CONSTRUCTION PLANNING AND SCHEDULING METHODS ADOPTED BY CONTRACTORS IN PREPARING WORK PROGRAMME

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CONSTRUCTION PLANNING AND SCHEDULING METHODS ADOPTED BY CONTRACTORS IN PREPARING WORK PROGRAMME

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A dissertation submitted in partial fulfillment of the
requirements for the awards of the degree of
Bachelor of Science (Construction)

Faculty of Built Environment
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JUNE 2015

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I declare that this thesis entitled "**CONSTRUCTION PLANNING AND SCHEDULING METHODS ADOPTED BY CONTRACTORS IN PREPARING WORK PROGRAMME**" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

To my beloved parents, supervisor and friends
Thanks for supporting, understanding, guiding and encouragement.

Lecturer and staff from Department of Quantity Surveying,
Thanks for giving me guidance and educate me.

I extend my deepest appreciation to each of the above.

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ABSTRACTS

Construction development is a complex process involving multidisciplinary parties and various work stages. Work programme is an important tool for contractors in ensuring efficient and effective project performance. Traditional planning and scheduling methods are commonly used by contractors in preparing the work programme. However, due to the increase in size and complexity of construction projects, coupled with rapid technological change, there has been a shift from the traditional methods to more technology intensive methods. Against this backdrop, the study investigates the current planning and scheduling methods adopted by contractors, factors influencing their choices, and problems encountered in using the various planning and scheduling methods. The questionnaire survey was used for data collection and the respondents are grade G7 contractors. The ranking analysis based on frequency distribution and mean analysis using Microsoft Excel was adopted for descriptive data analysis. The findings show that bar chart is the most popular planning and scheduling method adopted by contractors, followed by the S-curve chart, milestone chart, PDM and CPM in AOA. On the other hand, the LSM, PERT and GERT methods are seldom being adopted by the contractors. Specialist software were the most used in preparing bar chart, milestone chart, CPM in AOA, PDM, PERT and GERT, while the s-curve chart and LSM are mostly prepared using computer spreadsheet system. Microsoft Project is the most used specialist software while Microsoft Excel is the most used computer spreadsheet system. The size and complexity of projects are the most important factors influencing the choice of planning and scheduling methods. Problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. On the other hand, time consuming, the requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software as well as insufficient training are the common problems in using network based methods (CPM in AOA, PDM, PERT and GERT).

ABSTRAK

Pembangunan pembinaan adalah satu proses kompleks yang melibatkan pelbagai disiplin parti dan peringkat kerja. Program kerja adalah satu alat yang penting bagi kontraktor dalam memastikan prestasi projek yang cekap dan berkesan. Kaedah perancangan dan penjadualan tradisional biasa digunakan oleh kontraktor dalam menyediakan program kerja. Walaubagaimanapun, disebabkan oleh peningkatan saiz dan kerumitan projek pembinaan, ditambah pula dengan perubahan teknologi yang pesat, terdapat peralihan penggunaan kaedah tradisional kepada kaedah lebih berintensif. Dengan latar belakang ini, kajian ini mengkaji kaedah perancangan dan penjadualan semasa yang digunakan oleh kontraktor, faktor yang menpengaruhi pilihan mereka, dan masalah yang dihadapi dalam menggunakan pelbagai kaedah perancangan dan penjadualan. Kajian soal selidik telah digunakan untuk pengumpulan data dan responden adalah kontraktor gred G7. Analisis ranking berdasarkan taburan frequensi dan analisis min dengan menggunakan Microsoft Excel untuk analisis data deskriptif. Dapatan kajian menunjukkan carta bar adalah kaedah perancangan dan penjadualan yang paling banyak digunakan oleh kontraktor, diikuti dengan carta s-curve, carta milestone, PDM dan CPM dalam AOA. LSM, PERT dan GERT adalah kaedah jarang digunakan oleh kontraktor. Pakar perisian paling banyak digunakan dalam penyediaan carta bar, carta pencapaian, CPM dalam AOA, PDM, PERT dan GERT, manakala carta s-curve dan LSM kebanyakkan disediakan dengan menggunakan sistem komputer spreadsheet. Microsoft Project adalah pakar perisian yang paling banyak digunakan manakala Microsoft Excel adalah sistem komputer spreadsheet yang paling banyak digunakan. Saiz dan kerumitan projek adalah faktor yang paling penting mempengaruhi pilihan kaedah perancangan dan penjadualan. Masalah yang dihadapi dalam menggunakan kaedah yang tidak berasaskan rangkaian (carta bar, carta s-curve, carta milestone dan LSM) termasuk keperluan untuk maklumat terperinci, perkakasan dan perisian komputer, dan ketidakupayaan untuk mengawal laluan kritikal projek. Sebaliknya, memakan masa, keperluan untuk perancang / penjadual yang pakar dan berpengalaman, maklumat terperinci, perkakasan dan perisian komputer serta latihan yang tidak mencukupi merupakan masalah biasa dalam menggunakan kaedah berasaskan rangkaian (CPM dalam AOA, PDM, PERT dan GERT).

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LIST OF ABBREVIATIONS

ABBREVIATION		FULL NAME
ADM		Arrow Diagramming Method
AOA	-	Activity-On-Arrow
AON	-	Activity-On-Node
BIM	-	Building Information Modelling
CPM	-	Critical Path Method
CIDB	-	Construction Industry Development Board
EOT	-	Earliest Occurrence Time
EFT	-	Earliest Finish Time
EST	-	Earliest Start Time
FF	-	Finish-To-Finish
FF	-	Free Float
FS	-	Finish-To-Start
GERT	-	Graphical Evaluation and Review Technique
ICT	-	Information, Communication and Technology
IF	-	Independent Float
INT.F	-	Interfering Float
IT	-	Information Technology
LOB		Line Of Balance
LOT	-	Latest Occurrence Time
LFT	-	Latest Finish Time
LSM		Linear Scheduling Method
LST	-	Latest Start Time
PDM	-	Precedence Diagramming Method

PERT	-	Programme Evaluation and Review Technique
PMI	-	Project Management Institute
SF	-	Start-To-Finish
SS	-	Start-To-Start
TF	-	Total Float

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Background

Construction industry is a collaborative industry involving a multi-disciplinary team, which includes the owners, architects, engineers, consultants, and contractors (Sun and Aouad, 1999) (Cited by Al-Hussein, 2004). It is also an industry involving various process from early design brief stage to design stage followed by construction stage and lastly to the post practical completion stage (RIBA, 2007). One of the important process that ensure the success of the construction project is planning and scheduling (Gould and Joyce, 2000). Project planning involves the function to establish project activities, their logical relationships and interrelationship to each other and the sequences in which they are to be accomplished. Project scheduling deal with the process of assigning activities duration and identifying the start and completion times of activities. Both process is no doubt important to prepare systematic work schedule during the preconstruction stage which is important in determining the success or failure of the project in relation to time. Complex construction environment significantly make planning and scheduling process more important for the development of more systematic and accurate work programme during the start of construction project (Charoenngam, 1988).

Project planner and scheduler work within the construction industry who are concerned with the project overall work programme. They are involved in the development and construction of residential, commercial, industrial, agricultural, infrastructure work and others. Planners and schedulers are commonly based at the home office but often move to the construction site during the construction stage. The planner and scheduler prepare basic work programme for a particular construction project, advice on the work sequencing in the construction activities, monitor job progress, coordinate subcontractors, analyse the changes and the impact of delays and solve problems (Gould and Joyce, 2000). The traditional form of scheduling method by preparing the Gantt chart (bar chart) is commonly use to prepare construction work programme. However, as the construction project become more complex, critical path method (CPM) proven to be successful planning and scheduling method to prepare systematic schedule in the management for the construction project (Charoenngam, 1988). Different method of planning and scheduling used to prepare work programme have their application and disadvantages. Therefore, the method of planning and scheduling to be used to prepare work schedule for project planning and control commonly depend on characteristic of the project, size of the project, knowledge and level of sophistication user as well as the level of detail information require to monitor the project (Barrie and Paulson, 1992).

Development of information technology (IT) and computer technologies significantly impact the planning and scheduling works. Practically all the construction companies can benefit by learning the use of IT on their project. The availability of computer software become one of the important factor influence the choice of method taken to prepare work programme by the construction contractor. This is because computer specialist software for planning and scheduling works such as Microsoft Project from Microsoft and Primavera P6, Primavera Sure Track from Primavera able to improve and speed up the planning and scheduling process to prepare work programme (Newitt, 2005). Peansupap and Walker (2005) concluded that the use of IT provides the opportunities to improve and enhance the effectiveness of many construction processes. Hence, construction planners and schedulers can also adopt IT and software in planning and scheduling practices to enhance their work.

1.2 Problem Statement

Construction industry is highly dynamic sector and plays a very important role in the development of country and hence in Malaysia, construction industry started a rapid growth since its independence. However, construction industry in Malaysia is facing chronic problems including poor performance of planning and scheduling that had become the main causes of construction project delays. In Malaysia, only 20.5 % of the public sector projects and 33.35% of the private sector projects were completed within the time (Endut et al., 2009) (Cited by Aftab Hameed Memon et.al, 2012). Poor planning and scheduling by contractors is one of the major factors that causes of delay in construction project (Sambasivan and Yau, 2006). Therefore, it is important for the contractors to use the most suitable planning and scheduling methods in preparing their work schedule for better project performance.

Work schedule is a powerful management and communication tool used to ensure the success of the project. Depending on the user's sophistication, different form of planning and scheduling method have been used to prepare the work schedule (Gould and Joyce, 2000). According to Newitt (2005), with increase in size and complexity of project, project planning and scheduling methods become more important. The planning and scheduling work in preparing work programme are commonly based on simple bar chart, critical path method in activity-on-arrow (CPM in AOA) and precedence diagramming method (PDM) while both programme evaluation and review technique (PERT) and linear scheduling method (LSM) is least prefer method use in preparing work programme (Roslan Amirudin, 2012). Beside the traditional bar chart method, CPM in AOA and PDM scheduling method have been the biggest undertaking method to prepare work schedule compared to LSM, PERT, GERT and other method. However, the preparation of the complex CPM and PDM network schedule for large and complex building project could take several weeks without the use of computer specialised software (Gould and Joyce, 2000).

In the last two decades, the construction industry has experienced a surge in developing and applying IT. Thus, IT has been widely used for planning and scheduling application in the late 1980s with rapid expansion in the development of IT application available to all construction professional (Al-Hussein, 2004). There is an increasing trend in the construction industry to use computer software and other high tech software tools in construction project planning and scheduling to prepare work schedule (Mubarak, 2005). Rapid development in IT and the used of planning and scheduling software has led to the use of non-traditional planning and scheduling methods such as CPM and PERT in preparing work programme. Microcomputers and specialized software have become common tools in assisting project managers, planners and schedulers with complex and time consuming calculations involve in determining schedule dates and other information related to the scheduling process (Conlin and Retik, 1997). However, some contractors still lacked up-to-date skills in using the non-traditional planning and scheduling methods in preparing their work programme (Hutchings, 2004). Thus, there is a need to investigate the current method for planning and scheduling work adopted by Malaysian construction contractor in preparing their work programme.

1.3 Research Question

i. What are the planning and scheduling methods adopted by contractors in preparing work programme?

ii. What are the factors influencing their choice of planning and scheduling methods in preparing work programme?

iii. What are the problems encountered in using the chosen planning and scheduling methods to prepare work programme?

1.4 Research Objectives

The objectives of this study are:

i. To identify the planning and scheduling methods adopted by contractors in preparing work programme

ii. To determine the factors influencing their choice of planning and scheduling methods in preparing work programme

iii. To determine the problems encountered in using the chosen planning and scheduling methods to prepare work programme

1.5 Scope and Limitation of Research

This study focus on the Grade G7 construction contractors in Malaysia that are registered with the Construction Industry Development Board Malaysia (CIDB). The respondents of the research are construction personnel involved in the planning and scheduling works to prepare work programme. The focus of the study is on the planning and scheduling methods adopted by contractor in preparing work programme.

1.6 Significance of Research

This study is important to provide an insight on the current planning and scheduling methods adopted by construction contractors in preparing work programme and the problems encountered of using the chosen planning and scheduling methods. Moreover, factors influencing the choice of planning and scheduling methods in preparing the work programme is discussed to identify the criteria of favoured planning and scheduling methods to be adopted for the purpose of preparing work programme. The outcome of this research can be used as a basis for future improvement in the planning and scheduling methods that can be adopted to prepare work programme. At the same time, it provides construction management students and professions the awareness of current planning and scheduling practices adopted by Malaysian construction contractors so that they can prepare themselves for the actual industrial practices.

1.7 Research Methodology

The study strategy undertakes in the study is based on quantitative research. The research design undertakes the survey approach for primary data collection. Questionnaires were designed to collect the necessary information for this research that includes general information of the respondent, types of planning and scheduling methods adopted, factors influencing the choice of planning and scheduling methods and problems encountered in using the chosen planning and scheduling methods. The respondents for this research was the construction personnel involved on the planning and scheduling works to prepare work programme in the grade G7 construction contractors registered with Construction Industry Development Board Malaysia (CIDB). The data collected is analysed using Microsoft Excel in which those data are translated and tabulated into graphical figures, tables and schedules.

1.8 Organisation of Chapters

The study is organised into the following chapters:

i. **Chapter 1:** Introduction. This chapter contain the background of study, problem statement, research question, research objectives, scope and limitation of research, significance of research, research process and organisation of chapters.

ii. **Chapter 2:** Literature Review. This chapter reviews the relevant literature that includes the construction industry, project client, construction contractor, work programme, planning and scheduling, traditional planning and scheduling method, network logic based diagram, non-traditional planning and scheduling method, manual approach for planning and scheduling works, impacts of ICT/IT on planning and scheduling in construction industry, computerization of planning and scheduling works, computer spreadsheets approach for planning and scheduling works, specialist software approach for planning and scheduling works, factors influencing the choice of the planning and scheduling methods in preparing work programme and problems in using the chosen planning and scheduling methods to prepare work programme.

iii. **Chapter 3:** Research Methodology. This chapter describes the research process undertaken that includes the identification of issues and problem statement, literature review, research design, data analysis and conclusion and recommendation.

i. **Chapter 4:** Data Analysis and Findings. The chapter discusses the analysis undertaken and the findings from the analysis The chapter is structured into introduction, questionnaire delivered, location of respondents, position of respondents within the organization, planning and scheduling methods adopted by grade G7 construction contractors, approaches used by contractors in preparing the various planning and scheduling methods, types of computer spreadsheet system used, types of specialist software used, factors influencing the choice of planning and scheduling methods in preparing work programme and problems encountered in using the chosen planning and scheduling methods to prepare work programme.

ii. **Chapter 5:** Conclusion and Recommendations. The chapter describes the conclusion, limitation of study and recommendation for future research.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The construction industry is a very competitive industry and rapid developing industry especially in adopting new technologies (Olodapo, 2006). Construction plan and schedule is a management tool that enables planners, schedulers or other related construction profession to direct the accomplishment of construction projects so as to complete them in a timely and cost effective manner (Willis, 1986). Traditional planning and scheduling methods unable to fulfilled the need of modern project scheduling. Thus, there is a high demand on hiring professional project scheduler with knowledge in computerized scheduling to handle more complex projects (Hutchings, 2004). This chapter discuss the Construction Industry, Project Client, Construction Contractor, Contractor's Project Manager, Construction Manager, Site Engineer, Project Planners and Schedulers, Work Programme, Planning and Scheduling, Traditional Planning and Scheduling Method, Network Logic Based Diagram, Non-Traditional Planning and Scheduling Method, Manual Approach for Planning and Scheduling Works, The Impact of ICT/IT on Planning and Scheduling, Computerization of Planning and Scheduling Works, Computer Spreadsheet Approach for Planning and Scheduling Works, Specialist Software Approach for Planning and Scheduling Works, Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Programme, Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Programme.

2.2 Construction industry

Construction industry is a wide industry that covers all the parties involved in the construction process which includes the contracting industry, the professions and some suppliers who respond to the needs of the client of the industry. The outcome of the construction industry is a large and involve large sum of money and at the same time the construction product generally fixed at one location (Hillebrandt, 1984).

Construction covers many different types of work which are industrial, residential, commercial, retail, health, education, leisure and recreation as well as civil engineering works. Basically, it is the industry that involved the design and construction of buildings, civil engineering and infrastructure work and the material industry. The characteristics of the construction industry are its large size, the influence of government as a client, the high cost of construction items, nature of construction work, variety of construction technology, organisation of the construction process, the time lags involved in construction, and the structure of the construction industry (Ofori, 1990).

Construction industry is a large, dynamic and complex sector that plays an important role in the national economy. The construction industry is a unique industry where the design stage traditionally separate from the construction stage. There are numerous range of activities in respect of the type and size of the projects. In construction industry, government is the major project client in the construction industry who can influence the construction work through commissioning, and indirectly through taxation, grants and legislation (Willis and Ashworth, 1987).

Thus, the construction industry can be concluded as a complex industry that involved a lot of parties and it is industry that supports the economy of a country.

2.3 Project Client

The project client can be individuals seeking a home for their growing family, a large organization responding to a change in technology, a municipality seeking to improve its infrastructure, or a developer working to make money by filling a perceived market need (Gould and Joyce, 2000). In construction industry, project client is the individual, the firm, or the organization that funds the construction project and at last own the completed project (Willis, 1986).

2.3.1 The Construction Industry' Client

The construction industry client can be categorized into public owner and private owner (Gould and Joyce, 2000). The public sector traditionally includes government departments, central government agencies, public utilities, the nationalised industries, the post office, government education institutions, local authorities and housing associations of the country (Gould and Joyce, 2000; Patrick, 2004).

In comparison, for the private sectors, there are many different types of private sector client that possible to describe in broad groups. They are from large industrial, commercial companies, small buildings client that acquiring buildings for their own use, the property developers and the house buyers (Gould and Joyce, 2000).

2.3.2 The Client's Responsibility

The client has a tremendous responsibility to ensure that their project is successfully realized but unfortunately, this is not usually not the case. Much has been writing regarding client responsibility in construction project (NEDO, 1974; CIOB, 1980; CIRIA, 1987) (Cited by Kometa et al., 1995). The degree of involvement and client's responsibility to the construction process depend on the structure of the client's organisation, the client's knowledge and experience of the construction process, the authority vested in the various levels of the client's organisation and the personal characteristics of the client's people who have responsibility for the project (Walker, 2007). An experienced client is one that builds on a regular or continuous basis, for example more than once every 5 years, while inexperienced clients build only once or less every 5 years (Masterman, 1992 and Walker, 1984) (Cited by Kometa et al., 1995).

The important of client responsibilities involve in the construction project are planning or design, project finance, project implementation or management and project definition or formulation, legal agreement, schedule urgency and schedule duration, ensure adequacy of senior management support, implement fiscal policy, safety and employment regulation and contracting (Kometa et al., 1995).

Client is the person who takes a decision in the method of organisation to adopt for their construction and they will be the one who choose the first appointee which is a designer or other professional. Besides that, the function of client is not producing brief of the project, the client also involved in the approval of the design at various stages and ensuring the design and construction is proceeding smoothly. In addition, the construction client responsible to make decision on the contractor selection for the tender project. Lastly, construction client responsibility in the project implementation or management is constantly check on the project progress (Hillebrandt, 1984).

2.4 Construction Contractor

Construction contractor is an expert in the construction industry who hires skilled and unskilled workers to actually construct a financed project. A contractor must be licensed examining board before involve on the project bidding. They are professionals with advanced technical degrees who manage projects with sophisticated means and methods. The construction contractor team which involve on the construction project include project manager, construction manager, site engineer planner/scheduler and others (Wikipedia, 2015).

2.4.1 Contractor's Project Manager

A project manager is the person responsible for the management of all phases for his organisation. In contractor's organization, the contractor's project manager is in complete charge of the project for the general contractor. The contractor's project manager responsibilities include coordination of subcontractors, scheduling, cost control, labour relation, billing, purchasing, expediting and numerous other functions related to the project (Gould and Joyce, 2000). The four main essential skills of a project managers are management knowledge and skill, technical knowledge and skill, business knowledge and skill and human knowledge and skill (Abu Bakar et. al, 2011). For effective project planning and scheduling, project manager responsible for develop a plans that focus on the work to be performed. Moreover, project manager establish project objectives and performance requirements early so everyone involved knows what is required. Project manager also establish clear and well-defined milestones in the project so all concerned will know what is to be accomplished, and when it is to be completed, and when it is to be completed. It also build contingencies into the plan to provide a reserve in the schedule in the schedule for unforeseen future problems. Lastly, in term of communication, project manager responsible to communicate the project plan to clearly define individual responsibilities, schedules, and budgets (Muzani Mustapa, 2013; Abu Bakar et. al, 2011).

2.4.2 Construction Manager

Construction managers are often an important person of construction projects and responsible for construction sites 24 hours a day. Common duties of construction managers include planning, directing, and coordinating activity on construction sites, overseeing project design, hiring and supervising workers, choosing sub-contractors and monitoring supplies. They also responsible for preparing budgets and estimates, reporting progress to clients and complying with legal requirement. In preparing the work programme, project planning and scheduling is one of the important education requirement for professional construction manager (Education Portal, 2015).

2.4.3 Site Engineer

Site engineer perform a technical, organisational and supervisory role on construction projects, setting out and determining the location for above and underground infrastructural installation involved in construction operations. A site engineer works as part of the site management team liaising with working along architects, engineers, construction managers, supervisors, planners, surveyors and subcontractors. In planning and scheduling, site engineer is responsible for efficiently planning the construction works in order to meet agreed deadlines (Agcas, 2013).

2.4.4 Project Planner and Scheduler

Planning and scheduling as well as the career position has evolve within the construction industry because the needs unfulfilled by the traditional planning and

scheduling methods to prepare work schedule (Hutchings, 2004). Construction planner and scheduler in construction project is part of the construction team and can work by any construction professional such as project manager, architect, planning engineer and others who have knowledge in planning and scheduling the construction project (Mubarak, 2005). Planner and scheduler in construction project are separate discipline but linked to each other (Brown, 2011).

Planner in construction creates the plan and figures out how to build project in the most efficient way (Brown, 2011). In construction, a project planner must have a full understanding of what it is they are planning to build, where the project is going to be built and the parameters that control the site (site condition) (Brown, 2011). Scheduler is knowledgeable with the critical path method (CPM) of scheduling and familiar with all the techniques and practices of proper scheduling which involve the proper use of durations, scheduling relationship, lags, constraints and logic to derive the critical path (Brown, 2011).

The planning discipline grow concurrent with the scheduling discipline. Therefore, an effective scheduler is also an effective planner. A planner and scheduler must know the plan and how the activities work in what sequence in order to related to others the impacts of delay to a schedule and create with some other way to recover the lost time (Hutchings, 2004; Brown, 2011). Hence, project planner and scheduler is a sunrise career opportunity on the threshold of a bright and profitable future because the construction is an ever demanding industry and professionals involve on the project production planning and scheduling (Hutchings, 2004).

The basic service provided by the construction planner and scheduler in the construction project are preparing the master work schedule, advice on the work planning and sequencing in the construction activities, monitor job progress, coordinate subcontractor and analyse changes and the impact of delays and solve problem on the delay by come out with some alternatives (Gould and Joyce, 2000).

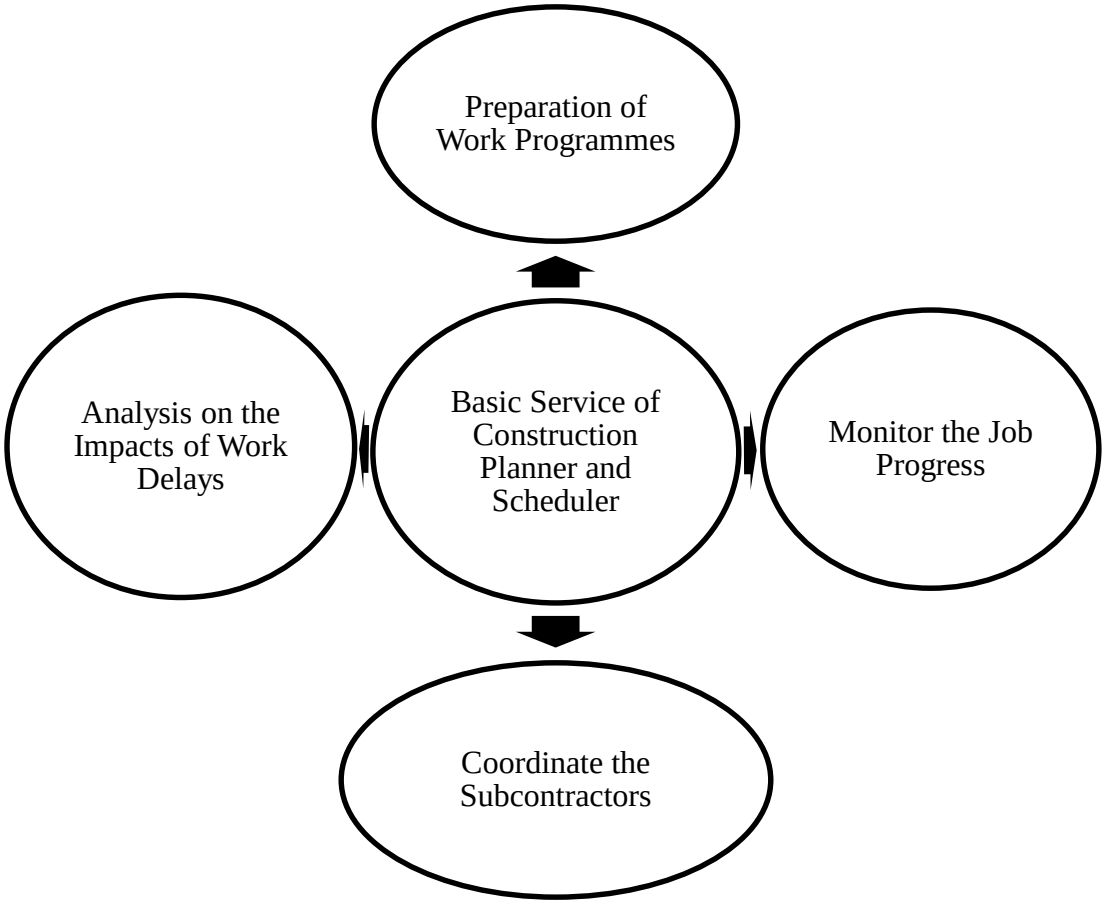


Figure 2.1 Basic Service of Construction Planner and Scheduler

(Source: Adapted from Gould and Joyce, 2000, p 43)

The five fundamental knowledge require for a construction player such as project planner and scheduler are negotiation skills, ethics, leadership, business writing and management organization (Chris Souder and Gier, 2006). The professional skill that includes theoretical knowledge on building construction and civil engineering, knowledge in working the construction sequences in advance such as CPM, PDM, PERT and other methods as well as experience on actual construction work are required for planning and scheduling engineer. Furthermore, the intellectual skill that includes problem judgement, flexibility and imagination require for planner and scheduler to perform their daily task (Dressel, 1968).

2.5 Work Programme

The term work programming is based on the traditional production of graphical, paper based schedule which the term programming now largely replaced by scheduling (Baldwin and Bordoli, 2014). Work programme form the basis of planning and scheduling that not merely a timetable but a detailed schedule dealing graphically with every stage of work (Broughton, 1965). The advance project work schedule is the contractual network diagram of the project's planned activities, their sequence determined by job logic, the contractual time in working days required for completion (activity duration) and the conditions necessary for their completion (specifications) (Hutchings, 2004). It is submitted by the contractor, usually in the form of bar chart supported by CPM network diagrams. It describes the relationship of interdependent activities and duration of each activity involved in the work, together with the overall contract time. The detailed work programme and method statement will be established during the planning stages (Tang et al., 2003).

2.5.1 Category of Work Programme

Planning for the programme of work can be categorised into long term work programme, medium term work programme and short term work programme. The long term work programme is defined as a period extending more than 2 to 3 months into the future, the whole period of which should receive similar detail in the planning process. The medium term work programme is defined as period which extends up to 1, 2 or 3 months in the future, the whole period of which should be receive similar detail in the planning process. Lastly, the short term work programme is a continuous process. It impinges on more people directly that any other form of planning on a project. It is therefore perhaps the most important form of planning on a project (Mawdesley, 1997).

2.5.2 Preparations of Work Programme

The factors that must be considered when preparing the work programme are date of completion of contract, nature of work, particular specification, labour force, provision of plant, limitation of site, time of the year of construction and supply of material. The work schedule actually be prepared by a scheduler assisted by other members of the contractor's staff and sometimes by scheduling consultants. The work programme should be prepared by a person with experiences in construction process and good understanding on the factors to be considered when preparing the work programmes (Tang et al., 2003). The schedule normally prepared in a graphic format, in a tabular format or sometime in both formats (Willis, 1986). The ways to prepare the master work programme involve the coordination between general contractor and sub-contractor (Mubarak, 2005).

Table 2.1 Preparation of Master Work Programme

Preparation	Description
1. Build a master schedule that includes several sub-schedules	The sub-schedule represent the activities for one sub-contractor in the project. The external relationships will show only in the master schedule. The scheduler must consider the external relationship.
2. Include all activities in one schedule and assign responsibility code for contracting party	The scheduler apply a filter to show activities belonging to only one party.

(Source: Mubarak, 2005, p 262 – 264)

Master schedule is not the creation of general contractor. Contracting parties such as subcontractor will create their own schedule and submit to the general contractor which assemble these sub-schedules into one master schedule (Mubarak, 2005).

