for the project.

In Ghana, the Client for all public building construction projects is the Government acting through the MDAs with foreign donor's support that comes in different packages.

- Type of Client (Public/ Private/ Developer)

Considering the role the Client(s) plays in construction projects, as mentioned above, any improper action or decision that they take can have effect on the timely completion of the project.

- Financial Ability/ Payment Records

The amount of liquid asset of a Client is a direct reflection of its financial ability. Since the Client(s) is responsible for payments, its ability to meet timely financial commitment plays a key role in the completion of projects within predetermined construction duration.

- Project Finance Method/ Appropriate Funding in Place on Time

The method that the client adopts in financing construction projects has influence on the rate of completion as most of payment methods can be linked to the cash-flow of the Contractor. Example, a Client may incorporate in the contract document monthly payment for monthly value of work done and the Contractor relies on this information in preparing his cash flow which reflects times of inflow and an outflow taking into account it's negotiated arrangement for all inputs for the project in terms of labour, materials and plants.

- Partnering Arrangements

Partnering and Alliance is a kind of contract procurement method that relies on the relationship of the parties to achieve project objective through a collaborative and cooperative work. The extent of collaboration or cooperation on a project and the form of partnering agreement can therefore affect its duration.

- Priority on Construction Time/ Deadline Requirements

The importance that the Client attached to the construction time of a project is an indication of its commitment to the project in terms of early completion. Example, where the project is intended for commercial activity, the Client may have budgeted for the revenue collection to commence within a particular time in order to meet a target, hence its co-operation to ensure timely completion of the project

- Experience on Procuring Construction Work

The experience of client in procuring construction works is an indication of its understanding of construction contracts and procedures with greater attention on cost – time relation. The extent of Client(s) experience in the procurement of construction works influences project timely delivery and should be considered in the fixing of the duration.

- Client Requirement on Quality

Client's preferences for specific materials and workmanship that will bring out the quality of work they desire, do sometimes have influence on the completion of a construction project most especially because of accountability. This becomes more apparent when the specified material is not readily available on the local market and need to be imported or the one to provide the right standard of workmanship is not readily available.

- Certainty of Project Brief/ Possible Changes to Initial Design

The certainty of Client's brief for a project determines the extent of likely changes he will call for during the construction stage. A project with high certainty of brief suffers minimum changes at the construction stage and vice versa. Since these changes will have time implications and were not contained on the programme of work, the project is most likely to suffer time overrun.

- Specified Sequence of Completion

Contractor will normally prepare his programme of work on the basis of the method of construction he intends to adopt, the available resources and timeliness of the resources. The construction method relates to sequence of completion. In the event where the Client(s) specifies a particular sequence of completion, is up to the planner to consider this in his plan. In order words, the programme of construction should commensurate with the Client's prescribed sequence of completion not to bring any distortion in the programme that will result in overall time overrun.

Consultant and Design Characteristics

- Completeness and Timeliness of Project Information (Design, Drawings, Specifications)

The completeness and timeliness of project information such as Design, Drawings and Specification is very crucial for timely delivery of projects. Incomplete and delayed project information fails to communicate adequately for appropriate and timely decision to be taken on the method of construction resulting in avoidable delays, hence time overruns.

- Buildability of Design

Design buidability is an expression of the possibility of its translation into the physical structure. A design that is capable of easy translation into the construction product is said to be more buildable and lends itself to timely delivery. On the other hand, a design that is incapable of easy translation into a construction product delays the project completion unnecessarily.

- Working Relationship with Client/ Contractors/ Other Design Team Consultants (Previous/ Present)

Previous and present working relation among the parties to construction contract plays an important role in the successful delivery of the project. Good working relation among parties fosters smooth administration of contracts and this translates into timely completion of construction projects and vice versa.

- Variation Orders and Additional Works (Magnitude, Timing, Interference Level)

The timing, magnitude and interference level of additional works ordered by consultants have time implications and mostly have adverse effects on the delivery time of the project. It is therefore very important to allow for additional works in the determination of project duration.

- Quality of Design and Specification

With quality of Design and Specification, what it means is the clarity of the design and specification. Design and Specifications are expected to be clear enough to communicate the desire of the client to the construction organization. The ease with which the Contractor interprets the design and specifications has a direct bearing on the rate of delivery of the construction product.

- Inspection, Testing and Approval of Completed Works

Activities such as Inspection, Testing and Approval of completed works have time implications especially where the consultant has to delay in carrying-out these activities. The delays due to the above activities are normally not catered for in the programme of work, so their performance tends to disrupt the programme and this results in time overrun.

- Submission of Early Proposal for Costing and Cost Planning

Cost planning is an activity performed by the Contractor to provide basis for cost control. Timeliness of the proposal for this activity affects the commencement of the project, hence the delivery time.

- Absence of Alterations and Late Changes to Design (no " design- as –we- go" on site philosophy)

Alterations and late changes to designs are not catered for in the work programme but have time implication, their presence and absence will affect the completion of a project.

- Provision for Ease of Communication

Ease of communication within the Consultants smoothens administration of the project hence saves the Contractor a lot of time and enables timely project delivery.

- Priority On Construction Time

Consultant's priority on construction time is a reflection of its prompt response to issues concerning the execution of the contract both on the part of the Client and the Contractor. The level of priority that a Consultant attached to project time impacts on the delivery rate and time. It is therefore necessary to consider this in project duration estimation.

Contractors Characteristics, Firm's Ability and Site Management

The Contractor(s) is the organization that the Client contracts to translate the design into a physical structure and in so doing, has the responsible for delivering of the construction product to meet the quality, cost and time requirement of the client. This organization will normally execute the works in accordance with a prepared work programme taking into consideration the resource requirement of the project and a construction method.

- Management Team (Suitability, Experience and Performance)

The project delivery rate of a contractor depends greatly on the suitability, experience and performance of its management team. A well experience management team with good performance achieves effective work delivery in terms of planning and construction, hence timely completion of project and vice versa.

- Management Labour Relationships and Confidence in Workforce

Management-labour relationship and confidence in workforce is very essential for the effective performance of a construction organization. This is because these are two different levels of workers and the organization can only achieve maximum performance with effective co-operation between them. Where the two groups are able to co-operate effectively, they have confidence in each other and this promote effective working environment, hence timely delivery of projects.

- Financial Capability

Contractor's financial capability is a measure of its ability to undertake the construction project. All things being equal, a Contractor with adequate financial resources is more likely to deliver project on time compared to the one with lesser financial resources. This suggests that the financial capability of a Contractor has an influence on the rate of its delivery of project so should be considered in estimation of project duration.

- Experience on similar projects

A Contractor's experience on a similar project eases its understanding of the design and specification. This informs the Contractor on the choice of construction methods that will enable him deliver the project on time.

- Current Workload

The current workload of a Contractor is an indication of its readiness to undertake any project. A Contractor's resources in terms of labour, material and plant are limited. This means a Contractor with large current workload may not be able to deploy resources to meet the timely delivery of a new project.

- Level of Communication Within the Contractor's Organization

Communication within the Contractor's organization is an effective tool that ensures that instructions are well understood and promotes teamwork. This ensures that the various aspects of the work are executed effectively resulting in timely delivery of the overall project. Level of communication within the Contractor's organization therefore influences its project delivery, hence should be considered in estimating project duration.

- Estimation Methods and Cost Techniques (Accuracy and Reliability)

The reasonability of a Contractor's price for a project is a reflection of the accuracy and reliability of its estimation method and cost techniques. A Contractor's being profit minded will normally be discouraged by unreasonably low contract price and this affects the timely completion.

- Planning Capability and Level of Resource Deployment/ Utilisation/ Optimization

Construction plans implemented by a Contractor in delivering a project is a reflection of its planning capability. Also, the level of resource deployment/utilization or optimization depends on the construction plan of the Contractor for the particular project especially at the contract planning stage. A Contractor having good planning capability produces plans that ensure effective resource deployment/utilization and optimization. All these influences project delivery rate.

- Productivity Effects (Managerial, Organisational, Labour, Technology)

The productivity of the Contractor's workforce in terms of Management, Organisation, Labour and Technology have a bearing on its performance, hence its project delivery rate.

- Percentage of Main Contractor's Direct Work and Percentage of Sub-Contractor's Work

The type of procurement arrangement adopted for a project determines the parties to the contract and contractual relationships. In the traditional method of procurement which is mostly adopted for public projects, the contract is mostly between the Main Contractor and the Client. With this, the Main Contractor is under the obligation to comply with the provision enshrined in the contract including delivering the project within the contract duration. In such a situation the Main Contractor takes up the responsibility of ensuring that Subcontractors deliver their aspect of the works on time because he will be held responsible for delay of the project. Since Subcontractors have a lesser obligation for timely delivery, delays on project usually comes from them. The relative percentage of the Main Contractor's direct work to that of the Subcontractor therefore has great influence on the completion of the project and should be considered in project duration estimation.

- Number of Sub-contractors

In the same vein as above the number of Sub-contractors on a project has a bearing on the completion time. Normally, the larger the number, the more delay the project suffers and vice versa.

- Mark-up Policies and Percentage (General and Project Wise) (Special Or Normal Conditions Applied)

The mark-up is what the Contractor charges the Client for his service to cater for profit and head office overhead. The mark-up either contribution or profit has the effect of either encouraging or discouraging a Contractor to deliver project on time. A Contractor will normally be motivated by a relatively high mark-up to deliver project promptly.

- Record of Payments of Sub-contractors

Where Sub-contractor's payments are delayed mainly by the Main Contractor, it has a negative turn on their delivery rate which could result in time overrun of the entire project. On the other hand prompt payments to Sub-contractors normally translate into timely delivery of their aspect of the works, hence completion of projects within contract time. It is therefore worthy to consider the Main Contractor's payment records of Sub-contractors in the estimation of project durations.

- Present claims (size and quantity)

The size and quantity of a Contractors claim determines the how early the consultant will finish working on it and Client making payment. Large claims will normally be disputed and this brings delay on the project.

- Accidents on-site record

The accident on-site record of a Contractor indicates the extent of health and safety measures he puts in place during construction. However, high accident rate on construction projects translate into delay in the delivery of the works. It is therefore of much importance to take the accident record of a construction organization in the estimation of project duration.

- Bond/ warranty arrangements

Bonds and Warranties are securities that the Contractor provides to secure the Clients interest in the contract. Different Bonds or Warranties will normally come with different conditions and would affects project time differently.

- CDM Regulation Awareness

Construction Design and Management (CDM) Regulations are provisions that ensure that the proposed management method will achieve the design objective within a specified time frame. However, these regulations are not yet in force in Ghana, so this factor it was not considered for review.

- Programming Construction Work

Construction is carried out according to predetermined programme of work. There are several forms of construction programming each having its advantages and disadvantages. The effectiveness of the programme therefore has a bearing on the delivery time of a construction project. Programming of construction works at all stages is of paramount importance and should be critically undertaken in estimating project duration.

- Previous Performance of Site Management Team

The performance record of a Contractor's site management team reveals its ability to manage construction projects. Excellence performance record of a Contractor's management team is an indication that the company is capable of effectively managing projects to completion without avoidable delays.

Project Characteristics

Pyron (1999) defined project as "a collection of activities or tasks designed to achieve a specific but temporary goal of the organization with specific performance requirement and subject to time and cost constraints".

In the context of construction, project can be defined as a collection of construction activities in a chronological order to produce a specific construction product that will meet a specific performance requirement and constructed within predetermined technical specifications, time and cost constraint.

The time requirement of a project as indicated in the definition calls for critical consideration.

- Type/ Function (Residential, Commercial, Industrial, Office)

The type and function of a building determines the use. However, the use of a construction project is an expression of the priority that the Client will attach to it early completion, be it residential, industrial, commercial, office, religious etc. Example a Client is most likely to give priority to commercial or industrial projects due to the expected renew from its operation. It then implies that the type or function of a building is an important parameter that influences timely delivery of project

- Size/ Gross Floor Area

Large construction projects takes longer time to complete compared to smaller ones all things being equal. A prominent reason for this is that large projects will normally require effective management of resources and time with the large number of specialist works that may require Sub-contractors. Small projects on the other hand, will not require the caliber of management personnel and level of planning expected on large projects. Since effective management requires time, this translate into some of the difference in delivery time of large and small projects aside difference in the magnitude or quantity of work involved in the two.

- Height/ Number of Stories, Number of Basement Levels

The output rate of construction operatives decreases with increase in height or number of stories. High structures will normally encounter lower ouput rates at relatively higher floors, this reduces the overall productivity on site and slows the rate of delivery compared to single storey or shorter buildings. More so, construction at higher levels requires special equipments as hoists, cranes and other forms of elevators. The bringing to site, mounting and operations takes some amount of time.

- Level of Uncertainty of Soil Conditions

It is often required to conduct site investigation at the planning stage of a project to ascertain among others the soil conditions at the proposed site. The level of certainty of the works to be carried out in treating the soil will normally not be fully ascertained before the commencement of the works and this affects the project duration during execution.

- Complexity

The complexity of a project is an indication of the ease of interpreting its design and the translation of the design into the physical construction product. The ease with which the design is interpreted is an expression of the rate of delivery of the construction project. Project complexity therefore plays a significant role in its timely execution and should be considered in the determination of its duration.

- Type of Structure (steel, concrete, brick, timber, masonry)

The type of structure is an expression of the material employed in its construction. The ease and time required for assembling the material into the construction product influences the productivity of operative on site, taking into consideration the weight and possibility of prefabrication. Example, steel structures normally have heavy components that although lend themselves to pre-fabrication requires special equipment for its lifting and fixing in position compared to masonry structures that have relatively lighter components but did not lend themselves to much pre-fabrication . These two structures will have deferent delivery rate. This shows that the type of structure also influences the timely production of a construction product hence worthy of consideration in the estimation of projects duration.

- Location (Region/ Rural; Urban) (Intercity/ Outskirts)

The location of a project determines its proximity to resources required and assess to site. Urban areas will normally have easy assess to manufactured component of the project and some amount of materials required in their natural state such as timber and aggregates (coarse and fine) coupled with good labour and management team as against projects located in the rural areas that will normally have more of the natural materials but suffer good labour and management. On the other hand the use of certain equipments for faster delivery may be acceptable in the rural or outskirts but not in the urban or intercity due to the noise level associated with its operation. The balance of these also affects timely completion of projects so has to be considered in coming-out with project duration.

- Site Conditions/ Site Topography

The site conditions or topography determines the kind and amount of groundwork to be carried-out on the project. The kind and amount of groundwork has its time implications. Since ground conditions vary from one project to the other, it means the time required for groundwork also varies from project to project. It then implies that the site conditions or topography influences timely delivery of projects need to be considered in the estimation of project duration.

- Construction Method/ Technology

Construction projects are carried out according to work programme prepared based on a specific method of construction. The construction method or technology employed on a project therefore determines the progress rate, hence its completion. This then suggests that consideration of construction method or technology in project duration estimation is very necessary.

- Type of Foundations (Pile/Raft/ Pad etc.)

The type of ground determines the type of foundation for any building construction project. A normal strip foundation may be suitable for a project to be sited on fairly stable ground such as sand but this may not be the case with unstable grounds such as clay. Time requirement for the construction of the various types of foundations varies and this translates into project delivery time. It is therefore essential to consider the type of foundation required for a project in the determination of its duration.

- Off-site Prefabrication

Off-site prefabrication promotes faster construction. The amount of off-site prefabrication on with a project influences its delivery time. The larger the amount of prefabrication works on a project the faster its delivery and vise versa. Consideration of the amount of off-site prefabrication on a project is an essential parameter in the estimation of its duration.

- Type of Cladding and External Wall (Brick, Double Glass)

Working with different types of cladding will have different delivery rate with the same workforce depending on the weight and possibility of off-site fabrication. The type of cladding and external wall therefore affects project timely delivery.

- Access to Site

Access to site is an expression of the ease of getting resources to the project. It takes longer time and much difficulty to get materials to sites that are not easily accessible and this translates into delayed commencement time and untimely delivery of the project.

- Intensity and Complexity of Building Services

The various services works in building construction are mostly carried-out by different specialist that normally associates with the project as Subcontractors. These works are interdependent, so the intensity and complexity can influence project timely delivery. It is therefore essential to consider the intensity and complexity of building services in estimating project durations.

- Phasing Requirements (areas to be handed over first or initial non-availability)

Construction projects are executed in accordance with a work programme which will have to take into consideration the phasing requirements. Different phasing requirements will require different programme and this will translate into different completion times of a project.

- Quality of Finishing

Finishes to construction products are done to specification which is a reflection of the quality. The availability of the material and workmanship to achieve the desired quality affects the completion time.

Contract Procedure and Procurement Method

Contract procurement methods are management systems used the Client to secure the design and construction services required for the execution of a proposed project to the quality, cost and time. There are different procurement methods depending on the extent of integration of the design and construction. This ranges from the traditional method to the varying management oriented methods.

- Type of Contract/ Standard Forms of Contract

There are many forms of contract such as Ghana Government's Conditions of Contract, FIDIC, PINK FORM, the World Bank Conditions of Contracts etc. and their applicable standard forms employed for the execution of construction projects. These forms of contracts have varying provisions on time control of projects and influences timely delivery of projects differently.

- Tender Selection Method (Open, Selected, Negotiated, Single Or Two-Stage)

There are different tendering methods each having different effect on the time for the commencement of work on site. On Government projects in Ghana, the open tendering method is mostly employed, hence its consequences on project delivery.

- Payment Modalities (Fixed Price, Cost Plus, BOT, PFI-DBFO, and others)

Many payment modalities are applicable to construction projects with varying incentives for timely completion. Some cost plus methods as

- Method of Procurement (Traditional, Design and Build, Project Management and Others)

There are several methods of procuring construction projects ranging from the traditional to the varying management oriented methods. Each of these methods has its own time implication, hence affect project delivery differently.

- Spread of Risk Between Construction Parties(Client /Consultants /Contractors)

The spread of risk between construction parties varies with the forms of contract applied. The risk is normally associated with the obligation of the party under the contract. Where the spread of risk between parties is such that none of them feels stressed-up, projects will normally not suffer excessive time overrun.

- Claims and Dispute Resolution Methods (Litigation/ Arbitration/Others)

Claims are request by Contractors for re-compensation for some loss and/ or expense for which he will not be reimbursed by payment under any other provision of the contract. Contractors will normally submit claims for Consultants' approval and onword honouring by the Client. The timeliness of the approval and payments of claims affects project completion rate.

Disputes normally retard progress on project and if the method adopted for the resolution is not suitable the situation turns to worsen.

- Interviewing of selected prospective contractors

Interviewing of selected prospective contractors gives the client the chance to further confirms their readiness and capability for timely delivery of the job.

- Suitability of Project Time

Project times are mostly given by the Client instead of Contractors who are responsible for execution of the job according to work programmes. Where the project time agreed upon is not reasonable considering the programme and ability of the Contractor, the project will normally suffer time overrun.

External Factors and Market Characteristics

- Material Prices/ Availability/ Supply/ Quality/ Imports

Material is one of the three major resources for any construction project. In most cases material represent the greater part of construction cost constituting between 40 to 60%. Material therefore constitutes a major aspect of construction projects and some cases it is linked to the programme of work in a resource aggregation chart. This suggests that material prices, availability, supply, quality or import influences project delivery hence should be considered in the estimation of project duration.

- Labour Costs/ Availability/ Supply/ Performance/ Productivity

Equally important as the material is the labour which is also a major resource for construction projects. Labour is the human resource required for the execution of construction projects. Most astute contractors link the anticipated labour to the programme of work in a resource aggregation chart. Labour therefore represents a crucial aspect of construction work so has a high possibility to influences project completion. It is in this light that labour costs, availability, supply, performance and productivity is worthy of consideration in the determination of project durations.

