FLEXIBLE SCHEDULING FOR CONSTRUCTION PROJECT USING FUZZY LOGIC METHOD AND CRITICAL PATH METHOD (CPM)

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By

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ABSTRAK

Satu jadual projeck yang berjaya adalah salah satu faktor utama untuk menonjolkan kejayaan. Dalam kajian ini, kaedah fuzzy logik (Penilaian pembuat keputusan risiko indeks nilai ranking) telah digunakan untuk menganggarkan tempoh kelewatan sesuatu projek. Kaedah perisian penjadualan projek konvensional adalah menggunakan kaedah sama ada berketentuan atau kebarangkalian untuk mengira tempoh jadual, kelewatan dan masa lag. Kaedah ini hanya menggunakan input kuantitatif bukan aspek kualitatif yang berkaitan dengan tindakan individu. Pengurus projek yang berkurang dalam pengalaman akan memberi kesan yang besar ke atas tempoh projek. Kaedah yang digunakan untuk menentukan laluan kritikal dalam kajian ini adalah aktiviti yang menpunyai risiko yang paling rendah. Indeks risiko untuk setiap aktiviti mesti dikirakan. Satu projek realistik dipertimbangkan untuk FPERT telah disediakan menggunakan Excel. Projek ini akan dikemas kinikan secara sehingga projek tamat.

ABSTRACT

A successful project schedule is one of the primary keys to project success. In this study, Fuzzy logic method (Decision maker's risk index ranking value) is used to estimate the delay period of a project. It is obvious that the conventional project scheduling software is using either deterministic or probabilistic method to compute the schedule duration, delays and lags. In other words, these methods use only quantitative inputs but not qualitative aspects associated with individual activities. Project manager who lack in experience will have a significant impact on the accessed duration. The method used in this paper which determined the critical path by the lowest risk path. The risk index is computed for each individual activity. A realistic project is considered for FPERT has been prepared using Excel. This project has been periodically updated until the project completion.

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NOMENCLATURES

ES_j	Earliest start
EF_{ij}	Earliest finish
LS_{ij}	Latest start
LF_{ij}	Latest finish
t_{ij}	Activity duration
TF_i	Total float
$F\tilde{A}T_{ij}$	Fuzzy activity time
$F\tilde{E}S_{ij}$	Fuzzy earliest start
$F\tilde{E}F_{ij}$	Fuzzy earliest finish
$F\tilde{L}S_{ij}$	Fuzzy latest start
$F\tilde{L}F_{ij}$	Fuzzy latest finish
$F\tilde{E}T_{ij}$	Fuzzy activity time
a_{ij}	Optimistic duration
m_{ij}	Most probable duration
b_{ij}	Pessimistic duration
λ	Decision Maker's Risk Index
t	Number of activities in a project
$R(\tilde{L}_i)$	Decision Maker's Risk Index ranking value

CHAPTER 1

INTRODUCTION

1.1 Introduction

Scheduling is a key activity during the preconstruction stage. Schedules are essential to the successful execution of any complex projects. Optimization of project scheduling through time control is considered as the most important factor in project management (Haroun et al, 2012). Schedules establish the start, duration, and completion dates of a project or a task. They let people and organisations know in advanced when to expect a certain action to take place. Scheduling can be prepared manually and using commercial software such as Primavera Project Planner (P3), Primavera Project Management (P5), or Microsoft Project. Sometimes the assumptions that are made during construction phase changed and this assumption not always can be fulfilled with the satisfying accuracy (Gonzalez, 2007).

Critical Path Method (CPM) may be classified as deterministic methods. In many situations, projects can be complicated and challenging to manage. Critical path method (CPM) has been demonstrated to be a useful tool in managing projects in an efficient manner to meet this challenge (Hillier, 2012). However, most of the information used in these methods is nondeterministic. To deal quantitatively with imprecise data, the program evaluation and review technique (PERT) (Krajewski and Ritzman, 2005). The incorporation of uncertainty in the parameters in project scheduling techniques leads to the probabilistic method which is the fuzzy logic method. The main focus of the paper is the practical application of fuzzy sets and system theory in predicting delay, with reasonable accuracy, a wide range of factors pertaining to construction projects (Pandey et al, 2012.).