2.5.3 Purpose of Work Programme

The purpose of using the work programme or schedule which are the schedule generally will improve the communication between the architect and the builder. In quantity surveying field, the schedule also immense help the quantity surveyor in preparing the bill of quantities. The schedule also be utilized in the placement of orders for materials and equipment (Tang et al., 2003).

Lastly, in term of contractual, it is a very important document for supporting contractual claims or disputes. Work programme is a contract document linking the lender, developer, prime contractor and subcontractors. It serves, within the contract specifications, to advise the lender and developer of any unsatisfactory progress in any activity's production, and as a strategy for the prime contractor and activities sub-contractors of the projects they must accomplish within their contractual timeframe (Hutchings, 2004).

2.5.4 Advantages of Work Programme

Broughton (2005) claimed that the several advantages of preparing work programme are:

i. It a part of for competitive tendering which is necessary to show the reasonable duration of the construction process
ii. Reflect the work on the field by providing information on operation times, sequences, gang sizes and short term material and plant requirements
iii. Contribute factual data for use in future planning and scheduling
iv. Show the most expeditious and economical method of carrying out a work

2.5.5 Disadvantages of Work Programme

According to Broughton (1965), there are several objection on preparing the work programme which are:

i. Pre-arranged programme cannot be maintained due to uncertain labour and material supplies
ii. Difficult to understand and explain due to complicate planning and scheduling
iii. Bad weather consistently delay and disrupt the programme
iv. High cost of preparation added charge in the contract
v. Not possible for plan and schedule in early stage of project because details of the work are seldom agreed before the commencement of work in site by the contractor as programme upset by subsequent variation orders

2.6 Planning and Scheduling

2.6.1 Introduction

Planning and scheduling are two terms that are often thought as synonymous. However, they are not. Scheduling is part of the planning effort (Mubarak, 2005). Planning relates to what work is to be done while scheduling relates to when the work is to be done (Spinner, 1997). The scheduling phase begins after completing the project planning process and constructing the planning diagram. Pre-production planning is the process of carefully considering all the activities of the project development as the activities will be group into phases while followed by the production planning scheduling which the steps to accomplish the activities to be determine and layout in a logical production sequence (Hutchings, 2004). The

concurrent effort to plan and schedule cause timing discrepancies and a potential distortion of the project schedule (Spinner, 1997).

Project planning has been defined as "the process of choosing the one method and order of work (activities) to be adopted for a project from all various ways and sequences in which it could be done" (Antill and Woodhead 1990, 8; Callahan, Quackenbush, and Rowings 1992, 2) (Cited by Mubarak, 2005). Project scheduling is the determination of the timing and sequence of operations in the project and their assembly to give overall completion of time (Mubarak, 2005). Gould (2002) further stated the scheduling is the process of listing number of duties or events in the sequence that they will occur. It is timetable, and it formulates the activities that must be accomplished to reach certain goal or objective. Scheduling throughout the project can be divided into three stages which are preconstruction planning, scheduling during construction and post-construction scheduling (Gould and Joyce, 2000).

Planning and scheduling methods to prepare work programme can classified into two ways which are traditional and non-traditional method or network based and non-network based method. Traditional methods includes bar chart, s-curve chart, milestone chart and linear scheduling method (LSM) also known as non-network based methods while the non-traditional methods includes critical path method (CPM) in activity-on-arrow (AOA) network, precedence diagramming method (PDM), programmes evaluation and review techniques (PERT) and graphical evaluation and review techniques (GERT) also known as network based methods (Samdani Saurabh Arun, 2005).

Fundamental of the construction planning and scheduling process is the development of a work programme (Patrick, 2004). Thus, the development of network work programme is the effort from the planning and scheduling process. According to Gould (2000), the seven stages of planning and scheduling process are shown in the following figure below:

1. **Establish objective** – The objective establish must be a specific, measure project goal. The objective should be attainable and fit within corporate goals.
2. **Identify project activities** – Break down the project into definable work activities to attain the objectives. The level of detail is important because the activities must be appropriate for the way which construction manager will manage the project. The activities can be sorted by area, discipline and phase. The Work Breakdown Structure (WBS) involve to breakdown the project and identify the project activities.
3. **Determine the activity sequence** – The order of the activities take place will be determine. It is important to identify the preceding activities and succeeding activities. The more activities that can occur concurrently, the faster the activities to be completed.
4. **Determine activity duration** – At this stage, the normal duration which the duration of activity to be completed in the most effective manner will be determine. The scheduling process will completed and followed by the determining the critical activities.
5. **Perform schedule calculation** – Once the activity durations are determined, the durations of different activity sequences or paths. Activities along the shorter path will have flexibility while activities along the longest path will have no flexibility and known as critical path which determine duration of the project.
6. **Revise and adjust** – Scheduling is an iterative process and normal levels of resources and optimum crew sizes assumed in the first schedule that had been prepared. The first schedule is the most efficient with the least direct cost. However, as the project progress, there are overcommitted resources or an unacceptable completion date, thus the scheduler can make adjustment on the crew sizes or plan over the work to meet project goals. The scheduler can applied crashing to accelerate the work to shorten the duration of the project. It is important step to determine the optimum duration for a project.
7. **Monitor control** – The optimum schedule is the baseline or target schedule for the project and defines when the work begins. The changes is required as the project progress because of scope revision, unforeseen conditions or mistakes. Appropriate adjustments to keep the forecasted completion date. Target or baseline schedule must kept secure and revisions are sequentially labelled.

2.6.2 The Reason of Planning and Scheduling

Mubarak (2005) claimed that planning and scheduling are important for following reasons:

1. **To calculate the project completion date** - In most construction projects, the general contractor (GC), as well as other team members, is obligated to finish the project by a certain date specified in the contract. The contractor has an incentive to finish the project earlier than contractually required. The schedule may show the stage substantial completion, where the owner may start occupying and using the facility while the contractor is still doing some final touches.
2. **To calculate the start or end date** - Specific activities may require special attention such as ordering and delivering materials or equipments. For instance, the project manager may wan special and expensive equipment to be delivered just in time for installation. Long lead items may have to be ordered several month in advance. The work schedule must show such important dates.
3. **To expose and adjust conflict between trades** - The general contractor role mostly to coordinate different subcontractors. The responsibility of the general contractor may be allocate the time of used of tower crane among subcontractors or to just ensure adequate work space is available for all subcontractors. These tasks are in addition to coordinating logical relationship such as when a subcontractor activity depends on the completion of another subcontractor's activity.
4. **To predict and calculate cash flow** - The timing of an activity from the work programme has an impact other cash flow, which may be an important factor for the contractor to consider. The contractor must know the total spending in any time period and might delay the start of certain activities, within available float, to make sure the cash flow does not exceed a certain cap.
5. **To evaluate the effect of changes** - Change of orders are almost inevitable, but well planned projects may have minor change orders. The owners would like to know the effect of changes before authorizing it. This change may be an addition, a deletion, or a substitution. Cost estimators may estimate the cost of change orders, but the schedulers can predict the impact of the change on the entire project schedule. Change may not only affect the time frame but also impact on the overhead cost.

6. To improve work efficiency - By properly distributing workers and equipment, the general contractor can save time and money.

7. To resolve delay claim - Construction delay claims are common. Lawyers often use expert witnesses who are professional schedulers. In most cases, only critical path method (CPM) schedule can prove or disprove a delay claim.

8. To serve as an effective project control tool - Project control must have base with which current performance can be compared. Project controlled can be achieved by comparing the actual schedule and budget with baseline schedule and budget subject.

2.7 Traditional Planning and Scheduling Method

Traditional methods is also known as non-network based methods (Samdani Saurabh Arun, 2005). Non-network based planning and scheduling methods such as bar chart, s-curve chart, milestone chart, linear scheduling method (LSM) commonly lack of interrelationship between activities and thus it is often difficult to control the large and complex project (Hinze, 2008). The following will discusses four types of traditional planning and scheduling method to prepare work programme:

2.7.1 Bar Chart

Bar chart is a graphical representation of project activities shown in a time-scaled bar line with no links shown between activities (Popescu and Charoenngam 1995, 1996) (Cited by Mubarak, 2005). It is the most familiar methods for presenting the work plan by listing activities and identify a time for each activity to start and a time for activity to finish (Baldwin and Bordoli, 2014). The bar chart was originally developed by Henry L. Gantt in 1917 and is alternatively called a Gantt chart

(Mubarak, 2005; Patrick, 2004). Bar chart can easily show the important facts of the project that includes the planned overall length of the project, the planned duration of each project component and the calendar start and finish dates for each project phase (Gould, 2002). Thus, bar charts method still important and best used with network based method such as CPM in preparing work programme (Mubarak, 2005)

Advantages of using bar chart method are simplicity and ease preparation of the bar chart, easy for understanding on the project scheduling as bar chart are uncomplicated and simple to interpret and bar chart particularly appeal to persons who do not have technical background. Therefore, bar charts have become the accepted method for communication of the project plan for over 100 years (Baldwin and Bordoli, 2014). Disadvantages of using bar chart in planning and scheduling to prepare work programme are bar chart does not automatically show the effects of changes, bar chart does not show the critical activities that determine the completion date of the project and as well as it is very difficult with bar chart to see the effects of a change and whether or not a potential change will affect the project completion date (Newitt, 2005; Baldwin and Bordoli, 2014). The major limitation of the bar chart is that interdependencies between activities cannot be shown and thus bar charts cannot be used to determine specific project activity start dates, completion dates and available float time (Gould, 2000; Baldwin and Bordoli, 2014; Patrick, 2004).

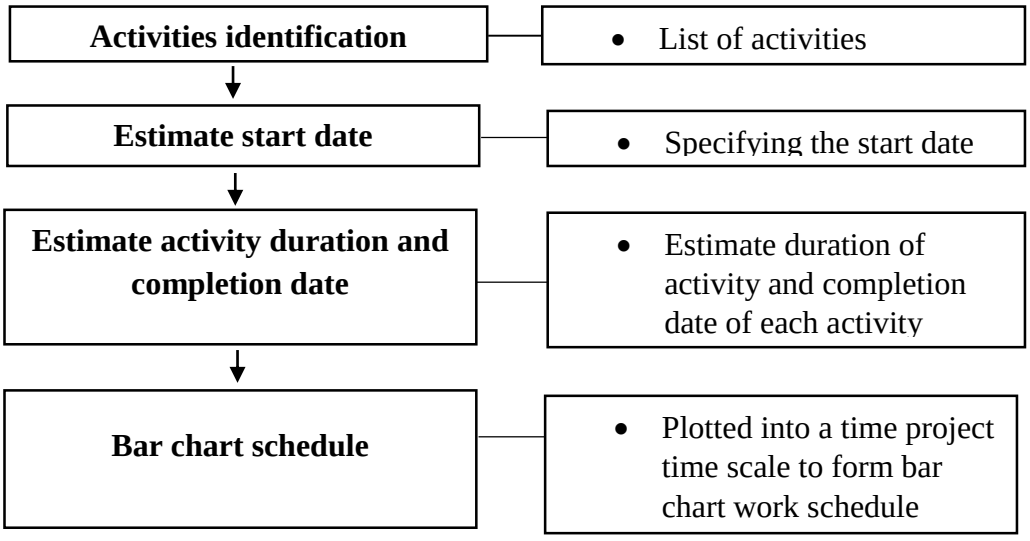


Figure 2.2 Steps to Prepare Bar Chart Schedule

(Source: Baldwin and Bordoli, 2014, p 55 - 56)

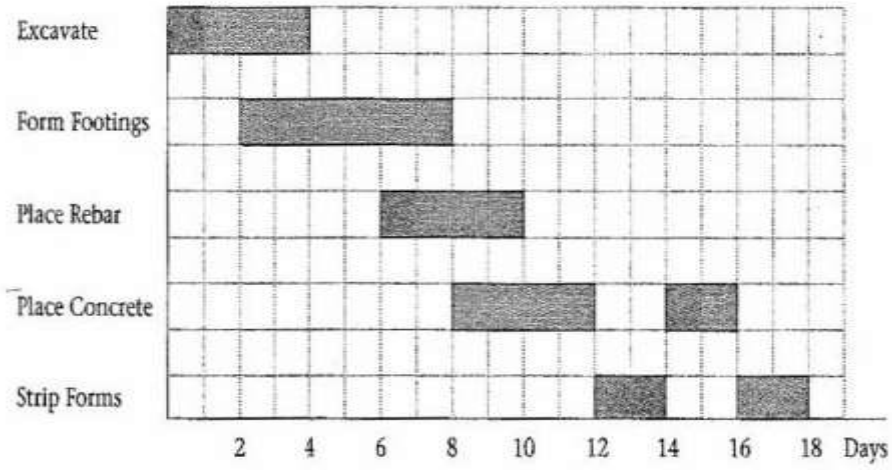


Figure 2.3 Simple Bar Chart
(Source: Saleh Mubarak, 2005, p 11)

2.7.2 S-Curve Chart

S-curve chart is the extension to the traditional bar chart system that lack of interrelationship float capability by adding the timeline momentum to the bar charts (Hutchings, 2004). This chart also known velocity chart. It is a scheduling method that shows the relationship between time and output of a construction project in a straightforward and simple way (Fisk, 1982). S-curve chart with two lines show the established schedule of total tasks and activities graphically with the actual work progress along the project progress (Hutchings, 2004). The slope of the production line from traditional S curve allow user to determine at a glance whether a project proceeding on schedule or whether it is behind schedule but catching up or falling further behind schedule (Fisk, 1982). S-curve chart more advantageous than the bar chart by providing more scheduling control over subtasks within activities because S-curve charts are structured with a one week timeline that open up the detail of the sub-task for better control (Hutchings, 2004). Moreover, the chart show interrelationship of sequential and parallel activities more clearly than traditional bar charts (Hutchings, 2004). However, the S-curve chart only suitable for smaller construction project that linear in nature and it does not provide time-scale manipulation (Hutchings, 2004; Fisk, 1982).

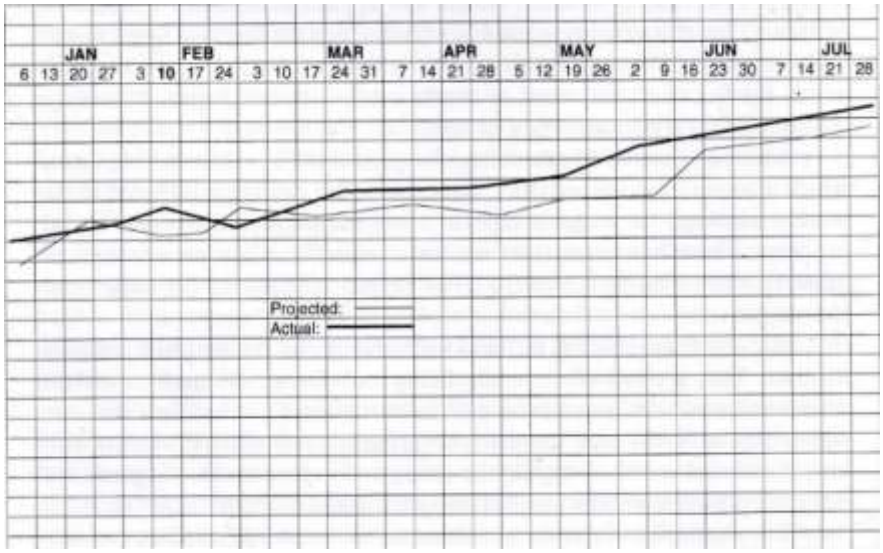


Figure 2.4 S-Curve Chart

(Source: Hutching, 2004, p 100)

2.7.3 Milestone Charts

Milestones are points in time that have been identified as being important intermediate reference points during the accomplishment of the work (Clough et. al, 2000). The milestone event is referred to either the start of an event or completion of event (Clough et. al, 2000; Rajiv Gupta, 2008). The managers find difficulty to keep track of all details of the construction task especially on large complex project that involved hundreds and even thousands of activities (Rajiv Gupta, 2008). Therefore, on large projects, contractors frequently establish a series of milestones extending throughout the project and use these as reference points for project monitoring (Clough et. al, 2000). Milestones can indicate on bar chart or project network using any symbol desired (Clough et. al, 2000; Rajiv Gupta, 2008). Milestone chart important to be developed in order show to the top management on the important events (Rajiv Gupta, 2008).

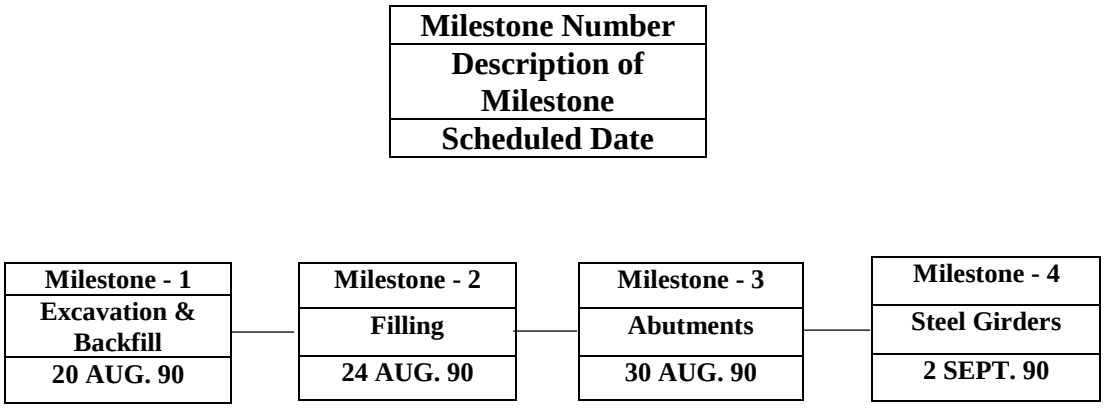


Figure 2.5 Milestone Symbol and Milestone Chart
(Source: Adapted from Rajiv Gupta, 2008, p 102)

2.7.4 Linear Scheduling Method (LSM)

Linear scheduling method (LSM) have not been applied widely to construction projects even though they have been identified as very useful (Thiruvengadam, 2004). LSM is a method of planning and scheduling that is very effective for repetitive work that involve tall buildings (floors are identical), housing projects (identical houses or buildings), highway construction (projects are divided into sections) and others (Roslan Amiruddin, 2012). LSM also known as line of balance (LOB) method which commonly used in manufacturing industry to prevent delays or bottleneck (Hinze, 2008).

The principles of using the LSM for construction project work schedule are the method summarise a group of similar activities onto one line, the method shows the rate at which the work that makes up all of the activities has to be undertaken to stay on schedule and lastly the method show the relationship of one group of activities to the subsequent group and if one group is running behind schedule, it will impact on the following group (Roslan Amirudin, 2012).

LSM require the planner and scheduler to understand the rate of handover of the construction unit to clients and work gang production rates. It is less complex that the CPM (Baldwin and Bordoli, 2014). Harmelink and Rowings (1998) (Cited by Thiruvengadam, 2004) however have explained the shortage of LSM computer applications is that LSM typically has been regarded as a visual technique lacking the analytical qualities of CPM.

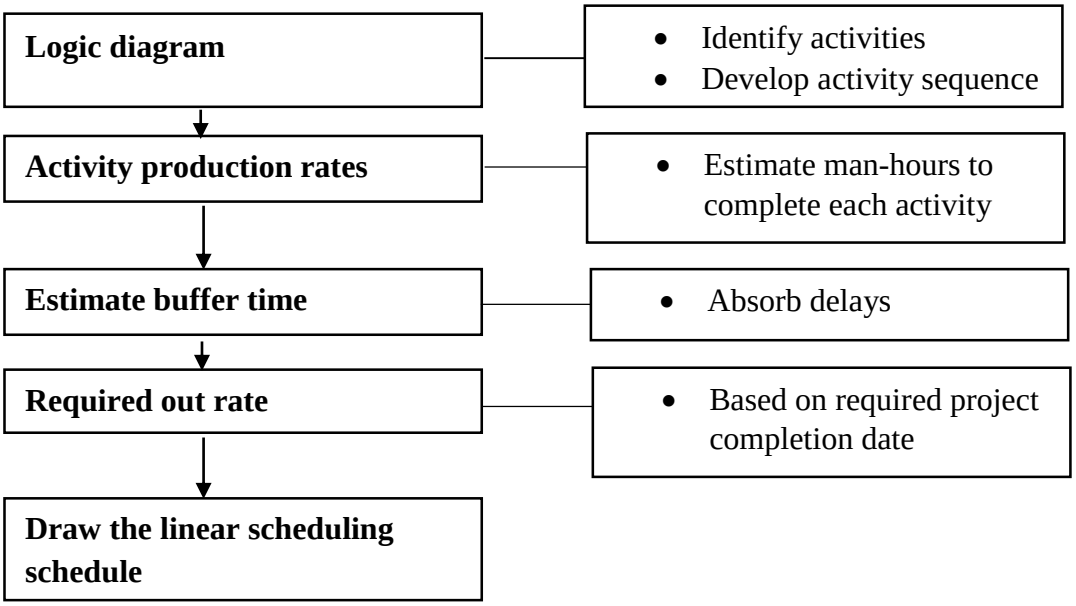


Figure 2.6 Steps to Prepare Schedule from Linear Scheduling Method (LSM)

(Source: Roslan Amiruddin, 2012, p 4 -7)

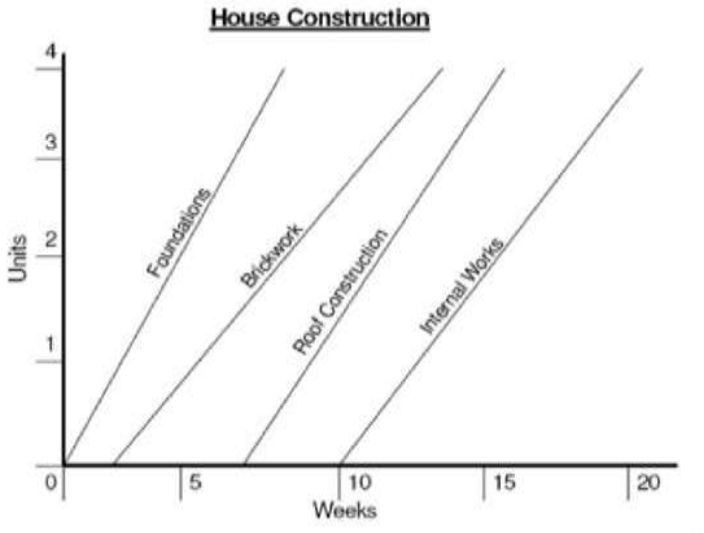


Figure 2.7 Simple Linear Scheduling

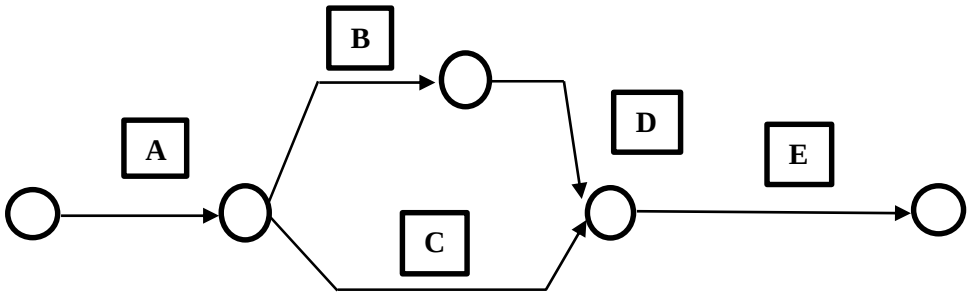
(Source: Roslan Amiruddin, 2012, p 2)

2.8 Network Based Diagramming

Network logic based diagram is the graphical representation of a detailed project plan where it is illustrated the job logic and basic sequencing (Hildreth and Munoz, 2005). In general, a network logic based diagram shows the 'big picture', what is going to happen and in what order (Hildreth and Munoz, 2005). It is an accurate, efficient and reliable method to prepare work schedule (Hildreth and Munoz, 2005). Willis (1986) claimed that the two basic types of logic network diagrams used in prepare the network based schedule are Activity-On-Arrow (AOA) and Activity-On-Node (AON).

2.8.1 Activity-On-Arrow (AOA) Network

Activity-on-arrow (AOA) network is a network showing activities on arrows between nodes which are events representing instants in time (Willis, 1986; Patrick, 2004; Mubarak, 2005). The activities description is located on the arrow. Used to model that one activity cannot start until other have finished (Mubarak, 2005).



Notes:

A predecessor to B and C — B and C successor to A

B predecessor to D — D successor to B

Figure 2.8 Simple Activity on Arrow Network

(Source: Mubarak, 2005, p 21)

There are dummies activities which an activity inserted in an arrow network to maintain proper logic or distinguish activities identities (Willis, 1986; Patrick, 2004). However, the dummies complicate the schedule which main disadvantages on arrow network. Willis (1986) further stated activity-on-arrow network is redundant.

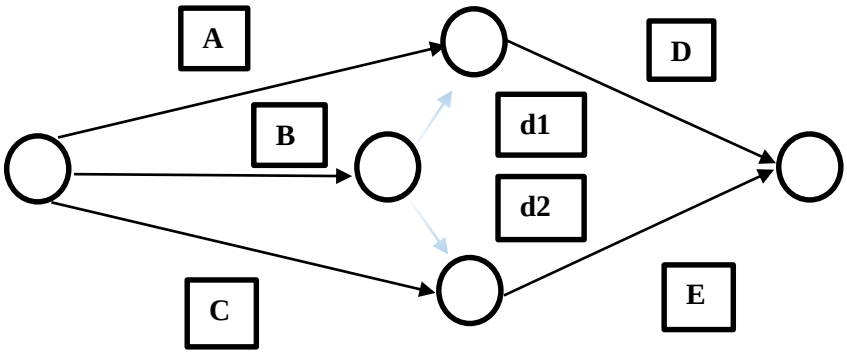


Figure 2.9 Dummies Activities in Activity-On-Arrow Network
(Source: Mubarak, 2005, p 26)

2.8.2 Activity-On-Node (AON) Network

Activity-on-node (AON) network is a network shows activities in boxes (or nodes) linked together with arrows representing the logical relationships between activities (Willis, 1986; Patrick, 2004; Mubarak, 2005). The activities description is located at the activity box. Basic node network often start with one node (project start) and end it with one node (project finish). The network form the basis for precedence diagramming method (PDM) (Mubarak, 2005).

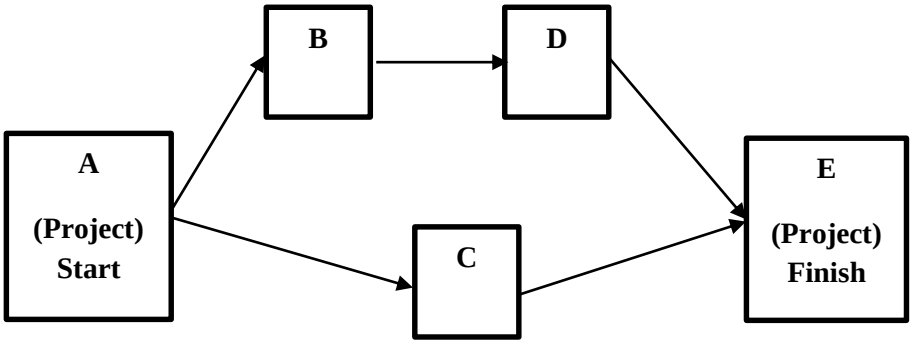


Figure 2.10 Simple Activity on Node Network

(Source: Mubarak, 2005, p 29)

2.9 Non Traditional Planning and Scheduling Method

Non-traditional methods is also known as network based methods which is the modern methods (Samdani Saurabh Arun, 2005). Network based planning and scheduling methods that include critical path method (CPM) in activity-on-arrow (AOA) network, precedence diagramming method (PDM), programme evaluation and review technique (PERT) as well as graphical evaluation and review technique (GERT) are all involve the preparation of logic network diagram, show interrelationship between activities and separate planning and scheduling into two separate phase in preparing the work programme (Willis, 1986; Samdani Saurabh Arun, 2005). Thus, the following will discusses four types of non-traditional planning and scheduling method to prepare work programme.

2.9.1 Critical Path Method (CPM) in Activity-On-Arrow (AOA) Network

Critical path method (CPM) is based on the establishment of logical relationships between tasks or activities (Willis, 1986; Roslan Amirudin, 2012). CPM in activity-on-arrow (AOA) network is the first network diagramming technique to be use for CPM and thus CPM in Activity-On-Arrow (AOA) network commonly known as Arrow Diagramming Method (ADM) (Hutchings, 2004). It involve the CPM computation and graphically present in activity-on-arrow (AOA) network. CPM prescribes the project modelling process where activities are defined, sequenced, and diagrammed and where duration are assigned and the schedule is calculated (Patrick, 2004). CPM permit the scheduler to compute the critical path through a logic diagram which represent the project (Willis, 1986). The chain of activities require the longest time to complete is critical path (Patrick; 2004; Kelley, 2013). The critical path passes through tasks that must be completed on schedule (Willis, 1986). In theory, the delay in critical path will delay the project completion. All activities not on critical path are non-critical and have some level of flexibility or float (Patrick, 2004).

Purpose of using the CPM in activity-on-arrow (AOA) network for planning and scheduling works to prepare work programme are to show the construction logic, identifies the critical activities, determine the effects of change orders or delays, adapts to any project (simple or complex), easy to follow visually, analysis of different methods or sequences of construction, useful for court cases and create teamwork (Newitt, 2005). CPM is well established, with little variation in the use of convention (Willis, 1986).

CPM in activity-on-arrow (AOA) network is easily to be learned (Willis, 1986). However, the disadvantages of CPM in activity-on-arrow (AOA) network in preparing the work programme is the inability of the single logical relationship (finish to start relationship) to express all the various complex relationships that exist in the real world of project management (Willis, 1986).

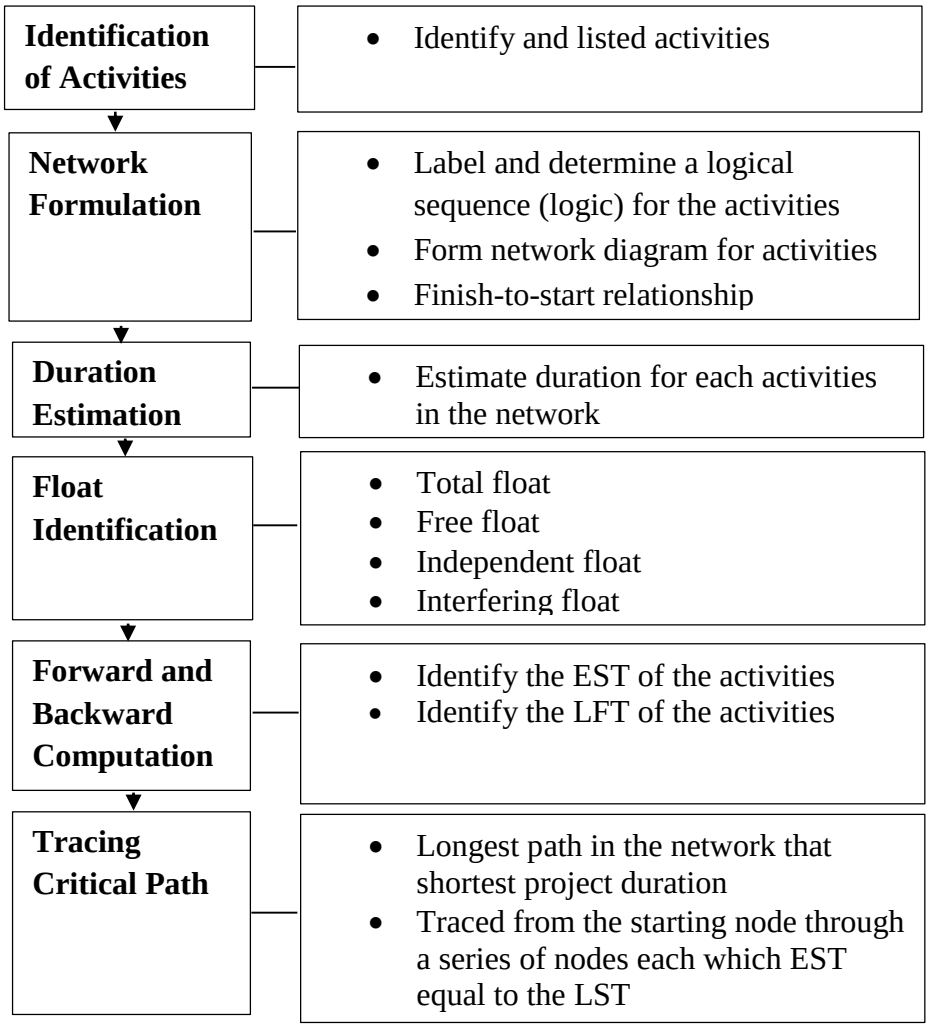


Figure 2.11 Steps in Construct Critical Path Method (CPM)

(Source: Adapted from Tang, 2003 and Harris, 1983)

Act.	Dur (days)	Activity Time (days)				Float (days)				Remarks
		EST	EFT	LST	LFT	TF	FF	IF	INT.F	
A	2	0	2	0	2	0	0	0	0	Critical
B	3	0	3	6	9	6	6	6	0	
C	7	2	9	2	9	0	0	0	0	Critical
D	2	2	4	10	12	8	0	0	8	
E	2	4	6	12	14	8	8	0	0	
F	5	9	14	9	14	0	0	0	0	Critical
G	3	9	12	10	13	1	0	0	1	
H	1	12	13	13	14	1	1	0	0	
I	4	12	16	16	20	4	4	3	0	
J	6	14	20	14	20	0	0	0	0	Critical

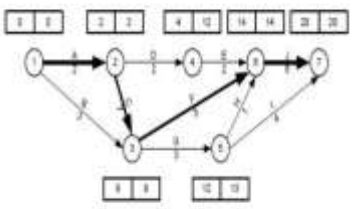


Figure 2.12 CPM Computation in Activity-on-Arrow (AOA) Network

(Source: Roslan Amirudin, 2012, p 8)

2.9.2 Precedence Diagramming Method (PDM)

Precedence diagramming method (PDM) is an extension to activity-on-node (AON) networks using four different types of connection between the start and finishes of the activities (Mubarak, 2005). PDM activities are represented by boxes connected by lines that indicate the work flow (Hutchings, 2004; Kelley, 2013). PDM is an alternative approach to AOA network to prepare CPM in activity-on-arrow (AOA) network (Hinze, 2008). In the preparation PDM, PDM follows the same steps of the CPM in activity-on-arrow (AOA) network with slight variation to suit activity-on-node (AON) network (Roslan Amirudin, 2012). The slight variation of PDM to the CPM in activity-on-arrow (AOA) network are PDM allow to specify more complex relationship between construction tasks with the use of four types of relationships which are finish-to-start (FS) relationship, start-to-start (SS) relationship, finish-to-finish (FF) relationship and start-to-finish (SF) relationship (Willis, 1986; Mubarak, 2005).

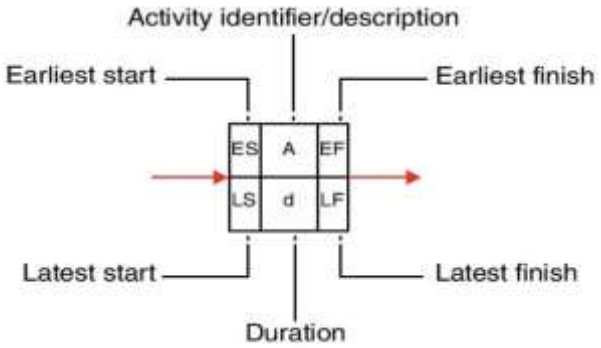


Figure 2.13 Boxes Representing Activities in Precedence Diagramming Method (Source: Baldwin and Bordoli, 2014, p 64)

PDM relationships show lead time and lag time. Lead time show the relationship where an activity cannot finish until a specific amount of time after another activity finishes while lag time creates a relationship where one activity cannot start until a specific amount of time after another activity has started (Kelley, 2013).

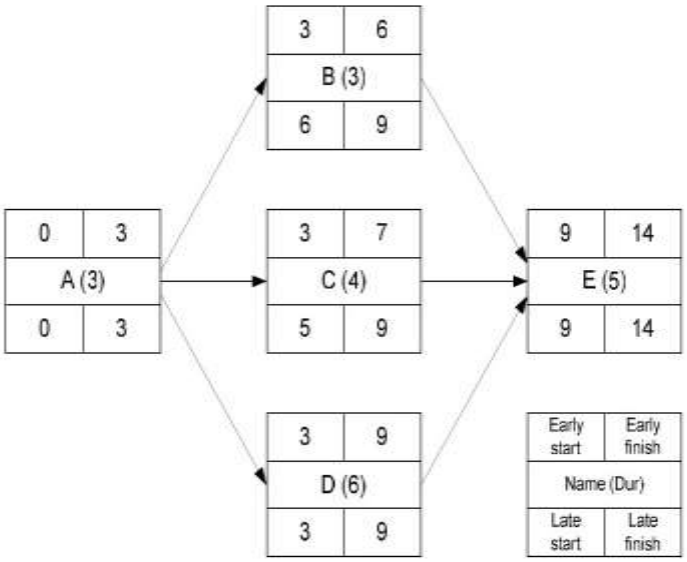
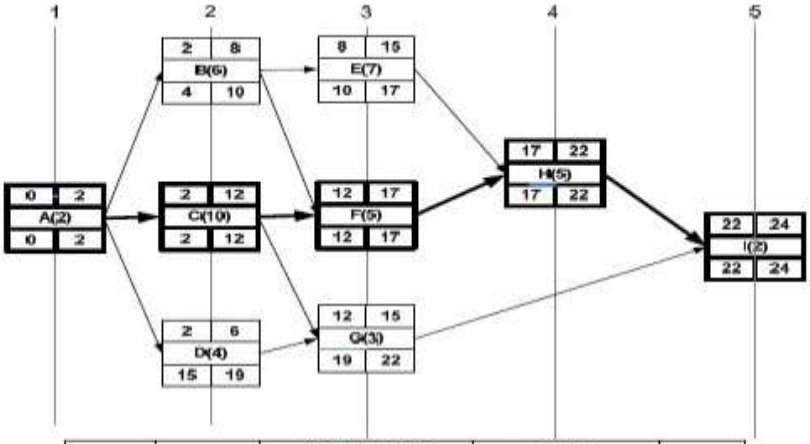


Figure 2.14 Simple Precedence Network with Nodes

(Source: Roslan Amirudin, 2012, p 1)



Activity	Duration	Activity Times				Floats				Note
		EST	EFT	LST	LFT	TF	FF	IF	Int.F	
A	2	0	2	0	2	0	0	0	0	Critical
B	6	2	8	4	10	2	0	0	2	
C	10	2	12	2	12	0	0	0	0	Critical
D	4	2	6	15	19	13	6	6	7	
E	7	8	15	10	17	2	2	0	0	
F	5	12	17	12	17	0	0	0	0	Critical
G	3	12	15	19	22	7	7	0	0	
H	5	17	22	17	22	0	0	0	0	Critical
I	2	22	24	22	24	0	0	0	0	Critical

Figure 2.15 CPM Computation in Precedence Network

(Source: Roslan Amirudin, 2012, p 13)

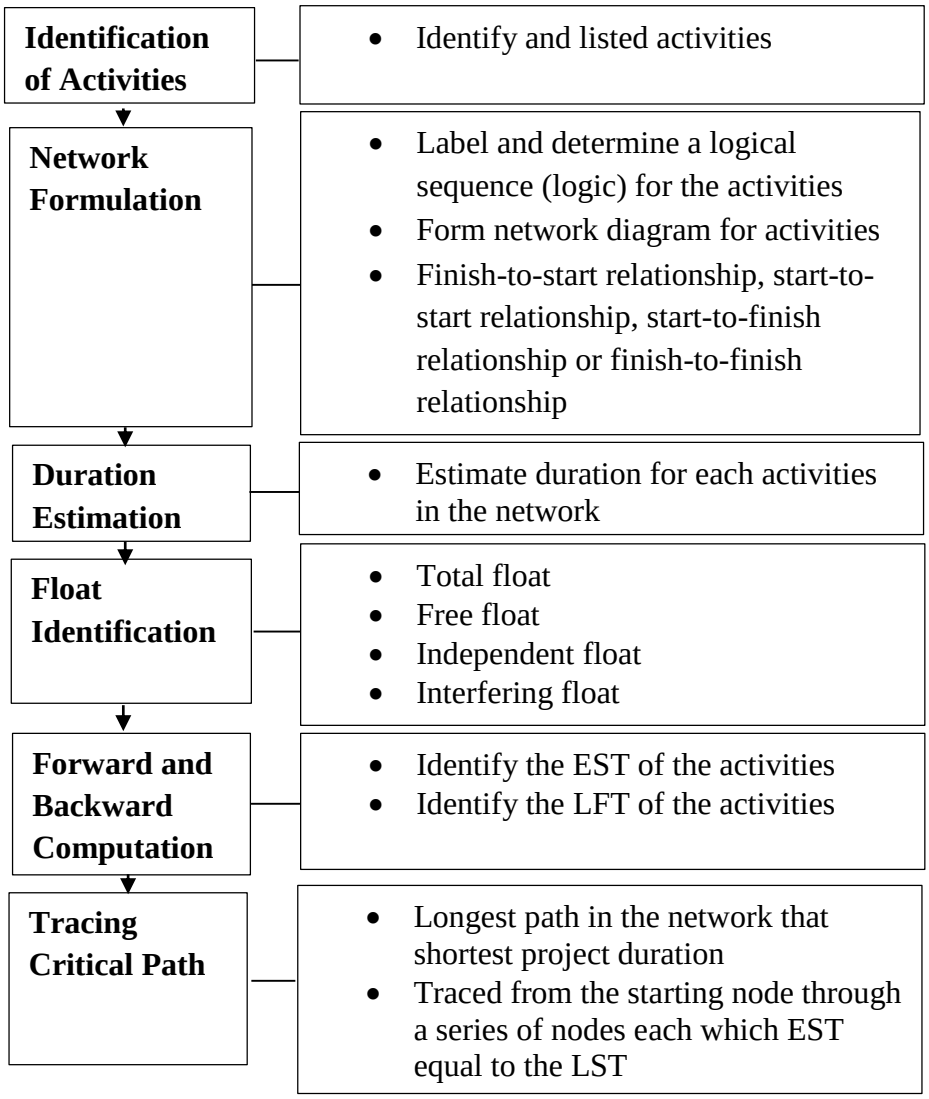


Figure 2.16 Steps to Construct Precedence Diagramming Method (PDM) (Source: Adapted from Tang, 2003 and Harris, 1983)

Advantages of using PDM which are it allows the scheduler to depict complex relationship between the tasks that make up project, fewer restrictive conventions than does the CPM in activity-on-arrow (AOA) network and permits the drafting of more compact logic diagrams that does the CPM in activity-on-arrow (AOA) network. However, disadvantages of using PDM are the network is not well established as the CPM in activity-on-arrow (AOA) network, complex logical relationship (Willis, 1986). However, the method had gained popularity because of the availability of software which make it very easy to use and which represents complicated dependencies between activities more easily (Hinze, 2008).

2.9.3 Programme Evaluation and Review Technique (PERT)

Programme evaluation and review technique (PERT) is an event oriented network analysis technique used to estimate project duration when individual activity duration estimates are highly uncertain (Mubarak, 2005). PERT applies the CPM to a weighted-average duration estimate (Mubarak, 2005). PERT is considered a probabilistic or stochastic method, which requires duration frequency distribution for each activity (Mubarak, 2005; Willis, 1986). There are three range of durations which are optimistic duration, most likely duration and pessimistic duration that constitute that treat as a normal distribution to produce the statistical mean and variance for the duration of activity (Mubarak, 2005; Willis, 1986).

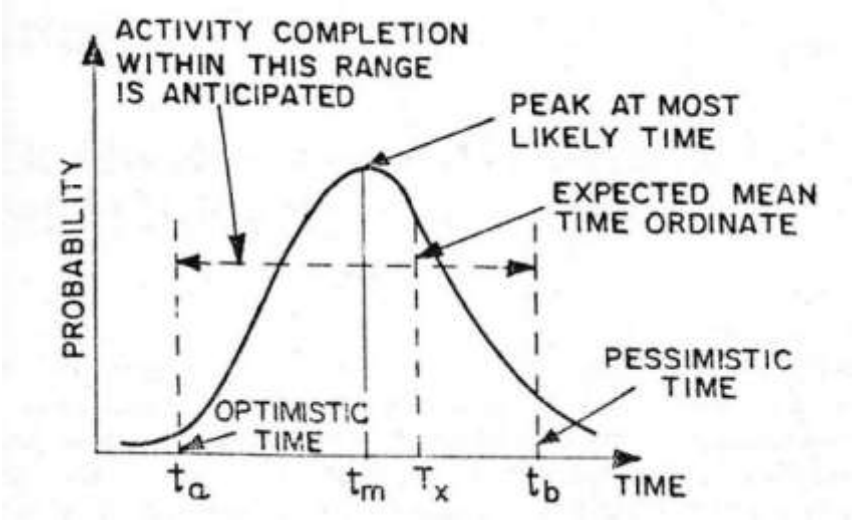


Figure 2.17 Graph between Probability and Time

(Source: Rajiv Gupta, 2008, p 111)

PERT method permit calculation of the probability of completing the project times (Willis, 1986; Mubarak, 2005). PERT has its disadvantages as well. Only simple dependencies can be handled. The tasks are carried out parallel to each other normally, which requires the definition of more complex relationships (Bokor et. Al, 2011). Dawson and Dawson (1998) (Cited by Thiruvengadam, 2004) found that the standard planning and scheduling methods such as PERT and the popular software tools that support them, are inadequate for projects involving uncertainties in the project direction and task durations.

2.9.4 Graphical Evaluation and Review Technique (GERT)

Graphical evaluation and review technique (GERT) is a network analysis technique that allows both conditional and probabilistic treatment of logical relationships (Project Management Institute, 2000) (Cited by Mubarak, 2005). Similar to CPM and PERT, GERT involves the basic concepts of network scheduling including the use of arrows and nodes to prepare work programme (Rajiv Gupta, 2008). GERT show two type of branching which are deterministic and probabilistic branching and incorporates both in the network analysis (Mubarak, 2005).

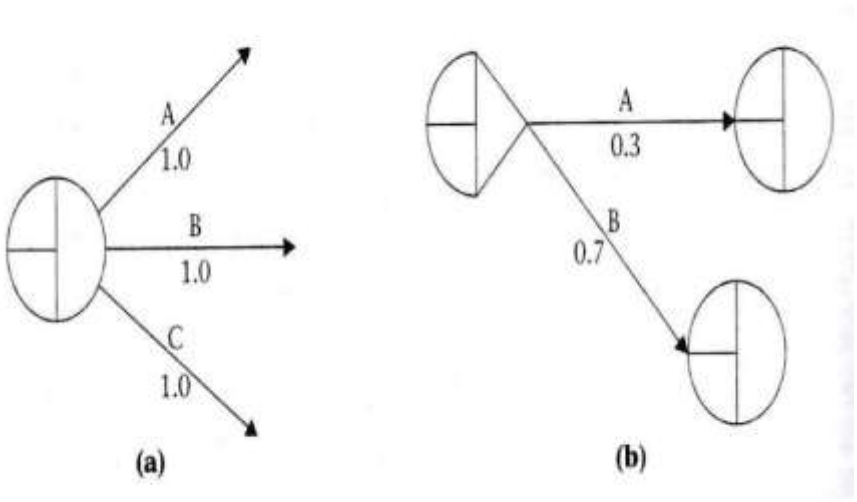


Figure 2.18 (a) Deterministic and (b) Probabilistic Branching
(Source: Saleh Mubarak, 2005, p 292)

GERT involves the uses probabilistic nodes and combination deterministic and probabilistic nodes that allow GERT to applicable in many diverse fields (Rajiv Gupta, 2008). The different between GERT to CPM and PERT is that GERT allows looping where both CPM and PERT do not allow (Rajiv Gupta, 2008). However, GERT has not gained popularity in the construction industry (Mubarak, 2005).

2.10 Manual (Free Hand) for Planning and Scheduling Works

Implementation of traditional and non-traditional method to prepare work programme are manually prepared by handwritten approach before introduction of computer spreadsheet system and specialist software in the preparation of work schedule (Hutchings, 2004). As project become complex, manual approach with methods to prepare work schedule is time consuming and often difficult (Hinze, 2008). However, manual approach in planning and scheduling works is still widely used although there is computer applications to job management. Manual approach in planning and scheduling work rely on hand methods for limited portions of a project and to carry out computations for making quick checks, to determine the effect of changes, or to study a specialized portion of the work. The objective of manual approach in planning and scheduling works involve developing a thorough understanding of the procedures involved and the significance of the project time data generate (Clough et al., 2000).

In term of CPM and PDM network based schedule computation, the approach involved repeatedly performing manual computation calculation of several kinds of network based planning and scheduling tools such as CPM, PDM, PERT, GERT and others by hand (Clough et al., 2000). It involve the use of tabular calculation sheets before replace by computerized spreadsheets and the calculation moved from one calculation to another, making subjective decisions and modifying data when required (Naylor, 1995). However, as the project increase in size and complexity, the manual calculation effort can be time consuming and lack of accuracy (Hinze, 2008). Manual approach for planning and scheduling works to prepare work programme involve manual process by free hand to identify project activities, determine activity sequence, determine activity duration, perform schedule calculation, draw and prepare the work programme. In conclusion, manual (free hand) approach can be used in preparing bar chart, s-curve chart, milestone chart, LSM, CPM in AOA, PDM, PERT and GERT for planning and scheduling work.

2.11 Impacts of ICT/IT on Planning and Scheduling in Construction Industry

ICT is improving the quality of professional services in the construction industry and its impact on the professional practice is mainly the jobs of professionals easier, facilitating in decision making and reduce the overall costs (Olodapo, 2006). IT in construction has been mainly used for planning and scheduling up to the late 1980s (Cutting – Decelle et al, 1997) (Cited by Al- Hussein, 2004). Task in project management that include planning, scheduling and performance-measurement aspects have been largely computerized (Hutchings, 2004). The development of ICT with the use of Building Information Modelling (BIM) have the ability to link elements and quantities from the computer model to project management software such as Microsoft Project and others to introduce the dimension of time and generate simulations showing the construction would proceed the throughout the duration of the project (Baldwin and Bordoli, 2014). However, Chiocchio et al. (2006) found that people in the construction industry still prefer manual approach in their working and lack of IT adoption.

2.12 Computerization of Planning and Scheduling Works

Manual or formal planning and scheduling mechanism to prepare work programme can be time consuming and labour intensive when the complexity of work tasks is high and the coordination of a multiplicity of different operative and trades are required. Many of the practical problems associated with formal or manual scheduling mechanisms can be overcome by computerisation of the planning and scheduling duties (Conlin and Retik, 1997). The computation of activity times in preparing work schedule can be done by computer other than manually by hand (Clough et. al., 2000). The work programme normally takes hours complete if done manually by hand, can be accomplished in seconds by computer programs incorporating program logic (Hutchings, 2004).

The advantages of the computerized approach for planning and scheduling works in preparing the work programme are:

i. It able to handle very rapidly the time and cost schedule calculations for a project that normally would require many more labour-hours if calculation were done manually (Spinner, 1997).
ii. It handle accurately countless computation calculation that if done manually, would be subject to error and would require time to find and correct (Spinner, 1997; Clough et. al, 2000; Patrick, 2004).
iii. The computation calculations can be displayed graphically in the form of project network or in the form of tabular reports (Clough et. al, 2000).
iv. Make project updating for control purposes effective as well as reduce the time consuming and excessive costs of manual report preparation (Spinner, 1997).
v. Generate print project status reports in many varied readable format (Spinner, 1997).
vi. Capacity to sort information in terms of specific activities, spans of time, physical location of site, area of responsibility, or other desired criteria (Clough et. al, 2000).

In market there are a lot of planning and scheduling specialist software program can be used to prepare work programme that have developed specifically for construction industry such as Microsoft Project, Primavera Project Planner, Sure Track Project Manager, Artemis and others (Clough et.al, 2000; Patrick, 2004). As a result, work programme for most complex construction projects and many simple ones are created using computer with high tech spreadsheet system or specialized software (Hinze, 2008).

2.13 Computer Spreadsheets System for Planning and Scheduling Works

A spreadsheet display is a grid of horizontal rows and columns set up on the screen. The grid locations are referred to by row numbers and column letters and may termed 'cells' (Cooke and Balakrishnan, 1985). In preparation for the work programme, computer spreadsheet program such as Microsoft Excel is an excellent spreadsheet program that will help in the creation of bar charts. Basically, enter the dates across the top of the spreadsheet. Next, enter activity names down the left column of the spreadsheet. Format the cell and shade them to show the bars on the dates. The activities could be double spaced, leaving room to mark the schedule with a highlighter showing the actual start and finish dates so that performance can be measured and reported (Newitt, 2005).

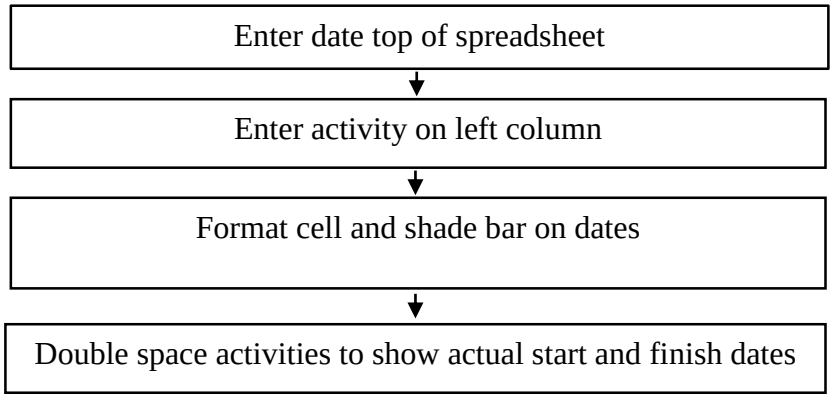


Figure 2.19 Simple Bar Chart Schedule Using Computer Spreadsheet

(Source: Newitt, 2005, p 38)

Project milestone chart in tracking milestone and report progress to the team at large can be done main by spreadsheet (Excel) based core system (Hardin, 2011). S-curve chart commonly can prepare using computer spreadsheet that speed up the work of preparing work schedule (Muhammad et.al, 2007). For LSM, the spreadsheet model was mainly built by Al Sarraj (1990) for scheduling larger group activities and present the schedule automatically. The model developed based the linear scheduling assumptions with adaptions into its logic (Mendes, et.al., 1998).

The use of spreadsheets provide a natural interface for model building, are easy to use in terms of inputs, solutions and report generation, and allow users to perform what if analysis. CPM, PDM and PERT scheduling method in preparing the work programme using computer spreadsheet such Microsoft Excel can be achieved by using a total of four worksheets. The first worksheet is used for the input of data. The second worksheet are used to calculate the Earliest Start Time (EST) and the Earliest Finish Time (EFT). The third worksheet are used to calculate the Latest Start Time (LST) and the Latest Finish Time (LFT) of the activities. Lastly, the fourth worksheet is used for reporting the critical path as well as for calculating the average project completion time and the project variance. Two additional worksheets are used after solving the problem for displaying CPM, PDM or PERT schedule in the form of network diagram other for the project and the range names used in the spreadsheet (Seal, 2001).

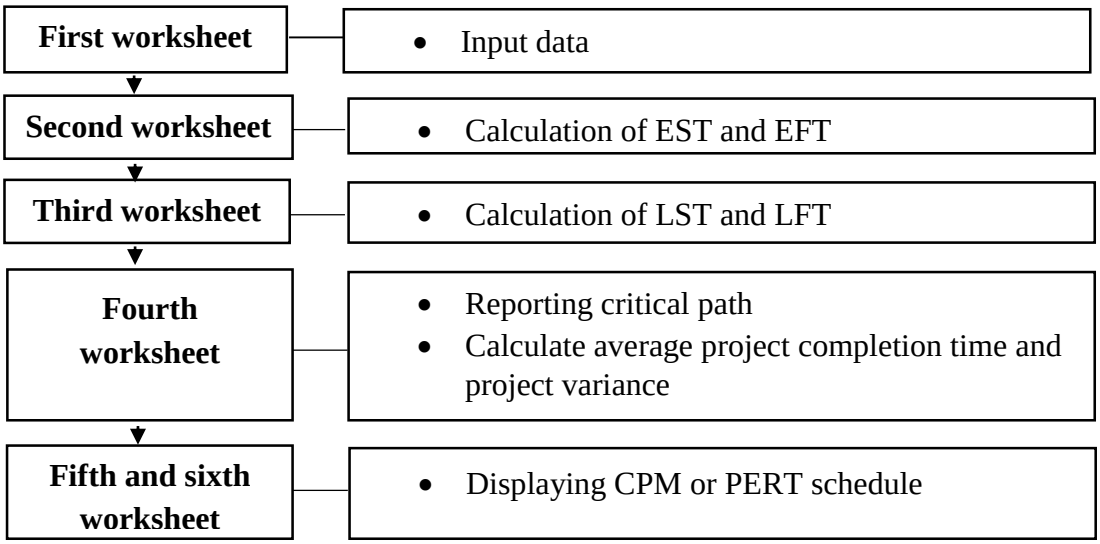


Figure 2.20 Network Based Schedule Using Computer Spreadsheet

(Source: Seal, 2005, p 3)

In conclusion, computer spreadsheet system can be used in preparing bar chart, s-curve chart, milestone chart, LSM, CPM in AOA, PDM, PERT and GERT for planning and scheduling work. The available spreadsheet systems are including Accel Spreadsheet, Gnumeric, KSpread, Lotus 1-2-3, Microsoft Excel and OpenOffice (Wikipedia Spreadsheet, 2014).

2.14 Specialist Software for Planning and Scheduling Works

Specialist software is a program that' arranged to suit the needs of the users. To be specific, specialist software tools for preparing the work programme are based on network analysis and scheduling methods, a schematic display of the logical relationship of the project activities (McGonigle, 1992) (Cited by Bani Ali and Anbari, 2004). Those specialist software for planning and scheduling works are also known as project management software. In this technological era, there are many computer scheduling specialized software on the market that essentially perform the same principal task namely to assist in the development and management of schedules. Project Management Institute (PMI) is a large project management body to evaluate different types of planning and scheduling software and compare the strength and weakness to help project professionals to choose appropriate tools that suit their needs (Bani Ali and Anbari, 2004).

Factors enhance the use of planning and scheduling software in project management categorised into software characteristics that include ease of use, information quality and functionality, user characteristic that include level of experience, training and level of education and lastly project characteristics that include organization size, project size and project complexity (Bani Ali and Anbari, 2004). Hinze (2008) further claimed the factors that to be considered when choosing an appropriate construction planning and scheduling specialized software program are the specialized software program's features and cost, along with needs, resources, types of work performed by the contractor and characteristic of the projects.

In conclusion, specialist software can be used in preparing bar chart, s-curve chart, milestone chart, LSM, CPM in AOA, PDM, PERT and GERT for planning and scheduling work.

2.14.1 Microsoft Project

Microsoft Project is an extremely popular project management software especially in planning and scheduling used by all types of project manager (Newitt, 2005). Many construction firm prefer Microsoft Project due to its ease of use and similarity to other Microsoft programs. Microsoft Project provide most of the functions and features as other, more expensive programs and allows a maximum of 10, 000 activities. It includes an interactive assistant, pop-up screen tips and context sensitive help information. The screen tips appear when changes are made to the schedule to alert the user of alternative scheduling options or verify that the information is input correctly. Twenty predefined reports and graphic representations are included. The program layout and operations are designed to be user friendly (Hinze, 2008). Main advantages of the Microsoft Project is that it is designed to interface with other Microsoft programs. This feature allows easy transferring of information between programs and creation of scheduling reports containing both text and graphics along with the schedule. Additionally, task entered in Microsoft Outlook can be displayed in Microsoft Project to maintain assigned activities in one convenient location (Hinze, 2008).

2.14.2 Primavera Project Planner

Primavera Project Planner is one of the most popular computer scheduling software programs used in the construction industry. Its popularity has led to continued development of additional features and functions to make it a full service program. Main advantages of using Primavera Project Planner are that the software has a maximum capacity of 100, 000 activities on a single project, the ability to group an unlimited number of projects together and used on virtually any project. Creation of schedule is facilitated by templates made from similar projects and the use of various assistant, called Wizards, which lead the user through the input of specific data

or the use of program features. Moreover, schedule development can speed up by writing subroutines to automatically input or modify the activity information. Primavera Project Planner offers over 150 predefined reports and related graphic representations of the schedule. However, it is generally used by large firm that are able to absorb the initial investment and work on large projects requiring the greater capabilities and additional features provided (Hinze, 2008).

2.14.3 Sure Track Project Manager

Sure Track Project Manager by Primavera is basically Primavera Project Planner little brother. Sure Track Project Manager provides most of the same functions as Primavera Project Planner at much lower price. However, Sure Track only allowed a maximum of 10, 000 activities on a single project and it does allowed the projects to be grouped. This features essentially allow much larger project to be represented as a group of smaller projects. In term of presentation, Sure Track Project Manager provides 40 pre-programmed reports and related graphic representations (Hinze, 2008).

2.14.4 Artemis

Artemis originated from Artemis Project Management System developed by Metier Management Systems in 1978. Artemis is a major product lines to support project planning and scheduling, earned value management (project performance measurement, portfolio management, resource management, and time reporting (Artemis Wikipedia, 2014). The two Artemis software currently used in project planning and scheduling are Artemis 7000 and Artemis Schedule Publisher. Both software are able to show multiple calendars, control material and costs, perform

resource scheduling and produces resource scheduling report, show resource loading conflict and mark critical path. Artemis 7000 able to handle 999, 999 tasks per project while Artemis Schedule Publisher only able to handle 12, 000 tasks per project. Thus, Artemis 7000 is commonly used in sophisticated project compare to Artemis Schedule Publisher only used in smaller project (Conlin and Retik, 1997).

2.14.5 Open Plan

Open Plan is an enterprise-wide project management software system that substantially improves the ability to manage and complete multiple projects on time and within budget. It was developed by Welcome Software. It highly integrated, comprehensive system that users able to customize to fit their specific requirements (SoftScout, 2014). It is the most technically advanced planning and scheduling system on the market because the Open Plan software has unlimited activities handling capabilities and able to control 1, 430 resources per project (Conlin and Retik, 1997).

2.14.6 Micro Planner X-Pert

Micro Planner X-Pert is a project management software package in continuous development since 1979. The main purpose of Micro Planner X-Pert is to produce critical path method (CPM) and PERT schedules for major, complex, and long term projects. It is one of the few packages still fully supporting the activity-on-arrow (AOA) project network process. Moreover, it supports the full cycle of project management through multi-level work breakdown creation, transition to multiple projects using critical path diagrams and Gantt chart presentation. It has the ability to handle 15, 000 tasks per project and 500 resources per project 20 per operation (MicroPlanner X-Pert Wikipedia, 2014).

2.14.7 FastTrack Schedule

FastTrack Schedule is a project management software used for planning, tracking and reporting project goals. It developed by AEC Software, Inc. The application enables users to organize tasks into project plans, assign resources to tasks, use effort driven scheduling, and view project details in Gantt charts, monthly calendars, and others. In addition, it suited for project management beginners as well as experienced project manager. In term of information exchanging, FastTrack Schedule also exchanges data with spreadsheets including Microsoft Excel, databases, organisers including Microsoft Outlook and other project management software including Microsoft Project (Fast Track Schedule Wikipedia, 2014).

2.14.8 Primavera Engineering and Construction Web Based Programmes

Several software companies offer computer scheduling capabilities via we-based programs. Primavera Engineering and Construction, for example, is an online version of Primavera Project Planner. The main advantages of Primavera Engineering and Construction Web Based Programmes is it provides integrated team communication and collaboration, coordinated, schedule-based procurement and project planning and control to ensure successful design, construction and facility management projects. The web based Primavera on-line version of Primavera Project Planner provide scheduling capabilities for projects with up to 2, 000 activities. Moreover, the web based programmes provide the convenience of access to schedules and project management information from any computer via the internet (Hinze, 2008).

2.15 Factors Influencing the Choice of Planning and Scheduling Methods in Preparing the Work Programme

The type of method to prepare work programme depend upon the nature of the project (Willis, 1986). To be specific, factors to be considered to make the choice on planning and scheduling method in preparing work programme are the background and experience of the planner and scheduler, the availability of the computer software for the planning and scheduling works, the type of project, the size of project, the duration of project, the complexity of the project, the time available for the project and the client preferences (specification) (Mawdesley, 1997). Baldwin and Bordoli (2014) stated the selection of the method to prepare work programme depend upon the type of project, the degree of development of the project and the client requirement.

The size of the project is one of the important factor to be consider when choosing a suitable method for preparing work programme. Which planning and scheduling method to be used for the project, it depends on the size the project. The size of the project can be divided into three main category which small project, medium project and large project. The project's size commonly based on total financial resources available, number of team members involved, number and size of deliverables to be produced, complexity of deliverables to be produced and timeframes involved in delivery (MMPM, 2015).

The complexity of the project affect the choice of planning and scheduling method used. Complex construction project consist dozen of crafts and subcontractors simultaneously working on as many or more different elements of the project. The progress of one party may affect the rate of other party and very difficult for the main contractor to take in account of all the interrelationships between the tasks. Non-network based method include bar chart and others not actually depict these relationship and not apparent for revision if changes occur. Network based method that include CPM, PDM, PERT and GERT could be more appropriate for complex project as it allow scheduler to depict the relationships between tasks. Thus, a more

sophisticated project requires a more sophisticated method to prepare the complex work programme for the sophisticated project (Newitt, 2005).

Thirdly, the type of the project will influence the choice of method used to prepare work programme. The different types of project in construction industry which are residential, building, institutional and commercial, industrial, specialised industrial construction, highway construction and heavy construction (Gould and Joyce, 2000). Different method of planning and scheduling have their own application in nature and disadvantages when used for different types of the project. Bar chart method is more appropriate for smaller project such as building project as budget is lower. LSM is however more suitable to be used to schedule the project linear in nature such as highway construction. CPM allow better control on the complex construction project that involve variety of works as the method allow to determine the impact of changes in the project (Galloway, 2006).

Next, the duration of the project. Construction duration can be defined as the time frame given by the owner for the contractor to complete the project under normal work conditions, normal practice of construction, and based on the minimum costs (Barrie and Paulson, 1992). Different duration of the project require different use of planning and scheduling methods to prepare work programme. Non network planning and scheduling methods such as bar chart and others is more suitable to prepare work programme for shorter duration project. Longer duration project involving project with high complexity require sophisticated network based planning and scheduling methods such as CPM and others to prepare work programme for an effective project monitoring and controlling (Galloway, 2006).

The experience of user will determine the type of method to be used to prepare work programme. The sophistication user involve using the scheduling system as factor to determine the use of scheduling method so that the users are comfortable and familiar with the scheduling method to prepare work programme (Hutchings, 2004). The level of detail in the work schedule depend on the level of experience of the

planner and scheduler where a less experience team will need more detailed schedule than an experience team (Newitt, 2005).

In term of flexibility, planning and scheduling method to prepare work programme must be flexible because they likely changes to be made during the construction process (Newitt, 2005). The use of CPM to generate work schedule often not precisely, as estimation are used to calculate times and it could upset the implementation of the project if the estimate is followed blindly and changes not addresses promptly. However, the CPM allow the variance from the original schedule to be measured to analyse the specific cause and impacts between the planned and actual work programme (Wikipedia, 2014).

The type of method used to prepare work programme also depend on the availability of software for the planning and scheduling method to assist in the development and management of schedules. Each types of specialized software have different scheduling capabilities, functions and features (Hinze, 2008). The management of project time is depending more and more on specialized software to prepare work programme. The use of specialized software allow the prime contractor to effectively manage their project especially managing the construction project that consist hundreds of activities. Eventually, prime contractor might have more than one projects per year. The used of specialized software speed up their process in preparing their work programme and effectively to control their project (Bell et al, 2009).

The client preferences (specification) will also influence the method for planning and scheduling to prepare work programme. Client will commonly specified their preferences scheduling method to prepare work programme (Galloway, 2006). Galloway (2006) on his study stated that 47.6% of the client specified CPM scheduling as their preference scheduling method to prepare work programme due to the flexibility to make changes on the work schedule if the project behind schedule or there is a change of order in work.

Lastly, the level of detail information for a particular project to prepare the work schedule. There are always some uncertainty concerning the factors that affect progress of the project. Weather conditions and labour and material availability will become the uncertainty and act as factor that determine the method to prepare work programme. Used of CPM work programme for high uncertainty information project enable the contractor to determine the impact of the uncertainty on the project progress and take corrective action to minimize the impact (Willis, 1986).

Hence, the factors to be consider when choosing the planning and scheduling method to prepare work programme are size and complexity of project, the type and duration of the project, comfortable and experience of sophisticated users, flexibility of the planning and scheduling method, the availability of the planning and scheduling method software, client preferences (specification), organisation standard method and level of detail information for a particular project.

2.16 Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare the Work Programme

Non-network based method that involve bar chart and others inadequate in controlling large project with many activities because of their lack of interrelationship float capability, thus result lack of control on the critical path that determine the project duration (Hutchings, 2004). Non-network schedule such as bar chart inherent graphic limitation which thus unable to show activities dependencies (Gould and Joyce, 2000). The use of s-curve chart only a better scheduling method for smaller and linear project where the method does not able control the critical path as well as provide an impact analysis of the work changes on the schedule. This is because the method does not provide time scale manipulation which a control domain of the project (Hutchings, 2004). Thus, this method is not suitable to control vertical project such as high-rise building because of the complex dependencies of the project (Fisk, 1982).

Another method to prepare work programme is preparing the milestone chart. Milestone chart which only show the key performance activities has difficulty to clearly visualize the relationship, dependencies and constraint among the construction activities (Hutchings, 2004). LSM prove to be suitable for project linear in nature but using LSM to prepare work schedule has training difficulty, variation of the construction activities cause problem in the analysis as LSM difficult to clearly visualize the relationship, dependencies and constraint of the construction activities and lastly it not very commonly computerized which the work done manually could be time consuming (Mawdesley, 1997).

Network based method able show the relationship between activities and ability to control the critical path of the project. However, the network based method that include CPM, PDM, PERT and GERT will increase the overall contract price which professional planner/scheduler must be hired to develop and manage the complex network schedule instead of project manager (Hutchings, 2004). Construction professional such as project manager is difficult to devote the time necessary to proficient with CPM and other network based method which are very complex to learn especially in large project (Newitt, 2005). The thorough preparation of the network based schedule may take several week and consume tremendous resources. Moreover, network based schedule require fairly detailed project detailed information to update and monitor the project. Lastly, availability of computer hardware and software as well as technical training must be provided in order to use the non-traditional method effectively to prepare work programme (Gould and Joyce, 2000).

Hence, the problems of the use for traditional planning and scheduling method (non-network based) is inability to control the critical path of the project that lead to high cost of the project, not flexible to make analysis on the changes and technical training requirement for LSM while the problems encountered from the non-traditional planning and scheduling method (network based) are time consuming, high complexity and difficult to learn, detail information requirement, availability of computer hardware and software, technical training requirement as well as

planner/scheduler specialist requirement to create and maintain the planning and scheduling method.

2.17 Chapter Summary

Planning and scheduling is a process of identifying and sequencing the activities in preparing the work programme. There are various types of planning and scheduling methods that categorised into two main categories which are traditional (non-network based) methods that include bar chart, s-curve chart, milestone chart and linear scheduling method (LSM) and non-traditional (network based) methods that include CPM in activity-on-arrow (AOA) network, PDM, PERT and GERT can be used by the construction contractor in preparing the work programme. The various planning and scheduling methods adopted by contractors can be prepare using three approaches either by prepared manually, by computer spreadsheet system or by specialist software. The literature review also highlighted the factors influencing the choice of planning and scheduling methods in preparing work programme and the problems encountered in using the chosen planning and scheduling methods to prepare work programme. The following chapter will discuss about the research methodology which consists of the type of research method, research instrument and methods of data analysis.

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CHAPTER 3

RESEARCH METHODOLOGY

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3.1 Introduction

This chapter will discuss the methodology applied in attaining the objective of this research. The research process is divided into five stages as shown below:

a) Initial stage – Identification of issues and problem statement
b) Second stage – Literature Review
c) Third stage – Research Design
d) Fourth stage – Data analysis and discussion
e) Final stage – Conclusion and recommendation

3.2 Initial Stage – Identification of Issues and Problem Statement

During the initial stage of the study, a wide area of the research topic will be studied. Generally, the wide area of topic concentrated on the construction planning

and scheduling issues and field. It can be studied from the secondary source such as journals, previous research, articles, books and related internet website. The research problem statement will be develop from the identified research issue. Then from the arisen of research problem statement, the research's topic will be formulated. After that, the research question and research objectives will be formed from the problem statement that has been identified earlier. Then, the scope and limitation of study will be stated and lastly following by the significance of the study.

3.3 Second Stage – Literature Review

Literature review is the essential stage in conducting a research project, it amounts on average, to between 20 and 25 per cent of a dissertation content. It involves reading and appraising on what other people have written on the subject matter. The literature review can be both descriptive and analytical. It is descriptive when it describes the work that other people had written and it is analytical when it critically analyses the contributions of others with the view of identifying similarities and differences made from the previous writers. There are two purposes of the literature review which are to help the researcher have better understanding of their research by gathering the information and to give insight on how to design the study more effectively (Naoum, 2007). Thus, books, journals, previous thesis studies and others related to construction planning and scheduling methods had been read and reviewed to obtain a general idea on the research study of planning and scheduling methods adopted by Malaysian construction contractors in preparing work programme to be conducted.

3.4 Third Stage – Research Design

The research design is an action plan to attaining the objectives of the study. Quantitative research can be defined as an inquiry into a social or human problem, based on a hypothesis testing or a theory composed of variables, measure with numbers, and analysed with statistical procedures, in order to determine whether the hypothesis or theory hold true. In addition, quantitative data are hard and reliable, measurements of tangible, countable, sensate features of the world (Naoum, 2007). Therefore, research strategy used in the study is based on quantitative research.

3.4.1 Data Collection

There are three approaches in collecting the primary data which are the survey approach, the case study approach and the problem-solving approach. The research approach use for this research to achieve the objective is the survey approach because it is able to collect data from a relative in large number of respondents within a limited time frame (Naoum, 2007). The research technique used for data collection is postal questionnaire because the technique offers relatively high validity of results due to their wide geographical coverage and a quick method of conducting a survey. Firstly, the list of registered grade G7 construction contractor in Malaysia with addresses, telephone number and email addresses were obtained from the Construction Industry Development Board Malaysia (CIDB).

3.4.2 Development of Questionnaire

A well designed postal questionnaire is important to get the best responses and results. The questions must be well-organised and prepared to meet the research objectives. Hence, the 'closed' form of questionnaire will be used on this research because it is easy to ask and quick to answer, require no writing from the respondent and the analysis for the question is straightforward (Naoum, 2007). By choosing the 'closed form of questionnaire', the chosen question must be clear and concise as possible to make sure the respondent fully understand the chosen questions. The design questionnaire consist of both factual and opinion question. The format for opinion question in the questionnaire involve rating scale and likert scale.

The rating scale is used as formats for questioning respondents because it is common formats for questioning respondents on their views or opinions of an object, event or attribute and at the same time allow the respondents to express their degree of agreement or disagreement on a particular scale. Likert scale is also chosen as formats for questioning respondents because the questions consist of attitudinal statement (Naoum, 2007). Likert scale is suitable for the questionnaire because according to Moser and Kalton (1993):

> "*If the scale is divided too finely the respondents will be unable to place themselves within the scale, and if too coarsely the scale will not differentiate adequately between them. The choice between an odd or even number depends on whether or not respondents are to be forced to divide the direction of their attitude; with an odd number there is a middle category representing a neutral position, but with an even number there is no middle category, so that respondents are forced to divide to which side of neutral they belong. Another factor to take into account in fixing the number of categories is that respondents generally avoid the two extreme positions, thus effectively reducing the number they choose between.* "

The designed questionnaire is divided into four main sections which are:

i. **Section A:** General information. This section contains the general information of the construction contractor and respondent information that include the name of organisation, organisation address, name of respondent and current position of respondent and e-mail address. Signature and office stamp are compulsory in respondent information to ensure the validity of the answered questionnaire to be included into analysis.
ii. **Section B:** Planning and Scheduling Methods Adopted by Grade G7 Construction Contractors in Preparing Work Programme. This section is to identify the planning and scheduling methods adopted by grade G7 construction contractors in Malaysia, the approaches used in preparing the various planning and scheduling methods, the types computer spreadsheet system and the types of specialist software used in preparing work programme
iii. **Section C:** Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Programme. This section is to identify the factors influencing the choice of planning and scheduling methods in preparing work programme by grade G7 construction contractors in Malaysia.
iv. **Section D:** Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Programme. This section is to identify the problems encountered in using the chosen planning and scheduling methods to prepare work programme by grade G7 construction contractors in Malaysia.

3.4.3 Population & Sampling

According to O'Leary (2014), population can be defined as 'the total membership of a defined class of people, objects or events' (O'Leary, 2014, p 182). The population of this research study were grade G7 Malaysia construction contractor registered with Construction Industry Development Board Malaysia (CIDB). Based

on the list obtained from the Construction Industry Development Board Malaysia (CIDB), there are total of 5,343 grade G7 construction contractor in Malaysia.

3.4.4 Sampling

According to Naoum (2007), 'sample' can be defined as a specimen or part of whole (population) which is drawn to show what the rest is like (Naoum, 2007, p 58). The type of sampling used for the research is simple random sampling because the specifics about the characteristic of the sample are not essential. The sample involve for the study is the grade G7 construction contractors in Malaysia. The target respondent for the study was the personnel of the grade G7 construction contractors registered with Construction Industry Development Board (CIDB) in Malaysia who are involved with the planning and scheduling works in preparing work programme. The respondent can be project manager, construction manager, site engineer, project planner/scheduler or others.

From the list of registered grade G7 construction contractor obtained from the Construction Industry Development Board in Malaysia, the total number of registered grade G7 construction contractor with CIDB in Malaysia is 5,343. Based on the population and sampling size table, the suggested sampling size for the research is at least 359 or more (Krejcie and Morgan, 1970). Thus, the concluded suggested sampling size for this research must be 359 or more. However, according to Mohd. Najib Abdul Ghafar (2003), the minimum sample size is 30.

Table 3.1 Population and Sampling Size Table

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	2015	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

N = Population; S = Sampling Size

$$\frac{5{,}343 - 5{,}000}{6{,}000 - 5{,}000} = \frac{X - 357}{361 - 357}$$

$$X = 358.372$$

$$X = 359$$

(Sources: Krejcie and Morgan, 1970, p 608)

3.5 Fourth Stage – Data Analysis

The method for data analysis for the research is descriptive statistics because it is the simplest method of analysis which provide a general overview of the results. Moreover, the method gives an idea of what is happening. Normally the descriptive statistic will either analyse the data in percentages or actual numbers (Naoum, 2007).

Data obtained from the questionnaire are processed using the Microsoft Excel 2013 to transform the raw data into meaningful information in tabulation form, graph or chart to achieve the research objectives. The method used to describe aspect of group data in the research are 'frequency distribution' and 'measurement of central tendency'.

3.5.1 Frequency Distribution

Frequency distribution was used for the purpose to summarise large amount of raw data. It used to distribute the data into categories to determine the number of individuals or cases belonging to each category. The highest percentage or frequency of actual number shows the most preferred and chosen answer among the listed respondent. The result of the research can be presented in the form of tabulation, a bar chart, a pie chart or a graph. The percentage or frequency calculation can be determined by multiplying the ratio of total frequency of selected answer to total respondents with 100 % (Naoum, 2007). The percentage or frequency calculation is as the following:

$$\text{Percentage (\%)} = \frac{\text{Frequency of Selected Answer}}{\text{Total Respondents}} \times 100\%$$

(Sources: Naoum, 2007)

Table 3.2 Example of Frequency Distribution Analysis

Types of Planning and Scheduling Methods	Frequency	Percentage (%)
Simple Bar Chart	40	42.11
S-Curve Chart	3	3.16
Milestone Chart	0	00.00
Linear Scheduling Method (LSM)	0	00.00
CPM in Activity-On- Arrow Network (known as Arrow Diagramming Method)	5	5.26
CPM in Activity-On-Node/Precedence Network (known as Precedence Diagramming Method)	45	47.37
PERT	2	2.11
GERT	0	00.00
Others	0	0

The CPM in Activity-On-Node/Precedence Network is the most chosen planning and scheduling method adopted by respondents in preparing work programme because CPM in Activity-On-Node/Precedence Network method accumulate almost half of the respondent with 47.37%.

3.5.2 Measurement of Central Tendency (Mean Analysis)

Mean was used to analyse the likert scale question. The likert scale include the ranging from 1-5 with indication from never to very frequent or from not important to most important and strongly disagrees to strongly agree (Naoum, 2007). Firstly, the raw data from the questionnaires was tabulated to analyse further. Then, the data was analysed by using the mean method. The purpose of using the mean score method for the research are to examine the level of usage of the planning and scheduling methods

adopted, the level of usage for approach used for planning and scheduling methods, level of important of the factors influencing the choice of planning and scheduling methods in preparing work programme and level of agreement of the problems encountered in using the chosen planning and scheduling methods to prepare work programme. Mean score can be calculated by adding all the values in the group and then dividing by the number of values.

The mean range is chosen as the method of analysis to analyse the questions in Section B, C and D. of the questionnaire. The mean range in Section B with ranging 1 to 5 with representation from never to very frequent. In Section C, the ranging 1 to 5 with representation from not important to most important. Lastly, in Section D, the ranging 1 to 5 with representation from strongly disagree to strongly agree. The mean range will first determined according to the formulae shown below.

$$\text{Mean Range} = \frac{\text{(Largest Scale) - (Smallest Scale)}}{5}$$

$$= (5 - 1)/5$$

$$= 0.80$$

(Sources: Levin et al., 1998)

First of all, for section B, the mean range is divided into five categories which never, seldom, medium, frequent and very frequent. The following scale of mean range will be used to illustrating the data analysis result in Section B to make the findings more understandable as follows:

Table 3.3 Mean Range for Planning and Scheduling Methods Adopted in Preparing Work Programme

Frequency	Mean Value
Never	1.00 – 1.80
Seldom	1.80 – 2.60
Medium	2.60 – 3.40
Frequent	3.40 – 4.20
Very Frequent	4.20 – 5.00

Table 3.4 Mean Range for the Different Approaches Used in Preparing the Various Planning and Scheduling Methods

Frequency	Mean Value
Never	1.00 – 1.80
Seldom	1.80 – 2.60
Medium	2.60 – 3.40
Frequent	3.40 – 4.20
Very Frequent	4.20 – 5.00

For Section C, the mean range is divided into five categories which are not important, slightly important, important, very important and most important. The following scale will be used for illustrating the finding in Section C to make the findings more understandable as follows:

Table 3.5 Mean Range for Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Programme

Frequency	Mean Value
Not Important	1.00 – 1.80
Slightly Important	1.80 – 2.60
Important	2.60 – 3.40
Very Important	3.40 – 4.20
Most Important	4.20 – 5.00

For Section D, the mean range is divided into five categories as well are strongly disagree, disagree, neither agree or disagree, agree and strongly agree. The following scale will be used for illustrating the finding in Section D to make the findings more understandable as follows:

Table 3.6 Mean Range for Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Programme

Frequency	Mean Value
Strongly Disagree	1.00 – 1.80
Disagree	1.80 – 2.60
Neither Agree or Disagree	2.60 – 3.40
Agree	3.40 – 4.20
Strongly Agree	4.20 – 5.00

Mean Value

The method used to analyse the findings of Section B, C and D of the questionnaire is mean score. The mean score will be based on the respondent agreement on the problem statement. The result of mean score can be calculated by using the formulae below:

$$\text{Mean Value, } \chi = \frac{\Sigma aiXi}{\Sigma Xi}$$

Where: χ = Mean Value

ΣaiXi = Sum of all scores in the set

ΣXi = Number of scores or observations in the set

(Sources: Adapted from Abdul Majid and McCaffer, 1997, p 1)

Table 3.7 Example of Mean Value Analysis

Scale	Scale Score	Frequencies
Never	1	8
Seldom	2	14
Medium	3	30
Frequent	4	33
Very Frequent	5	15

$$\text{Mean Value} = \frac{(1 \times 8) + (2 \times 14) + (3 \times 30) + (4 \times 33) + (5 \times 15)}{8 + 14 + 30 + 33 + 15}$$

Mean Value = 3.33

Thus, the mean value for the sample problem statement is 3.33 which will categorise in the range of Medium (2.60 – 3.40) based on the mean range.

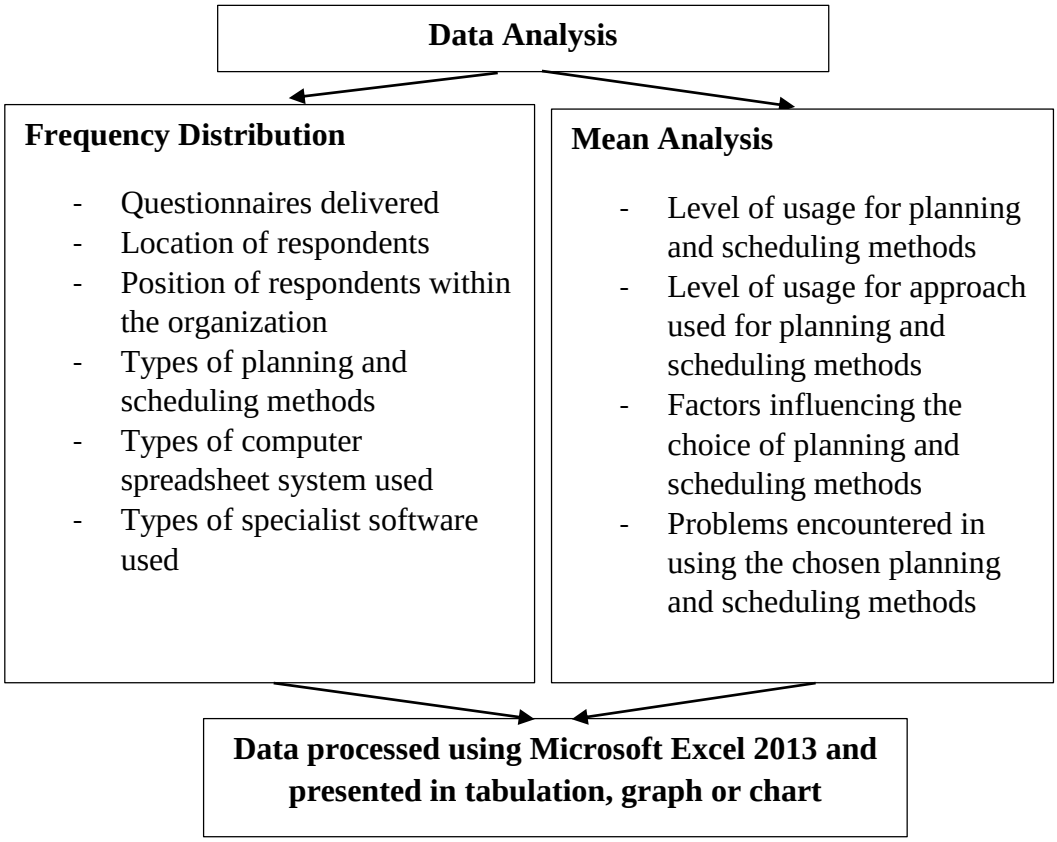

Figure 3.1 Data Analysis Adopted for Research

3.6 Final Stage – Conclusion and Recommendation

After the result of the data analysis, the interpreted information will be presented in context. During the presentation stage, the researchers will present the final result of the study based on the information obtained from the analysis. From the analysed data, the researcher will come out a conclusion toward the research objectives. In addition, personal recommendation will be given for future study and limitations of the study also will be stated in the research methodology stage.

3.7 Chapter Summary

This chapter described in detail how this research study was conducted. There are five stage involve in the research study methodology namely initial stage (identification of issues and problem statement), second stage (literature review), third stage (research design), fourth stage (data analysis and discussion) and lastly final stage (conclusion and recommendation). All the data obtained from the collected questionnaire were analysed to become useful information to attain the research objectives. The following chapter will discuss about the data analysis and findings.