- Plant Costs/ Availability/ Supply/ Condition/ Performance

Plant is the third major resource for construction works. Plants are the mechanical equipments employed on construction projects for the execution of activities that labour will not have performed economically or timely. It is often also linked to programme of work in a resource aggregation chart. This suggests that plant costs, availability, supply, condition and performance can influence project timely delivery so needs consideration in the estimation of project duration.

- Weather Conditions

Construction is mostly an outdoor activity that often comes into contact with the weather. In this case, it means depending on the stage of the works and the activity (internal or external) being performed weather can influence the delivery. Also certain weather conditions favour some construction activities. Example, in filling to excavations good compaction level is achieved during rains but good concrete work cannot be achieved during the rains. Weather therefore plays a very important role in construction project execution and have a high tendency of influencing the timely delivery so needs consideration in the estimation of project duration.

- Government Regulations/ Policies (Health and Safety, Fire, CDM Etc)

Construction projects must be carried out in compliance with Government Regulations and policies prevailing at the time and place. Some of these regulation are the need to obtain permit or approval for the building, health and safety permit, permit for fire and many other environmental protection regulation especially where the impact of the particular development will have to be assessed and permitted or otherwise. The process involved in obtaining permit or clearance for these regulations require some amount of time and need to be considered in the estimation of project durations.

- Level of Competition and Level of Construction Activities

In times of recess on construction activities, Contractors will normally want to impress their client so that they could continue to get jobs and by this they tend to complete projects on time. Other hand too, in times of many construction works Contractors will normally deliver projects promptly to get new jobs.

- Number of Bidders on Competitive Projects

The number of bidders for a project reflects the competitiveness of the bid. In desperation for the project Contractors will normally quote unreasonably low bid prices and shorter project durations to win the bid. At the construction stage, the Contractor gets discouraged realizing that he will loose on the job and this affects the project's delivery rate.

- Interest Rate/ Inflation Rate

The cost of public construction projects are normally predetermined and contract budget prepared. Mostly the cost and budget did not take cognizance of interest and inflation rates. However, changes in interest and inflation rates invariably increase the cost of construction, and this has e replication effect delivery time.

- Stability of Market Conditions

Construction projects are executed according to programme of work. Resources needed for the execution of the works which are mostly linked to the programme in a resource aggregation chart comes from the market. Market conditions can therefore influence the delivery of projects according the programme of work. This is an indication that market conditions need to be considered in the determination of construction project duration.

- Statutory undertakes (Water, Gas etc.)

Where the work of the contractor includes connection to main service, the procedure involved in getting approval for such connections can sometimes drag the project beyond the intended completion. It is therefore necessary to allow for the time required for statutory undertakes in the estimation of project duration.

3.2 SUMMARY

Elhag and Boussabaine's (2002) and Nkado (1995) were reviewed leading to the identification of Seventy-two (72) construction time-influencing factors put into six categories namely; Client Characteristics, Consultant and Design Characteristics, Contractors Characteristics (Firm's Ability and Site Management), Contract Procedure and Procurement Method, Project Characteristics and External Factors and Market Characteristics.

CHAPTER FOUR - RESEARCH METHOD AND DESIGN

4.0 INTRODUCTION

Chapter Three concluded with the identification of Seventy –two (72) construction time-influencing factors in six factor categories.

This chapter details the research strategy and research method adopted for the study. Also the method and procedures employed for data collection are discussed. This comprises the determination of sample size, Sampling, Data Collection, Design and Administration of questionnaires and interview conduction.

The chapter also outlines the data analyses methods. The details of the analyses have been presented in Chapter Five.

4.1 RESEARCH STRATEGY

Research strategy is the overall approach adopted for a research from data collection stage through data analyses stage to decision making. This is illustrated in Fig. 4.1. There two types of research strategies namely the Qualitative Research Strategy and Quantitative Research Strategy. The strategy adopted determines the research method to be employed because not all, methods are applicable under the two strategies as indicated in Fig 4.1.

The research strategy adopted in this study is as indicated in Fig. 4.1 with the path traced by the bolded texts.

4.1.1 QUALITATIVE RESEARCH STRATEGY

This involves the collection of qualitative or categorical data and the use of qualitative data analysis techniques such as logical deductions and others to arrive at decisions. Qualitative data are data whose values fall into one or another of a set of mutually exclusive and exhaustive classes or categories. The strategy lends itself to the application of only certain research methods as indicated in Fig 1.4 below.

4.1.2 QUANTITATIVE RESEARCH STRATEGY

This involves the collection of quantitative or numeric data and the use of quantitative data analysis techniques such as statistical tools and others to arrive at decisions based on numbers, percentages or proportions. Quantitative data assume numerical values representing the number of opinion on issues through survey or result of measurements or observations. The strategy lends itself to the application of only certain research methods as indicated in Fig 1.4 below.

The quantitative research strategy is what is adopted for this study as indicated by the bolded path in Fig. 4.1.

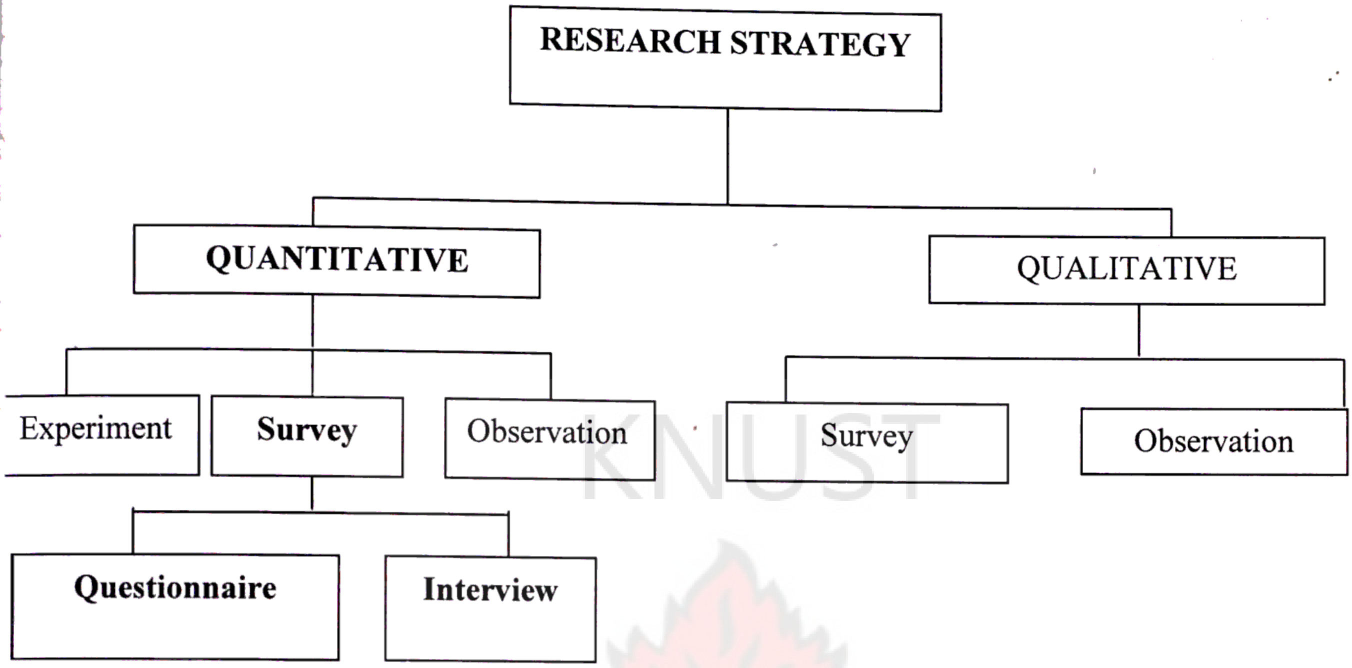

Fig. 4.1 Outline of Research Strategy

4.2 RESEARCH METHOD

Research method is the approach adopted for data collection for a study. In line with the quantitative research strategy there are three main research methods such as Survey, Experiment and Observation as indicated in Fig 4.1.

Experiment

Experiment involves subjection of a system to specific conditions and the results measured in numeric terms representing the data of interest. Experiments will normally require apparatus for the observation and measurement of outcomes. This mostly generates quantitative data. It is often considered as the most accurate form of data collection method.

Observation

Observation involves attentive watching of events and the result registered as the data of interest. Observation can be on natural occurring events or induced event in which case the event is subjected to specific conditions. This is used to generate both qualitative and quantitative data.

Survey

Survey is a process of seeking the opinion of people on an issue under investigation. It normally involves seeking of expert opinions on occurrences or issues concerning their field of discipline. It can be used to generate both qualitative and quantitative data especially where opinion can be quantified in terms of number of experts that share a particular view on an issue under investigation. Survey lends itself to many data collection methods such as the variants of Questionnaires and Interviews.

In this research, the survey method is employed to seek the opinion of professionals of the Ghanaian construction industry on project duration estimation methods employed in practice for public building project. The professionals' opinions were also sought on the time performance of the public building projects and relevant construction time influencing factors.

4.3 DETERMINATION OF SAMPLE SIZE

In determining the sample size of the research the target group was divided into Contractors group and Consultant groups. The Contractors group is constituted by contractors registered with the Ministry of Water Resources, Works and Housing (MWWH) within the works classification D1 because this is the category that is supposed to have qualified professional Architects, Engineers and Quantity Surveyors on their staff. The Consultant group is constituted by the Engineers (Structural and Services), Architects and Quantity Surveyors in private and public practice. Clients' representatives were considered in the Consultants group because they constitute the in-house technical team who also play the role of Consultants on projects within their technical capability and most of them are supposed to be members of the construction professional institutions.

The total number of Contractors registered with the MWWH within the limit set for this Study was considered as the population size for the group (Table 4.1). This is a small population size, so used for the data collection.

The total number of Architects, Civil Engineers and Quantity Surveyors as contained in the membership directory (2007/2008) of the corresponding professional Institutions is considered for the population size for the consultant group (Table 4.2). The sample size for the group was determined with the Kish Formula (Kish, 1965).

Details of the sample size calculation is as shown below:

According to Kish formula,

$n = n'/(1 + n'/N)$ ....(4.1)

where n = Sample Size

$n' = S^2/V^2$

N = Population size

V = Standard error of sampling distribution (5%)

$S^2 = P(1-P)$

P = Proportion of population elements that belong to the defined class (50%)

Using $N = 1025$, $V = 0.05$ and $P = 0.50$

$S^2 = P(1-P) = 0.50(1-0.50) = 0.25$,

$n' = S^2/V^2 = 0.25/0.05^2 = 100$ and

$n = n'/(1 + n'/N) = 100/(1 + 100/1025) = 91.11 \approx 92$No

Hence the computed sample size for Consultants is 92 respondents and by allowing for possibly unreturned and uncompleted questionnaires 33 is added to bring the estimated sample size to125 respondents for the consultants group.

4.4 SAMPLING

The stratified sampling method was employed for the selection of respondents to the questionnaire and simple random sampling for the interview. Taking the sample sizes determined above into consideration, the consultants constitute 75.8% and Contractors constitute the remaining 24.2% of the research sample.

Sampling was limited to Contractors and Consultants in the Ashanti and Greater Accra Regions of Ghana because these are the regions that have the largest numbers of Consultants and Contractors of the preferred category, representing 70% and 65% respectively.

For the questionnaire Sixty-five 65) percent of the respondents where were selected from the Greater Accra Region while the remaining thirty-five (35) percent was selected from the Ashanti Region because of the number available.

4.5 DATA COLLECTION

Two methods were employed for the collection of data for this research. These are the Questionnaires Administration (self-administered questionnaires) and Interview (semi structured interview).

4.5.1 QUESTIONNAIRE

4.5.1.1 Design of Questionnaires

The introduction section of the questionnaire defined the overall aim of the research work and project duration.

The questionnaire had sections for Organizational Information, Personal Information and Project Information (information on a specific project).

Basically, the questionnaire is in two (2) parts. Part 1, contained questions that seeks general information on building construction project duration estimation in Ghana and the Part 2 contained the list of construction time influencing factors that were identified by earlier researchers, categorized under six characteristics, that were required to be ranked with respect to a specific public building construction project completed in Ghana (Ref: Appendix B).

4.5.1.2 Administration of Questionnaires

The questionnaires were self administered so that portion that respondents may require clarification on can be addressed. This ensured that respondents had actual understanding of the questionnaire and responses received can be relied on as, a true reflection of the information needed for the research.

As earlier on mentioned the questionnaires were administered to Consultants (Architects, Quantity Surveyors and Engineers in public and private practice) and Contractors registered with the MWRWH within the works Classification D1 who were operating in the Greater Accra and Ashanti regions of Ghana.

The questionnaires were retrieved personally again to ensure that each completed copy is fully responded to without respondents missing any of the questions, since the response to every question provides essential information for the success of the research work.

Although a few challenges and constraints were encountered in the course of the questionnaire administration, these were managed to the success of the study.

4.5.2 INTERVIEW

Semi structured interview was conducted to obtain information that were not provided for on the questionnaire regarding the methods employed in the determination of construction project duration in Ghana. This was done to supplement the responses received on the questionnaires. The key questions asked were as contained on the Interview List (Appendix C).

The interview was also limited to respondents in Ashanti and Greater Accra regions of Ghana and only limited to forty (40) respondents from both group.

This number was selected because only Quantity Surveyors were interviewed since they are mostly involved in project planning and duration estimation. Also, this is due to time and financial limitations.

4.6 DATA ANALYSIS

Although the analysis aspect of this research is a subject of Chapter 5, it is worth outlining the methods employed in the analysis as part of the presentation on the research method and design. This is as presented below.

4.6.1 ANALYSIS OF PART 1 OF QUESTIONNAIRE AND INTERVIEW RESULTS

Data collected on the Part 1 of the questionnaire and interview was analyzed in terms of percentages of the responses received in respect of set of questions geared toward achieving some of the objectives of this research. This extends to the analysis of the Time Performance Indices (TPIs) of building construction projects in Ghana.

4.6.1.1 Time Performance Index (TPI)

In this study the Time Performance Index (TPI) was used as an indicator to assess the level of construction time performance of public building projects in a Ghana, where TPI is the ratio of actual contract duration to original contract duration. A significant number of earlier studies used the similar indicator but with different terms. For instance, Georgy *et al.* (2000) called it schedule performance index, Dissanayaka and Kumaraswamy (1999a, b) referred to it as time index, Kaka and Price (1991) named it as duration performance while McKim *et al.* (2000) addressed it as schedule performance factor.

The Time Performance Index (TPI) was determined using Equation 5.1 and this is in fulfillment of one of the objectives of this research work.

The hypothesis that projects delay beyond predetermined duration (original contract duration) will be tested using the normal test statistics computed from Equation 5. and buttressed by the *P-value* to either confirm or refute the claims on project delays.

4.6.2 ANALYSIS OF PART 2 OF QUESTIONNAIRE

The analysis of this Part 2 aimed at achieving the objective of reviewing the construction time-influencing factors to identify those relevant to the Ghanaian construction industry and to select the significant factors that are suitable as model attributes. In this respect the factors will first be ranked on the basis of their relative importance index (RII) from the perspective of each of the respondent groups and the overall ranking by combining the rankings of the two respondent groups on the basis of the weighted means of the relative importance index of the factors. The relative importance index (RII) will be computed from Equation 5.5.

Consistency in the ranking by the two respondent groups was ascertained by first computing the coefficient of variance(CV) of each of the factors, with a relatively low value of CV indicating relatively high consistency in the ranking by the respondent groups and vice versa. The CVs were computed using Equation 5.8.

The result of the CV was confirmed using the Spearman's Rank Correlation Coefficient (r_s). This was computed using Equation 5.9a. A positive value of r_s indicated consistency in the rankings of the two respondent groups and vice versa. The strength of the estimated value of r_s was further tested using the normal test statistics from Equation 5.9b and buttressed by the *P-value*, to ascertain the reliability of the decision on the consistency of the ranking.

The factors were then subjected to significance test using the normal test statistics from Equation 5.10 and buttressed with the *P-Value* for the selection of the relevant factors to the Ghanaian construction environment.

4.7 SUMMARY

The quantitative research strategy and survey research methods were adopted for this research. The target group for the research was partitioned into the Consultants and the

Contractors. The Consultants group is constituted by Engineers (Structural and Services), Architects and Quantity Surveyors in public and private practice. The Contractors group is constituted by contractors registered with the MWRWH within the works classification D1 operating in the Greater Accra and Ashanti regions of Ghana.

The Kish Formula is applied for the determination of the sample size of the Consultants Group for the questionnaire but in the case of the Contractors, the entire population was considered due to the small size. The computed sample size for the research is 92 but 125 was used for the data collection in the case of the consultants representing 75.8% and 40 for the Contractors representing 24.2% of distribution size. The stratified sampling and Simple Random Sampling methods were employed for the selection of respondents to the questionnaires for the Consultants and Contractors respectively. Simple Random Sampling methods was again employed for the selection of respondents for the interview in the case of the two groups. Self-administered questionnaire and Semi-structured Interview were employed for the data collection.

The various methods of analysis for the selection of the relevant construction time influencing factors and determination of the model for improving project duration estimation were also outlined.

CHAPTER 5 - SURVEY RESULTS, ANALYSES AND DISCUSSION

5.0 INTRODUCTION

Chapter Four concluded that the qualitative research strategy and survey research method were adopted for this study for the collection and analyses of data.

This Chapter contains the survey results and analyses. The analyses are in two stages. The first stage involves the analysis of the responses received in respect of the Part 1 of the questionnaire and interview results, to determine the Time Performance Index (TPI) of public building construction projects and evaluate the current process of estimating project duration in Ghana.

The second stage involves the analysis of the responses received in respect of the Part 2 of the questionnaire. This comprises the determination of the Relative Important Index (RII) of the identified factors for the purpose of ranking, Coefficient of Variance and Spearman's Rank Correlation Coefficient for the purpose of consistency test between the rankings of respondent groups and Significance Test for the selection of the relevant construction time-influencing factors.

5.1 SURVEY RESULTS

5.1.1 RESPONSE TO QUESTIONNAIRE

A recall from Section 4.5 indicates that self-administered questionnaire and semi-structured interview were the two data collection methods employed in this research.

A total of 125 questionnaires were sent to Consultants and Contractors within the target group for this research. In all, 99 valid responses were received out of the administered 125 questionnaires for the Consultants resulting in 79.2% response rate and 28 out of the administered 40 for the Contractors resulting in 70.0% response rate (Table 5.1).

From this table, it was shown that the consultants had the highest response rate of 79.2% as against 70.0% for the Contractors. Although the difference in the response rates was small the high rate for the Consultants is an indication that they are more often stable and committed to responding to the questionnaire.

5.1.2 RESPONSE TO INTERVIEW

In all, Forty (40) respondents were interviewed and they all responded fully to all the questions. This comprised of Twenty (20) Contractors and Twenty (20) Consultants within the target group for the research. Appendix C is the sample Interview List.

5.2 ANALYSIS OF SURVEY RESULTS

The analyses of the survey results as received from the questionnaires and the interview were done in two stages. At the first stage, the responses to the Part 1 of the questionnaire (general information on project duration estimation) and interview results were analyzed. The second stage involves the responses to the Part 2 of the questionnaire (rating of construction time-influencing factors) were analyzed.

5.2.1 ANALYSIS OF THE RESULT OF PART "A" OF QUESTIONNAIRE AND INTERVIEW

5.2.1.1 Project Planning Techniques and Duration Estimation Methods in Current Use

The first three questions sought for the current project duration estimation methods applicable to public building construction projects in Ghana. In this regard, four methods were provided and the responses were as analysed in Table 5.2. For simplicity the methods: Bar Chart, Arrow Diagram, Programme Evaluation and Review Techniques (PERT) and Precedence Diagram were denoted by A,B,C and D respectively.