1.2 Problem Statement

The construction industry has a difficulty to cope with. As a result, many major projects fail to meet schedule deadlines (Duran, 2006). Ajanlekoko (1987) observed that the construction industry showed poor performance in terms of time. Seven out of 10 projects surveyed in Nigeria suffered delays in their execution (Odeyinka and Yusuf, 1997). In Indonesia, Trigunarsyah (2004) identified that only 47% of the projects were completed within the schedule, 15% ahead of schedule, and 38% were behind schedule.

Schedule delays are very common in construction field due to its nature of non-deterministic nature. Thus, a probabilistic schedule delay analysis method is needed instead of using the Critical Path Method (CPM). In this study, the deterministic and probabilistic methods are applied and compared.

1.3 Aim of Study

The aim of this Final Year Project (FYP) is to evaluate the use of Fuzzy Logic Method in project scheduling. Two different software were used, which were Primavera (P6) and Microsoft Excel.

The objectives of the study are:

i. To conduct a literature review of using Fuzzy Logic Method in scheduling projects.

ii. To evaluate a new approach in minimizing project delays using Fuzzy Logic Method.

iii. To apply the proposed method in a real case study and compare with CPM.

1.4 Research Significance

The main contribution of this study is the analysis of a different methodology to determine the length of a construction project and its critical path based on probabilistic method.

1.5 Scope of Study

This paper mainly focus on the monitoring and controlling in network analysis diagram and contribution of flexible project scheduling. The case study used in this study is provided by consultant from M.E.I Consultant Company in Penang. The case study is an actual factory project which is located at Bayan Lepas, Penang. Details of the project is given in Table 1.1.

Table 1.1: Project Information

Title of Project	CADANGAN PINDAAN DAN TAMBAHAN KEPADA KILANG 2 TINGKAT YANG SEDIA ADA YANG MENGANDUNGI: (A) KILANG 2 TINGKAT KILANG YANG SEDIA ADA SERTA (B) TAMBAHAN 4 TINGKAT KILANG BARU KEPADA KILANG 2 TINGKAT SEDIA ADA DI ATAS LOT 15519 DAN 15997 KAWASAN PERINDUSTRIAN BEBAS BAYAN LEPAS FASA 4, MUKIM 12, DAERAH BARAT DAYA, PULAU PINANG.
Site Location	Bayan Lepas, Pulau Pinang.
Consultant Company	M.E.I Consultants Sdn. Bhd.
Contractor Company	M.E.I Project Engineers Sdn. Bhd.
Height of Building	B4 Building: 24.5m
	Canteen : 14.4m
Date of Project Start	1st November 2016
Date of Completion	23rd September 2017

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Project scheduling is necessary in planning and during the construction periods. The benefits of implementing and maintaining this set of three management systems are reduced construction time, reduced cost overruns and the minimization of disputes (Callahan et al. 1992). These benefits accrue to the contractor, owner, suppliers and workers in the form of improvements in productivity, quality and resource utilization (Mattila and Abraham 1998). Construction scheduling helps when problems encountered as it may prevent the parties from accurately assessing whether the project is ahead of or behind schedule (Ackley et al. 2007).

In the construction industry, potential uncertainties should be included in the schedule planning stage. Decision makers have to find the right decision during the planning stage since the uncertainties may generate extra cost and time. In order to do this, problems have to be analysed using different approaches rather than just traditional Critical Path Method (CPM) schedules including mathematical models or optimization methods. In practice, optimization methods are not frequently used due to the time required to find optimal solutions. In contrast, most construction companies use commercial software such as Primavera Project Planner (P6), or Microsoft Project because they are easier and faster to use. Even though these generate solutions that are not optimal, they are usable solutions. Therefore, probabilistic method would be useful for identifying and analysing different paths and rescheduling the project.