3.8 Flow Chart of the Research Process

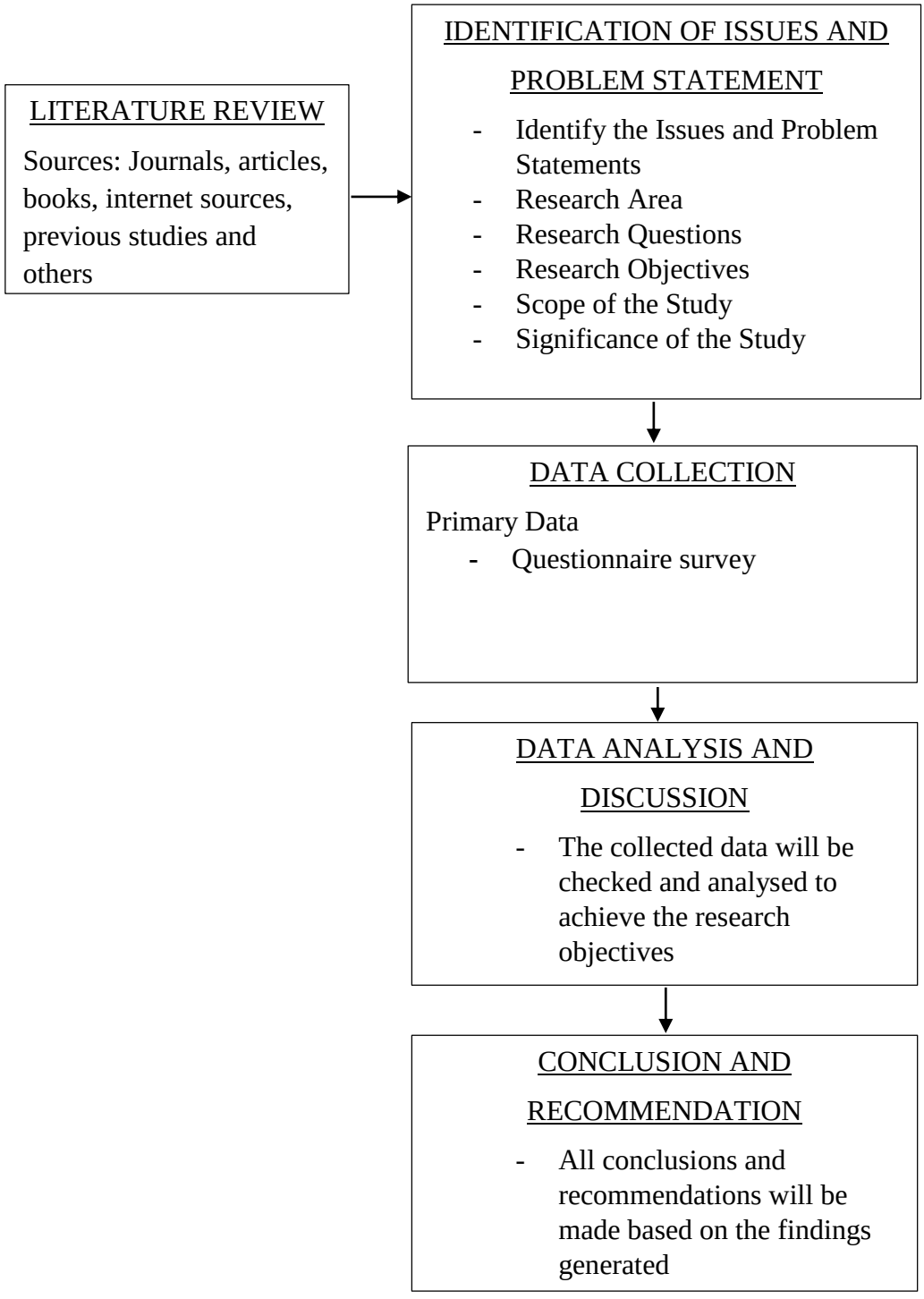

Figure 3.2 Flow Chart of Research Process

CHAPTER 4

DATA ANALYSIS AND FINDINGS

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter discusses the result of analysis and the findings from the questionnaire surveys in relation to the three objectives of the research study which are to identify the construction planning and scheduling methods adopted by Malaysian construction contractors in preparing work programme, to determine the factors influencing their choice of planning and scheduling methods in preparing work programme and to determine the problems encountered in using the chosen planning and scheduling methods to prepare work programme. This study was carried out on grade G7 construction contractor registered with Construction Industry Development Board Malaysia (CIDB). This chapter consists of five main parts. The first and second part discusses the background of the questionnaires and respondents. The third part discusses the planning and scheduling methods adopted in preparing work programme. Factors influencing their choice of planning and scheduling methods in preparing work programme is discussed in the fourth part and problems encountered in using the chosen planning and scheduling methods are discussed in the fifth part.

4.2 Questionnaires Delivered

A total of 360 questionnaires were distributed to all registered grade G7 contractor in Malaysia through postal, email and direct visit. 33 questionnaires were returned, representing 9.17 % from the total distributed questionnaires. All the data collected from the questionnaires were analysed and used as the basis of the study.

Table 4.1 Summary of Questionnaires Delivered

No	Questionnaires Status	Frequency	Percentages (%)
1	Returned Questionnaires	33	9.17
2	Unreturned Questionnaires	327	90.83
TOTAL		360	100.00

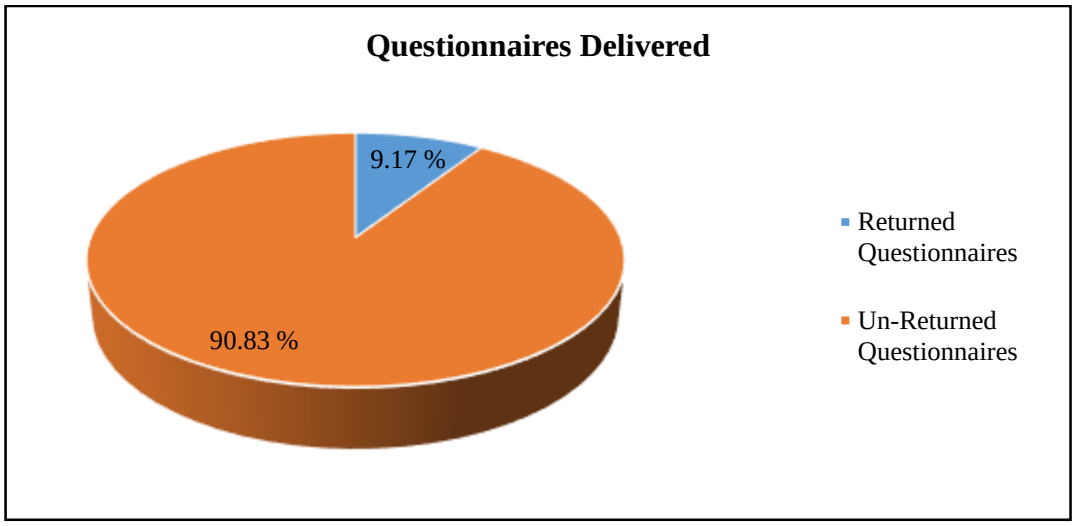

Figure 4.1 Questionnaires Delivered

4.3 Background of Respondents

4.3.1 Location of Respondents

Table 4.2 and Figure 4.2 show the composition of respondents' location. A total of 33 sets questionnaires were received from the respondents. Majority of respondents were from Johor and Kuala Lumpur representing 36.36 % and 24.24 % respectively. 15.15 % of respondents were from Selangor and 9.09 % of respondents were from Pulau Pinang. The percentages of respondents from Pahang were 6.06 %. Respondents from Kedah, Melaka and Sabah were 3.03 % each.

Table 4.2 Numbers of Respondents by Location

No	Location of Respondents	Frequency	Percentage (%)
1	Kuala Lumpur	8	24.24
2	Selangor	5	15.15
3	Sarawak	0	0.00
4	Sabah	1	3.03
5	Kelantan	0	0.00
6	Pulau Pinang	3	9.09
7	Terengganu	0	0.00
8	Johor	12	36.36
9	Kedah	1	3.03
10	Pahang	2	6.06
11	Melaka	1	3.03
12	Perak	0	0.00
13	Negeri Sembilan	0	0.00
14	Perlis	0	0.00
TOTAL		33	100.00

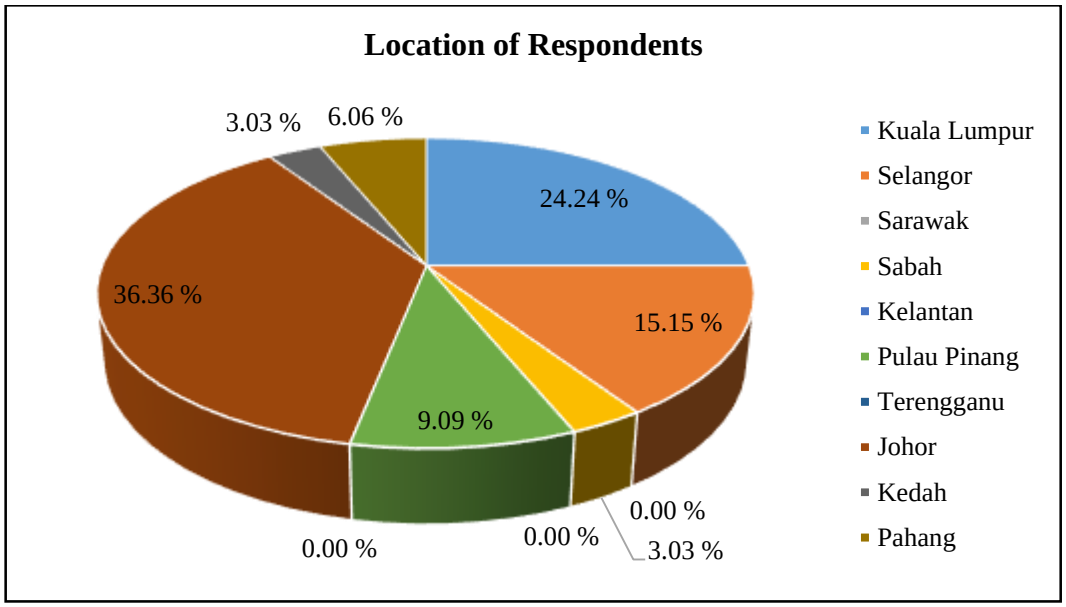

Figure 4.2 Percentage of Respondents by Location

4.3.2 Position of Respondents Within the Organisation

Table 4.3 and Figure 4.3 show the composition for position of the respondents. Majority of the respondent were project manager representing 39.39 %. 12.12 % of the respondents were project planner/scheduler. Only 3.03 % of the respondent were construction manager. Other designations that include project engineer representing 9.09 %, both contract manager and project director representing 6.06 % each respectively and lastly assistant contract manager, site manager, site agent, site coordinator as well as quantity surveyor representing 3.03 % each respectively.

Table 4.3 Position of Respondent within the Organisation

No	Position of Respondents	Frequency	Percentages (%)
1	Project Manager	13	39.39
2	Construction Manager	1	3.03
3	Site Engineer	3	9.09
4	Project Planner/Scheduler	4	12.12
5	Other: Contract Manager	2	6.06
6	Other: Assistant Contract Manager	1	3.03
7	Other: Project Engineer	3	9.09
8	Other: Project Director	2	6.06
9	Other: Site Manager	1	3.03
10	Other: Site Agent	1	3.03
11	Other: Site Coordinator	1	3.03
12	Other: Quantity Surveyor	1	3.03
TOTAL		**33**	**100.00**

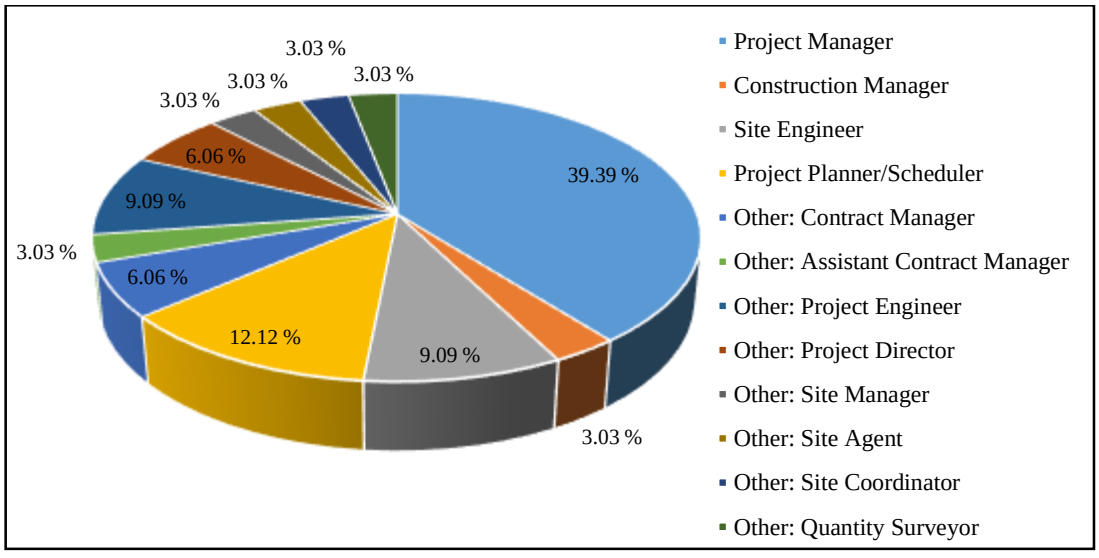

Figure 4.3 Percentages of Respondents for Position within the Organisation

4.4 Planning and Scheduling Methods Adopted in Preparing Work Programme by Grade G7 Construction Contractors

4.4.1 Planning and Scheduling Methods

4.4.1.1 Types of Planning and Scheduling Methods

This section discusses the planning and scheduling methods adopted by grade G7 construction contractors. From the data obtained from the questionnaire, bar chart, s-curve chart and milestone chart were the most common planning and scheduling method recorded 100 %, 96.97 % and 90.91 % respectively of the total respondents. 50.51 % of respondent have use LSM for planning and scheduling. For network-based method, CPM in AOA recorded 75.76 % of the total respondents. 90.91 % of respondent choose PDM for planning and scheduling. Both PERT and GERT were the least prefer method which recorded 39.39 % and 33.33 % respectively of the total respondents.

Table 4.4 Planning and Scheduling Methods by Contractor

No	Type of Planning and Scheduling Method	Frequency	Percentage (%)
1	Bar Chart	33	100.00
2	S-Curve Chart	32	96.97
3	Milestone Chart	30	90.91
4	LSM	17	51.52
5	CPM in AOA	25	75.76
6	PDM	30	90.91
7	PERT	13	39.39
8	GERT	11	33.33
9	Others:	0	0.00
TOTAL		33	

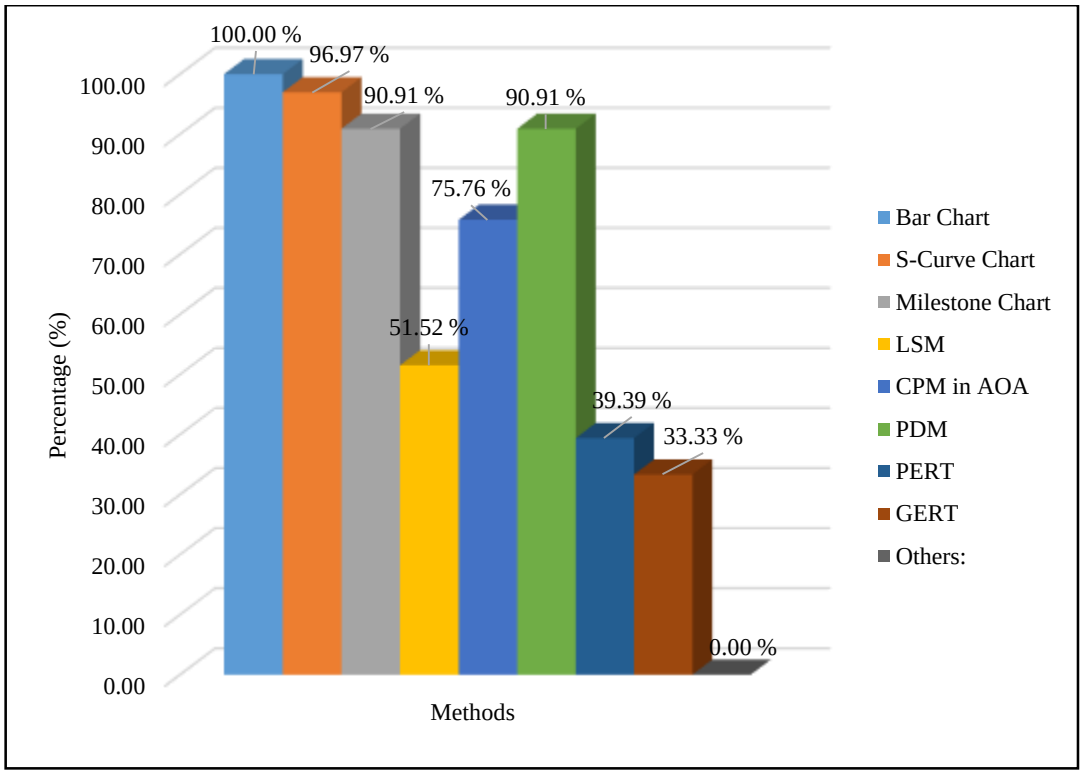

Figure 4.4 Percentages of Planning and Scheduling Method Chosen

Table 4.4 and Figure 4.4 also reflects that the contractors use a combination of different planning and scheduling methods. Figure 4.4 shows that majority of the contractors use bar chart, s-curve chart, milestone chart and PDM in their planning and scheduling works. This is probably because the bar chart and milestone chart is easily to understand and most simple ways in preparing work programme. PDM commonly used in combination with bar chart and milestone chart to show critical path of the project to enable the ability for controlling overall progress of the project. Meanwhile, s-curve chart commonly used by contractors for planning and scheduling to show planned and actual progress of the project. Other than PDM, CPM in AOA also used by contractor in planning and scheduling for critical path development. LSM, PERT and GERT was less prefer method used by contractors in planning and scheduling probably due to that LSM require user to have sufficient knowledge to be used for preparing work programme while PERT and GERT commonly known to be more probabilistic in nature that are not similar to the construction industry which more deterministic in nature.

4.4.1.2 Level of Usage for Planning and Scheduling Methods

This section will discuss about the level of usage for each type of the planning and scheduling methods used by grade G7 contractors. Respondent were asked to rate the level of usage for each type of planning and scheduling method. Five point Likert scale was used for this section analysis, where "1" represents "Never" and "5" reflects "Very Frequent". The mean score for each planning and scheduling method was calculated to identify the level of usage for each type of planning and scheduling method. The mean score and category for level of usage was explained in Chapter 3. Table 4.5 shows the overall mean value for the planning and scheduling methods.

Table 4.5 Usage of the Planning and Scheduling Methods

No	Type of Planning and Scheduling Method	Frequencies for Likert Scale						Mean	Level of Usage
		1	2	3	4	5	TOTAL		
1	Bar Chart	0	0	3	15	15	33	4.36	Very Frequent
2	S-Curve Chart	1	2	5	13	12	33	4.00	Frequent
3	Milestone Chart	3	1	9	13	7	33	3.61	Frequent
4	LSM	16	4	5	7	1	33	2.18	Seldom
5	CPM in AOA	8	6	2	12	5	33	3.00	Medium
6	PDM	3	6	10	11	3	33	3.15	Medium
7	PERT	20	2	7	4	0	33	1.85	Seldom
8	GERT	22	1	4	6	0	33	1.82	Seldom
9	Others:	0	0	0	0	0	0	0.00	N/A

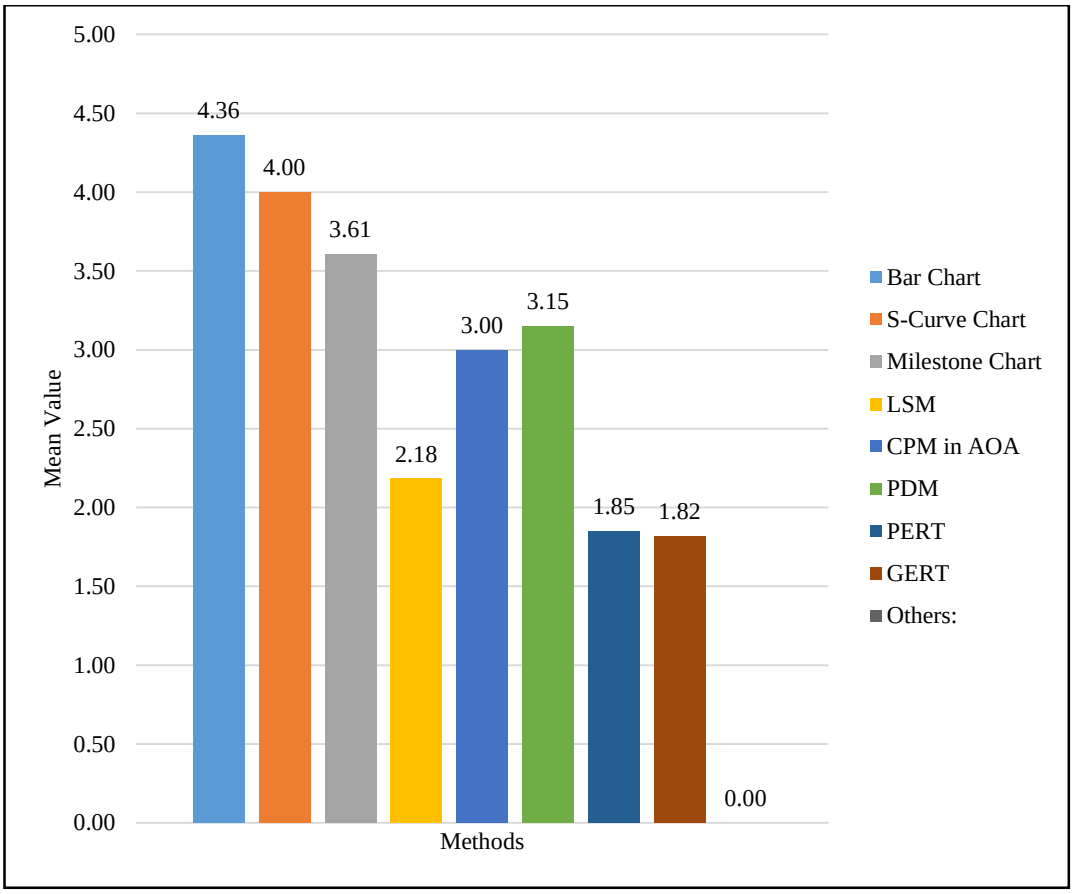

Figure 4.5 Mean Value for the Planning and Scheduling Methods

Table 4.5 and Figure 4.5 shows the mean values for the planning and scheduling methods adopted by contractors in preparing work programme. It can be seen from Table 4.5 and Figure 4.5 that the bar chart method is the most frequently used method with a mean value of 4.36; followed by the s-curve chart and milestone chart with a mean value of 4.00 and 3.61 respectively, indicating frequent usage of these methods. The network based methods of PDM and CPM in AOA with the mean values of 3.15 and 3.00 respectively indicate that the respondents have medium usage of this methods. The analysis also show that the mean values for the LSM, PERT and GERT are 2.18, 1.61 and 1.48 respectively. This shows that these methods are seldom being been adopted by the contractors. The analysis also reflects that the traditional or non-network based methods still dominate the planning and scheduling methods adopted by the contrators.

4.4.2 The Approaches Used by Contractors in Preparing the Various Planning and Scheduling Methods

This section will discusses about the usage of approaches namely manual (free hand), computer spreadsheet system and specialist software to be used in preparing the various planning and scheduling methods by contractors. Respondents were asked to rate the level of usage of approaches used in preparing the various planning and scheduling methods. Five point Likert scale was used for this section analysis, where "1" represents "Never Use" and "5" reflects "Very Frequent Use". The mean score for each approaches used in preparing the various planning and scheduling methods used was calculated to identify the level of usage for each approaches used in preparing the various planning and scheduling methods. The mean score and category for level of usage was explained in Chapter 3. Table 4.6 shows the overall mean value of approaches used in preparing the various planning and scheduling methods.

Table 4.6 The Approaches Used in Preparing the Various Planning and Scheduling Methods

Methods	Approach	Frequency for Likert Scale					TOTAL	Mean	Level of Usage
		1	2	3	4	5			
Bar Chart	Manual (Free Hand)	21	2	2	4	4	33	2.03	Seldom
	Computer Spreadsheet System	7	2	7	8	9	33	3.30	Frequent
	Specialist Software	2	3	5	9	14	33	3.91	Frequent
S-Curve Chart	Manual (Free Hand)	24	5	0	2	1	32	1.47	Never
	Computer Spreadsheet System	6	4	4	7	11	32	3.41	Frequent
	Specialist Software	8	4	6	9	5	32	2.97	Medium
Milestone Chart	Manual (Free Hand)	22	2	2	3	1	30	1.63	Never
	Computer Spreadsheet System	9	2	4	10	5	30	3.00	Medium
	Specialist Software	2	4	5	11	8	30	3.63	Frequent
LSM	Manual (Free Hand)	10	3	4	0	0	17	1.65	Never
	Computer Spreadsheet System	5	4	5	2	1	17	2.41	Seldom
	Specialist Software	5	4	7	1	0	17	2.24	Seldom
CPM in AOA	Manual (Free Hand)	14	8	1	1	1	25	1.68	Never
	Computer Spreadsheet System	15	2	5	2	1	25	1.88	Seldom
	Specialist Software	1	5	8	7	4	25	3.32	Medium
PDM	Manual (Free Hand)	19	8	2	0	1	30	1.53	Never
	Computer Spreadsheet System	19	3	5	1	2	30	1.80	Seldom
	Specialist Software	2	6	8	7	7	30	3.37	Medium
PERT	Manual (Free Hand)	7	3	3	0	0	13	1.69	Never
	Computer Spreadsheet System	4	3	4	2	0	13	2.31	Seldom
	Specialist Software	4	3	4	2	0	13	2.31	Seldom
GERT	Manual (Free Hand)	4	5	1	1	0	11	1.91	Seldom
	Computer Spreadsheet System	3	4	3	1	0	11	2.18	Seldom
	Specialist Software	3	4	2	2	0	11	2.27	Seldom

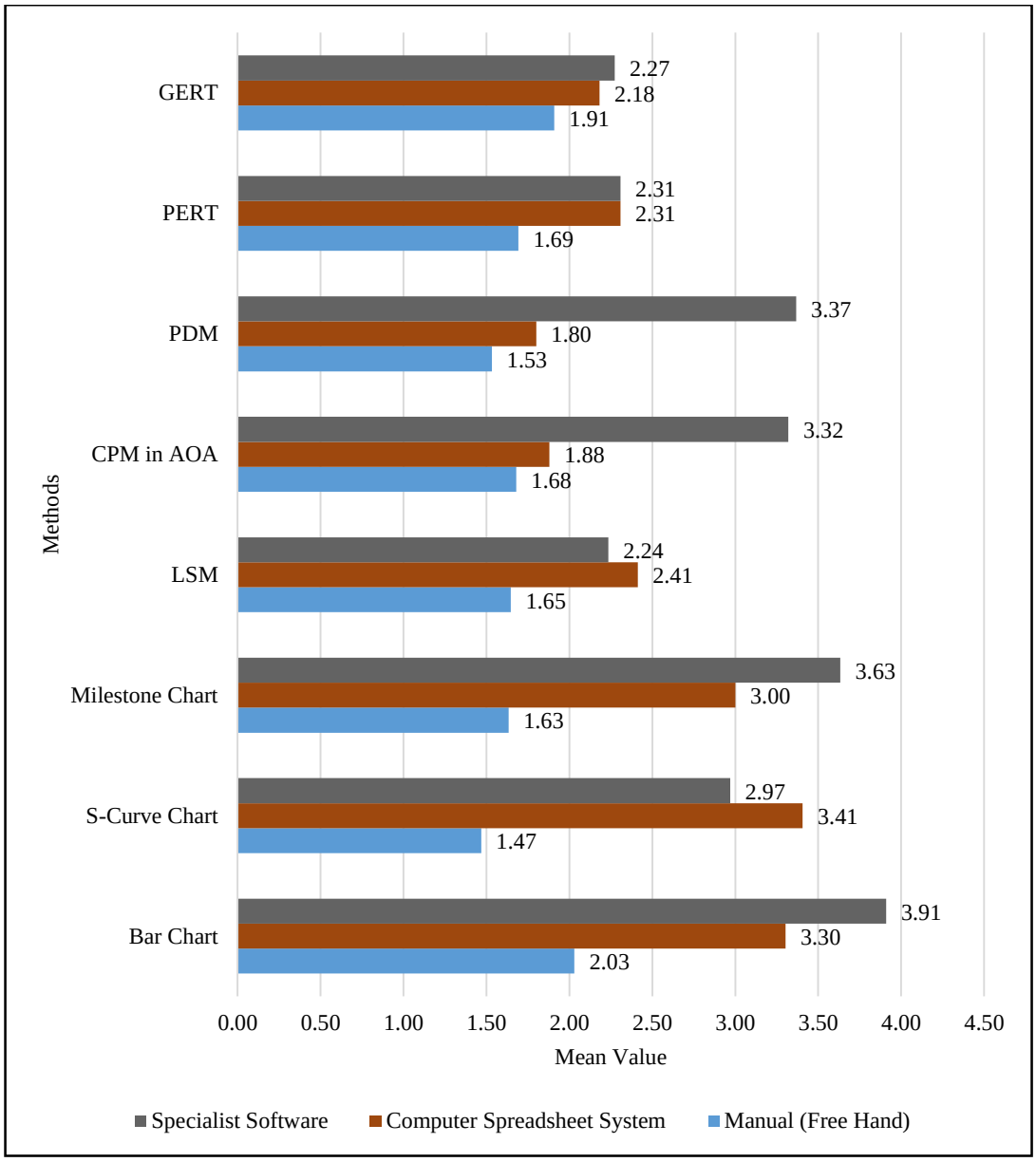

Figure 4.6 Mean Value of the Different Approaches Used in Preparing the Various Planning and Scheduling Methods

Table 4.6 and Figure 4.6 shows the mean values for three approaches used for planning and scheduling method by contractors. From the analysis, specialist software were the most approach used in preparing bar chart, milestone chart, CPM in AOA, PDM and GERT while computer spreadsheet system were the most approach used in preparing s-curve chart and LSM. Both specialist software and computer spreadsheet system was the most approach used in preparing PERT.