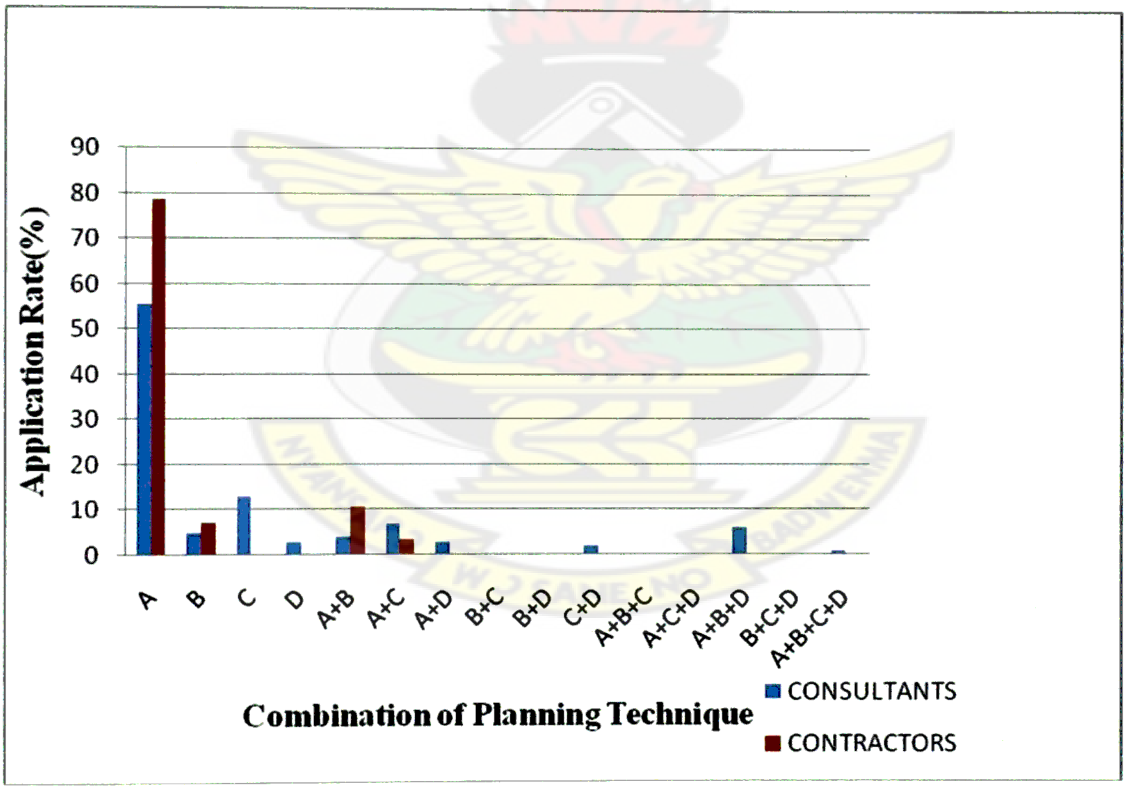

Figure 5.1 Application of Combined Planning Techniques Among Contractors and Consultants

From Table 5.2a, it can be deduced that majority of both Consultants and Contractors employ only Bar Chart in project planning as indicated by the highest application rates 55.56% and 78.57 respectively. PERT registered 13.13% application rate among the Consultants ranking second to Bar Chart and Precedence Diagram registered 3.03% as the least applied, whiles Arrow Diagram registered 7.14% , a comparatively very low application rate among the Contractors, ranked second to Bar Chart and the least applied is the Precedence Diagram.

However, some of the respondents employ more than one of the Project Planning Techniques in the determination of project durations. The use of Bar Chart and PERT registered 7.07% application rate among the Consultants, with the use of all four techniques being the least. On the Contractor's side, use of Bar Chart and Arrow Diagram registered 10.71% application rate, with the use of Bar Chart and PERT registered 3.57% application rate as the least.

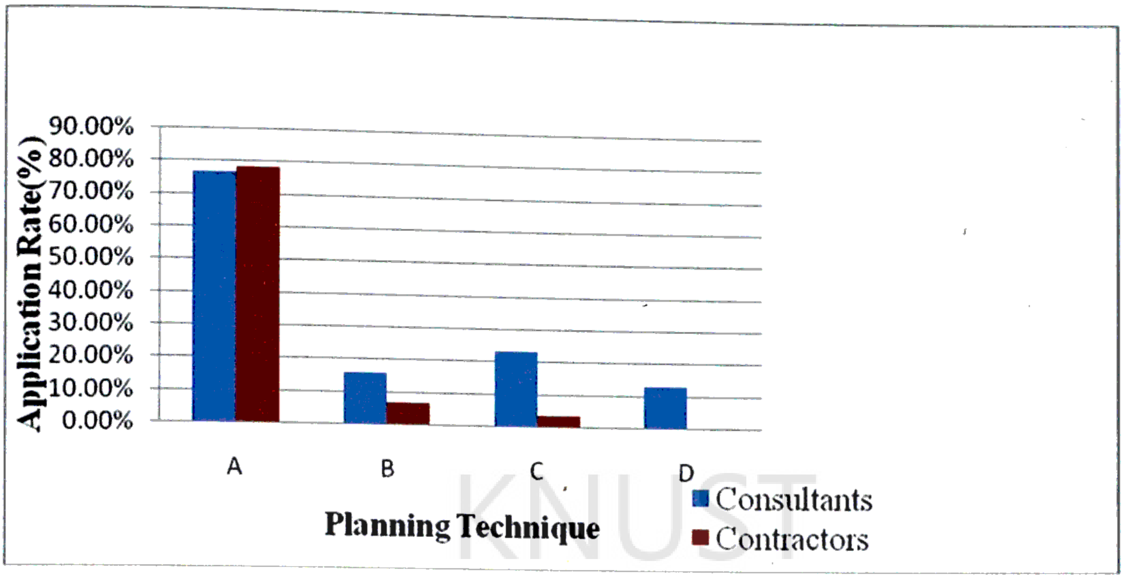

Fig. 5.2 Application Rate of Individual Planning Techniques among Contractors & Consultants

On the whole, the results of the survey reveals that Bar Chart is the commonly used techniques among the Consultants with the application rate of 76.77%, followed by PERT with application rate of 23.23%, then Arrow Diagram with application rate of 16.16% and Precedence Diagram with application rate of 13.13% as the least. Among the Contractors too, Bar Chart is the commonly used with the application rate of 92.86% followed by Arrow Diagram with application rate of 17.86%, then PERT with the application rate of 3.57% with Precedence Diagram not being used (Table 5.2b).

5.2.1.2 Time Performance Index (TPI)

In this study the Time Performance Index (TPI) was used as an indicator to assess the level of construction time performance of public building projects in a Ghana, where TPI is the ratio of actual contract duration to original contract duration. A significant number of earlier studies used the similar indicator but with different terms. For instance, Georgy *et al.* (2000) called it schedule performance index, Dissanayaka and Kumaraswamy (1999a, b) referred to it as time index, Kaka and Price (1991) named it as duration performance while McKim *et al.* (2000) addressed it as schedule performance factor.

Questions four and five sought for the performance of the predetermined/original project duration in Ghana. In this respect, for ranges of the ratio of the actual duration to the predetermined were provided. The responses were as analysed in Table 5.3a and depicted in Fig. 5.3 below:

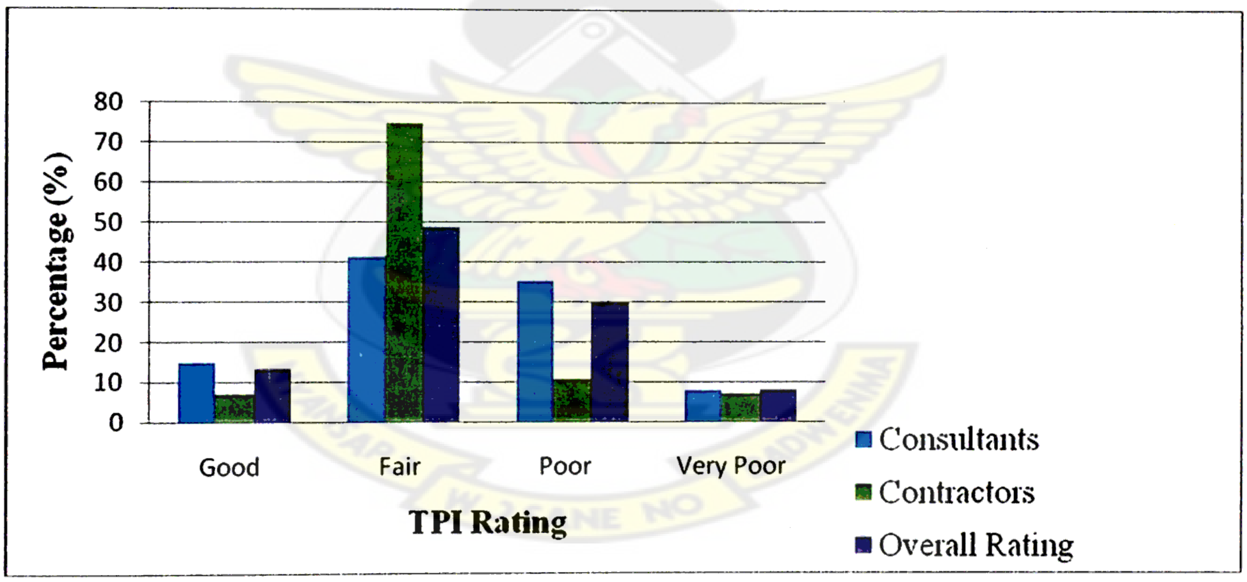

Fig. 5.3 Rating of TPI in Ghana

From Table 5.3a, it is shown that 48.82% of construction projects executed in Ghana suffered time-overrun, and took at most one and half times the original duration to complete representing the dominant range of project time performance index in the country. On the other extreme, 7.87% of construction projects executed in Ghana suffered time-overrun and took at least twice the original duration to complete representing the worst range of project time performance index in the country.

Also it was determined that 86.62% of construction projects executed in Ghana suffered time-overrun of various degrees and only 13.38% get completed on or before schedule.

In comparison with the above result, the Time Performance Indices (TPIs) were calculated for all projects specified in the responses received, and the mean used as an indicator to ascertain the construction time performance level of public building construction projects in Ghana. TPI is defined as the ratio of actual contract duration to original contract duration. These were calculated using the Equation 5.1 and the results presented in the Table 5.3b.

$$TPI = \frac{ACD}{OCD} \quad \text{.......... Eqn 5.1}$$

where:

ACD = Actual Contract Duration

OCD = Original Contract duration

TPI > 1, project exceeded original contract duration;

TPI < 1, project completed before original duration;

TPI=1, completion exactly on time.

From table 5.3b, applying the definition of the ranges of TPI, 108 projects were completed beyond the original contract duration representing 95.58%, only one(1) project was completed on schedule representing 0.8% and four(4) projects were completed before the elapse of the original contract duration representing 3.54%. These figures compares favourably well with what as obtained earlier from Table 5.3a.

However, the sample mean TPI of projects was estimated at 2.3089 as obtained from Equation 5.2 below:

$\bar{X}_t = \sum TPI/n_t$ ....Eqn. 5.2

$= 260.9044/113$

$= 2.308888$

Where n_t = number of projects in the sample considered for the analysis

The sample standard deviation of projects TPI was estimated at 1.3179 as obtained from Equation 5.3 below.

$S_t^{\ 2} = (1/n_t-1) \sum(X_i - \bar{x}_t)^2$ ....Eqn. 5.3

Where S_t^2 = variance of project TPI

S_t = sample standard deviation of TPI

X_i = TPI of the ith project among those considered

$\bar{x}_t$ = sample mean TPI of the projects considered

$S_t^{\ 2} = 194.5143/112 = 1.736735$

Hence the sample standard deviation is $S_t = 1.317852$

This is a measure of the deviation of the time performance indices from the mean time performance index of construction projects in Ghana obtained above.

With these values, the 95% confident interval of the mean TPI was estimated as below:

$CI_{95\%} = 2.3089 \pm 1.96\ (1.3179/\sqrt{113}) = [1.9035, 2.7143]$

According to inferential statistics, this means there is 95% certainty that the mean TPI of projects in Ghana falls within the range 1.9035 to 2.7143.

Coefficient of Variation of Time Performance Indices

This measure was used to ascertain the degree of variation in the time performance of projects in Ghana.

This was computed from Equation 5.4 below:

$$CV_t = (S_t/\bar{X}_t) \times 100\% \quad \text{......Eqn. 5.4}$$

$$= 1.317852/2.308888$$

Hence the $CV_t = 0.570773$

This value of CV_t is slightly on the higher side and suggests that the time performances of construction projects in Ghana vary significantly.

Testing for Timely Completion of Projects

The following Null hypothesis (H_O) and Alternative hypothesis (H_1) were tested at 5% significance level to ascertain timely completion of projects in Ghana.

H_O; $\mu \leq 1$; projects are completed within original contract duration (OCD)

H_1; $\mu > 1$; projects are not being completed within original contract duration(OCD)

$Z = (X - \mu)/ (S/\sqrt{n}) = (2.3089 - 1)/(1.3179/\sqrt{113}) = 10.5576$

Testing the above hypotheses at 5% significant level (α), the critical value (Z_α) is 1.65. Since $Z_{calculated} = 10.5576 > Z_\alpha = 1.65$, we reject the Null hypothesis that projects in Ghana are completed within predetermined project durations. This means that generally construction projects in Ghana suffer time-overrun.

To give further insight into the strength of the above decision, the *P-value* of the test is determined and compared with the significant level (α).

P-value = $P(Z \geq 10.56) = 1 - P(Z < 10.56) \doteq 1 - 0.9998 = 0.0002$,

According to inferential statistics, since the *P-value,* which is the actual probability of rejecting the null hypothesis = $0.0002 < \alpha = 0.05$, the above decision is confirmed.

5.2.1.3 Analysis of Interview Results

The results obtained from the interview were as analysed to determine the short falls in the determination of public building construction projects durations in practice, in Ghana. The analysis is as presented below in Table 5.4a and depicted in Fig. 5.4.

From table 5.4a, 55% of the respondents were of the view that project duration estimation should be solely the responsibility of Contractors for the reasons that he will execute the job according to his chosen method and in the best position to assess resource availability and efficiency. However, 22.5% were for of the view that it should be solely the responsibility of Consultants because most of the contractors do not have the technical capability to make realistic estimates. More so, 22.5% were of the view that it should be the responsibility of both Consultants and Contractors where the Consultants estimate will provide bases for assessing the Contractors'.

Sixty-five(65) percent have the view that durations specified in the contract should be given by Contractors, whiles 35% were for Clients giving the duration in Consultation with the Consultants. Moreover, it is evident from Table 5.4a that in practice it is the Clients that give project duration in consultation with the Consultants.

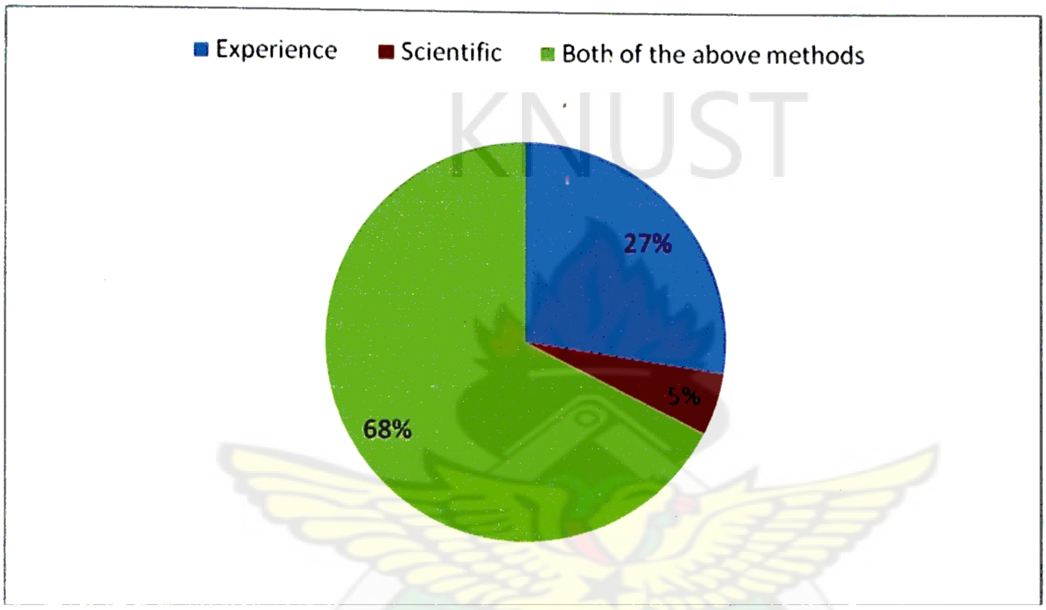

Fig. 5.4 Methods for Project Duration Determination in Ghana

From Fig. 5.4, 67.5% of employ both past experience and scientific methods to determine project durations, 27.5% used only past experience and 5% only scientific method. It is an indication that most of the professional in the construction industry rely vastly on their past experience to determine project durations.

It was also evident from the survey that most of the Consultant and Contractors organization did not have Planning Unit, so they depend on the Quantity Surveyors for the planning activities which may not be comparatively effective.

From Table 5.4c, the respondents do not conduct site visits on all projects in determining project durations. According to them, the performance of this activity depends on the ease of access to the site, location, size and sensitivity of the project but in most cases they make assumptions based on their experience.

The survey also reveals that vast majority of Contractors prepare Method Statement for all projects in to arrive at the durations whiles, the Consultants do not but depends solely on past experience (Table 5.4c). In preparing the Method Statement, almost all the Contractors take into consideration the method of executing individual activities, Gang Composition and Plant Combination, Sequence of Activities and Labour Output Rates (Table 5.4d).

On the determination of output rates, as revealed in Table 5.4e, 65% of the Contractors rely on past experience but 35% conduct work study to establish labour output rates. This indicates that most Contractors rely on past experience to establish output rates in their organization. However, majority of them rely on the combination of past experience and Work Study for the review of the output rates at irregular intervals.

5.2.2 ANALYSIS OF THE RESULT OF PART 2 OF QUESTIONNAIRE

The Part 2 of the questionnaire was intended to gather information that will lead to the review of the identified construction time-influencing factors to reflect the Ghanaian situation and to produce model attributes for project duration estimation.

In this respect, the Part 2 of the questionnaire provided a list of identified construction time-influencing factors (Nkado1995 and Elhag and Boussabaine 2002) put in six categories for respondents to rank on a five-point scale as; Not significant, Slightly significant, Moderate Significant, Very Significant and Extremely Significant. The responses received were analysed by first ranking the time-influencing factors from the perspective of each of the two groups of respondents based on the relative importance index.

5.2.2.1 Ranking of Identified Time-influencing Factors

The construction time-influencing factors identified in Chapter Three will now be ranked according to their Relative Importance Index (RII). The process involved in achieving this is as detailed below.

5.2.2.1.1 Calculation of Relative Importance Index (RII) of the Factors

Kometa et al. (1994) used the relative importance index method to determine the relative importance of the various causes and effects of delays. The same method was adopted in this study for the two respondent groups. The five-point scale ranged from 1 (not significant) to 5 (extremely significant) was adopted and transformed to Relative Importance Indices (RII) for each factor as using Equation 5.5 below:

$RII = \sum W/(A \times N)$; for $0 \leq RII \leq 1.0$ ....Eqn. 5.5

Where W = weighting given to each factor by the respondents (ranging from 1 to 5),

$\sum W$ = summation of the weighting assigned to the factors

A = highest rank (5)

N = total number of respondents for the particular factor

The RII value had a range from 0 to 1 (0 not inclusive), the higher the value of RII, the more important the factor.

The RII was used to rank (*R*) the identified construction time influencing factors from the perspective of each of the groups. These rankings made it possible to cross-compare the relative importance of the factors as perceived by the two groups of respondents (i.e. consultants and contractors). The weighted average of each individual factor's RIIs was computed and used to assess the general and overall rankings in order to give an overall picture of the time influencing factors in the Ghanaian construction industry.

From the Consultants' perspective, the computed relative importance indices of the factors were computed from Equation 5.5 and presented in Table 5.5 with the consequence ranking. The ranking was done in the descending order of magnitude of the computed RII values, with the factor having the highest RII value ranked first reflecting most importance and vice versa.

The relative importance indices of the factors from the Contractors' perspective were similarly computed and were as presented in the Table 5.6 with the consequence ranking.

The factors were finally ranked to reflect the combined or general order of importance. As earlier mentioned, this was done on the basis of the weighted mean of the RIIs corresponding to each of the factors. The weighted means were computed from the Equation 5.6 below and the results presented in Table 5.7.

$$RII_{WMi} = RII_{Ai} (N_A/N_{A+B}) + RII_{Bi}(N_B/N_{A+B}) \quad \text{.......... Eqn. 5.6}$$

Where RII_{WMi} = the weighted mean of the RIIs of the ith factor

RII_{Ai} = Relative importance index of the ith factor from consultants perspective

RII_{Bi} = Relative importance index of the ith factor from contractors perspective

N_A = No. of consultants' responses considered for the analysis

N_B = No. of contractors' responses considered for the analysis

N_{A+B} = sum of the number consultants and contractors considered for the analysis.

However, provision was made for respondents to give additional factors and a prominent factor given is the political influence in the country.

The categories were also ranked on the basis of the mean of the RII of all the factors under each of the six factor categories for the two respondent groups. The factor category with the highest mean is ranked first for each respondent group indicating its relative importance compared to the others and vice versa. The overall category ranking was done on the basis of the weighted mean of RII per category of the two respondent groups. The ranking is as computed and contained in Table 5.8.

From Table 5.8 Client Characteristics ranked first which is an indication that in general, project time overruns were mostly caused by an action or inaction of Clients and Contract Methods and Procurement Procedures having the least influence it is the least ranked.

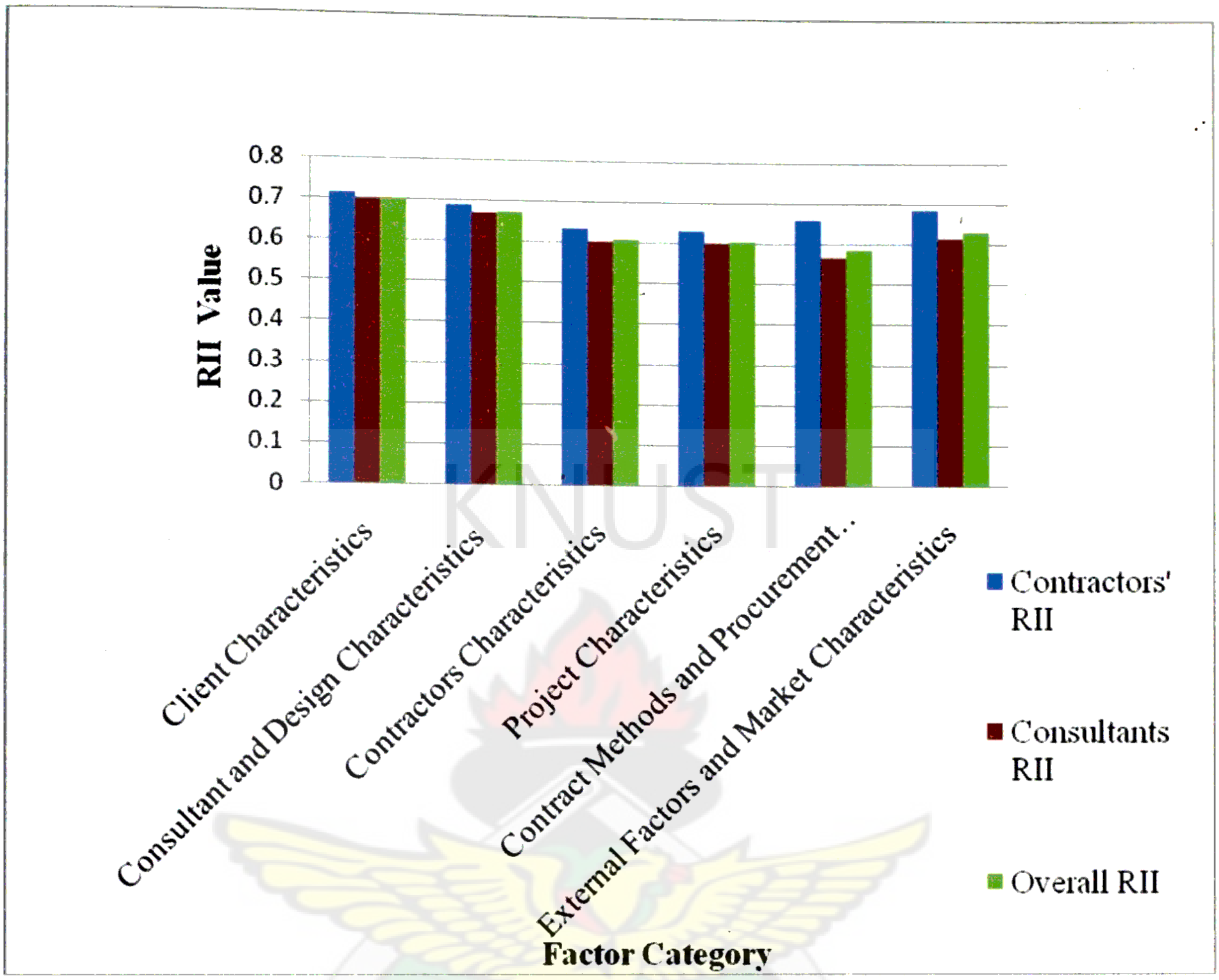

Fig. 5.5 Comparison of Group and Overall RIIs of Factor Categories

5.2.2.1.2 Consistency Test

Consistency Test was performed to ascertain the extent of agreement between the responses of the two respondent groups with respect to the construction time influencing factor.

Coefficient of Variation (CV)

According to Ronald et al. (2007), Coefficient of Variation (CV) is one effective tool for measuring the degree of variability in any two set of data. The Coefficient of Variation

(CV) was employed in the performance of the first instance of the consistency testing. The lower the CV the more consistent is the ranking and vice versa.

The formula for the computation of the CV is as indicated by Equation 5.7 below:

$$CV = (S/\bar{X}) \times 100\% \quad \text{......Eqn. 5.7}$$

Where CV = Coefficient of Variation of the data

S = Standard Deviation of the data

and $\bar{X}$ = Mean of the Data

In support of this, Elhag and Boussabaine (2002), indicates that the CV for each set of response is an expression of the standard deviations of the response as a percentage of the mean. According to them, analogous of the formula for the computation of the CV is as indicated by Equation 5.8 below and presented in Table 5.9.

$$CV_R = (S_R/\bar{X}_R) \times 100\% \quad \text{......Eqn. 5.8}$$

Where CV_R = coefficient of variation of ranking/response for each factor

S_R = standard deviation of the response/ranking for each factor

$\bar{X}_R$ = weighted mean ranking/response of the two groups for each factor

Other abbreviations in the Table 5.9 were as defined below:

MR_A = Consultant's mean ranking for each factor

MR_B = Contractor's mean ranking for each factor

VAR = variance of the ranking for each factor

From Table 5.9, the estimated CV values for most of the factors were less than 0.5. These are relatively low values, hence indicates that generally, there is consistency in the rankings of two respondent groups.

Spearman's Rank Correlation Coefficient (r_s)

According to Ronald et al. (2007), Spearman's Rank Correlation Coefficient (r_s) is a nonparametric measure of the association between two variables. The Spearman's Rank Correlation Coefficient (r_s) is determined to confirm the above result that there is no significant difference in the rankings of the two groups . This is calculated from the Equation 5.9a and the results presented in the Table 5.10.

$r_s = 1 - \{(6\sum d_i^2)/n(n^2 - 1)\}$; for $-1 \leq r_s \leq +1$.......................................Eqn 5.9a

where r_s = Spearman's Rank Correlation Coefficient

n = number of paired ranks

d_i = difference between the ranks

According to Ronald et al. (2007), r_s value of +1 or -1 indicates perfect association between the responses of the two respondent groups with the plus showing identical/consistent rankings (strong concordance) and the minus sign showing the reverse/inconsistent rankings (no concordance). Where r_s is close to zero, it indicates weak association between the rankings of the two groups.

In the above table, R_1 denotes consultant's ranking and R_2 denotes contractor's ranking of the time influencing factors.

Substituting into Equation 5.9:

$r_s = 1 - \{(6\sum d_i^2)/n(n^2 - 1)\}$

$r_s = 1 - 86328/72(72^2 - 1)$

$r_s = 0.7687$

In accordance with Nonparametric Statistics, the Spearman's Rank Correlation Coefficient (r_s) value of + 0.7687, suggests that there is a high consistency in the ranking of the factors by the two respondent groups.

Test for the Strength/Significance of the Decision.

$H_O : \rho \leq 0$; Null hypothesis that there is no consistency in the ranking of the factors by the two groups

$H_1 : \rho > 0$; alternative hypothesis that there is consistency in the ranking of the factors by the two groups.

According to Ronald et al. (2007), under the assumption of no correlation/association between the two sets of rankings, mean = 0 and SD = $1/\sqrt{(n-1)}$, as n> 30. The test statistics $Z = (r_s - 0)/[1/\sqrt{(n-1)}] = r_s\sqrt{(n-1)}$ is used and the critical value(Z_α) at 5% significant level was read from the Normal Distribution Table. The value of the test statistics is as computed below:

$Z = r_s\sqrt{(n-1)} = 0.7687\sqrt{(72 - 1)} = 6.4769$......................................Eqn. 5.9b

Approximately, this implies $Z_{Calculated} = 6.48$.

Testing at 5% level of significance, the critical value (Z_α) = 1.65. Since $Z_{Calculated} = 6.48 > Z_\alpha = 1.65$, we reject the Null Hypothesis that, there is no consistency in the ranking of the factors by the two groups, in favour of the Alternative Hypothesis that there is consistency in the ranking of the factors by the two groups.

As an additional insight into the strength of the above decision, the *P-Value* of the test is also computed and analysed as below;

P-Value = $P(Z \geq 6.48) = 1 - P(Z < 6.48) = 1 - .9998 = 0.0002$

According to inferential statistics, since *P –Value* = $0.0002 < \alpha = .05$, which is the actual probability of rejecting the Null hypothesis, the above decision is confirmed.

In conclusion, there is consistency in the ranking of the factors by the Consultants and Contractors.

However, the first six factors from the Consultants' perspective in the order of decreasing importance were Clients' Financial Ability, Contractors' Financial Capability, Project Finance Method in tie with Contractors' Management Team (Suitability, Experience & Performance), Completeness & Timeliness of Project Information and Contractors' Experience on Similar Projects . From the Contractors' perspective, Project Finance Method, Material (Price /Availability/Supply/Quality/ Imports), Clients' Financial Capability, Completeness and Timeliness of Project Information in tie with Variation Orders (Additional Works) and Contractors' Financial Capability.

In comparison, the two groups shared the Opinion that Clients' Financial Capability, Project Finance Method, and Completeness and Timeliness of Project Information were among the first six factors that influence the duration of public building construction project.

5.2.3 DETERMINATION OF SIGNIFICANT TIME INFLUENCING FACTORS

The above construction time influencing factors were each tested for significance at 5% significance level. Since the sample size(n) = 127 > 30, the test is conducted using the normal test statistics (Z). The test involved making decision on the following Null and Alternative hypotheses:

H_0; $\mu \geq 3.0$; the factor is significant to project duration estimation

H_1; $\mu < 3.0$; the factor is not significant to project duration estimation

The test statistics Z is computed using Equation 5.10 below.

$$z = (\bar{X}_i - \mu)/s/\sqrt{n} \quad \text{...Eqn. 5.10}$$

Where $\bar{X}_i$ = ranking sample mean of the individual factors;

μ = ranking population mean(3) of the factors

n = sample size(127);

and S = ranking sample standard deviation of the factor the sample mean and standard deviations of each of the factors were imported from Table 5.9, in which case $S = S_R$ and $\bar{X} = \bar{X}_R$. The computations and results of the test were as contained in Table 5.11 below.

To ascertain the strength of the above decision, *p-value* of the test on each factor is computed and interpreted as below.

According to inferential statistics, a *p-value* less the 1-α (0.05) will lead to the rejection of the Null Hypothesis (H_0) in favour of the Alternative Hypothesis (H_1) and vice versa. The computed p-values and the corresponding conclusions are as contained in Table 5.12.

A comparison of the results in Tables 5.10 and 5.11, revealed the consistency in the decision on the significant factors. In conclusion, the consistency in the results of the two tables, confirmed the decision on the significant factors, indicated with "Yes" in the last column of both tables.

5.2.3.1 Significant Construction Time Influencing Factors

In all, 35 significant construction time influencing factors were established out of the 72 identified from the confirmatory test and these were as listed in the Table 5.12 with their corresponding *P-Value*.

5.2.3.2 Identified Significant Construction Time Influencing Factors in Order of Decreasing Importance

The 35 identified significant construction time-influencing factors were further arranged in decreasing order of importance for easy reference (Table 5.13b and Fig. 5.6). From this table, the first six factors are Project Finance Method/ Appropriate Funding in Place, Material (Prices/Availability/Supply/ Quality/Imports), Financial Ability/ Payment Records of Clients, Completeness and Timeliness of Project Information, Variation Orders/ Additional Works (Magnitude, Timing, Interference Level) and Contractors' Financial Capability.

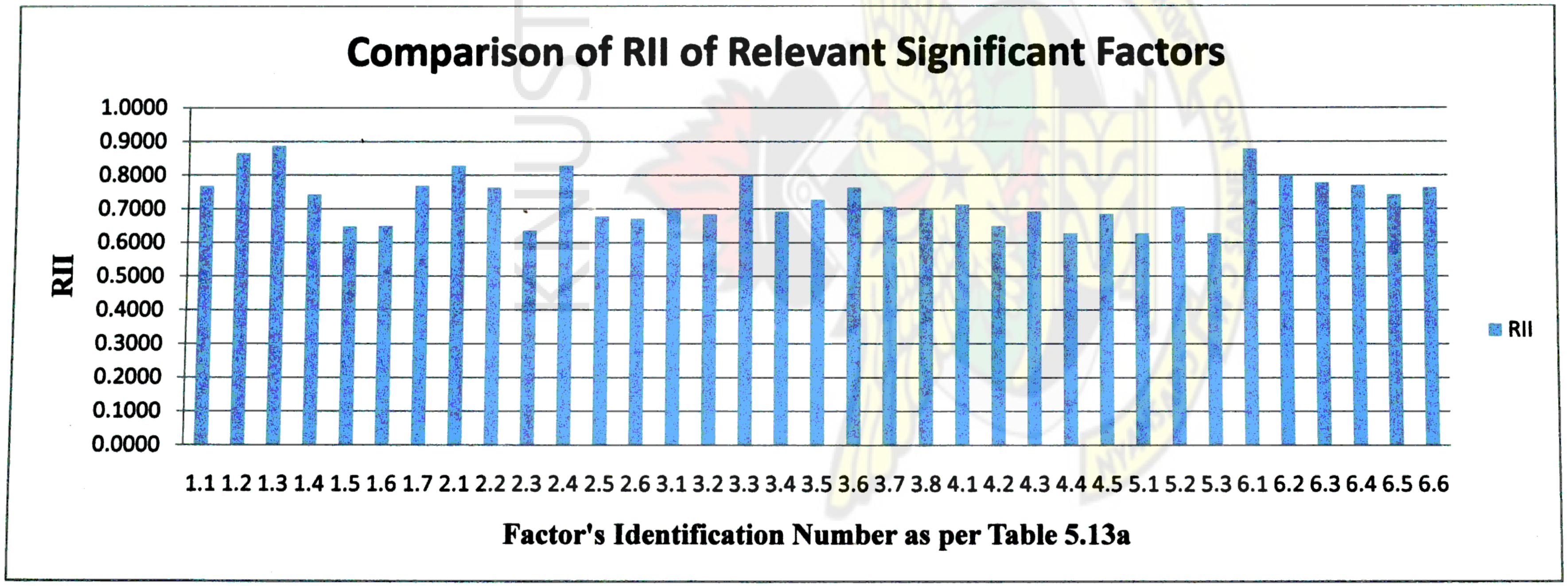

Fig. 5.6 Overall Ranking of Relevant Significant Factors

5.3 SUMMARY OF FINDINGS

The analyses of the survey results revealed the followings findings:

- Bar Chart was determined as the commonly used project planning techniques among both Consultants and Contractors in Ghana, with the application rates 69.70% and 92.86% respectively. This is followed by PERT in the case of the Consultants and Arrow Diagrams in the case of Contractors. However, Precedence Diagram is the least employed planning techniques among the two groups.

- It was however established that projects durations were mostly specified by Clients instead of Contractors who actually perform the job.

- Determination of project duration was mostly by experience and just a few of the professionals combine this with scientific methods. Most of the organizations do not have Planning Unit or Planners(s) and the duration estimation is also done by the Estimator which may not be comparatively effective. Mostly, site investigations were not carried-out on all projects and duration estimator relies solely on his experience. However, most of the contractors unlike the consultants prepare methods statement for the determination of project durations but the output rates used were mostly established and reviewed bases on experience. All these constitute the shortfalls to project duration estimation in Ghana, resulting in unrealistic estimates and the consequence time overruns on most public building construction projects in the country.

- It was also determined that there is 95% certainty that the mean Time Performance Index (TPI) of projects in Ghana falls within the range 1.9035 to 2.7143. The CV value of 0.57 for TPI suggests that the time performances of construction projects in Ghana vary significantly. A test of hypothesis at 5% significance level to ascertain project delivery indicated that generally construction projects in Ghana suffer time-overrun.

- There is agreement in the ranking of the construction time influencing factors by the Consultants and Contractors as reflected by the CV values of most of the factors and confirmed by the relatively high Spearman's Rank Correlation Coefficient (r_s) of +0.7687 and buttressed by significant test on the r_s value.

- Thirty-five (35) significant construction time influencing factors were established out of the 72 identified (Table 5.13b) through a test of the factors' significance to project duration estimation (Tables 5.11 and 5.12). The first six in these factors in the order of decreasing importance are Project Finance Method/ Appropriate Funding in Place, Material (Prices/Availability/Supply/ Quality/Imports), Financial Ability/ Payment Records of Clients, Completeness and Timeliness of Project Information, Variation Orders/ Additional Works (Magnitude, Timing, Interference Level) and Contractors' Financial Capability.
- On Factor Category basis, Client Characteristics was determined as the most cause of project time overrun, followed by Consultants and Design

Characteristics with Contract Method and Procurement Procedures being the least (Table 5.8).

CHAPTER SIX CONCLUSION AND RECOMMENDATIONS

6.0 INTRODUCTION

The preceding Chapter concluded with the findings of this research work as contained in Section 5.3.

This Chapter contains conclusion made on the findings and the recommendations for improving the time performance of public building construction projects in Ghana.

6.1 CONCLUSION

In this study, the time performance of public building projects was investigated and from the results, the following deductions were made.

- It was determined that there is 95% certainty that the mean Time Performance Index(TPI) of projects in Ghana falls within the range 1.9035 to 2.7143. This suggests that on the average, public building projects takes between 1.9035 to 2.7143 times the original project duration to complete, an indication of poor project time performance.

- Lack of proper planning of projects was determined to be a major shortfall in the determination of project duration. Mostly project durations were determined base on past experience with no consideration for site conditions and method statements. This mainly because almost all the organizations especially, the contractors do not have planning units or planners and the planning role is also performed by the Quantity Surveyors which may not be effective. This has the effect of unrealistic project durations, ineffective time control and the consequence poor project time performance.

- The most applied planning technique is the Bar Chart at the expense of Precedence Diagram, which for its four activity times, offers a more effective planning tool, hence will normally yield more realistic project durations. This will normally translate into ineffective time control particularly, on large projects with several work activities, resulting into poor time performance of projects.

- On most public building projects, the durations were mostly given by the client who will normally not have any scientific basis for it. This is more evident with the contract documentation prescribed by the Public Procurement Act 2003, Act 663 where it is required for the client to state the project duration in the contract data. Even when the astute contractors quote durations considering the resource requirement and method of construction the client still insists on his own duration for the project. This results in unreliable project durations, hence results in poor time performance of public building projects in the country.

- Thirty-five (35) significant construction time influencing factors were established out of the 72 identified with the first six in the order of decreasing importance being Project Finance Method/ Appropriate Funding in Place, Material (Prices/Availability/Supply/ Quality/Imports), Financial Ability/

Payment Records of Clients, Completeness and Timeliness of Project Information, Variation Orders/ Additional Works (Magnitude, Timing, Interference Level) and Contractors' Financial Capability (Table 5.13b). It is evident from the research that these factors were not being considered in fixing project durations in the country. This also contributes to unreliable project durations and the consequence poor time performance of public building construction projects in Ghana.

- On factor category basis, Client Characteristics were identified as the most cause of project time overruns, followed by Consultants and Design Characteristics, with Contract Method and Procurement Procedures being the least.

6.2 RECOMMENDATIONS

The studies by Okpala and Aniekwu (1988) in Nigeria and Nkado (1995) in the UK concluded that construction delays can be minimized, hence improving project time performance. The following recommendations were therefore made for improving the time performance of public building projects in Ghana.

- Contractors should establish planning section within their organization and employ qualified planners to take responsibility of planning activities in respect of construction project. In so doing the contractors could establish a reliable planning data such as labour output rates, plant output rates material usage and methods of construction which places the company in the position to carry-out effective planning and time control that could help minimize the poor time performance of projects in the country.

- In line with proper planning, Contractor's should conduct site visit on every proposed project as part of their pre-tender activities in order to acquaint themselves with site conditions and prepare a working method statement that will translate into effective planning and time control, hence minimize the poor project time performance currently experienced in the country.

- Contractors should employ Precedence Diagram for the planning of construction works especially, on large projects with several activities since the techniques present a more effective tool for estimating project durations, identification of critical activities and time control. Also, planning, analyzing and scheduling are separated with the use of network analysis which allows for concentration on the planning aspect, hence its efficiency.

- Durations given by Contractors as may be reflected by their work programmes should be accepted as the project duration since it will normally be determined based on the assessment of resource requirement of the project and the construction method that the contractors intends to employ for the execution of the works. Client's durations, even if determined by Consultants should only be used as a basis for assessing the reasonability of that of the Contractors.

- Planners should take into consideration the effects of the above identified significant construction time influencing factors in determining project durations. This will help to improve project duration estimation and making it more reliable.

- Consultants should always make Clients aware of the implications of any decision they take in respect of construction projects and advise them appropriately to avoid delays.

The implementation of the above recommendations will help improve the time performance of public building construction projects in Ghana.

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APPENDIX A - TABLES

Table 4.1 - Population of D1 Contractors

REGION	GREATER ACCRA	ASHANTI	TOTAL
NUMBER OF D1 CONTRRACTOR	27	13	40

**Source : Register of Regional Association of Contractors -Greater Accra and Ashanti- 2005/2006

Table 4.2 - Population of Consultants

PROFESSION	PROFESSIONAL MEMBERS/ POPULATION
ENGINEERS	463
ARCHITECTS	346
QUANTITY SURVEYORS	216
TOTAL	**1025**

**Source : Ghana Institution of Architects, Ghana Institution of Engineers and Ghana Institution of Surveyors Membership Directory 2007/2008.

Table 4.3 - Sample size

RESPONDENT GROUP	POPULATION SIZE	COMPUTED SAMPLE SIZE(No.)	CHOOSEN SAMPLE SIZE (No.)	PERCENTAGE BUFFER (%)
CONSULTANTS	1025	92	125	36
CONTRACTORS	40	-	40	-
TOTAL	**1065**	-	**165**	-

Table 5.1 Response to Questionnaires

Item	Respondent Group	Administered Questionnaires	Number Retrieved	Number Fully completed	Number Rejected	Response Rate (%)
1	Consultants	125	104	99	5	79.2
2	Contractors	40	30	28	2	70.0
TOTAL		165	134	127	7	76.96

Table 5.2a Applicable Project Duration Estimation / Project Planning Methods

METHOD	CONSULTANTS		CONTRACTORS	
	Number	Percentage (%)	Number	Percentage (%)
A	55	55.56	22	78.57
B	5	5.05	2	7.14
C	13	13.13	-	-
D	3	3.03	-	-
A+B	4	4.04	3	10.71
A+C	7	7.07	1	3.57
A+D	3	3.03	-	-
B+C	-	-	-	-
B+D	-	-	-	-

Table 5.2a Continued

METHOD	CONSULTANTS		CONTRACTORS	
	Number	Percentage (%)	METHOD	Number
C+D	2	2.02	-	-
A+B+C	-	-	-	-
A+C+D	-	-	-	-
A+B+D	6	6.06	-	-
B+C+D	-	-	-	-
A+B+C+D	1	1.01	-	-

Table 5.2b Application Rate of Individual Planning Techniques

METHOD	CONSULTANTS		CONTRACTORS	
	Number	Percentage (%)	Number	Percentage (%)
A	76	76.77	26	78.57
B	16	16.16	5	7.14
C	23	23.23	1	3.75
D	13	13.13	-	-

Table 5.3a Performance of Predetermined Project Durations

RATING	CONSULTANTS		CONTRACTORS		WEIGHTED PERCENTAGE (%)
	No.	Percentage (%)	No.	Percentage (%)	
Good	15	15.15	2	7.14	13.38
Fair	41	41.41	21	75.00	48.82
Poor	35	35.35	3	10.71	29.92
Very Poor	8	8.08	2	7.14	7.87
TOTAL	**99**	**100**	**28**	**100**	**100**

The ratings in Table 5.3a are as defined below:

Good = TPI ≤ 1, Fair = $1 <$ TPI ≤ 1.5, Poor = $1.5 <$ TPI ≤ 2.0 and Very Poor = TPI > 2.0

Where TPI = Actual Contract Duration/Original Contract Duration.

Table 5.3b Time Performance Indices (TPIs)

ITEM	OCD	ACD	TPI	ITEM	OCD	ACD	TPI
1	17	15	0.8824	58	18	42	2.3333
2	9	36	4.0000	59	10	12	1.2000
3	4	6	1.5000	60	6	28	4.6667
4	4	5.5	1.3750	61	8	18	2.2500
5	24	48	2.0000	62	18	30	1.6667
6	18	30	1.6667	63	12	50	4.1667
7	6	36	6.0000	64	15	22	1.4667
8	6	10	1.6667	65	6	15	2.5000
9	24	48	2.0000	66	24	98	4.0833
10	20	57	2.8500	67	12	20	1.6667
11	10	12.5	1.2500	68	8	15	1.8750
12	24	36	1.5000	69	24	92	3.8333
13	9	60	6.6667	70	10	18	1.8000
14	4	11	2.7500	71	6	10	1.6667
15	6	14	2.3333	72	9	26	2.8889
16	18	36	2.0000	73	8	15	1.8750
17	18	34	1.8889	74	12	22	1.8333
18	36	96	2.6667	75	16	38	2.3750
19	24	36	1.5000	76	12	28	2.3333
20	8	10	1.2500	77	6	10	1.6667
21	18	30	1.6667	78	8	12.5	1.5625
22	12	30	2.5000	79	6	9	1.5000
23	18	24	1.3333	80	24	66	2.7500
24	18	48	2.6667	81	9	12	1.3333
25	2	2	1.0000	82	15	78	5.2000
26	3	5	1.6667	83	18	24	1.3333
27	7	10	1.4286	84	8	12	1.5000
28	4	4.5	1.1250	85	18	24	1.3333
29	18	96	5.3333	86	24	102	4.2500
30	2.5	20	8.0000	87	15	20	1.3333
31	14	13	0.9286	88	6	8	1.3333
32	8	20	2.5000	89	20	64	3.2000
33	18	30	1.6667	90	12	68	5.6667

Table 5.3b (Continued)

ITEM	OCD	ACD	TPI	ITEM	OCD	ACD	TPI
34	9	18	2.0000	91	15	18	1.2000
35	12	36	3.0000	92	18	40	2.2222
36	6	15	2.5000	93	10	22	2.2000
37	24	66	2.7500	94	9	12	1.3333
38	9	24	2.6667	95	12	42	3.5000
39	2	5	2.5000	96	15	18	1.2000
40	36	132	3.6667	97	15	32	2.1333
41	16	24	1.5000	98	10	52	5.2000
42	6	4	0.6667	99	6	10	1.6667
43	6	5.5	0.9167	100	20	38	1.9000
44	8	13	1.6250	101	24	76	3.1667
45	9	13	1.4444	102	12	30	2.5000
46	8	9	1.1250	103	20	22	1.1000
47	7	9	1.2857	104	12	22	1.8333
48	12	18	1.5000	105	15	60	4.0000
49	30	72	2.4000	106	12	36	3.0000
50	36	144	4.0000	107	9	44	4.8889
51	15	17	1.1333	108	6	12	2.0000
52	18	36	2.0000	109	6	8	1.3333
53	18	27	1.5000	110	8	10	1.2500
54	16	44	2.7500	111	6	6	1.0000
55	20	56	2.8000	112	8	15	1.8750
56	12	20	1.6667	113	18	24	1.3333
57	9	15	1.6667		∑TPI		260.9044

Table 5.4a Estimation and Specification of Project Duration

Item	Question	Consultants	Contractors	Consultants and Contractors	Clients in Consultation with Consultants
1	Which Party should estimates duration	9 (22.5%)	22 (55%)	9 (22.5%)	0 (0%)
2	Which Party should give the duration	0 (0%)	26 (65%)	0 (0%)	14 (35%)
3	Which Party gives the duration	0 (0%)	0 (0%)	0 (0%)	40 (100%)

Table 5.4b Method for Determining Project Duration

Item	Method of determining project duration	Number	Percentage (%)
1.1	Experience	11	27.50
1.2	Scientific	2	5
1.3	Both of the above methods	27	67.5
Total		**40**	**100**

Table 5.4c Preparation Site Visit/ Investigation Report and Method Statement

Item	Activity	Contractors		Consultants	
		Yes	No	Yes	No
1	Site Visit / Investigation Report for all projects	0 (0%)	20 (100%)	0 (0%)	20 (100%)
2	Method statement for all projects	18 (90%)	2 (10%)	0 (0%)	20 (100%)

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Table 5.4d Preparation of Method Statement

Item	Content	Contractors		Consultants	
		Yes	No	Yes	No
1	Method of executing individual activities	16 (88.9%)	2 (11.1%)	0 (0%)	20 (100%)
2	Gang composition	18 (100%)	0 (0%)	0 (0%)	20 (100%)
3	Sequence of activities	18 (100%)	0 (0%)	0 (0%)	20 (100%)
2.4	Use of labour output Rates	18 (100%)	0 (0%)	0 (0%)	20 (100%)
2.5	Review of output rates	18 (100%)	0 (0%)	0 (0%)	20 (100%)

Table 5.4e Determination and Review of Labour Output Rates

Item	Activity	Work Study	Experience	Both Work study and Experience
1	Determination of Output Rates	7 (35%)	13 (65%)	0 (0%)
2	Review of Output Rates	2 (10%)	8 (40%)	10 (50%)

Table 5.5 Ranking of Construction Time-influencing Factors – Consultant's Perspective

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
1.0	**Client Characteristics**								
1.1	Type of Client (Public/ Private/ Developer)	6	6	9	59	19	376	0.760	7
1.2	Financial ability/ payment records	2	0	7	41	49	432	0.873	1
1.3	Project finance method/ appropriate funding in place on time	0	2	23	37	37	406	0.820	3
1.4	Partnering arrangements	25	23	24	23	4	255	0.515	64
1.5	Priority on construction time/ deadline requirements	4	12	23	41	19	356	0.719	10
1.6	Experience in procuring construction work	13	19	10	49	8	317	0.640	32
1.7	Client requirement on quality	12	21	23	31	12	307	0.620	42

Table 5.5 (Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
1.8	Specified Sequence of Completion	12	23	19	41	4	299	0.604	46
1.9	Possible changes to initial design	8	8	19	49	15	352	0.711	11
2.0	**Consultant and Design Characteristics**								
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	8	6	9	45	31	382	0.772	5
2.2	Buildability of design	17	2	14	45	21	348	0.703	14
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	8	15	21	49	6	327	0.661	24
2.4	Variation orders and additional works (magnitude, timing, interference level)	10	6	17	43	23	360	0.727	8
2.5	Quality of design and specification	11	6	27	45	10	334	0.675	20
2.6	Inspection, Testing and Approval of completed works (toughness/requirements)	15	4	39	35	6	310	0.626	38
2.7	Submission of early proposal for costing and cost planning	12	17	23	37	10	313	0.632	35
2.8	Absence of alterations and late changes to design (no " design-as –we- go" on site philosophy)	23	6	27	27	16	304	0.614	43
2.9	Provision for ease of communication	16	12	27	29	15	312	0.630	36
2.10	Priority on construction time	18	7	23	38	13	318	0.642	31

Table 5.5(Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
3.0	**Contractors Characteristics, Firm's Ability and Site Management**								
3.1	Management team (suitability, experience and performance)	0	0	13	63	23	406	0.820	3
3.2	Management labour relationships and confidence in workforce	2	11	21	55	10	357	0.721	9
3.3	Financial Capability	2	4	13	31	49	418	0.844	2
3.4	Experience on similar projects	4	4	17	53	21	380	0.768	6
3.5	Current workload	13	6	41	33	6	310	0.626	38
3.6	Level of communication within the contractor's organization	10	13	37	33	6	309	0.624	40
3.7	Estimation methods and cost techniques (accuracy and reliability)	12	17	33	29	8	301	0.608	44
3.8	Planning capability and level of resource deployment/ utilization/ optimization	6	11	29	47	6	333	0.673	21
3.9	Productivity effects (Managerial, Organizational, labour, Technology)	4	14	29	37	15	342	0.691	17
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work	17	25	39	14	4	260	0.525	58
3.11	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	39	23	23	14	0	210	0.424	70
3.12	Record of payments of Sub-contractors,	25	19	29	18	8	262	0.529	57

Table 5.5 (Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
3.14	Previous claim records i.e. assessment of " low tender"- " high claims" performance	35	23	17	20	4	232	0.469	68
3.15	Present claims (size and quantity)	23	14	39	23	0	260	0.525	58
3.16	Accidents on-site record	33	29	25	6	6	220	0.444	69
3.17	Bond/ warranty arrangements	39	27	27	2	4	202	0.408	71
3.18	CDM regulation awareness	-	-	-	-	-	-	-	-
3.19	Programming construction work	10	8	25	39	17	342	0.691	17
3.20	Previous performance of site management team	13	10	33	39	4	308	0.622	41
3.21	Number of Sub-contractors	23	19	41	12	4	252	0.509	65
4.0	**Project Characteristics**								
4.1	Type/ function (residential, commercial, industrial, office)	21	18	29	25	6	274	0.554	51
4.2	Size/ gross floor area	21	16	35	25	2	268	0.541	54
4.3	Height/ number of stories, Number of basement levels	17	8	19	41	14	324	0.655	27
4.4	Level of certainty of soil conditions	15	10	23	37	14	322	0.651	28
4.5	Complexity	8	8	23	49	11	344	0.695	16
4.6	Type of structure (steel, concrete, brick, timber, masonry)	6	19	21	47	6	325	0.657	26
4.7	Location (region/ rural; urban) (intercity/ outskirts)	16	17	37	23	6	283	0.572	50

Table 5.5 (Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
4.8	Site Conditions/ Site topography	8	10	31	35	15	336	0.679	19
4.9	Type of foundations (pile/raft/ pad etc.)	14	21	27	35	2	287	0.580	48
4.10	Off-site prefabrication	29	8	39	19	4	258	0.521	61
4.11	Type of cladding and external wall (brick, double glass)	27	25	27	18	2	240	0.485	67
4.12	Access to site	23	16	15	39	6	286	0.578	49
4.13	Intensity and complexity of building services	15	8	27	41	8	316	0.638	33
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	25	14	29	29	2	266	0.537	55
4.15	Quality of finishing	8	25	33	21	12	301	0.608	44
4.16	Construction method/ technology	17	2	10	48	21	348	0.703	15
5.0	**Contract Methods and Procurement Procedures**								
5.1	Type of contract/ use of standard form of contract	23	20	23	25	8	272	0.549	52
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	6	17	25	39	12	331	0.669	23
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	16	14	29	17	23	314	0.634	34
5.4	Method of procurement (traditional, design and build, project management etc.)	4	17	37	33	8	321	0.648	29
5.5	Spread of risk between construction parties(client /consultants /contractors)	29	23	23	20	4	244	0.493	66

Table 5.5 (Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
5.6	Claims and dispute resolution methods (litigation/ arbitration/others)	39	6	15	27	12	264	0.533	56
5.7	Interviewing of selected prospective contractors	51	19	10	15	4	199	0.402	72
5.8	Suitability of project time	19	12	27	33	8	296	0.598	47
6.0	**External Factors and Market Characteristics**								
6.1	Material prices/ availability/ supply/ quality/ imports.	10	10	19	37	23	350	0.707	13
6.2	Labour costs/ availability/ supply/ performance/ productivity.	4	16	23	35	21	350	0.707	13
6.3	Plant costs/ availability/ supply/ condition/ performance.	8	15	23	39	14	333	0.673	21
6.4	Weather conditions	8	15	35	27	14	321	0.648	29
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	23	21	31	20	4	258	0.521	61
6.6	Level of competition and level of construction activities.	12	25	43	15	4	271	0.547	53
6.7	Number of bidders on competitive projects.	20	27	27	23	2	257	0.519	63
6.8	Interest rate/ inflation rate.	8	25	21	35	10	311	0.628	37
6.9	Stability of market conditions.	8	13	27	43	8	327	0.661	24
6.10	Statutory undertakes (Water, Gas etc.).	20	25	31	19	4	259	0.523	60

Table 5.6 Ranking of Construction Time-influencing Factors – Contractor's Perspective

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
1.0	**Client Characteristics**								
1.1	Type of Client (Public/ Private/ Developer)	0	1	6	17	4	108	0.771	11
1.2	Financial ability/ payment records	0	0	4	11	13	121	0.864	3
1.3	Project finance method/ appropriate funding in place on time	0	0	0	13	15	127	0.907	1
1.4	Partnering arrangements	11	7	6	3	1	60	0.429	72
1.5	Priority on construction time/ deadline requirements	0	7	1	12	8	105	0.750	16
1.6	Experience in procuring construction work	5	2	6	11	4	91	0.650	37
1.7	Client requirement on quality	3	6	7	5	7	91	0.650	37
1.8	Specified Sequence of Completion	5	3	2	12	6	95	0.679	30
1.9	Possible changes to initial design	0	3	7	7	11	110	0.786	8
2.0	**Consultant and Design Characteristics**								
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	1	2	2	10	13	116	0.829	4
2.2	Buildability of design	1	4	2	13	8	107	0.764	13
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	3	6	6	9	4	89	0.636	43
2.4	Variation orders and additional works (magnitude, timing, interference level)	1	2	0	14	11	116	0.829	4