2.2 Definition of Scheduling

Scheduling the project activities is difficult unless there is a clear understanding of all the activity requirements and how each of the activities relates to one another. For instance, suppose a number of activities cannot begin until one or more preceding activities have been completed. Without a detailed breakdown of the project, it is easy to overlook these interrelationships or to overlook certain activities completely (Taylor, 2007). Schedules are created based on work break down structures, the sequential and logical organization of tasks, critical path analysis, and time estimations. The more accurate the information is, the better the schedule (Knutson, 1991).

2.3 Network Diagram

The network diagram is the tool used to organize all of the project activities. It is like the road map for the project – starting on the left (where the project begins) and reading across to the right (where the project ends). Depending on the sophistication of the project, many paths may exist through the network. Creating accurate network diagrams is difficult since they involve all the organisations in a project, each with individual goals. Creating the network diagram should be viewed as a management exercise and an opportunity to bring together all the key players on the project to determine the best way to complete the project (Gould and Joyce, 2011).

2.4 Definition of Critical Path Method (CPM) scheduling

Critical Path Method (CPM) scheduling has been used since the 1950s, when it was implemented on government projects to determine the best-trade-off between cost and time. Critical path methods are deterministic techniques that do not consider variations in estimated activity times (Morder et al, 2002). Currently, CPM schedules are used on large construction projects and they are required in most public contracts. The information from CPM schedules are used by Decision Makers (DMs) or people involved in the decision process to plan and control projects and to train new DMs (Revelle et al, 1997). Project managers use commercial project management software based on critical path analysis, such as Primavera Project Planner (P3) or Microsoft Project, which are based on heuristic methods to plan and control schedules (Liberatore et al. 2001).

2.5 Fuzzy Logic

Fuzzy sets theory was developed specifically to deal with uncertainties that are not statistical in nature (Zadeh, 1965). The concept of fuzzy sets theory differs from that of the conventional crisp sets mainly in the degree by which an object belongs to a set. In crisp set theory, objects are either included or excluded from a set. In fuzzy sets theory, on the other hand, objects are described in such a way to permit a gradual transition from being a member of a set to a non-member. Each object contains a degree of membership ranging from zero to one, where zero signifies non-membership, one indicates full membership, and values in between describe the degrees of partial membership. One of the most widely used form is called fuzzy numbers (Dubois and Prade 1988).

Application of Fuzzy Logic in Short Term Load Forecasting. Presented fuzzy concept in forecasting of load in engineering using fuzzy variables (Nayak and

Mahendru, 2012). A fuzzy logic approach to model delays in construction projects (Al-Humaidi, 2007) used the translational, rotational, angular, and triangular models to the fuzzy fault tree analysis, and a comparison of these four different models to find delay. A probabilistic schedule delay analysis in construction projects by using fuzzy logic incorporated with relative importance index (RII) method (Mustafa Özdemir, 2010). The comparison of the fuzzy approach and stochastic approach to project scheduling can be found in (Shipley et al, 1997).

2.6 Software Scheduling Terms

Before using the software as a communication tool, we need to understand the term used in the software needed the schedule for further analysis (listed in Table 2.1).

Table 2.1: Terms used in software

Terms	Means
Activity code	A value assigned to each activity to help organize the activities into manageable groups. Similar to cost codes, activity codes are typically used to facilitate sorting and filtering activities according to specific criteria. Example, a common set of activity codes may be given to all activities performed by the electrical subcontractor or all activities that require use of crane. The schedule can then be filtered to view only those activities related to the electrical subcontractor or to view the utilization of the tower crane.
Activity form	A window that displays detailed information about a specific activity. While typically only one of several tools that the scheduling programme makes available for input, viewing, and modifying activity information, the activity form provides convenient access to the most commonly referenced activity data.
Base calendar	A calendar that applied to all of the activities in a project. The base calendar describes the days on which work can be performed. It also indicates such days as holiday and weekends on which work cannot be performed. A modified base calendar can be created for a task that cannot be performed or is prohibited from being performed on specific working days. These calendars are typically based on either a working-day or calendar-day schedule and are developed when the project schedule is initially created. Most scheduling software programs provide a default base calendar that reflects the normal Monday-