For bar chart, majority of the respondents prepare bar chart with specialist software with mean value of 3.91 that fall under category of frequent use, followed by computer spreadsheet system with mean value of 3.30 that fall under category of frequent use and lastly manual (free hand) with mean value of 2.03 that fall under category seldom use. For s-curve chart, majority of the respondent prepare s-curve chart with computer spreadsheet system with mean value of 3.41 that fall under category of frequent use, followed by specialist software with mean value of 2.97 that fall under category of medium use and lastly manual (free hand) with mean value of 1.47 that fall under category never use.

For milestone chart, majority of the respondent prepare milestone chart with specialist software with mean value of 3.63 that fall under category of frequent use, followed by computer spreadsheet system with mean value of 3.00 that fall under category of medium use and lastly manual (free hand) with mean value of 1.63 that fall under category never use. Meanwhile, for LSM, majority of the respondent prepare LSM with computer spreadsheet system with mean value of 2.41 that fall under category of seldom use, followed by specialist software with mean value of 2.24 that fall under category of seldom use and lastly manual (free hand) with mean value of 1.65 that fall under category never use.

For CPM in AOA, majority of the respondent prepare CPM in AOA with specialist software with mean value of 3.32 that fall under category of medium use, followed by computer spreadsheet system with mean value of 1.88 that fall under category of seldom use and lastly manual (free hand) with mean value of 1.68 that fall under category never use. For PDM, majority of the respondent prepare PDM with specialist software with mean value of 3.37 that fall under category of medium use, followed by computer spreadsheet system with mean value of 1.80 that fall under category of seldom use and lastly manual (free hand) with mean value of 1.53 that fall under category never use.

For PERT, majority of the respondent prepare PERT with specialist software and computer spreadsheet system with mean value of 2.31 each respectively that fall under category of seldom use and followed by manual (free hand) with mean value of 1.69 that fall under category of never use. Lastly for GERT, majority of the respondent prepare GERT with specialist software with mean value of 2.27, followed by computer spreadsheet system with mean value of 2.18 and lastly manual (free hand) with mean value of 1.91. This reflect that all three approach used for GERT fall under category of seldom use.

To summarise, the specialist software is the most frequently used in preparing bar chart and milestone chart, medium usage for s-curve, CPM in AOA and PDM; and seldom being used for preparing the other planning and scheduling methods. This is probably because of that majority of the specialist software such as Microsoft Project use by contractor in preparing work programme are user friendly in preparing bar chart, milestone chart, CPM in AOA and PDM. However, those specialist software which commonly used by contractors has limited function in preparing LSM, PERT and GERT. The preparation of s-curve and bar chart had frequently use the computer spreadsheet system. Apart from milestone chart with medium usage of computer spreadsheet system, the preparation other methods seldom use computer spreadsheet system. The computer spreadsheet system frequently used in preparing s-curve chart by contractors because due to that majority of the contractors are more convenient on using computer spreadsheet system and at the same time still lack of knowledge on using specialist software in preparing s-curve chart. Across all the planning and scheduling methods, contractors seldom or never prepare them manually. This indicates that the contractors have move with the shift in technology used in preparing their work programme. This is probably due to that preparing various planning and scheduling methods manually is time consuming and lack of flexibility to analyse changes on the project. In contrast, computerised planning and scheduling by using the computerised spreadsheet system and specialist software for planning and scheduling will speed up the process in preparing the various planning and scheduling methods and at the same time more flexible to analyse the changes on the project.

4.4.3 Computer Spreadsheet System Used

4.4.3.1 Types of Computer Spreadsheet System Used

Table 4.7 and Figure 4.7 shows the type of computer spreadsheet system used by contractors. Based on the analysis as illustrated in Table 4.7 and Figure 4.7, Microsoft Excel is the most common computer spreadsheet systems used by contractors with 93.94 % because of the fact that Microsoft Excel is very common in the country and easy to acquire. Table 4.7 and Figure 4.7 also indicates that not all the computer spreadsheet system are familiar to contractors in Malaysia. While OpenOffice.org is the second highest, which is 18.18 % and followed by Ssuite Accel, 9.09 %. Gnumeric, Kspread and Lotus 1-2-3 were the least used spreadsheet system used by contractors with 6.06 % each respectively. Hence, Microsoft Excel is the most used computer spreadsheet system by contractors in preparing work programme.

Table 4.7 Types of Computer Spreadsheet System Used

No	Type of Spreadsheet System	Frequency	Percentage (%)
1	Microsoft Excel	31	93.94
2	OpenOffice.org	6	18.18
3	Ssuite Accel	3	9.09
4	Gnumeric	2	6.06
5	Kspread	2	6.06
6	Lotus 1-2-3	2	6.06
7	Others:	0	0.00
TOTAL		33	

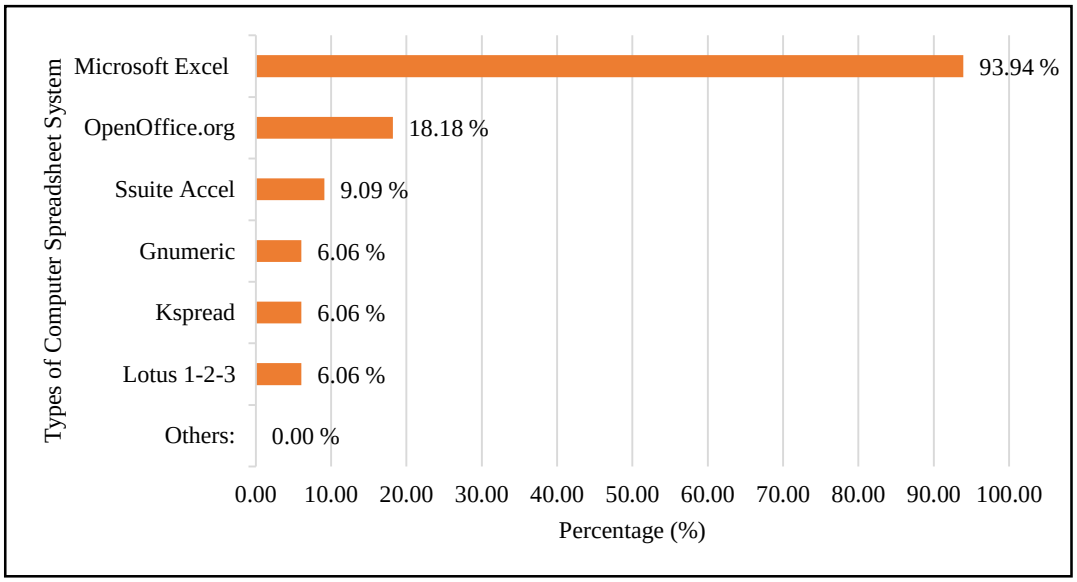

Figure 4.7 Percentage for Type of Computer Spreadsheet System Used

4.4.3.2 Level of Usage for Computer Spreadsheet System

This section discusses the level of usage for each type of computer spreadsheet systems used by contractors. Respondents were asked to rate the level of usage for each type of computer spreadsheet systems. Five point Likert scale was used for this section analysis, where "1" represented "Never Use" and "5" reflected "Very Frequent Use". The frequency for each computer spreadsheet systems was calculated to identify the level of usage for each type of computer spreadsheet systems. The frequency distribution was explained in Chapter 3. Table 4.8 shows the overall frequency for the computer spreadsheet systems.

Table 4.8 Usage of Type of Computer Spreadsheet System

No	Type of Spreadsheet System	Frequencies for Likert Scale					
		1	2	3	4	5	TOTAL
1	Microsoft Excel	2	0	1	11	19	33
2	OpenOffice.org	27	1	0	3	2	33
3	Ssuite Accel	30	0	2	1	0	33
4	Gnumeric	31	0	1	1	0	33
5	Kspread	31	0	2	0	0	33
6	Lotus 1-2-3	31	1	1	0	0	33
7	Others:	0	0	0	0	0	0

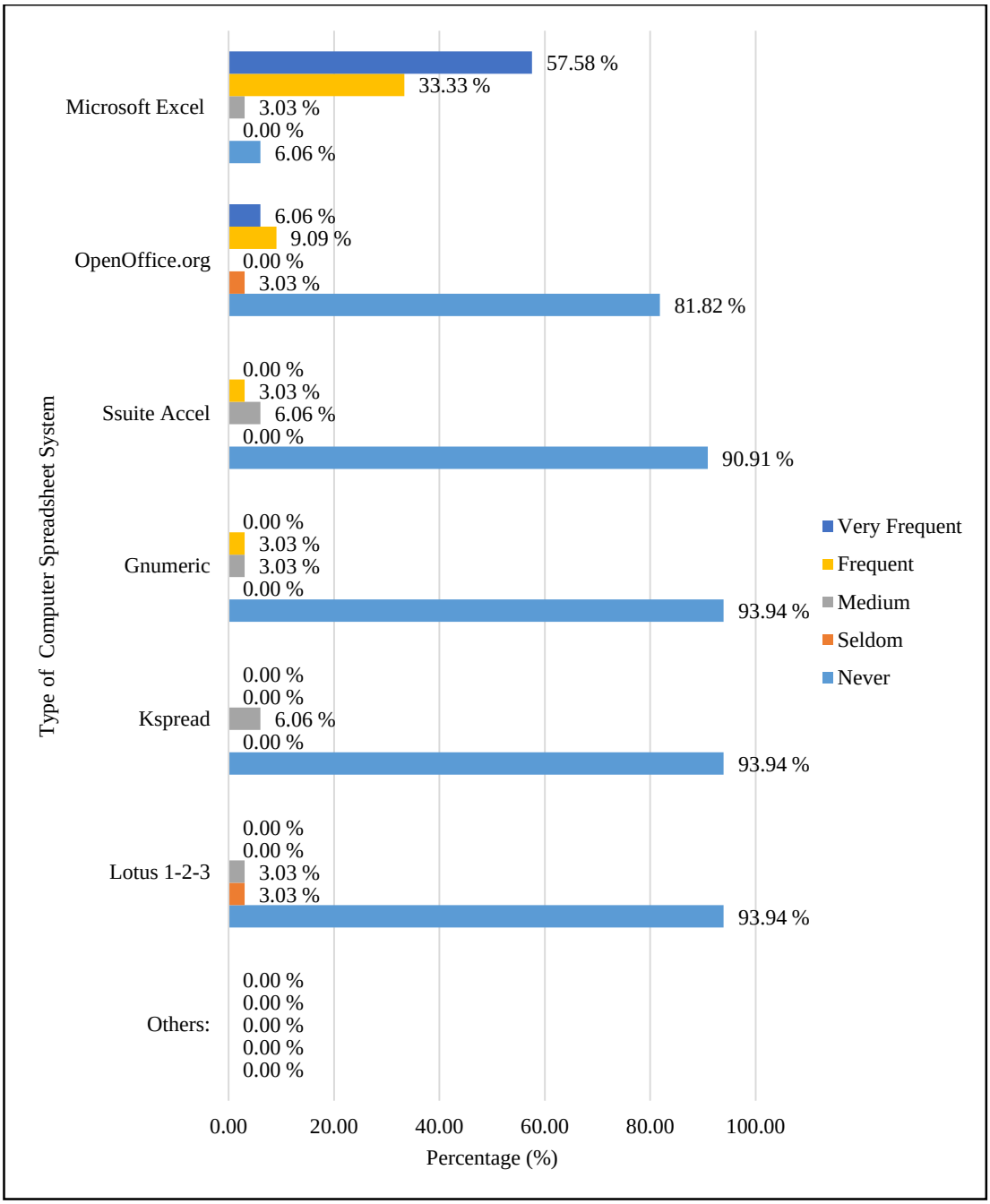

Figure 4.8 Percentage for the Usage of Type of Computer Spreadsheet System

Table 4.8 and Figure 4.8 show the usage of computer spreadsheet systems. Table 4.8 and Figure 4.8 show that Microsoft Excel has the highest percentage in very frequent usage with 57.58 % and followed secondly by Open Offce.org with 6.06 %. Hence, it can be concluded that the most very frequent use computer spreadsheet system by contractors in preparing work programme is Microsoft Excel.

4.4.4 Specialist Software Used

4.4.4.1 Types of Specialist Software Used

Table 4.9 and Figure 4.9 show the type of Specialist Software used by contractors. Based on the analysis from Table 4.9 and Figure 4.9, the most popular specialist software used by contractors is Microsoft Project with 100.00 % because of the fact that Microsoft Project is more user friendly and well known among local contractors compared to other specialist software. The second highest are Primavera Project Planner with 54.55 %, followed by Primavera Engineering and Construction Web Based Programmes with 24.24 %. Micro Planner X-Pert is fourth highest with 9.09 % and followed by Sure Track Project Manager, Artemis, Open Plan and FastTrack Schedule as the lowest with 6.06 % each respectively. This indicate that not all the planning and scheduling software are familiar to contractors in Malaysia. Hence, it can be conclude that the most used Specialist Software by contractors in preparing work programme is Microsoft Project.

Table 4.9 Type of Specialist Software Used

No	Type of Specialist Software	Frequency	Percentage (%)
1	Microsoft Project	33	100.00
2	Primavera Project Planner	18	54.55
3	Primavera Engineering and Construction Web Based Programmes	8	24.24
4	Micro Planner X-Pert	3	9.09
5	Sure Track Project Manager	2	6.06
6	Artemis	2	6.06
7	Open Plan	2	6.06
8	FastTrack Schedule	2	6.06
9	Other:	0	0.00
TOTAL		33	

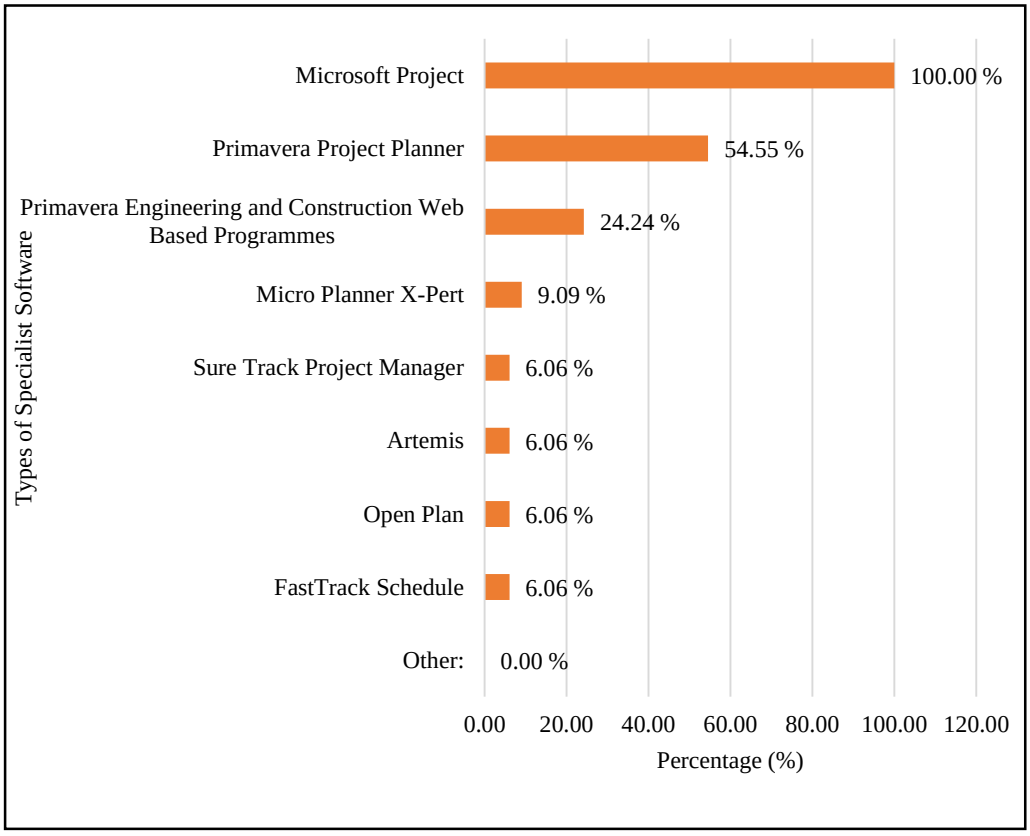

Figure 4.9 Percentage for Type of Specialist Software Used

4.4.4.2 Level of Usage for Specialist Software

This section will discuss about the level of usage for each type of specialist software's used by the contractors. Respondents were asked to rate the level of usage for each type of specialist software. Five point Likert scale was used for this section analysis, where "1" represented "Never Use" and "5" reflected "Very Frequent Use". The frequency for each specialist software was calculated to identify the level of usage for each type of specialist software. The frequency distribution was explained in Chapter 3. Table 4.10 showed the overall frequency for the specialist software.

Table 4.10 Usage of Type of Specialist Software

No	Type of Specialist Software	Frequencies for Likert Scale					
		1	2	3	4	5	TOTAL
1	Microsoft Project	0	2	5	9	17	33
2	Primavera Project Planner	15	5	5	5	3	33
3	Primavera Engineering and Construction Web Based Programmes	25	3	2	2	1	33
4	Micro Planner X-Pert	30	1	1	1	0	33
5	Sure Track Project Manager	31	1	0	1	0	33
6	Artemis	31	1	0	1	0	33
7	Open Plan	31	0	1	1	0	33
8	FastTrack Schedule	31	0	1	1	0	33
9	Other:	0	0	0	0	0	0

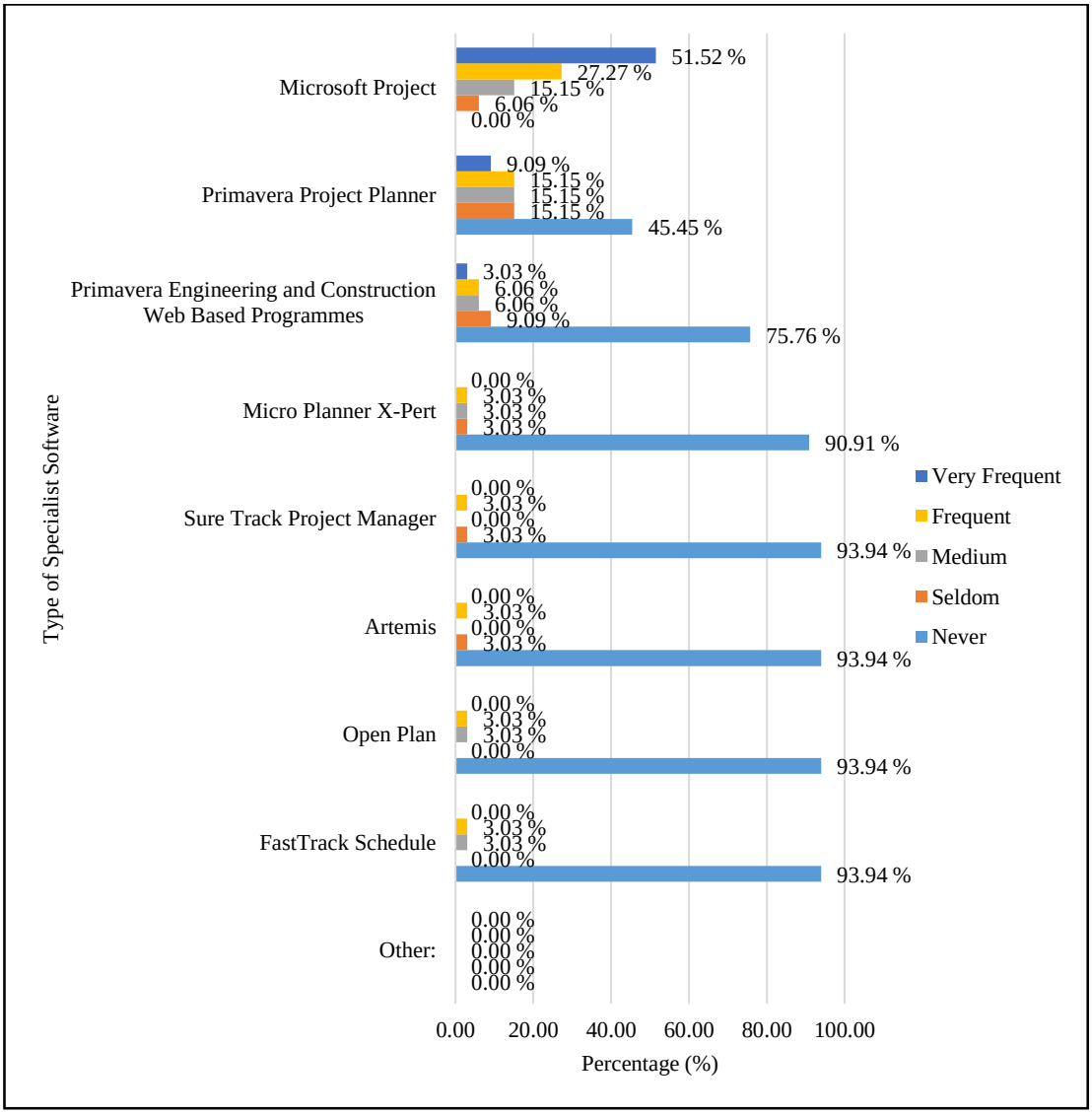

Figure 4.10 Percentage for the Usage of Type of Specialist Software

Table 4.10 and Figure 4.10 show the usage of specialist software. Based on the analysis, Microsoft Project has the highest percentage in very frequent usage with 51.52 %. Primavera Project Planner has the second highest percentage in very frequent usage with 9.09 % and followed thirdly by Primavera Engineering and Construction Web Based Programmes with 3.03 %. Therefore, it can be concluded that the most very frequent specialist software used by contractors in preparing work programme is Microsoft Project.

4.5 Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Programme

This section discusses the factors influencing the choice of planning and scheduling method. Respondents were asked to rate the level of importance for each of the thirteen factors given that influence the choice of the planning and scheduling methods. A five point Likert scale was used, where "1" represents "Not Important". The mean score for the factors was tabulated and then ranked from the highest to the lowest, as shown in Table 4.11. Table 4.11 also identifies the mean value for each factor. The category for level of importance is as explained in Chapter 3.

Table 4.11 Importance Level for Factors Influencing the Choice of Planning and Scheduling Methods

No	Factors	Frequencies for Likert Scale						Mean	Ranking	Category
		1	2	3	4	5	TOTAL			
1	The size of the project	0	2	1	16	14	33	4.27	1	Most Important
2	The complexity of the project	0	1	5	12	15	33	4.24	2	Most Important
3	The type of the project	0	3	10	12	8	33	3.76	5	Very Important
4	The duration of the project	0	4	6	11	12	33	3.94	4	Very Important
5	The experience of the users	0	5	7	13	8	33	3.73	6	Very Important
6	The flexibility of the methods adopted	1	1	12	12	7	33	3.70	7	Very Important
7	The availability of software for the planning and scheduling method	2	3	6	15	7	33	3.67	8	Very Important
8	The clients' preferences	1	4	9	12	7	33	3.61	9	Very Important
9	The level of detail information available for a particular project	0	1	7	16	9	33	4.00	3	Very Important
10	Other: Cost of project	0	0	0	0	1	33	0.15	11	Not Important
11	Other: Lead time for deliveries good and equipment	0	0	0	0	1	33	0.21	10	Not Important
12	Other: Cash flow of the developer	0	0	0	1	0	33	0.12	12	Not Important
13	Other: Construction drawing availability	0	0	0	1	0	33	0.12	12	Not Important

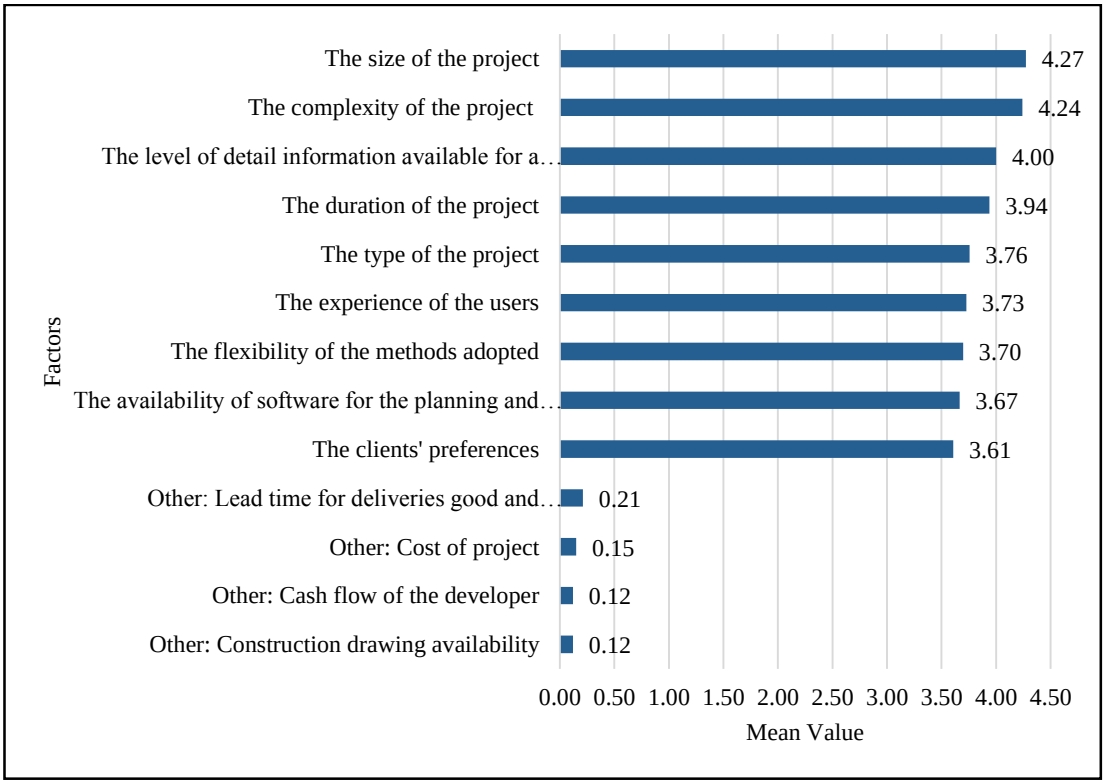

Figure 4.11 Mean Value for Factors Influencing the Choice of Planning and Scheduling Methods

Table 4.11 portrays the overall mean value for the importance level for thirteen factors influencing the choice of planning and scheduling methods to be used. The representation shows that most of the factors were found to be in the range of Very Important (3.40 – 4.20). Two of the factors were in the range of Most Important (4.20 – 5.00). Meanwhile, only four of the factors fall into the category of Not Important (1.00 – 1.80). This show that all the respondents think that suggested factors are important. From the analysis, majority of the respondents think that the size of the project and the complexity of the project are the most important factors that influencing the choice of planning and scheduling methods with a mean value of 4.27 and 4.24 respectively. This probably because the larger size construction project involving high complexity that consists of various subcontractor simultaneously working on as many as or more different element on the project. The progress of one party may affect the rate of other party and difficult for the main contractor to take in account of all the interrelationships between the tasks.

Meanwhile, the others five factors that influencing the choice of planning and scheduling methods fall under category very important. The level of detail information for a particular project with a mean value of 4.00, followed by the duration of the project with mean value of 3.94, the type of project with mean value of 3.76, the experience of the users with mean value 3.73, the flexibility of the methods adopted with mean value of 3.67, the availability of software for the planning and scheduling method with mean value of 3.61 and lastly the clients' preferences with mean value of 3.61. Level of detail information important due to some uncertainty that can affect the progress of the project. The information include weather record and labour and material availability important to the main contractor for their planning and scheduling work. The type of project such as residential, building, institutional and commercial, industrial, heavy construction and others will consider by the contractor when choosing the suitable method for planning and scheduling due different characteristic for each methods. Moreover, the experience and skill of the contractor on the methods important to be considered to ensure an effective planning and scheduling. Besides that, the method used must flexible for any changes on the project and availability of advanced software help the contractor to speed up the planning and scheduling process and making changes on their schedule if there are any changes on the project. Client

preferences will also be considered by the contractor although contractor have the choice to decide their own preference methods for planning and scheduling. Cost of the project, lead time for deliveries good and equipment, cash flow of developer and construction drawing availability are not important factor where each of those problems have only one respondent.

In conclusion, majority of the respondents agreed that the size of the project and the complexity of the project are the most important factor that influencing the choice of their planning and scheduling method. Thus, this shows that the complex planning and scheduling method commonly will be used for the large in size and high complexity project.

4.6 Problems Encountered in Using the Chosen Planning and Scheduling Methods in Preparing Work Programme

This section analyses and discusses the findings of the third objective which identify problems encountered using the chosen planning and scheduling methods. This section discusses the problems for all the eight types of the planning and scheduling methods. Respondents were asked to indicate the level of agreement for each of the eight problems given. A five point Likert scale was used, where "1" represents "Strongly Disagree" and "5" reflects "Strongly Agree". The mean score for the problems was tabulated and then ranked from the highest to the lowest. The category for level of agreement is as explained in Chapter 3.

4.6.1 Problems Encountered in Using Bar Chart

Table 4.12 Problems in Using Bar Chart

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	2	16	6	6	3	33	2.76	Neither Agree Nor Disagree
2	Not flexible to analyse changes on the project	0	13	5	14	1	33	1.94	Disagree
3	High complexity and difficult to learn	2	24	4	3	0	33	2.24	Disagree
4	Specialist and experienced planner/scheduler requirement	2	17	3	9	2	33	2.76	Neither Agree Nor Disagree
5	Detail information requirement	0	10	7	12	4	33	3.30	Neither Agree Nor Disagree
6	Computer hardware and software requirement	2	10	6	13	2	33	3.09	Neither Agree Nor Disagree
7	Sufficient training requirement	2	12	8	11	0	33	3.00	Neither Agree Nor Disagree
8	Inability to control critical path of the project	1	4	5	16	7	33	3.73	Agree
9	Others:	0	0	0	0	0	0	0.00	N/A

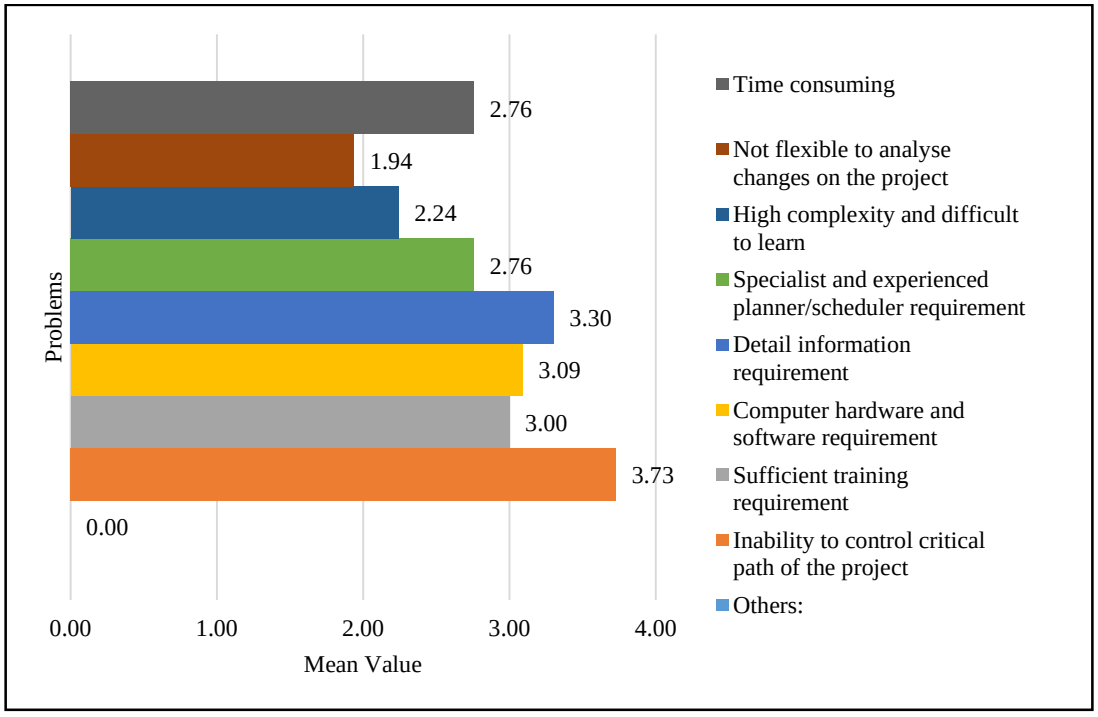

Figure 4.12 Mean Value for Problems in Using Bar Chart

Table 4.12 potrays the overall mean value of the Agreement level for the eight problems as indicated by the respondents. The representation shows that most of the problems were found to be in range of Neither Agree Nor Disagree (2.60 – 3.40). Only one problem fall under the category of Agree (3.40 – 4.20). It shows that not all of the problems stated are encountered when using the bar chart method. Meanwhile, there are two problems that fall under the category of disagree (1.80 – 2.60).

From the analysis, majority of respondents agreed that the problem encountered in using bar chart method was inability to control critical path of the project. The highest mean value is inability to control critical path of the project with mean value of 3.73. This probably because the simple bar chart method does not have the ability show activity relationship that control the critical path of the project. Not flexible to analyses changes on the project as well as high complexity and difficult to learn fall under the category of Disagree. This probably because the bar chart methods is simple to learn, easily to understand by the user and does not involve complex network diagram for planning and scheduling. Meanwhile, there are five problems are fall under the category of Neither Agree Nor Disagree namely time consuming with mean value of 2.76, specialist and experienced planner/scheduler requirement with mean value of 2.76, detail information requirement with mean value of 3.30, computer hardware and software requirement with mean value of 3.09 and sufficient training requirement with mean value of 3.00. This probably because the occurrence of problems depend on the contractors.

In conclusion, it seems that the majority respondents agreed that the problems of the bar chart method are inability to control the critical path of the project due to probably bar chart does not show the activity relationship.

4.6.2 Problems Encountered in Using S-Curve Chart

Table 4.13 Problems in Using S-Curve Chart

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	12	9	10	1	32	3.00	Neither Agree or Disagree
2	Not flexible to analyse changes on the project	0	16	6	9	1	32	2.84	Neither Agree or Disagree
3	High complexity and difficult to learn	0	19	8	5	0	32	2.56	Disagree
4	Specialist and experienced planner/scheduler requirement	0	9	8	14	1	32	3.22	Neither Agree or Disagree
5	Detail information requirement	0	4	5	20	3	32	3.69	Agree
6	Computer hardware and software requirement	1	2	6	21	2	32	3.66	Agree
7	Sufficient training requirement	0	6	8	18	0	32	3.38	Neither Agree or Disagree
8	Inability to control critical path of the project	0	5	6	17	4	32	3.63	Agree
9	Others:	0	0	0	0	0	0	0.00	N/A

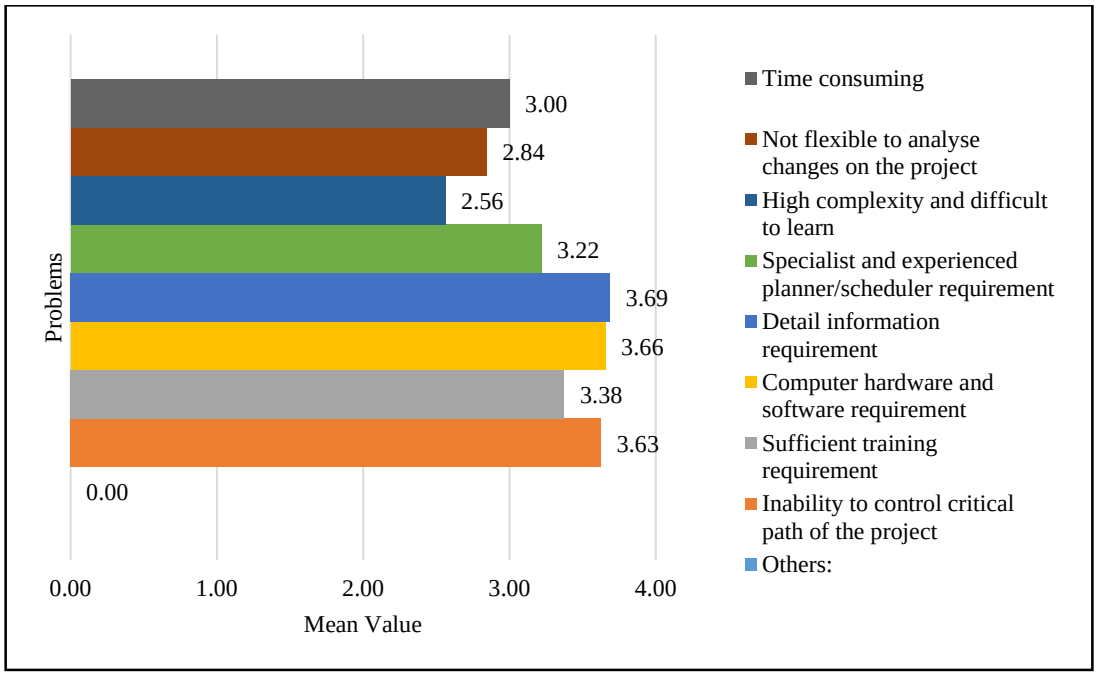

Figure 4.13 Mean Value for Problems in Using S-Curve Chart

Table 4.13 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that most of the problems were found to be in the range of Neither Agree Nor Disagree (2.60 – 3.40) whereas three problems fall under the category of Agree (3.40 – 4.20). It shows that most of the problems were not encountered when using S-curve chart. However, only one problems that fall under the category disagree (1.80 – 2.60).

From the analysis, majority of respondents agreed that the detail information requirement, computer hardware and software requirement and inability to control critical path of the project. The problems encountered with highest mean value is detail information requirement which is 3.69 and followed by computer hardware and software requirement with mean value of 3.66 and lastly inability to control critical path of the project with mean value of 3.63 respectively. This show that the respondents agreed that the s-curve chart are detail information requirement, computer hardware and software requirement and inability to control critical path of the project. This is probably because the s-curve chart involve calculation work to obtain the overall progress of the work and only be able to do conveniently using computer hardware and software. Only one problem disagree by the respondents which is high complexity and difficult to learn with a mean value of 2.56. This is probably s-curve chart only allow develop work schedule that show the progress of the project through the cumulative of the cost or duration of the project that had been planned and does not able to show the activity relationship. The others four problems fall under the category of Neither Agree Nor Disagree namely time consuming with mean value of 3.00, not flexible to analyse changes on the project with mean value of 2.84, specialist and experienced planner/scheduler with mean value of 3.22 and sufficient training requirement with mean value of 3.38. This is probably due to that occurrence of the problems depends on the contractors.

In conclusion, it seems that the majority respondents agreed that the problems of the s-curve chart method are detail information requirement, computer hardware and software requirement and inability to control the critical path of the project.

4.6.3 Problems Encountered in Using Milestone Chart

Table 4.14 Problems in Using Milestone Chart

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	13	11	5	1	30	2.80	Neither Agree or Disagree
2	Not flexible to analyse changes on the project	1	12	7	8	2	30	2.93	Neither Agree or Disagree
3	High complexity and difficult to learn	1	16	7	6	0	30	2.60	Neither Agree or Disagree
4	Specialist and experienced planner/scheduler requirement	0	9	10	11	0	30	3.07	Neither Agree or Disagree
5	Detail information requirement	0	3	8	17	2	30	3.60	Agree
6	Computer hardware and software requirement	0	4	9	16	1	30	3.47	Agree
7	Sufficient training requirement	0	6	9	15	0	30	3.30	Neither Agree or Disagree
8	Inability to control critical path of the project	1	8	7	10	4	30	3.27	Neither Agree or Disagree
9	Others:	0	0	0	0	0	0	0.00	N/A

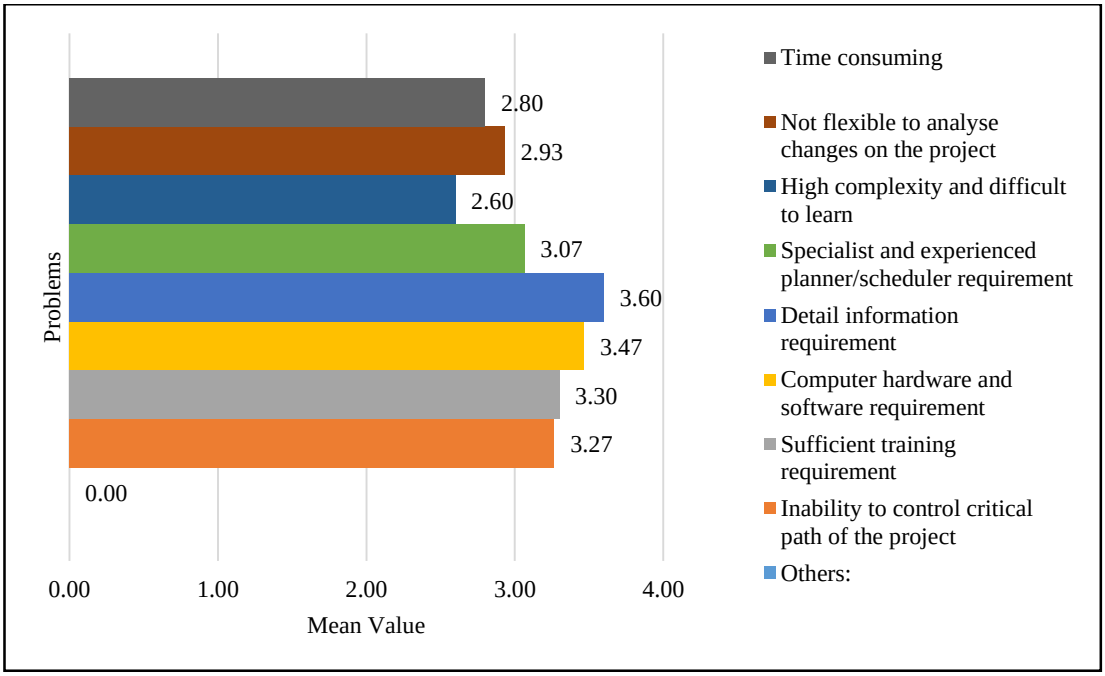

Figure 4.14 Mean Value for Problems in Using Milestone Chart

Table 4.14 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that most of the problems were found to be in the range of Neither Agree Nor Disagree (2.60 – 3.40). It shows that most of the problems were not encountered when using milestone chart. Only two problems fall under the category of Agree (3.40 – 4.20).

From the analysis, only two of the problems given are agreed by majority of the respondents which are detail information requirement and computer hardware and software requirement. The problem with the highest mean value is detail information requirement with mean value of 3.60, followed by computer hardware and software requirement with mean value of 3.47. This reflects that majority of the respondent agree that milestone chart for planning and scheduling require detail project information such as weather record and labour and material availability as this probably due to that all those project information is important for the contractor to set the preliminary milestone of the project. Besides that, computer hardware and software requirement to make the process of preparing the method more convenient and faster. Main contractor commonly will prepare the milestone chart together with the bar chart due to the availability of specialist software such as Microsoft Project The others six problems fall under the category of Neither Agree Nor Disagree namely time consuming with mean value of 2.80, not flexible to analyse changes on the project with mean value of 2.93, high complexity and difficult to learn with mean value of 2.60, specialist and experienced planner/scheduler requirement with mean value of 3.07, sufficient training requirement with mean value of 3.30 and inability to control critical path of the project with mean value of 3.27. This is probably due to that occurrence of the problems depends on the contractors.

In conclusion, it seems that the majority respondents agreed that the problems of the milestone chart method are detail information requirement and computer hardware and software requirement.

4.6.4 Problems Encountered in Using LSM

Table 4.15 Problems in Using LSM

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	5	7	4	1	17	3.06	Neither Agree or Disagree
2	Not flexible to analyse changes on the project	0	5	9	2	1	17	2.94	Neither Agree or Disagree
3	High complexity and difficult to learn	0	5	8	3	1	17	3.00	Neither Agree or Disagree
4	Specialist and experienced planner/scheduler requirement	0	5	7	5	0	17	3.00	Neither Agree or Disagree
5	Detail information requirement	0	2	9	6	0	17	3.24	Neither Agree or Disagree
6	Computer hardware and software requirement	0	4	6	5	2	17	3.29	Neither Agree or Disagree
7	Sufficient training requirement	0	4	6	6	1	17	3.24	Neither Agree or Disagree
8	Inability to control critical path of the project	0	2	8	6	1	17	3.35	Neither Agree or Disagree
9	Others:	0	0	0	0	0	0	0.00	N/A

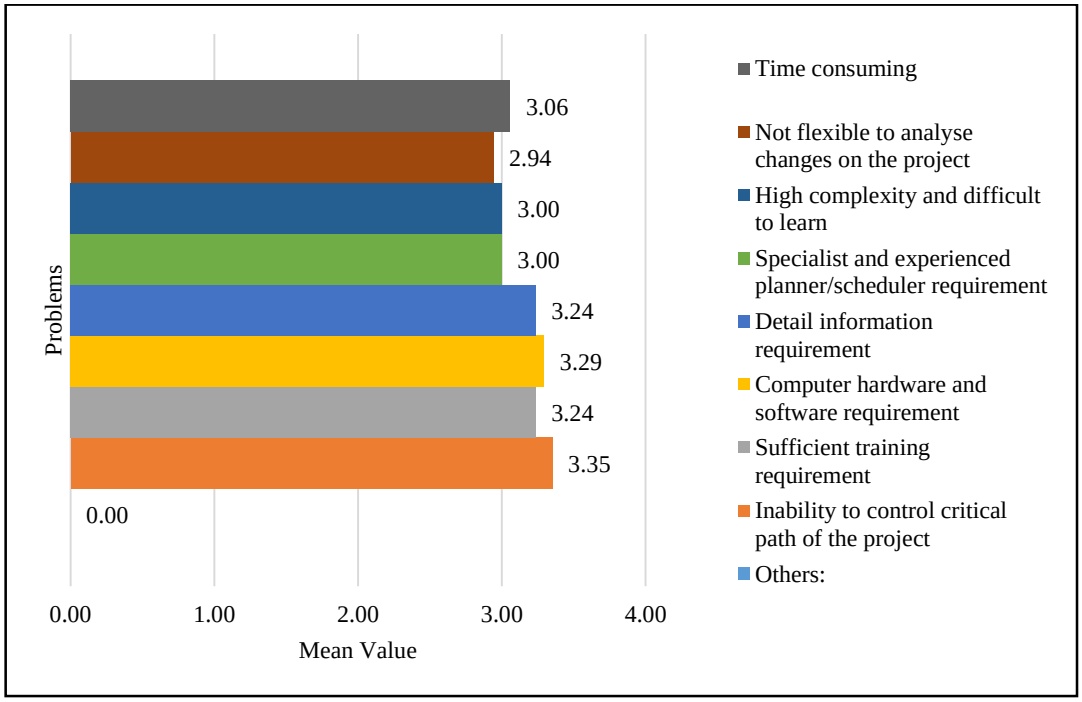

Figure 4.15 Mean Value for Problems in Using LSM

Table 4.15 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that all of the problems were found to be in the range of Neither Agree Nor Disagree (2.60 – 3.40). From the analysis, all the problems fall under the category of Neither Agree Nor Disagree namely time consuming with mean value of 3.06, not flexible to analyse changes on the project with mean value of 2.94, high complexity and difficult to learn with mean value of 3.00, specialist and experienced planner/scheduler requirement with mean value of 3.00, detail information requirement with mean value of 3.24, computer hardware and software requirement with mean value of 3.29, sufficient training requirement with mean value of 3.24 and inability to control critical path of the project with mean value of 3.35. In conclusion, respondents are unsure of the problems in using LSM because LSM is not well known to be used by contractors for planning and scheduling and the occurrence of the problems depend on the contractors.

4.6.5 Problems Encountered in Using CPM in AOA Network

Table 4.16 Problems in Using CPM in AOA

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	4	3	17	1	25	3.60	Agree
2	Not flexible to analyse changes on the project	0	14	5	6	0	25	2.68	Neither Agree or Disagree
3	High complexity and difficult to learn	3	5	4	11	2	25	3.16	Neither Agree or Disagree
4	Specialist and experienced planner/scheduler requirement	0	2	5	15	3	25	3.76	Agree
5	Detail information requirement	0	1	2	20	2	25	3.92	Agree
6	Computer hardware and software requirement	0	3	3	16	3	25	3.76	Agree
7	Sufficient training requirement	0	2	4	18	1	25	3.72	Agree
8	Inability to control critical path of the project	4	13	1	5	2	25	2.52	Disagree
9	Others:	0	0	0	0	0	0	0.00	N/A

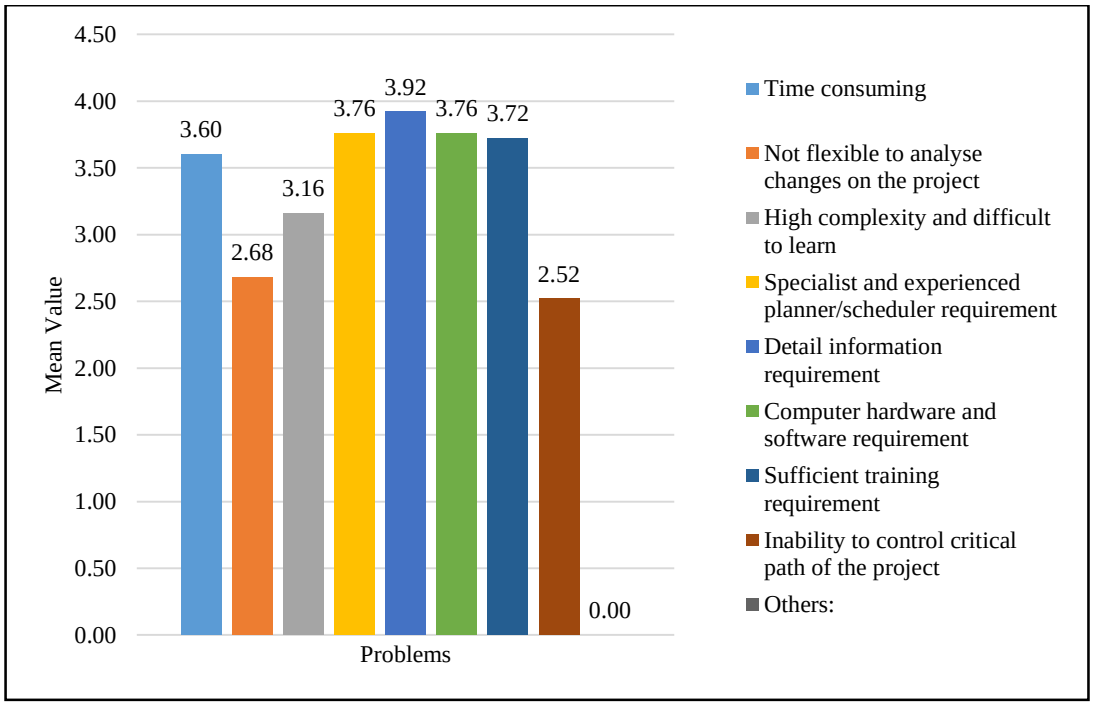

Figure 4.16 Mean Value for Problems in Using CPM in AOA

Table 4.16 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that all of the problems were found to be in the range of Agree (3.40 – 4.20). Two problems fall under category of Neither Agree Nor Disagree (2.60 – 3.40) and only one problem fall under category of disagree (1.80 – 2.60). It shows that most of the problems stated are encountered when using CPM in AOA. From the analysis, majority of respondents agreed that problem encountered in using the CPM in AOA are time consuming, detail information requirement, specialist planner/scheduler requirement, computer hardware and software requirement as well as sufficient training requirement. Detail information requirement has the highest mean value with 3.92, followed by computer hardware and software requirement as well as specialist and experienced planner/scheduler requirement with mean value of 3.76 each respectively, sufficient training requirement with mean value of 3.72, and lastly time consuming with mean value of 3.60. The use CPM in AOA for planning and scheduling involve the complex data computation process that are more time consuming to be used compare to others method. Since CPM in AOA have the ability to control the critical activities on the project, used of CPM require sufficient detail information on the project to develop the work programme. Majority of the respondent disagree that inability to control critical

path of the project as the problem encountered because the complex CPM in AOA able to show the activities dependencies which control critical path of the project. The others two problems fall under the category of Neither Agree Nor Disagree namely not flexible to analyse changes on the project with mean value of 2.68 and high complexity and difficult to learn with mean value of 3.16. This is probably due to that occurrence of the problems depends on the contractors.

In conclusion, it seems that the majority respondents agreed that the problems of the CPM in AOA method are time consuming, specialist and experienced planner/scheduler requirement, detail information requirement and computer hardware and software requirement and sufficient training requirement.

4.6.6 Problems Encountered in Using PDM

Table 4.17 Problems in Using PDM

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	4	5	18	3	30	3.67	Agree
2	Not flexible to analyse changes on the project	0	14	7	8	1	30	2.87	Neither Agree or Disagree
3	High complexity and difficult to learn	0	8	7	12	3	30	3.33	Neither Agree or Disagree
4	Specialist and experienced planner/scheduler requirement	0	1	9	17	3	30	3.73	Agree
5	Detail information requirement	0	0	5	22	3	30	3.93	Agree
6	Computer hardware and software requirement	0	2	5	19	4	30	3.83	Agree
7	Sufficient training requirement	0	1	6	21	2	30	3.80	Agree
8	Inability to control critical path of the project	3	12	5	8	2	30	2.80	Neither Agree or Disagree
9	Others:	0	0	0	0	0	0	0.00	N/A

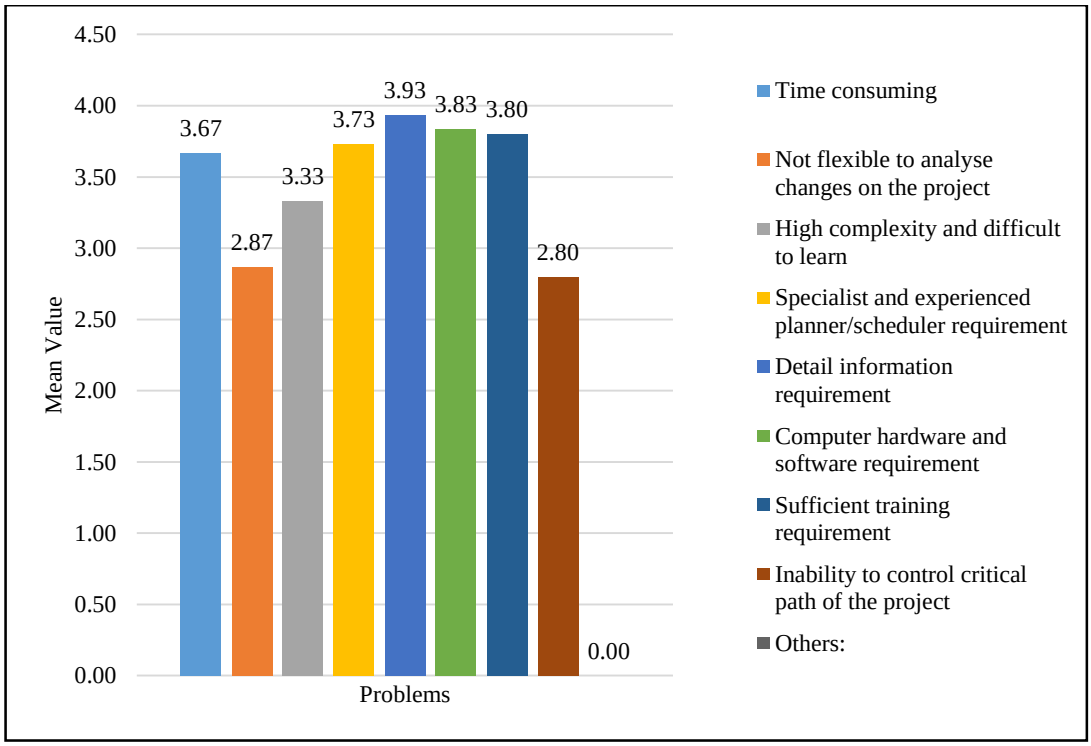

Figure 4.17 Mean Value for Problems in Using PDM

Table 4.17 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that all of the problems were found to be in the range of Agree (3.40 – 4.20). Three problems fall under category of Neither Agree Nor Disagree (2.60 – 3.40). It shows that most of the problems stated are encountered when using PDM.

From the analysis, majority of respondents agreed that problem encountered in using the PDM are time consuming, specialist planner/scheduler requirement, detail information requirement, computer hardware and software requirement as well as sufficient training requirement. Detail information requirement has the highest mean value with of 3.93, followed by computer hardware and software requirement with mean value of 3.83, sufficient training requirement with mean value of 3.80, specialist and experienced planner/scheduler requirement with mean value of 3.73 and lastly time consuming with mean value of 3.67. This probably due to that PDM involve the complex data computation when used for planning and scheduling, thus make PDM are time consuming, require specialist planner/scheduler, require detail information, require computer hardware and software and user must have sufficient training. The

analysis also show that inability to control critical path of the project is not a problem when using PDM. The others three problems fall under the category of Neither Agree Nor Disagree namely not flexible to analyse changes on the project with mean value of 2.87, high complexity and difficult to learn wth mean value of 3.33 and inability to control critical path of the project with mean value of 2.80. This is probably due to that occurrence of the problems depends on the contractors.

In conclusion, it seems that the majority respondents agreed that the problems of the PDM method are time consuming, specialist and experienced planner/scheduler requirement, detail information requirement and computer hardware and software requirement and sufficient training requirement.

4.6.7 Problems Encountered in Using PERT

Table 4.18 Problems in Using PERT

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	2	6	4	1	13	3.31	Neither Agree or Disagree
2	Not flexible to analyse changes on the project	0	3	7	3	0	13	3.00	Neither Agree or Disagree
3	High complexity and difficult to learn	0	2	7	4	0	13	3.15	Neither Agree or Disagree
4	Specialist and experienced planner/scheduler requirement	0	3	7	3	0	13	3.00	Neither Agree or Disagree
5	Detail information requirement	0	2	6	5	0	13	3.23	Neither Agree or Disagree
6	Computer hardware and software requirement	0	2	6	4	1	13	3.31	Neither Agree or Disagree
7	Sufficient training requirement	0	2	7	3	1	13	3.23	Neither Agree or Disagree
8	Inability to control critical path of the project	1	3	6	3	0	13	2.85	Neither Agree or Disagree
9	Others:	0	0	0	0	0	0	0.00	N/A

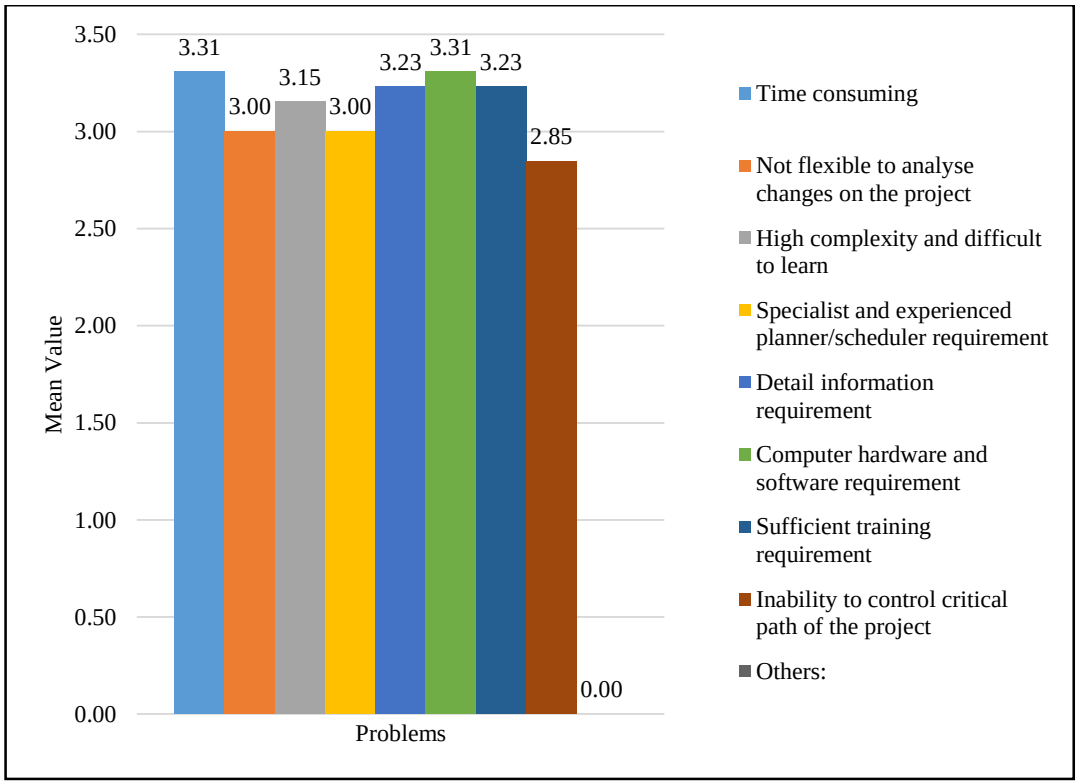

Figure 4.18 Mean Value for Problems in Using PERT

Table 4.18 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that all of the problems were found to be in the range of Neither Agree Nor Disagree (2.60 – 3.40). It shows that majority of the respondent are not familiar with PERT which the method is not commonly used in construction industry for planning and scheduling thus unable the respondents to determine the relevant problems encountered in using PERT. From the analysis, all the problems fall under the category of Neither Agree Nor Disagree namely time consuming with mean value of 3.31, not flexible to analyse changes on the project with mean value of 3.00, high complexity and difficult to learn with mean value of 3.15, specialist and experienced planner/scheduler requirement with mean value of 3.00, detail information requirement with mean value of 3.23, computer hardware and software requirement with mean value of 3.31, sufficient training requirement with mean value of 3.23 and inability to control critical path of the project with mean value of 2.85. In conclusion, respondents are unsure of the problems in using PERT because PERT is not well known to be used by contractors for planning and scheduling and the occurrence of the problems depend on the contractors.

4.6.8 Problems Encountered in Using GERT

Table 4.19 Problems in Using GERT

No	Problems	Frequencies for Likert Scale						Mean	Category
		1	2	3	4	5	TOTAL		
1	Time consuming	0	1	5	4	1	11	3.45	Agree
2	Not flexible to analyse changes on the project	0	1	6	4	0	11	3.27	Neither Agree or Disagree
3	High complexity and difficult to learn	0	1	5	5	0	11	3.36	Neither Agree or Disagree
4	Specialist and experienced planner/scheduler requirement	0	1	6	4	0	11	3.27	Neither Agree or Disagree
5	Detail information requirement	0	1	6	4	0	11	3.27	Neither Agree or Disagree
6	Computer hardware and software requirement	0	2	5	3	1	11	3.27	Neither Agree or Disagree
7	Sufficient training requirement	0	1	5	4	1	11	3.45	Agree
8	Inability to control critical path of the project	0	1	6	3	1	11	3.36	Neither Agree or Disagree
9	Others:	0	0	0	0	0	0	0	N/A

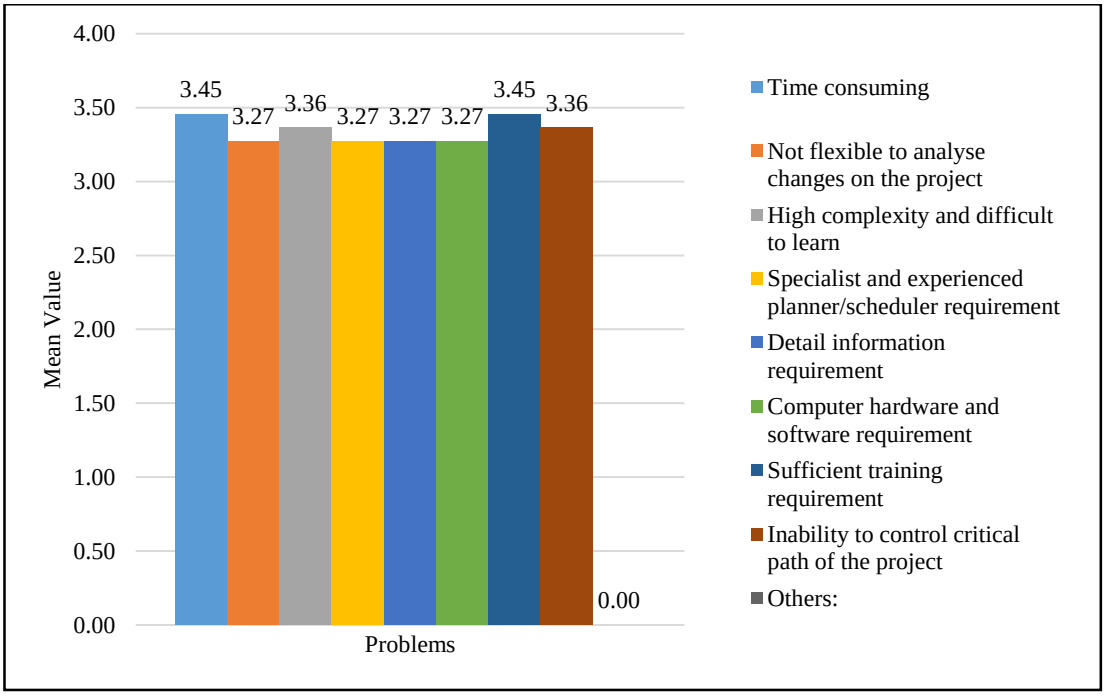

Figure 4.19 Mean Value for Problems in Using GERT

Table 4.19 potrays the overall mean value for the Agreement level for the eight problems as indicated by the respondents. The representation shows that all of the problems were found to be in the range of Neither Agree Nor Disagree (2.60 – 3.40). Meanwhile, there are two problems fall under category of Agree (3.40 – 4.20). It shows that majority of the respondent are not familiar with GERT which the method is not commonly used in construction industry for planning and scheduling.

From the analysis, the main problem in using GERT for planning and scheduling are time consuming and require sufficient training. Majority of the respondents think that time consuming and sufficient training requirement are the problem encountered when using GERT with mean value of 3.45 each respectively. This is probably due to that GERT is not a familiar method used for planning and scheduling in construction industry and at the same time involve high complexity that require to specialized training on the use of GERT. The others six problems fall under the category of Neither Agree Nor Disagree namely not flexible to analyse changes on the project with mean value of 3.27, high complexity and difficult to learn with mean value of 3.36, specialist and experienced planner/scheduler requirement with mean value of 3.27, detail information requirement with mean value of 3.27, computer hardware and software requirement with mean value of 3.27 and inability to control critical path of the project with mean value of 3.36. This is probably due to that occurrence of the problems depends on the contractors.

In conclusion, it seems that the majority respondents agreed that the problems of the GERT method are time consuming and sufficient training requirement.

4.6.9 Summary of Problems Encountered in Using the Various Planning and Scheduling Methods

This section discusses the overall summary for problems encountered in using the chosen planning and scheduling methods. Table 4.20 and Figure 4.20 shows problems encountered in using the various planning and scheduling methods. It can be summarised that the problems in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. Time consuming; requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were the problems in using network based methods (CPM in AOA, PDM, PERT and GERT). In general, majority of respondent agree that detail information requirement with average mean value of 3.52 and computer hardware and software with average mean value of 3.46 as the common problems for planning and scheduling.

Table 4.20 also reflects that PDM is the most difficult planning and scheduling methods to be used as PDM has the highest average mean value for the problem encountered among the chosen planning and scheduling methods adopted by contractors. From the analysis, PDM recorded the highest mean value for half of the problems mentioned compared to the other methods. All the problems encountered in using the PDM are under the category of Agree except high complexity and difficult to learn which is under the category of neither agree nor disagree. This probably because PDM is a complex network based method which require specialist planner/scheduler as well as sufficient training before using the method. Thus, it can be deduced that there are G7 contractors in Malaysia who still lack the skill and knowledge in using the complex planning and scheduling methods. Computer hardware and software is important also in using the PDM which help to speed up the planning and scheduling process however not all the contractors might able to purchase the advance hardware and software for planning and scheduling. In term of project information, PDM require detail information from the project for planning and scheduling however not all of those information will be available to the contractors.

Table 4.20 Summary of the Problems Encountered in Using the Various Planning and Scheduling Methods

Problems	Mean Value								Overall Average Mean Value
	Bar Chart	S-Curve Chart	Milestone Chart	LSM	CPM in AOA	PDM	PERT	GERT	
Time consuming	2.76	3.00	2.80	3.06	3.60	3.67	3.31	3.45	3.21
Not flexible to analyse changes on the project	1.94	2.84	2.93	2.94	2.68	2.87	3.00	3.27	2.81
High complexity and difficult to learn	2.24	2.56	2.60	3.00	3.16	3.33	3.15	3.36	2.93
Specialist and experienced planner/ scheduler requirement	2.76	3.22	3.07	3.00	3.76	3.73	3.00	3.27	3.23
Detail information requirement	3.30	3.69	3.60	3.24	3.92	3.93	3.23	3.27	3.52
Computer hardware and software requirement	3.09	3.66	3.47	3.29	3.76	3.83	3.31	3.27	3.46
Sufficient training requirement	3.00	3.38	3.30	3.24	3.72	3.80	3.23	3.45	3.39
Inability to control critical path of the project	3.73	3.63	3.27	3.35	2.52	2.80	2.85	3.36	3.19
Others:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall Average Mean Value	2.85	3.25	3.13	3.14	3.39	3.50	3.13	3.34	

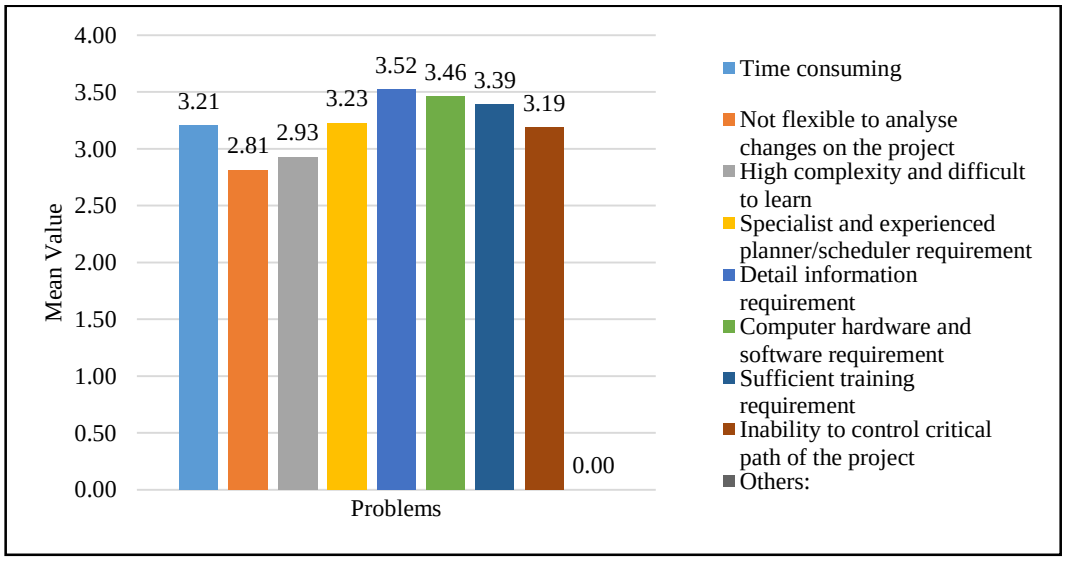

Figure 4.20 Overall Average Mean Value for Problems Encountered in Using the Various Planning and Scheduling Methods

4.7 Chapter Summary

This section summarized the overall findings of the research. The research intended to identify the planning and scheduling methods adopted by local contractors in preparing work programme, to determine the factor influencing their choice of planning and scheduling methods as well as problems encountered in using the chosen planning and scheduling methods. The research analysis and findings revealed that the planning and scheduling methods used by contractors in preparing their work programme is dominated by the traditional or the non-network based methods. Specialist software were the most used in preparing the various planning and scheduling methods followed by the computer spreadsheet system. Across all the planning and scheduling methods, contractors seldom or never prepare them manually. The size and complexity of projects are the most important factors influencing the choice of planning and scheduling methods. Problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. On the other hand, time consuming; the requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were among the problems identified in using the network based methods (CPM in AOA, PDM, PERT and GERT). Thus, the common problems encountered across all methods centred on the requirements for detail information, as well as for computer hardware and software. The research analysis and findings are the summarized and concluded in the next chapter.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter concludes the overall study that have been conducted with regards to the planning and scheduling methods adopted by grade G7 construction contractors in preparing work programme, factors influencing their choice of planning and scheduling methods in preparing work programme and problems encountered using the chosen planning and scheduling methods to prepare work programme. The predicaments encountered during the conduct of the research study will also be discussed in this chapter. Future recommended studies are highlighted at the end of the chapter.

5.2 Research Conclusion

The objective of the research is to identify the planning and scheduling methods adopted by contractors in preparing work programme, to determine the

factors influence their choice of planning and scheduling methods in preparing work programme and to identify problems encountered using the chosen planning and scheduling methods to prepare work programme. The conclusion of the research study is divided into three sections which are types of planning and scheduling methods adopted in preparing work programme, factors influencing their choice of planning and scheduling methods in preparing work programme and problems encountered in using the chosen planning and scheduling methods to prepare work programme. The conclusion is made in accordance with the objectives of the research study.

5.2.1 Types of Planning and Scheduling Methods Adopted by Contractors in Preparing Work Programme

It can concluded that the planning and scheduling methods used by contractors in preparing their work programme is dominated by the traditional or the non-network based methods with bar chart as the most popular, followed by the s-curve chart and milestone chart. Specialist software were the most used in preparing the various planning and scheduling methods followed by the computer spreadsheet system. Across all the planning and scheduling methods, contractors seldom or never prepare them manually. Microsoft Excel is the most adopted and most frequent used computer spreadsheet system by contractors in preparing work programme while Microsoft Project is the most adopted and most frequent used specialist software by contractors in preparing work programme.

5.2.2 Factors Influencing the Choice of Planning and Scheduling Methods in Preparing Work Programme

There are two most important factors that influence the choice of planning and scheduling methods which are the size of the project and the complexity of the project. It can therefore be concluded that these two factors are main factors influencing the choice of planning and scheduling methods to be used by contractors for planning and scheduling in preparing work programme.

5.2.3 Problems Encountered in Using the Chosen Planning and Scheduling Methods to Prepare Work Programme

The main problems in using the bar chart is inability to control critical path of the project. Meanwhile, the main problems in using the s-curve chart are detail information requirement, computer hardware and software requirement and inability to control critical path of the project. Moreover, the main problems in using milestone chart is detail information requirement and computer hardware and software requirement. For both CPM in AOA and PDM, the main problems encountered are time consuming, specialist and experienced planner/scheduler requirement, detail information requirement, computer hardware and software requirement and lastly sufficient training requirement. There are no problems reflected for LSM and PERT mainly due to the respondent not familiar with methods. Lastly, the problem encountered in using GERT is time consuming and sufficient training requirement.

Hence, problems encountered in using the non-network based methods (bar chart, s-curve chart, milestone chart and LSM) include the requirements for detail information, computer hardware and software, and the inability to control the critical path of the project. On the other hand, time consuming; the requirements for specialist and experienced planner/scheduler, detail information, computer hardware and software and sufficient training were the common problems in using network based methods (CPM in AOA, PDM, PERT and GERT).

Lastly, the analysis also concluded that PDM is the most difficult used planning and scheduling methods as recorded highest mean value for half the problem mentioned.

5.3 Limitation of Research

Throughout the entire process of the research, the problems encountered include the following:

i. Low rate of response from the respondents (360 sets of questionnaire have been distributed to the respondents but only 33 sets of questionnaire were returned)

5.4 Recommendations for Future Research

Based on the findings and conclusions of the research, the following are recommendations for future research.

i. Comparison between the benefits of using the traditional and non-traditional planning and scheduling methods

ii. Detail study on the specialist software used for planning and scheduling work in construction industry.

iii. The numbers of respondents involved should be higher to increase the accuracy of the findings and data collection techniques should include interviews to improve the accuracy of data.

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APPENDIX 1

QUESTIONNAIRE SURVEY FORM

BIL: | | | |

DEPARTMENT OF QUANTITY SURVEYING
FACULTY OF BUILT ENVIRONMENT

TITLE OF RESEARCH:

CONSTRUCTION PLANNING AND SCHEDULING METHODS ADOPTED BY CONTRACTORS IN PREPARING WORK PROGRAMME

QUESTIONNAIRE

Research Objectives:

1. To identify planning and scheduling methods adopted by contractors in preparing work programme
2. To determine the factors influencing their choice of planning and scheduling methods in preparing work programme
3. To determine the problems encountered in using the chosen planning and scheduling methods to prepare work programme

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This questionnaire is used to collect data for the above research. All information will be kept CONFIDENTIAL and will only be used for academic purposes.

Please kindly return the completed questionnaire using the envelope provided or scan and email to ivan_jienhoeng@hotmail.my

Your cooperation is highly appreciated.

Thank you

Ivan Loo Jien Hoeng (A11BE0046)
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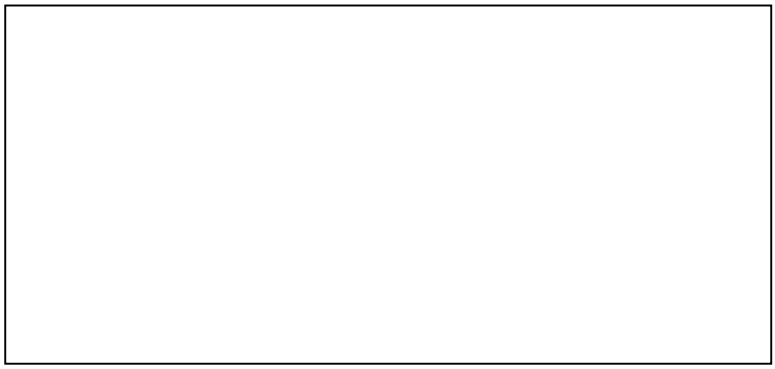
018-282 6163
ivan_jienhoeng@hotmail.my
Research Supervisor: Assoc. Prof. Sr. Dr. Fadhlin Abdullah

SECTION A: GENERAL INFORMATION

1) Name of Organisation:

_____

2) Please kindly place your address and Company Stamp Below:



3) Name of Respondent:

_____

4) Please indicate your position within the organisation?

- ☐ Project manager
- ☐ Construction manager
- ☐ Site engineer
- ☐ Project planner/scheduler
- ☐ Others (Please specify: _____)

5) E-mail Address:

_____

SECTION B:

PLANNING AND SCHEDULING METHODS ADOPTED IN PREPARING WORK PROGRAMME BY GRADE G7 CONSTRUCTION CONTRACTORS

Please tick (√) the appropriate cell.

1) Please indicate the relevant type of planning and scheduling methods used to prepare work programme in your organisation.

Methods	Categories				
	Never (1)	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**
i. Simple bar chart (also known as Gantt chart)					
ii. Velocity diagram (also known as S-curve chart)					
iii. Milestone chart					
iv. Linear scheduling method (LSM)					
v. Critical path method (CPM) in activity-on-arrow network (also known as Arrow diagramming method)					
vi. Critical path method (CPM) in activity-on-node (box)/precedence network (also known as Precedence diagramming method)					
vii. Programming evaluation and review technique (PERT)					
viii. Graphical evaluation and review technique (GERT)					
ix. Others (Please specify): _____					

2) Please indicate how the respective work programme are prepared by your organisation. (You may tick (√) more than one answer).

Methods	Manual (Free hand)					Computer Spreadsheet System					Specialist Software				
	Never (1)	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**	**Never (1)**	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**	**Never (1)**	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**
i. Simple bar chart (also known as Gantt chart															
ii. Velocity diagram (also known as S-curve chart)															
iii. Milestone chart															
iv. Linear scheduling method (LSM)															
v. Critical path method (CPM) in activity-on-arrow network (also known as Arrow diagramming method)															
vi. Critical path method (CPM) in activity-on-node (box)/precedence network (also known as Precedence diagramming method)															

	Methods	Manual (Free hand)					Computer Spreadsheet System					Specialist Software				
		Never (1)	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**	**Never (1)**	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**	**Never (1)**	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**
vii.	Programming evaluation and review technique (PERT)															
viii.	Graphical evaluation and review technique (GERT)															
ix.	Others (Please specify): _____ _____ _____ _____ _____ _____															

3) Please indicate whether your organisation uses any computer spreadsheet system in preparing work programmes.

Computer Spreadsheet System	Level of Usage				
	Never (1)	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**
i. Gnumeric					
ii. KSpread					
iii. Lotus 1-2-3					
iv. Microsoft Excel 2003/2007/2010/2013					
v. OpenOffice.org					
vi. SSuite Accel					
vii. Others (Please specify): _____					

4) Please indicate whether your organisation uses any specialist software in preparing work programmes.

Specialist Software's	Level of Usage				
	Never (1)	**Seldom (2)**	**Medium (3)**	**Frequent (4)**	**Very Frequent (5)**
i. Microsoft Project					
ii. Primavera Project Planner					
iii. Sure Track Project Manager					
iv. Artemis					
v. Open Plan					
vi. Micro Planner X-Pert					
vii. FastTrack Schedule					
viii. Primavera Engineering and Construction Web Based Programmes					
ix. Others (Please specify): _____					

SECTION C:

FACTORS INFLUENCING THE CHOICE OF PLANNING AND SCHEDULING METHODS IN PREPARING WORK PROGRAMME

1) Please indicate in priority order, the factors influencing the choice of planning and scheduling methods. (Please circle the appropriate rating scale on the right hand side).

Rating Scale:

1- Not Important	2- Slightly Important	3- Important
4- Very Important	5- Most Important	

i.	The size of the project	1	2	3	4	5
ii.	The complexity of the project	1	2	3	4	5
iii.	The type of the project	1	2	3	4	5
iv.	The duration of the project	1	2	3	4	5
v.	The experience of the users	1	2	3	4	5
vi.	The flexibility of the adopted method	1	2	3	4	5
vii.	The availability of software for the planning and scheduling method	1	2	3	4	5
viii.	The clients' preferences	1	2	3	4	5
ix.	The level of detail information available for a particular project	1	2	3	4	5
x.	Others (Please specify):	1	2	3	4	5

_____

SECTION D:

PROBLEMS ENCOUNTERED IN USING THE CHOSEN PLANNING AND SCHEDULING METHODS TO PREPARE WORK PROGRAMME

Please tick (√) the appropriate cell.

1) Please indicate your level of agreement with the problems encountered in using the chosen planning and scheduling methods to prepare work programme.

Problems Encountered	**Strongly Agree (5)**	**Agree (4)**	**Neither Agree Nor Disagree (3)**	**Disagree (2)**	**Strongly Disagree (1)**
1. <u>Simple Bar Chart</u> (also known as Gantt chart)					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					
2. <u>Velocity Diagram</u> (also known as S-Curve Chart)					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					

Problems Encountered	Strongly Agree (5)	Agree (4)	Neither Agree Nor Disagree (3)	Disagree (2)	Strongly Disagree (1)
3. <u>Milestone Chart</u>					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					
4. <u>Linear Scheduling Method (LSM)</u>					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					
5. <u>Critical Path Method (CPM)</u> **<u>In Activity-On-Arrow Network</u>** (also known as Arrow Diagramming Method)					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					

Problems Encountered	Strongly Agree (5)	Agree (4)	Neither Agree Nor Disagree (3)	Disagree (2)	Strongly Disagree (1)
6. <u>Critical Path Method (CPM)</u> <u>In Activity-On- Node (Box)/Precedence Network</u> (also known as Precedence Diagramming Method)					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					
7. <u>PERT</u>					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					
8. <u>GERT</u>					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					

Problems Encountered	Strongly Agree (5)	Agree (4)	Neither Agree Nor Disagree (3)	Disagree (2)	Strongly Disagree (1)
9. <u>Others (Please Specify):</u> _____					
- Time consuming					
- Not flexible to analyse changes on the project					
- High complexity and difficult to learn					
- Specialist and experienced planner/scheduler requirement					
- Detail information requirement					
- Computer hardware and software requirement					
- Sufficient training requirement					
- Inability to control critical path of the project					
- Others (Please specify): _____					

Thank you very much for your time and cooperation.

APPENDIX 2

LIST OF RETURNED QUESTIONNAIRES

FROM RESPONDENT

No	Name of Contractor	Location	Respondent Name	Respondent Designation
1	Ahmad Resource Zaki Berhad	Kuala Lumpur	Mohd Fadhli Ahmad Paruti	Project Planner
2	Aligan Construction Sdn Bhd	Kuala Lumpur	Thirumaran	Construction Manager
3	IAV Builders Sdn Bhd	Kuala Lumpur	Chong Choon Kiat	Senior Project Engineer
4	UEM Construction Sdn Bhd	Kuala Lumpur	Mohd Shahfeez Bin Sulaiman	Project Planner
5	UM Land Builders Sdn Bhd	Kuala Lumpur	Rina Oktariza	Project Planner
6	WCT Construction Sdn Bhd	Kuala Lumpur	Lee Choon Hong	Project Manager
7	Ekovest-MRCB Construction Sdn Bhd	Kuala Lumpur	Muhd. Fikri Bin Abdul Jalal	Project Manager
8	Binastra Ablebuild Sdn Bhd	Kuala Lumpur	Sawaluddin Ismail	Site Manager
9	Ban Lee Hin Engineering & Construction Sdn Bhd	Selangor	Steven Yin	Assistant Contract Manager
10	Clearwater Development Sdn Bhd	Selangor	Ahmad Khairul Zakri	Project Engineer
11	Sunway Construction Sdn Bhd	Selangor	Tan Jian Siang	Project Planner
12	Metropolitan Engineering & Construction Sdn Bhd	Selangor	Kwo Hwa Nam	Project Director
13	Jasmurni Construction Sdn Bhd	Selangor	Yuen Chee Wai	Site Agent
14	Actual Builders Sdn Bhd	Johor	Cheong Lap Choy	Project Manager
15	Blue Hill Development Sdn Bhd	Johor	Fazlie	Project Manager
16	Kim Lun Berhad	Johor	Low Lay Tiong	Contract Manager
17	Noah Ark Builder (Scientex)	Johor	Norsila Bt Samsudin	Project Manager
18	Pamir Development Sdn Bhd	Johor	Liang Boon Long	Project Manager
19	Sin Sin Construction Sdn Bhd	Johor	Tony Mannan	Project Manager

20	THBL Sdn Bhd	Johor	Chai Kin Yune	Site Engineer
21	Zhen Yuan Construction Sdn Bhd	Johor	Ho Hong Mee	Project Manager
22	Pyramid Phase Sdn Bhd	Johor	Teng Wee Seong	Project Manager
23	Dover Construction Sdn Bhd	Johor	Alan Teoh Ban Hin	Project Manager
24	Gerbang Nusajaya Sdn Bhd	Johor	Mohd Hisham Musa	Project Manager
25	MB Group (MB Galaxy Sdn Bhd)	Johor	Ting Tieu Sing	Project Engineer
26	Akawana Enterprise	Kedah	Abdul Kadir Bin Kassim	Project Manager
27	Builtech Project Management Sdn Bhd	Pulau Pinang	Lim Wai Shien	Project Director
28	Wabina Engineering & Construction Sdn Bhd	Pulau Pinang	Vincent Ooi	Site Coordinator
29	IJM Construction Sdn Bhd	Pulau Pinang	Chan Huan Sin	Site Engineer
30	WMA Resources Sdn Bhd	Pahang	Faizlina	Project Engineer
31	TSL Group	Pahang	Shahrill Affiz	Contract Manager
32	Marudu Engineering Sdn Bhd	Sabah	Teong Boon Hiung	Project Manager
33	PB Builders Sdn Bhd	Melaka	Rafidah Bt Maun	Quantity Surveyor