Table 5.6(Continued)

Item	Factor	Rank Frequency 1	2	3	4	5	Weighting	RII	Rank
2.5	Quality of design and specification	5	2	4	11	6	95	0.679	30
2.6	Inspection, Testing and Approval of completed wks(toughness/requirements)	3	3	10	8	4	91	0.650	37
2.7	Submission of early proposal for costing and cost planning	7	2	5	10	4	86	0.614	48
2.8	Absence of alterations and late changes to design (no " design- as –we- go" on site philosophy)	5	7	6	4	6	83	0.593	54
2.9	Provision for ease of communication	3	5	8	10	2	87	0.621	48
2.10	Priority on construction time	2	0	16	6	4	94	0.671	33
3.0	**Contractors Characteristics, Firm's Ability and Site Management**								
3.1	Management team (suitability, experience and performance)	2	5	2	15	4	98	0.700	23
3.2	Management labour relationships and confidence in workforce	2	5	4	13	4	96	0.686	27
3.3	Financial Capability	0	1	4	17	6	112	0.800	6
3.4	Experience on similar projects	1	5	4	16	2	97	0.693	25
3.5	Current workload	0	3	6	17	2	102	0.729	19
3.6	Level of communication within the contractor's organization	5	4	4	9	6	91	0.650	37
3.7	Estimation methods and cost techniques (accuracy and reliability)	2	5	7	12	2	91	0.650	37
3.8	Planning capability and level of resource deployment/ utilization/ optimization	0	1	5	20	2	107	0.764	13
3.9	Productivity effects (Managerial, Organizational, labour, Technology)	1	1	8	18	0	99	0.707	21
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work	3	1	8	14	2	95	0.679	30

Table 5.6(Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
3.11	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	10	0	13	5	0	69	0.493	69
3.12	Record of payments of Sub-contractors,	3	9	8	8	0	77	0.550	62
3.13	Previous claim records i.e. assessment of " low tender"- " high claims" performance	7	4	11	6	0	72	0.514	67
3.14	Present claims (size and quantity)	8	1	12	7	0	74	0.529	65
3.15	Accidents on-site record	8	7	5	8	0	69	0.493	69
3.16	Bond/ warranty arrangements	5	6	13	4	0	72	0.514	66
3.17	CDM regulation awareness	-	-	-	-	-	-	-	-
3.18	Programming construction work	1	0	13	12	2	98	0.700	23
3.19	Previous performance of site management team	4	4	7	13	0	85	0.607	52
3.20	Number of Sub-contractors	8	2	7	11	0	77	0.550	62
4.0	**Project Characteristics**								
4.1	Type/ function (residential, commercial, industrial, office)	5	7	2	12	2	83	0.593	54
4.2	Size/ gross floor area	5	3	8	10	2	85	0.607	52
4.3	Height/ number of stories, Number of basement levels	0	5	6	13	4	100	0.714	20
4.4	Level of certainty of soil conditions	4	6	4	7	7	91	0.650	37
4.5	Complexity	4	2	2	17	3	97	0.693	25

Table 5.6(Continued)

Item	Factor	Rank Frequency					Weighting	RII	Rank
		1	2	3	4	5			
4.6	Type of structure (steel, concrete, brick, timber, masonry)	8	2	6	9	3	81	0.579	59
4.7	Location (region/ rural; urban) (intercity/ outskirts)	2	6	14	8	0	88	0.587	56
4.8	Site Conditions/ Site topography	4	2	8	14	0	88	0.629	45
4.9	Type of foundations (pile/raft/ pad etc.)	2	2	9	15	0	93	0.664	34
4.10	Off-site prefabrication	3	7	4	13	1	86	0.614	49
4.11	Type of cladding and external wall (brick, double glass)	2	8	12	8	0	86	0.573	60
4.12	Access to site	1	9	2	16	0	89	0.636	43
4.13	Intensity and complexity of building services	2	2	8	14	2	96	0.686	27
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	3	8	9	6	2	80	0.571	61
4.15	Quality of finishing	4	1	9	11	3	92	0.657	36
4.16	Construction method/ technology	0	3	6	8	11	110	0.786	8
5.0	**Contract Methods and Procurement Procedures**								
5.1	Type of contract/ use of standard form of contract	5	2	11	6	4	86	0.614	49
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	4	4	6	12	2	88	0.629	45
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	0	4	8	13	3	99	0.707	21
5.4	Method of procurement(traditional, design & build, project management etc)	4	4	8	8	4	88	0.629	45
5.5	Spread of risk between construction parties(client /consultants /contractors)	2	6	2	17	1	93	0.664	34
5.6	Claims and dispute resolution methods (litigation/ arbitration/others)	2	0	6	16	4	104	0.743	17

Table 5.6 Continued

Item	Factor	Rank Frequency 1	2	3	4	5	Weighting	RII	Rank
5.7	Interviewing of selected prospective contractors	7	0	11	8	2	82	0.586	57
5.8	Suitability of project time	4	1	5	15	3	96	0.686	27
6.0	**External Factors and Market Characteristics**								
6.1	Material prices/ availability/ supply/ quality/ imports.	0	0	0	17	11	123	0.879	2
6.2	Labour costs/ availability/ supply/ performance/ productivity.	2	1	1	15	9	112	0.800	6
6.3	Plant costs/ availability/ supply/ condition/ performance.	0	4	3	13	8	109	0.779	10
6.4	Weather conditions	0	1	9	11	7	108	0.771	11
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	9	2	9	6	2	74	0.529	65
6.6	Level of competition and level of construction activities.	6	3	9	7	3	82	0.586	57
6.7	Number of bidders on competitive projects.	11	4	11	2	0	60	0.429	71
6.8	Interest rate/ inflation rate.	2	1	7	11	7	104	0.743	17
6.9	Stability of market conditions.	1	0	5	19	3	107	0.764	13
6.10	Statutory undertakes (Water, Gas etc.).	4	5	13	6	0	77	0.550	62

Table 5.7 Overall Ranking of Construction Time-influencing Factors – Combined Consultant's and Contractor's Perspective

Item	Factor	Contractors RII$_A$	Contractors N$_A$	Consultants RII$_B$	Consultants N$_B$	N$_{A+B}$	Weighted RII	Category Ranking	Overall Ranking
1.0	**Client Characteristics**								
1.1	Type of Client (Public/ Private/ Developer)	0.7714	99	0.7596	28	127	0.7688	4	9
1.2	Financial ability/ payment records	0.8643	99	0.8727	28	127	0.8662	2	2
1.3	Project finance method/ appropriate funding in place on time	0.9071	99	0.8202	28	127	0.8879	1	1
1.4	Partnering arrangements	0.4286	99	0.5152	28	127	0.4477	11	71
1.5	Priority on construction time/ deadline requirements	0.7500	99	0.7192	28	127	0.7432	5	15
1.6	Experience in procuring construction work	0.6500	99	0.6404	28	127	0.6479	9	34
1.7	Client requirement on quality	0.6500	99	0.6202	28	127	0.6434	10	40
1.8	Specified Sequence of Completion	0.6786	99	0.6040	28	127	0.6622	7	32
1.9	Possible changes to initial design	0.7857	99	0.7111	28	127	0.7693	3	8
2.0	**Consultant and Design Characteristics**								
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	0.8286	99	0.7717	28	127	0.8161	1	4
2.2	Buildability of design	0.7643	99	0.7030	28	127	0.7508	3	11

Table 5.7(Continued)

Item	Factor	Contractors		Consultants		N_{A+B}	Weighted RII	Category Ranking	Overall Ranking
		RII_A	N_A	RII_B	N_B				
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	0.6357	99	0.6606	28	127	0.6412	7	41
2.4	Variation orders and additional works (magnitude, timing, interference level)	0.8286	99	0.7273	28	127	0.8063	2	6
2.5	Quality of design and specification	0.6786	99	0.6747	28	127	0.6777	4	28
2.6	Inspection, Testing and Approval of completed works (toughness/requirements)	0.6500	99	0.6263	28	127	0.6448	6	37
2.7	Submission of early proposal for costing and cost planning	0.6143	99	0.6323	28	127	0.6183	9	49
2.8	Absence of alterations and late changes to design (no " design- as –we- go" on site philosophy)	0.5929	99	0.6141	28	127	0.5976	10	52
2.9	Provision for ease of communication	0.6214	99	0.6303	28	127	0.6234	8	47
2.10	Priority on construction time	0.6714	99	0.6424	28	127	0.6650	5	31

Table 5.7(Continued)

Item	Factor	Contractors		Consultants		N_{A+B}	Weighted RII	Category Ranking	Overall Ranking
		RII_A	N_A	RII_B	N_B				
3.0	**Contractors Characteristics, Firm's Ability and Site Management**								
3.1	Management team (suitability, experience and performance)	0.7000	99	0.8202	28	127	0.7265	3	17
3.2	Management labour relationships and confidence in workforce	0.6857	99	0.7212	28	127	0.6935	8	25
3.3	Financial Capability	0.8000	99	0.8444	28	127	0.8098	1	5
3.4	Experience on similar proj.	0.6929	99	0.7677	28	127	0.7094	4	8
3.5	Current workload	0.7286	99	0.6263	28	127	0.7060	5	21
3.6	Level of communication within the contractor's organization	0.6500	99	0.6242	28	127	0.6443	10	39
3.7	Estimation methods and cost techniques (accuracy and reliability)	0.6500	99	0.6081	28	127	0.6408	11	42
3.8	Planning capability and lev. of resource deployment/ utilization/ optimization	0.7643	99	0.6727	28	127	0.7441	2	13
3.9	Productivity effects (Managerial, labour, Organizational, Technology)	0.7071	99	0.6909	28	127	0.7035	6	22
3.10	Percentage of main contractor's direct work and sub-contractor's work	0.6786	99	0.5253	28	127	0.6448	9	37

Table 5.7(Continued)

Item	Factor	Contractors		Consultants		N_{A+B}	Weighted RII	Category Ranking	Overall Ranking
		RII_A	N_A	RII_B	N_B				
3.11	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	0.4929	99	0.4242	28	127	0.4778	20	70
3.12	Record of payments of Sub-contractors,	0.5500	99	0.5293	28	127	0.5454	14	61
3.13	Previous claim records i.e. assessment of " low tender"- " high claims" performance	0.5143	99	0.4687	28	127	0.5042	17	67
3.14	Present claims (size and quantity)	0.5286	99	0.5253	28	127	0.5279	16	65
3.15	Accidents on-site record	0.4929	99	0.4444	28	127	0.4822	19	69
3.16	Bond/ warranty arrangements	0.5143	99	0.4081	28	127	0.4909	18	68
3.17	CDM regulation awareness	-	-	-	-	-	-	-	-
3.18	Programming construction work	0.7000	99	0.6909	28	127	0.6980	7	23
3.19	Previous performance of site management team	0.6071	99	0.6222	28	127	0.6104	12	50
3.20	Number of Sub-contractors	0.5500	99	0.5091	28	127	0.5410	15	64
4.0	**Project Characteristics**								
4.1	Type/ function (residential, commercial, industrial, office)	0.5929	99	0.5535	28	127	0.5842	13	56

Table 5.7(Continued)

Item	Factor	Contractors		Consultants		N_{A+B}	Weighted RII	Category Ranking	Overall Ranking
		RII_A	N_A	RII_B	N_B				
4.2	Size/ gross floor area	0.6071	99	0.5414	28	127	0.5926	12	55
4.3	Height/ number of stories, Number of basement levels	0.7143	99	0.6545	28	127	0.7011	1	22
4.4	Level of certainty of soil conditions	0.6500	99	0.6505	28	127	0.6501	5	33
4.5	Complexity	0.6929	99	0.6949	28	127	0.6933	3	26
4.6	Type of structure (steel, concrete, brick, timber, masonry)	0.5786	99	0.6566	28	127	0.5958	10	53
4.7	Location (region/ rural; urban) (intercity/ outskirts)	0.5867	99	0.5717	28	127	0.5834	14	57
4.8	Site Conditions/ Site topography	0.6286	99	0.6788	28	127	0.6397	8	43
4.9	Type of foundations (pile/raft/ pad etc.)	0.6643	99	0.5798	28	127	0.6457	7	36
4.10	Off-site prefabrication	0.6143	99	0.5212	28	127	0.5938	11	54
4.11	Type of cladding & external wall (brick, double glass)	0.5733	99	0.4848	28	127	0.5538	16	60
4.12	Access to site	0.6357	99	0.5778	28	127	0.6229	9	48
4.13	Intensity and complexity of building services	0.6857	99	0.6384	28	127	0.6753	4	29
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	0.5714	99	0.5374	28	127	0.5639	15	59
4.15	Quality of finishing	0.6571	99	0.6081	28	127	0.6463	6	35
4.16	Construction method/ technology	0.7643	99	0.7030	28	127	0.7508	2	11

Table 5.7(Continued)

5.0	**Contract Methods and Procurement Procedures**								
5.1	Type of contract/ use of standard form of contract	0.6286	99	0.6687	28	127	0.6374	4	44
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	0.7071	99	0.6343	28	127	0.6910	2	26
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	0.6286	99	0.6485	28	127	0.6330	5	45
5.4	Method of procurement (traditional, design & build, project management etc.)	0.6643	99	0.4929	28	127	0.6265	6	46
5.5	Spread of risk between construction parties(client /consultants /contractors)	0.7429	99	0.5333	28	127	0.6967	1	24
5.6	Claims and dispute resolution methods (litigation/ arbitration etc.)	0.5857	99	0.4020	28	127	0.5452	8	62
5.7	Interviewing of selected prospective contractors	0.6857	99	0.5980	28	127	0.6664	3	30
5.8	Suitability of project time	0.6143	99	0.5495	28	127	0.6000	7	51
6.0	**External Factors and Market Characteristics**								
6.1	Material prices/ availability/ supply/ quality/ imports.	0.8790	99	0.7071	28	127	0.8411	1	3
6.2	Labour costs/ availability/ supply/ performance/ productivity.	0.8000	99	0.7071	28	127	0.7795	2	7
6.3	Plant costs/ availability/ supply/ condition/ performance.	0.7790	99	0.6727	28	127	0.7556	3	10
6.4	Weather conditions	0.7710	99	0.6485	28	127	0.7440	4	14
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	0.5290	99	0.5212	28	127	0.5273	9	66

Table 5.7(Continued)

Item	Factor	Contractors		Consultants		N_{A+B}	Weighted RII	Category Ranking	Overall Ranking
		RII_A	N_A	RII_B	N_B				
6.6	Level of competition and level of construction activities.	0.5860	99	0.5475	28	127	0.5775	7	58
6.7	Number of bidders on competitive projects.	0.4290	99	0.5192	28	127	0.4489	10	71
6.8	Interest rate/ inflation rate.	0.7430	99	0.6283	28	127	0.7177	6	18
6.9	Stability of market conditions.	0.7640	99	0.6606	28	127	0.7412	5	16
6.10	Statutory undertakes (Water, Gas etc.).	0.5500	99	0.5232	28	127	0.5441	8	63

Table 5.8 Overall (Combined) Factor Category Ranking

Item	Factor Category	Contractors		Consultants		Combined Category Mean RII	Overall Category Ranking
		Category Mean RII	Rank	Category Mean RII	Rank		
1.0	Client Characteristics	0.7117	1	0.6972	1	0.7004	1
2.0	Consultant and Design Characteristics	0.6886	2	0.6683	2	0.6728	2
3.0	Contractors Characteristics, Firm's Ability and Site Management	0.6322	5	0.6004	4	0.6074	4
4.0	Project Characteristics	0.6302	6	0.5966	5	0.6040	5
5.0	Contract Methods and Procurement Procedures	0.6572	4	0.5659	6	0.5860	6
6.0	External Factors and Market Characteristics	0.6829	3	0.6135	3	0.6288	3

Table 5.9 **Coefficient of Variation and Consistency Test**

ITEM	FACTOR	MR_A	MR_B	$\bar{X}_R$	VAR	S	CV_R
1.0	**Client Characteristics**						
1.1	Type of Client (Public/ Private/ Developer)	3.7980	3.8571	3.8110	2.6578	1.6303	0.4278
1.2	Financial ability/ payment records	4.3636	4.3214	4.3543	3.8342	1.9581	0.4497
1.3	Project finance method/ appropriate funding in place on time	4.1010	4.5357	4.1969	3.4325	1.8527	0.4415
1.4	Partnering arrangements	2.5758	2.1429	2.4803	2.2701	1.5067	0.6075
1.5	Priority on construction time/ deadline requirements	3.5960	3.7500	3.6299	2.3968	1.5482	0.4265
1.6	Experience in procuring construction work	3.2020	3.2500	3.2126	2.0452	1.4301	0.4452
1.7	Certainty of project brief	3.3737	3.2143	3.3386	2.1146	1.4542	0.4356
1.8	Specified Sequence of Completion	3.0202	3.3929	3.1024	2.0105	1.4179	0.4570
1.9	Possible changes to initial design	3.5556	3.9286	3.6378	2.4068	1.5514	0.4265
2.0	**Consultant and Design Characteristics**						
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	3.8586	4.1429	3.9213	2.8487	1.6878	0.4304
2.2	Buildability of design	3.5152	3.8214	3.5827	2.3395	1.5295	0.4269
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	3.3030	3.1786	3.2756	2.076	1.4408	0.4399

Table 5.9(Continued)

ITEM	FACTOR	MR_A	MR_B	$\bar{X}_R$	VAR	S	CV_R
2.4	Variation orders and additional works (magnitude, timing, interference level)	3.6364	4.1429	3.7480	2.5596	1.5999	0.4269
2.5	Quality of design and specification	3.3737	3.3929	3.3780	2.1428	1.4638	0.4333
2.6	Inspection, Testing and Approval of completed works (toughness / requirements)	3.1313	3.2500	3.1575	2.0248	1.4230	0.4507
2.7	Submission of early proposal for costing and cost planning	3.1616	3.0714	3.1417	2.0201	1.4213	0.4524
2.8	Absence of alterations and late changes to design (no " design-as –we- go" on site philosophy)	3.0707	2.9643	3.0472	2.0022	1.4150	0.4644
2.9	Provision for ease of communication	3.1515	3.1071	3.1417	2.0201	1.4213	0.4524
2.10	Priority on construction time	3.2121	3.3571	3.2441	2.0596	1.4351	0.4424
3.0	**Contractors Characteristics, Firm's Ability and Site Management**						
3.1	Management team (suitability, experience and performance)	4.1010	3.5000	3.9685	2.938	1.7141	0.4319
3.2	Management labour relationships and confidence in workforce	3.6061	3.4286	3.5669	2.3214	1.5236	0.4272
3.3	Financial Capability	4.2222	4.0000	4.1732	3.3765	1.8375	0.4403
3.4	Experience on similar projects	3.8384	3.4643	3.7559	2.5714	1.6036	0.4269
3.5	Current workload	3.1313	3.6429	3.2441	2.0596	1.4351	0.4424
3.6	Level of communication within the contractor's organization	3.1212	3.2500	3.1496	2.0224	1.4221	0.4515
3.7	Estimation methods and cost techniques (accuracy and reliability)	3.0404	3.2500	3.0866	2.0075	1.4169	0.4590
3.8	Planning capability and level of resource deployment/ utilization/ optimization	3.3636	3.8214	3.4646	2.2158	1.4886	0.4297
3.9	Productivity effects (Managerial, Organizational, labour, Technology)	3.4545	3.5357	3.4724	2.2232	1.4910	0.4294

Table 5.9(Continued)

ITEM	FACTOR	MR_A	MR_B	$\bar{X}_R$	VAR	S	CV_R
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work	2.6263	3.3929	2.7953	2.0419	1.4290	0.5112
3.11	Number of sub-contractors	2.4242	3.1786	2.5906	2.1676	1.4723	0.5683
3.12	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	2.1212	2.4643	2.1969	2.645	1.6263	0.7403
3.13	Record of payments of Sub-contractors,	2.6465	2.7500	2.6693	2.1094	1.4524	0.5441
3.14	Previous claim records i.e. assessment of " low tender"- " high claims" performance	2:3434	2.5714	2.3937	2.3676	1.5387	0.6428
3.15	Present claims (size and quantity)	2.6263	2.6429	2.6299	3.137	1.7712	0.6735
3.16	Accidents on-site record	2.2222	2.4643	2.2756	2.5248	1.5890	0.6983
3.17	Bond/ warranty arrangements	2.0404	2.5714	2.1575	2.7098	1.6461	0.7630
3.18	CDM regulation awareness						
3.19	Programming construction work	3.4545	3.5000	3.4646	2.2158	1.4886	0.4297
3.2	Previous performance of site management team	3.1111	3.0357	3.0945	2.0089	1.4174	0.4580
3.21	Number of Sub-contractors	2.5455	2.7500	2.5906	2.1676	1.4723	0.5683
4.0	**Project Characteristics**						
4.1	Type/ function (residential, commercial, industrial, office)	2.7677	2.9643	2.8110	2.0357	1.4268	0.5076
4.2	Size/ gross floor area	2.7071	3.0357	2.7795	2.0486	1.4313	0.5149
4.3	Height/ number of stories, Number of basement levels	3.2727	3.5714	3.3386	2.1146	1.4542	0.4356
4.4	Level of certainty of soil conditions	3.2525	3.2500	3.2520	2.0635	1.4365	0.4417
4.5	Complexity	3.4747	3.4643	3.4724	2.2232	1.4910	0.4294
4.6	Type of structure (steel, concrete, brick, timber, masonry)	3.2828	2.8929	3.1969	2.0388	1.4279	0.4466
4.7	Location (region/ rural; urban) (intercity/ outskirts)	2.8586	2.9286	2.8740	2.0159	1.4198	0.4940

Table 5.9(Continued)

ITEM	FACTOR	MR_A	MR_B	$\bar{X}_R$	VAR	S	CV_R
4.8	Site Conditions/ Site topography	3.3939	3.1429	3.3386	2.1146	1.4542	0.4356
4.9	Type of foundations (pile/raft/ pad etc.)	2.8990	3.3214	2.9921	2.0001	1.4142	0.4727
4.1	Off-site prefabrication	2.6061	3.0714	2.7087	2.0849	1.4439	0.5331
4.11	Type of cladding and external wall (brick, double glass)	2.4242	2.8571	2.5197	2.2307	1.4936	0.5928
4.12	Access to site	2.8889	3.1786	2.9528	2.0022	1.4150	0.4792
4.13	Intensity and complexity of building services	3.1919	3.4286	3.2441	2.0596	1.4351	0.4424
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	2.6869	2.8571	2.7244	2.076	1.4408	0.5289
4.15	Quality of finishing	3.0404	3.2857	3.0945	2.0089	1.4174	0.4580
4.16	Construction method/ technology	3.4747	3.4643	3.4724	2.2232	1.4910	0.4294
5.0	**Contract Methods and Procurement Procedures**						
5.1	Type of contract/ use of standard form of contract	2.7475	3.0714	2.8189	2.0328	1.4258	0.5058
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	3.3434	3.1429	3.2992	2.0895	1.4455	0.4381
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	3.1717	3.5357	3.2520	2.0635	1.4365	0.4417
5.4	Method of procurement (traditional, design and build, project management etc.)	3.2424	3.1429	3.2205	2.0486	1.4313	0.4444
5.5	Spread of risk between construction parties(client /consultants /contractors)	2.4646	3.3214	2.6535	2.12	1.4560	0.5487
5.6	Claims and dispute resolution methods (litigation/ arbitration/others)	2.6667	3.7143	2.8976	2.0105	1.4179	0.4893
5.7	Interviewing of selected prospective contractors	2.0101	2.9286	2.2126	2.62	1.6186	0.7316
5.8	Suitability of project time	2.9899	3.4286	3.0866	2.0075	1.4169	0.4590

Table 5.9(Continued)

ITEM	FACTOR	MR_A	MR_B	$\bar{X}_R$	VAR	S	CV_R
6.0	**External Factors and Market Characteristics**						
6.1	Material prices/ availability/ supply/ quality/ imports.	3.5354	4.3929	3.7244	2.5248	1.5890	0.4266
6.2	Labour costs/ availability/ supply/ performance/ productivity.	3.5354	4.0000	3.6378	2.4068	1.5514	0.4265
6.3	Plant costs/ availability/ supply/ condition/ performance.	3.3636	3.8929	3.4803	2.2307	1.4936	0.4291
6.4	Weather conditions	3.2424	3.8571	3.3780	2.1428	1.4638	0.4333
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	2.6061	2.6429	2.6142	2.1489	1.4659	0.5608
6.6	Level of competition and level of construction activities.	2.7374	2.9286	2.7795	2.0486	1.4313	0.5149
6.7	Number of bidders on competitive projects.	2.5960	2.1429	2.4961	2.254	1.5013	0.6015
6.8	Interest rate/ inflation rate.	3.1414	3.7143	3.2677	2.0717	1.4393	0.4405
6.9	Stability of market conditions.	3.3030	3.8214	3.4173	2.1742	1.4745	0.4315
6.10	Statutory undertakes (Water, Gas etc.).	2.6162	2.7500	2.6457	2.1256	1.4579	0.5511

Table 5.10 Computation of Spearman's Rank Correlation Coefficient (r_s)

ITEM	FACTOR	R_1	R_2	$d_i = R_1 - R_2$	d_i^2
1.0	**Client Characteristics**				
1.1	Type of Client (Public/ Private/ Developer)	10	7	3	9
1.2	Financial ability/ payment records	3	1	2	4
1.3	Project finance method/ appropriate funding in place on time	1	3	-2	4
1.4	Partnering arrangements	73	65	8	64
1.5	Priority on construction time/ deadline requirements	15	11	4	16
1.6	Experience in procuring construction work	37	33	4	16
1.7	Client requirement on quality	37	43	-6	36
1.8	Specified Sequence of Completion	30	47	-17	289
1.9	Possible changes to initial design	8	12	-4	16
2.0	**Consultant and Design Characteristics**				
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	4	5	-1	1
2.2	Buildability of design	12	15	-3	9
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	44	25	19	361
2.4	Variation orders & additional works (magnitude, timing, interference level)	4	9	-5	25
2.5	Quality of design and specification	30	20	10	100
2.6	Inspection, Testing and Approval of completed works (toughness/requirements)	37	39	-2	4
2.7	Submission of early proposal for costing & cost planning	50	36	14	196

Table 5.10 (Continued)

ITEM	FACTOR	R_1	R_2	$d_i = R_1 - R_2$	di^2
2.8	Absence of alterations and late changes to design (no " design- as –we- go" on site philosophy)	56	44	12	144
2.9	Provision for ease of communication	50	37	13	169
2.10	Priority on construction time	33	32	1	1
3.0	**Contractors Characteristics, Firm's Ability and Site Management**				
3.1	Management team (suitability, experience and performance)	22	3	19	361
3.2	Management labour relationships and confidence in workforce	27	10	17	289
3.3	Financial Capability	6	2	4	16
3.4	Experience on similar projects	25	6	19	361
3.5	Current workload	18	39	-21	441
3.6	Level of communication within the contractor's organization	37	41	-4	16
3.7	Estimation methods and cost techniques (accuracy and reliability)	37	45	-8	64
3.8	Planning capability and level of resource deployment/ utilization/ optimization	12	22	-10	100
3.9	Productivity effects (Managerial, Organizational, labour, Technology)	20	17	3	9
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work	30	59	-29	841
3.11	Number of sub-contractors	44	68	-24	576
3.12	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	71	72	-1	1

Table 5.10 (Continued)

ITEM	FACTOR	R_1	R_2	$d_i = R_1 - R_2$	di^2
3.13	Record of payments of Sub-contractors,	64	58	6	36
3.14	Previous claim records i.e. assessment of " low tender"- " high claims" performance	69	70	-1	1
3.15	Present claims (size and quantity)	67	59	8	64
3.16	Accidents on-site record	71	71	0	0
3.17	Bond/ warranty arrangements	69	73	-4	16
3.18	Programming construction work	22	17	5	25
3.19	Previous performance of site management team	54	42	12	144
3.20	Number of Sub-contractors	64	66	-2	4
4.0	**Project Characteristics**				
4.1	Type/ function (residential, commercial, industrial)	56	52	4	16
4.2	Size/ gross floor area	54	55	-1	1
4.3	Height/ number of stories, Number of basement levels	19	28	-9	81
4.4	Level of certainty of soil conditions	37	29	8	64
4.5	Complexity	25	16	9	81
4.6	Type of structure (steel, concrete, brick, timber, masonry)	61	27	34	1156
4.7	Location (region/ rural; urban) (intercity/ outskirts)	58	51	7	49
4.8	Site Conditions/ Site topography	47	19	28	784
4.9	Type of foundations (pile/raft/ pad etc.)	34	49	-15	225
4.10	Off-site prefabrication	51	62	-11	121

Table 5.10 (Continued)

ITEM	FACTOR	R_1	R_2	$d_i = R_1 - R_2$	di^2
4.11	Type of cladding & extl wall (brick, double glass)	62	68	-6	36
4.12	Access to site	44	50	-6	36
4.13	Intensity and complexity of building services	27	34	-7	49
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	63	56	7	49
4.15	Quality of finishing	36	45	-9	81
4.16	Construction method/ technology	8	12	-4	16
5.0	**Contract Methods & Procurement Procedures**				
5.1	Type of contract/ use of standard form of contract	51	53	-2	4
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	47	24	23	529
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	20	35	-15	225
5.4	Method of procurement (traditional, design and build, project management etc.)	47	30	17	289
5.5	Spread of risk between construction parties(client /consultants /contractors)	34	67	-33	1089
5.6	Claims and dispute resolution methods (litigation/ arbitration/others)	16	57	-41	1681
5.7	Interviewing of selected prospective contractors	59	74	-15	225
5.8	Suitability of project time	27	48	-21	441
6.0	**External Factors and Market Characteristics**				
6.1	Material prices/ availability/ supply/ quality/ imports.	2	13	-11	121
6.2	Labour costs/ availability/ supply/ performance/ productivity.	6	13	-7	49

Table 5.10 (Continued)

ITEM	FACTOR	R_1	R_2	$d_i = R_1 - R_2$	di^2
6.3	Plant costs/ availability/ supply/ condition/ performance.	9	22	-13	169
6.4	Weather conditions	10	30	-20	400
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	67	62	5	25
6.6	Level of competition and level of construction activities.	59	54	5	25
6.7	Number of bidders on competitive projects.	74	64	10	100
6.8	Interest rate/ inflation rate.	16	38	-22	484
6.9	Stability of market conditions.	12	25	-13	169
6.10	Statutory undertakes (Water, Gas etc.).	64	61	3	9
	$\sum d_i^2$				**14388**
	$6\sum d_i^2$				**86328**

Table 5.11 Decisions on Significant Factors

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value ($Z\alpha$)	Decision on Significance (Yes/No)
1.0	**Client Characteristics**					
1.1	Type of Client (Public/ Private/ Developer)	3.8110	1.6303	5.6063	1.6500	Yes
1.2	Financial ability/ payment records	4.3543	1.9581	7.7945	1.6500	Yes
1.3	Project finance method/ appropriate funding in place on time	4.1969	1.8527	7.2801	1.6500	Yes
1.4	Partnering arrangements	2.4803	1.5067	-3.8870	1.6500	No
1.5	Priority on construction time	3.6299	1.5482	4.5853	1.6500	Yes
1.6	Experience in procuring construction work	3.2126	1.4301	1.6753	1.6500	Yes
1.7	Client requirement on quality	3.1339	1.4205	1.0619	1.6500	No
1.9	Specified Sequence of Completion	3.1024	1.4179	0.8136	1.6500	No
1.10	Possible changes to initial design	3.6378	1.5514	4.6330	1.6500	Yes
2.0	**Consultant and Design Characteristics**					
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	3.9213	1.6878	6.1512	1.6500	Yes

Table 5.11(Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value ($Z\alpha$)	Decision on Significance (Yes/No)
2.2	Buildability of design	3.5827	1.5295	4.2931	1.6500	Yes
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	3.2756	1.4408	2.1555	1.6500	Yes
2.4	Variation orders & additional wks (timing, magnitude, interference level)	3.7480	1.5999	5.2691	1.6500	Yes
2.5	Quality of design and specification	3.3780	1.4638	2.9097	1.6500	Yes
2.6	Inspection, Testing and Approval of completed wks (toughness/requirements)	3.1575	1.4230	1.2472	1.6500	No
2.7	Submission of early proposal for costing and cost planning	3.1417	1.4213	1.1238	1.6500	No
2.8	Absence of alterations and late changes to design (no " design- as –we- go" on site philosophy)	3.0472	1.4150	0.3763	1.6500	No
2.9	Provision for ease of communication	3.1417	1.4213	1.1238	1.6500	No
2.10	Priority on construction time	3.2441	1.4351	1.9168	1.6500	Yes

Table 5.11 (Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value (Zα)	Decision on Significance (Yes/No)
3.0	**Contractors Characteristics, Firm's Ability and Site Management**					
3.1	Management team (suitability, experience and performance)	3.9685	1.7141	6.3676	1.6500	Yes
3.2	Management labour relationships and confidence in workforce	3.5669	1.5236	4.1933	1.6500	Yes
3.3	Financial Capability	4.1732	1.8375	7.1953	1.6500	Yes
3.4	Experience on similar projects	3.7559	1.6036	5.3123	1.6500	Yes
3.5	Current workload	3.2441	1.4351	1.9168	1.6500	Yes
3.6	Level of communication within the contractor's organization	3.1496	1.4221	1.1855	1.6500	No
3.7	Estimation methods and cost techniques (accuracy and reliability)	3.0866	1.4169	0.6889	1.6500	No
3.8	Planning capability and level of resource deployment/ utilization/ optimization	3.4646	1.4886	3.5171	1.6500	Yes
3.9	Productivity effects (Managerial, Organizational, labour, Technology)	3.4724	1.4910	3.5708	1.6500	Yes

Table 5.11 (Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value (Zα)	Decision on Significance (Yes/No)
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work	2.7953	1.4290	-1.6146	1.6500	No
3.11	No. of sub-contractors	2.5906	1.4723	-3.1341	1.6500	No
3.12	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	2.1969	1.6263	-5.5653	1.6500	No
3.13	Record of payments of Sub-contractors,	2.6693	1.4524	-2.5661	1.6500	No
3.14	Previous claim records i.e. assessment of " low tender"- " high claims" performance	2.3937	1.5387	-4.4405	1.6500	No
3.15	Present claims (size and quantity)	2.6299	1.7712	-2.3547	1.6500	No
3.16	Accidents on-site record	2.2756	1.5890	-5.1377	1.6500	No
3.17	Bond/ warranty arrangements	2.1575	1.6461	-5.7678	1.6500	No
3.18	Programming construction work	3.4646	1.4886	3.5171	1.6500	Yes
3.19	Previous performance of site management team	3.0945	1.4174	0.7513	1.6500	No
3.20	No. of Sub-contractors	2.5906	1.4723	-3.1341	1.6500	No

Table 5.11 (Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value ($Z\alpha$)	Decision on Significance (Yes/No)
4.0	**Project Characteristics**					
4.1	Type/ function (residential, commercial, industrial etc.)	2.8110	1.4268	-1.4926	1.6500	No
4.2	Size/ gross floor area	2.7795	1.4313	-1.7359	1.6500	No
4.3	Height/ number of stories, Number of basement levels	3.3386	1.4542	2.6239	1.6500	Yes
4.4	Level of certainty of soil conditions	3.2520	1.4365	1.9767	1.6500	Yes
4.5	Complexity	3.4724	1.4910	3.5708	1.6500	Yes
4.6	Type of structure (steel, concrete, brick, timber, masonry)	3.1969	1.4279	1.5536	1.6500	No
4.7	Location (region/ rural; urban) (intercity/outskirts)	2.8740	1.4198	-1.0000	1.6500	No
4.8	Site Conditions/ Site topography	3.3386	1.4542	2.6239	1.6500	Yes
4.9	Type of foundations (pile/raft/ pad etc.)	2.9921	1.4142	-0.0627	1.6500	No
4.1	Off-site prefabrication	2.7087	1.4439	-2.2738	1.6500	No
4.11	Type of cladding and external wall (brick, double glass)	2.5197	1.4936	-3.6242	1.6500	No
4.12	Access to site	2.9528	1.4150	-0.3763	1.6500	No

Table 5.11 (Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value ($Z\alpha$)	Decision on Significance (Yes/No)
4.13	Intensity and complexity of building services	3.2441	1.4351	1.9168	1.6500	Yes
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	2.7244	1.4408	-2.1555	1.6500	No
4.15	Quality of finishing	3.0945	1.4174	0.7513	1.6500	No
4.16	Construction method/ technology	3.7244	1.5890	5.1377	1.6500	Yes
5.0	**Contract Methods and Procurement Procedures**					
5.1	Type of contract/ use of standard form of contract	2.8189	1.4258	-1.4315	1.6500	No
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	3.2992	1.4455	2.3327	1.6500	Yes
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	3.2520	1.4365	1.9767	1.6500	Yes
5.4	Method of procurement (traditional, design and build, project management etc.)	3.2205	1.4313	1.7359	1.6500	Yes
5.5	Spread of risk between construction parties(client /consultants /contractors)	2.6535	1.4560	-2.6815	1.6500	No

Table 5.11 (Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value (Zα)	Decision on Significance (Yes/No)
5.6	Claims & dispute resolution methods (litigation/arbitration/others)	2.8976	1.4179	-0.8136	1.6500	No
5.7	Interviewing of selected prospective contractors	2.2126	1.6186	-5.4821	1.6500	No
5.8	Suitability of project time	3.0866	1.4169	0.6889	1.6500	No
6.0	**External Factors and Market Characteristics**					
6.1	Material prices/ availability/ supply/ quality/ imports.	3.7244	1.5890	5.1377	1.6500	Yes
6.2	Labour costs/ availability/ supply/ performance/ productivity.	3.6378	1.5514	4.6330	1.6500	Yes
6.3	Plant costs/ availability/ supply/ condition/ performance.	3.4803	1.4936	3.6242	1.6500	Yes
6.4	Weather conditions	3.3780	1.4638	2.9097	1.6500	Yes
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	2.6142	1.4659	-2.9661	1.6500	No
6.6	Lev. of competition & lev. of construction activities.	2.7795	1.4313	-1.7359	1.6500	No
6.7	Number of bidders on competitive projects.	2.4961	1.5013	-3.7827	1.6500	No

Table 5.11 (Continued)

Item	Factor	Sample Rank Mean($\bar{x}_i$)	Sample Rank SD (s)	Computed Standardized Value (z)	Critical Value ($Z\alpha$)	Decision on Significance (Yes/No)
6.8	Interest rate/ inflation rate.	3.2677	1.4393	2.0961	1.6500	Yes
6.9	Stability of market conditions.	3.4173	1.4745	3.1895	1.6500	Yes
6.10	Statutory undertakes (Water, Gas etc.).	2.6457	1.4579	-2.7389	1.6500	No

Table 5.12 *P- Values* of Factors and Consequence Decision

Item	Factor	Computed Standardized Values(z)	P-Value	Accept H_0 (Yes/No)
1.0	**Client Characteristics**			
1.1	Type of Client (Public/ Private/ Developer)	5.6063	0.9998	Yes
1.2	Financial ability/ payment records	7.7945	0.9998	Yes
1.3	Project finance method/ appropriate funding in place on time	7.2801	0.9998	Yes
1.4	Partnering arrangements	-3.8870	0.0002	No
1.5	Priority on construction time/ deadline requirements	4.5853	0.9998	Yes
1.6	Experience in procuring construction work	1.6753	0.9535	Yes
1.7	Client requirement on quality	1.0619	0.8554	No
1.8	Specified Sequence of Completion	0.8136	0.7910	No
1.9	Possible changes to initial design	4.6330	0.9998	Yes
2.0	**Consultant and Design Characteristics**			
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	6.1512	0.9998	Yes
2.2	Buildability of design	4.2931	0.9998	Yes
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	2.1555	0.9846	Yes

Table 5.12(Continued)

Item	Factor	Computed Standardised Values(z)	P-Value	Accept H_0 (Yes/No)
2.4	Variation orders and additional works (magnitude, timing, interference level)	5.2691	0.9998	Yes
2.5	Quality of design and specification	2.9097	0.9982	Yes
2.6	Inspection, Testing and Approval of completed works (toughness/requirements)	1.2472	0.8925	No
2.7	Submission of early proposal for costing and cost planning	1.1238	0.8686	No
2.8	Absence of alterations and late changes to design (no " design-as –we- go" on site philosophy)	0.3763	0.6443	No
2.9	Provision for ease of communication	1.1238	0.8686	No
2.10	Priority on construction time	1.9168	0.9726	Yes
3.0	**Contractors Characteristics, Firm's Ability and Site Management**			
3.1	Management team (suitability, experience and performance)	6.3676	0.9998	Yes
3.2	Management labour relationships and confidence in workforce	4.1933	0.9998	Yes
3.3	Financial Capability	7.1953	0.9998	Yes
3.4	Experience on similar projects	5.3123	0.9998	Yes
3.5	Current workload	1.9168	0.9726	Yes

Table 5.12(Continued)

Item	Factor	Computed Standardised Values(z)	P-Value	Accept H_0 (Yes/No)
3.6	Level of communication within the contractor's organization	1.1855	0.8830	No
3.7	Estimation methods and cost techniques (accuracy and reliability)	0.6889	0.7549	No
3.8	Planning capability and level of resource deployment/ utilization/ optimization	3.5171	0.9998	Yes
3.9	Productivity effects (Managerial, Organizational, labour, Technology)	3.5708	0.9998	Yes
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work	-1.6146	0.0537	No
3.11	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)	-5.5653	0.0002	No
3.12	Record of payments of Sub-contractors,	-2.5661	0.0051	No
3.13	Previous claim records i.e. assessment of " low tender"- " high claims" performance	-4.4405	0.0002	No
3.14	Present claims (size and qty)	-2.3547	0.0094	No
3.15	Accidents on-site record	-5.1377	0.0002	No
3.16	Bond/ warranty arrangements	-5.7678	0.0002	No
3.17	Programming construction work	3.5171	0.9998	Yes
3.18	Previous performance of site management team	0.7513	0.7734	No

Table 5.12(Continued)

Item	Factor	Computed Standardised Values(z)	P-Value	Accept H_0 (Yes/No)
3.19	Number of Sub-contractors	-3.1341	0.0009	No
4.0	**Project Characteristics**			
4.1	Type/ function (residential, commercial, industrial, office)	-1.4926	0.0681	No
4.2	Size/ gross floor area	-1.7359	0.0409	No
4.3	Height/ number of stories, Number of basement levels	2.6239	0.9956	Yes
4.4	Level of certainty of soil conditions	1.9767	0.9761	Yes
4.5	Complexity	3.5708	0.9998	Yes
4.6	Type of structure (steel, concrete, brick, timber, masonry)	1.5536	0.9394	No
4.7	Location (region/ rural; urban) (intercity/ outskirts)	-1.0000	0.1587	No
4.8	Site Conditions/ Site topography	2.6239	0.9956	Yes
4.9	Type of foundations (pile/raft/ pad etc.)	-0.0627	0.2643	No
4.1	Off-site prefabrication	-2.2738	0.0116	No
4.11	Type of cladding and external wall (brick, double glass)	-3.6242	0.0002	No
4.12	Access to site	-0.3763	0.3520	No
4.13	Intensity and complexity of building services	1.9168	0.9726	Yes

Table 5.12(Continued)

Item	Factor	Computed Standardised Values(z)	P-Value	Accept H_0 (Yes/No)
4.14	Phasing requirements (areas to be handed over first or initial non-availability)	-2.1555	0.0154	No
4.15	Quality of finishing	0.7513	0.7734	No
4.16	Construction method/ technology	5.1377	0.9998	Yes
5.0	**Contract Methods and Procurement Procedures**			
5.1	Type of contract/ use of standard form of contract	-1.4315	0.0764	No
5.2	Tender selection method (open, selected, negotiated, single or two-stage)	2.3327	0.9901	Yes
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	1.9767	0.9761	Yes
5.4	Method of procurement (traditional, design and build, project management etc.)	1.7359	0.9591	Yes
5.5	Spread of risk between construction parties(client /consultants /contractors)	-2.6815	0.0037	No
5.6	Claims and dispute resolution methods (litigation/ arbitration/others)	-0.8136	0.209	No
5.7	Interviewing of selected prospective contractors	-5.4821	0.0002	No
5.8	Suitability of project time	0.6889	0.7549	No

Table 5.12(Continued)

Item	Factor	Computed Standardised Values(z)	P-Value	Accept H_0 (Yes/No)
6.0	**External Factors and Market Characteristics**			
6.1	Material prices/ availability/ supply/ quality/ imports.	5.1377	0.9998	Yes
6.2	Labour costs/ availability/ supply/ performance/ productivity.	4.6330	0.9998	Yes
6.3	Plant costs/ availability/ supply/ condition/ performance.	3.6242	0.9998	Yes
6.4	Weather conditions	2.9097	0.9982	Yes
6.5	Government regulations/ policies (health and safety, fire, CDM etc).	-2.9661	0.0015	No
6.6	Level of competition and level of construction activities.	-1.7359	0.0409	No
6.7	Number of bidders on competitive projects.	-3.7827	0.0002	No
6.8	Interest rate/ inflation rate.	2.0961	0.9817	Yes
6.9	Stability of market conditions.	3.1895	0.9993	Yes
6.10	Statutory undertakes (Water, Gas etc.).	-2.7389	0.0031	No

Table 5.13a **Significant Construction Time-influencing Factors Ranked in the Order of Importance within the Corresponding Factor Category.**

Item	Factor	RII	*P-Value*	*Rank*
1.0	**Client Characteristics**			
1.1	Type of Client (Public/ Private/ Developer)	0.7688	0.9998	11
1.2	Financial ability/ payment records	0.8662	0.9998	3
1.3	Project finance method/ appropriate funding in place on time	0.8879	0.9998	1
1.4	Priority on construction time/ deadline requirements	0.7432	0.9998	15
1.5	Experience in procuring construction work	0.6479	0.9535	30
1.6	Possible changes to initial design	0.7693	0.9998	10
2.0	**Consultant and Design Characteristics**			
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)	0.8286	0.9998	4
2.2	Buildability of design	0.7643	0.9998	12
2.3	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)	0.6357	0.9846	31
2.4	Variation orders and additional works (magnitude, timing, interference level)	0.8286	0.9998	5
2.5	Quality of design and specification	0.6786	0.9982	27
2.6	Priority on construction time	0.6714	0.9726	28

Table 5.13a(Continued)

3.0	**Contractors Characteristics, Firm's Ability and Site Management**			
3.1	Management team (suitability, experience and performance)	0.7000	0.9998	21
3.2	Management labour relationships and confidence in workforce	0.6857	0.9998	25
3.3	Financial Capability	0.8000	0.9998	6
3.4	Experience on similar projects	0.6929	0.9998	23
3.5	Current Workload	0.7286	0.9726	17
3.6	Planning capability and level of resource deployment/ utilization/ optimization	0.7643	0.9998	12
3.7	Productivity effects (Managerial, Organizational, labour, Technology)	0.7071	0.9998	19
3.8	Programming construction work	0.7000	0.9998	22
4.0	**Project Characteristics**			
4.1	Height/ number of stories, Number of basement levels	0.7143	0.9956	18
4.2	Level of certainty of soil conditions	0.6500	0.9761	29
4.3	Complexity	0.6929	0.9998	24
4.4	Site Conditions/ Site topography	0.6286	.9956	32
4.5	Intensity and complexity of building services	0.6857	0.9726	26
4.6	Construction method/ technology	0.7691	0.9998	11
5.0	**Contract Methods and Procurement Procedures**			
5.1	Tender selection method (open, selected, negotiated, single or two-stage)	0.6286	0.9901	33

Table 5.13a(Continued)

Item	Factor	RII	*P-Value*	*Rank*
5.1	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)	0.7071	0.9761	20
5.3	Method of procurement (traditional, design and build, project management etc.)	0.6286	0.9591	34
6.0	**External Factors and Market Characteristics**			
6.1	Material prices/ availability/ supply/ quality/ imports	0.8790	0.9998	2
6.2	Labour costs/ availability/ supply/ performance/ productivity.	0.8000	0.9998	7
6.3	Plant costs/ availability/ supply/ condition/ performance.	0.7790	0.9998	8
6.4	Weather conditions	0.7710	0.9982	9
6.5	Interest rate/ inflation rate.	0.7430	0.9817	16
6.6	Stability of market conditions.	0.7640	0.9993	14

Table 5.13b Significant Construction Time Influencing Factors Listed in Order of Decreasing Importance.

Item	Factor
1	Project finance method/ appropriate funding in place on time
2	Material prices/ availability/ supply/ quality/ imports.
3	Clients' Financial ability/ payment records
4	Completeness and Timeliness of project information (Design, Drawings Specifications)
5	Variation orders and additional works (magnitude, timing, interference level)
6	Contractors' Financial Capability
7	Labour costs/ availability/ supply/ performance/ productivity.
8	Plant costs/ availability/ supply/ condition/ performance.
9	Weather conditions
10	Possible changes to initial design
11	Construction method/ technology
12	Type of Client (Public/ Private/ Developer)
13	Buildability of design
13	Planning capability and level of resource deployment/ utilization/ optimization
15	Stability of market conditions.
16	Clients' Priority on construction time/ deadline requirements
17	Interest rate/ inflation rate.
18	Current Workload
19	Height/ number of stories, Number of basement levels
20	Productivity effects (Managerial, Organizational, labour, Technology)
21	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)

Table 5.13b(Continued)

Item	Factor
22	Management team (suitability, experience and performance)
23	Programming construction work
24	Experience in procuring construction work
25	Complexity
26	Management labour relationships and confidence in workforce
27	Intensity and complexity of building services
28	Quality of design and specification
29	Consultants' Priority on construction time
30	Level of certainty of soil conditions
31	Working relationship with Client/ Contractors/ other design team Consultant (Present/Previous)
32	Priority on construction time
33	Site Conditions/ Site topography
34	Tender selection method (open, selected, negotiated, single or two-stage)
35	Method of procurement (traditional, design and build, project management etc.)

APPENDIX B - QUESTIONNAIRE

This questionnaire aims at collecting data to improve the estimation of the duration of building construction projects in Ghana.

Project duration is defined as the elapse of time from the start of the project to completion. This time frame is normally predetermined to provide yardstick for measuring the success of a project. However, this is usually influenced by a number of factors. Research had identified these time influencing factors as listed in Part 2 of this questionnaire. This questionnaire is designed to allow for the ranking of these factors with respect to SPECIFIC PUBLIC BUILDING CONSTRUCTION PROJECTS COMPLETED IN GHANA to reflect the significance of each of these factors to project duration estimation and also provide input for project duration estimation models.

The questionnaire is in two parts. Part 1 is on general information and Part 2 is on construction time influencing factors.

Please tick as appropriate and do not hesitate to provide any information you consider relevant to the success of this research work.

Your contribution by way of responding to this questionnaire will be very much appreciated.

ORGANIZATIONAL INFORMATION

Party (Client, Consultant or Contractor):...

Financial Class (if a contractor):...

Principal Place of Business (Region):...

PERSONAL INFORMATION

Profession (Engineering, Quantity Surveying, Architecture etc.):....................................

Designation:...

Duty:...

PROJECT INFORMATION

Type of Project:...

Intended Duration:....................................Actual Duration:....................................

Region:...District:...

PART 1 – GENERAL QUESTIONS

This part of the questionnaire contains general question on project duration estimation. Please tick as appropriate and any additional information will be much appreciated.

1. **Are you a member of the project management team in your organization?**

Yes ☐ **No** ☐

2. If yes, do you personally take in the estimation of building project duration in your organization?

Yes ☐ No ☐

3. Which of the following planning techniques do you (your organization) employ in determining project duration?

Bar Chart ☐ Network Analysis ☐

Programme Evaluation

and Review Techniques ☐ Precedence Diagram ☐

Please indicate any other(s)...

....

4. Are you involved in the supervision of the projects?

Yes ☐ No ☐

5. If yes, on the average how will you assess the performance of your predetermined project durations?

Good ☐ Fair ☐ Poor ☐ Very poor ☐

Hint: Good = Actual Duration/Predetermined Duration ≤ 1

Fair = 1< Actual Duration/Predetermined Duration ≤ 1.5

Poor = 1.5 < Actual Duration/Predetermined Duration ≤ 2.0

Very Poor = Actual Duration/Predetermined Duration> 2.0

6. If NOT Good, do you think it is due to the effect of construction time influencing factors on the project?

Yes ☐ No ☐

7. If yes, please indicate such factors...

....

....

....

8. **In your opinion, do you think the use of statistical model for determining construction duration could improve project duration estimation?**

Yes ☐ **No** ☐

Please indicate any other approach apart from statistical model...........................

....

PART 2 - Construction Time Influencing Factors

This part of the questionnaire provides some construction time influencing factors which have been identified by earlier researchers. We wish to seek your opinion on the applicability and significance of these factors to a specific public building construction project executed in Ghana. You are hereby provided with five rank categories namely; Not Significant, Slightly Significant, Moderate Significant, Very Significant and Extreme Significant.

Please tick as appropriate with respect to the project you specified on page 1 and do not hesitate to provide any addition factors that you consider relevant for the success of this research work.

The ranks are abbreviated as follows for simplicity.

Not Significant = NS, Slightly Significant = SS, Moderate Significant = MS,

Very Significant = VS and Extreme Significant = ES. Applicable = AP (Indicate Yes/No)

ITEM	FACTOR	AP	RANK				
			NS	SS	MS	VS	ES
1.0	**Client Characteristics**						
1.1	Type of Client (Public/ Private/ Developer)						
1.2	Financial ability/ payment records						
1.3	Project finance method/ appropriate funding in place on time						
1.4	Partnering arrangements						
1.5	Priority on construction time/ deadline requirements						
1.6	Experience in procuring construction work						
1.7	Client requirement on quality						
1.8	Specified Sequence of Completion						

ITEM	FACTOR	AP	RANK				
			NS	SS	MS	VS	ES
1.9	Possible changes to initial design						
2.0	**Consultant and Design Characteristics**						
2.1	Completeness and Timeliness of project information (Design, Drawings Specifications)						
2.2	Buildability of design						
2.3	Working relationship with Client/ Contractors/ other design team Consultants (Previous/ Present)						
2.4	Variation orders and additional works (magnitude, timing, interference level)						
2.5	Quality of design and specification						
2.6	Inspection, Testing and Approval of completed works (toughness/ requirements)						
2.7	Submission of early proposal for costing and cost planning						
2.8	Absence of alterations and late changes to design (no " design-as –we- go" on site philosophy)						
2.9	Provision for ease of communication						
2.10	Priority on construction time						
3.0	**Contractors Characteristics, Firm's Ability and Site Management**						
3.1	Management team (suitability, experience and performance)						
3.2	Management labour relationships and confidence in workforce						
3.3	Financial Capability						
3.4	Experience on similar projects						
3.5	Current workload						
3.6	Level of communication within the contractor's organization						
3.7	Estimation methods and cost techniques (accuracy and reliability)						
3.8	Planning capability and level of resource deployment/ utilization/ optimization						
3.9	Productivity effects (Managerial, Organizational, labour, Technology)						
3.10	Percentage of main contractor's direct work and percentage of sub-contractor's work						
3.11	Number of sub-contractors						
3.12	Mark-up policies and percentage (general and project wise) (special or normal conditions applied)						
3.13	Record of payments of Sub-contractors,						
3.14	Previous claim records i.e. assessment of " low tender"- " high claims" performance						
3.15	Present claims (size and quantity)						

ITEM	FACTOR	AP	RANK				
			NS	SS	MS	VS	ES
3.16	Accidents on-site record						
3.17	Bond/ warranty arrangements						
3.18	CDM regulation awareness						
3.19	Programming construction work						
3.20	Previous performance of site management team						
3.21	Number of Sub-contractors						
4.0	**Project Characteristics**						
4.1	Type/ function (residential, commercial, industrial, office)						
4.2	Size/ gross floor area						
4.3	Height/ number of stories, Number of basement levels						
4.4	Level of certainty of soil conditions						
4.5	Complexity						
4.6	Type of structure (steel, concrete, brick, timber, masonry)						
4.7	Location (region/ rural; urban) (intercity/ outskirts)						
4.8	Site Conditions/ Site topography						
4.9	Type of foundations (pile/raft/ pad etc.)						
4.10	Off-site prefabrication						
4.11	Type of cladding and external wall (brick, double glass)						
4.12	Access to site						
4.13	Intensity and complexity of building services						
4.14	Phasing requirements (areas to be handed over first or initial non-availability)						
4.15	Quality of finishing						
4.16	Construction method/ technology						
5.0	**Contract Procedure and Procurement Methods**						
5.1	Type of contract/ use of standard form of contract						
5.2	Tender selection method (open, selected, negotiated, single or two-stage)						
5.3	Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)						
5.4	Method of procurement (traditional, design and build, project management etc.)						
5.5	Spread of risk between construction parties(client /consultants / contractors)						
5.6	Claims and dispute resolution methods (litigation/ arbitration/others)						
5.7	Interviewing of selected prospective contractors						
5.8	Suitability of project time						

ITEM	FACTOR	AP	RANK				
			NS	SS	MS	VS	ES
6.0	**External Factors and Market Characteristics**						
6.1	Material prices/ availability/ supply/ quality/ imports.						
6.2	Labour costs/ availability/ supply/ performance/ productivity.						
6.3	Plant costs/ availability/ supply/ condition/ performance.						
6.4	Weather conditions						
6.5	Government regulations/ policies (health and safety, fire, CDM etc).						
6.6	Level of competition and level of construction activities.						
6.7	Number of bidders on competitive projects.						
6.8	Interest rate/ inflation rate.						
6.9	Stability of market conditions.						
6.10	Statutory undertakes (Water, Gas etc.).						
7.0	**Additional Factors (Please provide factors you deem relevant)**						

RETURN OF COMPLETED QUESTIONNAIRE

Please return the completed questionnaires to the address below:

Mr. Constance Shine Seshie

Department of Building Technology

K N U S T

Kumasi.

APPENDIX C - INTERVIEW LIST

1. Which of the Parties to construction projects in opinion should estimate project durations and why?
2. Which of the Parties should give the project duration and why?
3. What method do you employ in determining project durations in your organization and why?
4. Does your organization have a planning unit?
5. If No, who performs the planning activities in your organization?
6. Does your organization carry-out site investigation as part of activities for estimating project durations?
7. How often is this done?
8. Does your organization prepare Method Statement as part of activities for estimating project duration and how often?
9. If yes, do you take into consideration the following:
   - Method of performing individual activities
   - The sequence of activities
   - The gang composition and plant combination for each activity
   - The gang/plant output rate on each activity
   - How do you determine the output rates
     1. Use of Experience
     2. Work Study
   - How often do you revise your output rates (Labour and Plant)
10. Do you prepare pretender programmes in your organization for proposed projects.