	through-Friday working-day schedule and all major recognized holidays. Additional holidays can be added with ease.
Baseline schedule	The original schedule created at the beginning of the project against which the project's progress is measured. This schedule is typically saved as a separate, read-only file so that it cannot be overwritten or modified and can be referenced later in the project.
Collapsing the schedule	Consolidating the sub-tasks within their respective summary tasks so that only the summary tasks are shown. This action helps one view the main project activities without cluttering the screen with the minor activities. It provides a way to broadly view the overall project schedule.
Constraint	A restriction imposed on the start or finish of an activity. Constraints are used to prescribe limitations on the schedule based on external conditions such as contractual restrictions or imposed float requirements.
Data date	The data used as the starting point for schedule calculations. During development of the schedule prior to the construction phase, this date is the anticipated day on which construction is to begin. During the construction phase, it is the date on which schedule data is input or modified.
Data date line	A vertical line on a Gantt Chart representing the current date. The number of days to completion is calculated from the date. This line provided a helpful graphical view of the current date on the project timescale.
Expanding the schedule	Showing the sub-tasks within their respective summary tasks. This action shows the detailed activities of the project schedule rather than just the general activities.
Filtering	Searching through the project activities and showing only the activities that match specific criteria. Filtering does not delete activities from the schedule, but merely hides activities from view. Filtering allows for focusing on specific activities, such as those performed only by the mechanical subcontractor during

	the upcoming month. Filtering also allows user to view those activities staring after a given date, activities completed in a given time period, or those meeting a variety of other criteria.
Global change	A change that affects all activities or a selected group of activities at same time, even those filtered from view.
Layout	The appearance of the schedule on the computer screen. The layout is essentially how the visual elements of the schedule, such as the format and colour of the bars, organisations of the activities, and visible columns, appear when viewed on the computer screen. Different layout can be saved for convenient viewing each time the schedule is accessed.
Link line	The line that connects the connects the bars of linked tasks on the Gantt Chart to show logic relationships.
Linking	The process by which relationships between activities are created. Activities are linked finish-to-start, start-to-start, finish-to-finish, or start-to-finish and can include lag or lead times.
Milestones activity	A zero duration activity that signifies the start or finish of an activity or group of activities.
Network loop	Circular logic within a network of activities that prevents progression across or through the network. When illogical scheduling relationships are created, calculations cannot be performed; that is, all loops must be eliminated for computations to be made.
Progress bar	A bar on Gantt chart that represents the progress of a particular task. Progress bars are used to provide a graphical representation of the percent completion of an activity at a specific date. The bars are typically shown adjacent to or within, and a different colour than, the activity bars.
Recurring calendar	A task that occurs at regular intervals in a project, such as a weekly project meeting or a safety walk-though of the job site. Recurring tasks can be input only once and the program will automatically place them at the appropriate dates.

Resource calendar	A calendar that applies to a specific resource to define when the resource is available. Resource calendars are utilized for limited resources that may control the scheduling multiple activities at the same time. The scheduling of an activity that utilizes a limited resource is controlled by both the base calendar (or modified base calendar) and the resource calendar.
Sorting	Organizing the project activities according to a specific format. Sorting allows for grouping activities to control the order in which the activities are shown on the screen and presented in the printed schedule. Sorting does not eliminate tasks form view, but merely rearranges them according to a specified format. Colours are often used to highlight grouped activites.
Sub-task	A minor task typically representing detailed effort. This task is subordinate to a summary task.
Summary task	A task representing detailed a general activity of construction. Summary tasks contain multiple sub-task. Summary tasks provide an outline structure to the schedule that identifies the project's major phases. Typically, no duration is associated with summary tasks.

2.6.1 Software Scheduling features

Current computer scheduling programs offer a wide variety of features. The features are designed to assist in the development and management of schedules, some of more useful than other. Features that are easy to use and allow precise control and management of the schedule greatly enhance program effectiveness (Lewis, 1993) are listed below: