S11-6

A TIME DETERMINATION MODEL INCORPORATING RISK MANAGEMENT BASED ON MALAYSIAN CASE STUDIES

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ABSTRACT: Determining the total duration for a construction project is an integral part of project management in the construction industry. This is to ensure the project and all its associated activities can be carried out and completed within the time frame stipulated. There are several commonly used scheduling methods and techniques in project management, some of which involves manual calculation while others involve computer software. This paper looks into the various time determination methods, extracting out their differences and similarities. It also seeks to draw out the problems when determining time for projects, especially those encountered of case studies. Based on the results from the case studies, there were delays on certain projects even though time determination had been carried out rigorously prior to the commencement of the projects. This paper seeks to develop a time determination model, which incorporates risk management techniques into the calculations in order to improve the method for time estimation to minimize the chances of project delay.

Keywords: Time determination, risk management, model, methods

1. INTRODUCTION

Time in civil engineering construction is defined as the period taken to measure the construction progress of site activities when field operation starts till its end and generally measured in term of days, months or years. Before project's activities begin, the determination of project's time is vital part to work on. By properly estimating the duration of associated activities, the chances of the project being completed within a given period or time frame stipulated are enhanced greatly.

Every construction project has a task time, which indicates the earliest and latest dates for the tasks to start and be completed (Willis, 1986). Therefore, duration is estimated for every task from the activities start until finish. As per Adeli (2000), activity duration is the amount of time assigned to complete a particular activity. Once the duration of each activity is determined, the project's duration can be calculated the start and finish time for each activity defined. A project schedule is a projected timetable of construction operations that will serve as the principal guideline for project execution (Clough, 2000).

Estimating is the process of determining the amount and type of work to be performed and the quantities of material, equipment, and labor required (Nkado, 2006). It is important that estimates are properly done on scheduled work to determine the time duration and later on the project's progress. This way time can be managed more effectively and efficiently.

The effectiveness and efficiency in project time management essentially depends on being able to estimate or approximate the time to complete the each activity in construction project as accurately as possible and good execution of the controlling and monitoring functions. This is important in order to avoid or minimized time delay related problems in construction projects.

1.1 Problem Statement

There are different methods that can be used in scheduling to estimate time for construction activity which essential is when the activity will be performed; the estimation of the activity duration and the finishing date of the activity. Delays or more seriously undelivered projects, which mean inability to complete the project within the stipulated time frame, are the most prevalent problems in construction. This can be defined in the view of several parties involved in construction process.

To the private owner, delay can mean a loss of revenues through the resulting lack of production facilities and rentable space, as well as through a continuing dependence on present facilities. To the public owner, it can mean that a building or facility is not available for use at the proper time. The service revenues lost through delay can never be recovered.

To the contractor/builder, delay means higher overhead costs resulting from the longer construction period, higher prices for materials because of inflation, and escalation costs to increase of labor cost. Further, working capital and bonding capacity are so tied up that other projects cannot be undertaken.

A variety of factors in an ongoing project can lead to a delay. Among the most common causes of project delay, inclement weather, and poor initial site investigation process and latent site conditions are the more frequent reasons. It is important that the probable effects of these situations be reflected in the final project time schedule.

Furthermore, delays may occur as a result of the actions, or inaction, on the part of the owner, the contractor, subcontractors, or the designer which may affects the completion date. Inaccurate time estimates on certain activities can lead to contractual claims for both extra time and additional compensation. Disputes cases could arise. The clients may blame it on the poor performance of the contractor. While contractors accused on delayed responses in problem solving by client and their representative consultants. Claims and disputes are the common causes of project delays and abandonment of projects.

Another subtle yet reasonable cause of delay which has always been overlooked, is the inaccuracy during the initial time estimation and therefore, unfair timeline set. Time has always been assumed to be deterministic, yet in real life, there are many situations which will affect the fulfillment of the time objectives. These situations are basically risks to the project. Inaccuracy on time estimation can be an important factor contributing to project delays as the entire bases for controlling and monitoring are fundamentally wrong. The loss in money and more seriously, the abandoned projects, do lead us to think that proper methods to establish correct and accurate time must be done.

This study first conducted an in depth study on four (4) construction projects in the aspects of their time determination methods and whether there were delays on the activities. If delay did occur, the situation/s causing the delays would be probed and understood.

2. BACKGROUND OF CASE STUDIES

2.1 Case 1

Case 1 is the constructioin of 10 units of 2-storey shophouse in Asajaya New Township Ph 3 on Lot 520, block 32 in Samarahan, Sarawak. The project time was estimated by the Quantity Surveyor (QS) after the assistant project manager estimate the duration for every task based on his experience using Microsoft Project (M.P) as a method of mathematically evaluating the project duration. The whole project takes about 228 days to complete (23/8/04-1/6/05).

2.2 Case 2

Case 2 is the construction of housing for Government offices, in Mukah, Sarawak. In this construction project, there were 3 types (type A, B and C), which depended on the sizes of the housing. Type B covered biggest area as compared with Type A and C and it took longest duration to complete every task. This project started from 25/3/04 and finished on 24/9/05. No activities were performed on the Sunday. All construction operations are to be constructed under the surveillance of the site engineer, who was generally responsible for overseeing the progress of the work.

2.3 Case 3

Case 3 is a flood mitigation design option for Panchor and Sekeduk Areas, Kota Samarahan The flood mitigation study programme was schedule to start on December 20, 2004 until June 7, 2005. This durations of the programme was estimated by the engineer who in charged the water and drainage department. The engineer estimated the time by referring to the past similar projects on flood mitigation study.

2.4 Case 4

Case 4 is the construction of 30 units' 3-storey shop houses on lot 924 & 927 block 68 in Mukah Land District, Sarawak. The project manager and team members in charged of how long the activities would last had based the durations on their experience and information from participants in past shop houses project. All tasks must be completed by the early of July, 2006. Usually there were no events performed on Sunday. The site operations were followed by the engineer and supervisor responsible in instructed the labors completed the task within the scheduled period.

3. SUMMARYOF RESULTS

Table 1 shows the main activities of each cases and the estimated and actual duration of construction and the status of the project at the point of study.

Table 1. Summary of Case Studies' Time and Progress

Descriptions	Estimated duration, days	Actual duration, days	Status
Case 1 :			
Building Works			
A) Work below Ground Level	64	72	Delayed
B) Work above Ground Level	177	207	Delayed
C) Clearing and Cleaning	10	25	Delayed
Case 2 :			
A) Setting up	14	20	Delayed
B) Structural works			
Type A	283	297	Delayed
Type B	341	258	Delayed
Type C	341	259	Delayed
C) Architectural works			
Type A	324	349	Delayed
Type B	345	361	Delayed
Type C	325	353	Delayed
D) Infrastructure and Civil works	450	468	Delayed
Case 3:			
A) Hydrological analysis	11	11	Completed within time
B) Hydrological modeling	7	6	Completed within time
C) Hydraulic analysis and modeling	29	29	Completed within time
D) Benefits and cost analysis	16	15	Completed within time
Case 4:			
A) Structure work			
Aug,05	20	20	Delayed
Sep,05	24	24	Delayed
Oct,05	74	68	Completed within time
Nov,05	87	100	Delayed
Dec,05	115	149	Delayed
B) Architectural Work			Still on progress

Table 2 indicates of the summary of the comparison between theoretical time estimation methods with the methods applied in the case studies.

Table 2. Summary of comparison between theoretical and methods applied in case studies

Methods	Advantages	Disadvantages
(i) Theoretical		
1. Critical Path Method	❖ **User friendly software** ❖ **Identifying the critical activities** ❖ **Determine the effects of delay** ❖ **Adapting to any project** ❖ **Allowing analysis of different methods or sequences**	❖ **Complex than others method** ❖ **Single logical relationship that is allowed is not adequate to express all of the various complex relationship that exist in real word of project management**
2. Pert	❖ **Create a major network** ❖ **The ability to evaluate the effect of changes in the program.** ❖ **Allows a large amount of sophisticated data to be presented in a well-organized diagram**	❖ **Complexity program** ❖ **Utilized most often on large ,complex programs** ❖ **Usage limited**
(ii) Case studies		
1. Microsoft project (bar chart)	❖ **Easy to establish and understand the technique** ❖ **Project are displayed effectively** ❖ **Completion dates are specifically noted**	❖ **Critical activities that if delay occurs on them, will affect the overall project completion time are not identified.**
2. S-curve	❖ **Show comparisons of anticipated progress with actual progress.**	❖ **Fails to show the critical task**

4. ANALYSIS OF CASE STUDIES RESULTS

From the case studies, it was obvious that delay in the overall schedule was caused by delays in individual work activities. After obtaining the results from the case studies, each activities was analysed based on the reasons for delays should it occurred. Below are the causes for delays derived from the case studies results

4. 1 Case 1

There was a delay on some portion of works when conduct the work above ground level (WAGL) and work below ground level (WBGL). For the WBGL, the piling and excavation works were behind the scheduled. This was because the equipment rented not reaching the site on time.

As for WAGL, the delay was caused by the bad weather since the task carry out from the end of the year (22, October, 2004). The season of the particular work period was wet and raining in Malaysia and this caused the activity such as concreting the column, beam and slab to not start as per the scheduled date. As the result, these tasks were resumed after a raining period. Beside that, the concreting activity was also delayed due to late ordered or delivery concrete.

For the activities plumbing, electrical works, delays were due to shortage of skilled workers. Such activities were generally considered more complicated and would required licensed personnel to do.

4.2 Case 2

This case took a longer duration to complete as a result of phasing in the development during construction based of the type of houses being built. Every type of houses was allocated with different durations. For type A, the structural work started earlier than type B and C. Therefore, this task finished earlier.

The piling works for Type B and C were delayed due to insufficient number of equipment. Stump and backfilling pile cap were the major section of delays because the waiting time for the concrete to dry was lengthen due to probable heavy rainfall.

Ground slab started after the column and ground beam work. There was no delay for this activity because re-planning was carried out and materials were ordered before the work started and the labor team was ready to start working. The following activities including the formwork and reinforcement for the ground slab before putting a cement screed on the slab were then carried out on time.

Furthermore, the infrastructure and civil works was scheduled to start on the June 15 2004 until September 24 2005. This activity took long duration but did not affect to other activities as they were parallel activities, which could be carried out independently.

4.3 Case 3

For the flood mitigation study, the scheduling system uses was similar to that of the building works. However, this case, the time determination was generally simpler and easier to conduct in view of the fact that the activities and durations were not as many as that of a building work. Every activity was dependent of the previous, creating a link from start to the end. There were strictly no delay allowed and it did not occur in this case.

4.4 Case 4

This project was still in the progress during the study and the scheduled completion date is on July 2006. As the result, the analysis was done for the year 2005, which consisted of the structure work only. Most of the activities were completed in the scheduled duration except for plumbing work. Plumbing comprised various installments for water supply, sewage drainage systems and etc. This may result in delays on the subtasks.

For the installation of door frame and door leaf, there was a slight delay on the schedule. This was caused by not enough carpentry workers assigned to the job operation.

As for the electrical works, there was an obvious delay, which due to insufficient number of electricians and/or equipment.

From the s-curve, delayed on the November and December possibly affected by the adverse weather. However, we could conclude that there was not too serious a delay in the structure work as well as architectural work (on progress).

4.5 Other Causes for Delays in Case Studies

There are several possible reasons, which may contribute to delays of work in the case studies apart from the obvious. These included poor performance by the builders and their teams; incorrect reporting and lack of site control; differing projects' conditions such as geography and size; wrong and lack of equipment assigned; and an error in the initial time estimate.

With reference tor to case 1 and 2; there was an element of incompetency by the estimators to produce the effective time duration for the activities, especially certain mistakes were clearly avoidable. The personnel perhaps lack ability or experience to comprehend the seriousness of certain inaccurate estimation and therefore, failed to make the right estimation of the total duration. Poor judgment of the estimator concerning the times required for the accomplishment of certain works indicated that they fail to grapple and fully understand the activities, their sequences and the need of incorporating the law of worse case scenario in their calculations.

Case 3 seen to a satisfactory outcome in determining the durations. The project was completed within the schedule. Normally, the project managers are fully capable in planning, organizing, leading and controlling the project as long as the task lists were not too lengthy. It would get tougher to estimate the time consistently when the size of developments were bigger as number of risky situations will increase.

Detail and rigorous planning is required in large projects with multiple activities. Generally, in the planning stage, the estimator should list out the details information of the work activities that contribute to construction process. Then, the estimator will determine the material availability and delivery times; equipment needs (time, quantity, and duration); labor/craft skills needed; time to complete the work. This is followed by the consideration of the construction methods, sequence and strategy to be applied to the projects. Each of these stages presented its own risky situations that the estimator should consider. Even though, this process be very difficult initially, but it will get easier as expertise and experience will improve the planning skills of the estimator.

When the construction works are on the progress, it is important to control the activities and resources to achieve the desired end-point. This must be done rigorously by the site personnel and project team. The daily meetings held by project team throughout the project to report on the progress would be helpful. It should focus on progress made to date and look forward at the work that is to be done. In the meetings, it should also highlight any potential problems in order for actions to be taken to prevent them, or so that the consequences can be acknowledged. Site personnel who are incapable to quick problem solving of the delayed situation once it occurred would mean prolonging it, which then affected other activities connected.

Taking into account of the many instances which could cause delay on a construction site, there seems to be a suggestion of a better time determination method than our traditional ones that the industry players could used to calculate the total project duration in order to minimize if not fully eliminate the problem of delays.

5. DISCUSSION

It was noted that for the case studies, the project time determination was generally carried out with the following procedures. However, depending on the type of the activity, the procedure used to determine the duration of the certain activity varies. The methods used in the case studies did not necessary limit to or include all of the following. Variation and omissions were noted.

5.1 Durations Estimations by Experienced

All the 4 case studies utilized this procedure for the time considerations. It was seen that in most of case studies that someone experienced in and familiar with the types of works involved was included when the activity durations were being estimated.

Generally, time information on the certain specialized activities were determined by talking to the appropriate subcontractor on site supervisor; researching on past projects of a similar nature; or by looking at the national data books. The durations of vendor items such as the manufacture and delivery of off-site items are referred to the particular vendor.

Besides that, project manager, site supervisor, subcontractor or who have worked on past projects in the construction area were usually consulted, as they have high experience level of the times and procedures involve in these estimation steps. Mostly, they are consulted for all kinds of difficult-to-quantify information to make that duration decision.

One way of their estimating is to forecast on the basis of historical data, for instance if a similar task has been done before. Then, the estimator was to prepare schedule in consistent and complete manner with the details of time and the work activities.

5.2 Duration Estimations based on Production Rate

Production rate is another method, which can be used to estimate time. This procedure is actually necessary before actual time estimation exercise is carried. First, it is necessary to carry out quantity take off on the type and amount of work in good details. This can be done by surveying the conditions of the construction area or from the drawings. The purpose is to measure the quantity of work that needs to be performed on the project. This information is required for the following calculations steps. For example, quantities of materials used and sizes.

(i) Estimating crew productivities

(a) Duration = Quantity (cubic yards) / productivity (cubic_yards_per_hour) = hours

(b) Duration = total hours / hours worker per day = days

Typically, it is better to use the company's own production rates because productivity may vary in different organizations and/or location of the site and/or under differing weather conditions. This method is more suitable with very large construction projects with known previous production rate.

4.3 Duration Estimations based Site Investigations

In estimating the duration of an activity, it is important to survey the condition of the site, which the construction activities will be conducted. Conditions on site will generally present differing risky situation which subsequently delay time.

Understanding job conditions and sequences is another important factor in accurate estimating of time duration. Once the job conditions are understood, assuming each operation as using a normal crew size, working a normal shift, and working under normal weather conditions, time can be estimated. Then considering the potential risky situations, time is lengthened accordingly.

4.4 Considerations on Others Aspects

As a general rule in construction, as project size gets bigger, the duration of the project will increase. So, it is imperative to identify the sizes of the development before estimate any others tasks' duration. Furthermore, it needs to consider the working hours in the site. As can see in the cases study, the activities carry out for 6 days (Mon-Fri) and normally from 8 a.m to 5 p.m. As a result, one day from a week should be cut off to make sure the accuracy of the estimate duration. Besides that, the public holidays must be accepted by referring the calendar.

Weather conditions and the time of year are other important factor to be considered in determining durations. Climates where the weather and temperature vary will also have productivity figures that vary. For example, rainy seasons do affect many on site activities. . As noted in case 4, it was obvious that the project begin to delay since November (which is the heavy rain season in Malaysia). As a result, the duration estimation must take into account of this factor.

Another important factor is labour and machinery. Labor and machinery play important roles in the construction works. Contractors assign labor and machinery resources based on the amount of scheduled work available to perform. The status (skilled or non-skilled) and amount worker indicates quantity of job need to be carried out and affect duration to complete the task. The same is applicable to machinery. Therefore, it is important to assign the labor and machinery accordingly to every job operations.

4.5 Selection of Scheduling Methods

There are several items to be considered when selecting which scheduling system to use. The scheduling techniques selected depend on the size and complexity of the project. The scheduling method must also be flexible because there will likely be changes occurring during the construction process.

For case study 1, 2 and 3, Microsoft Project was used to determine the total duration and case 4 was managing the project by using S-curve (Earned Value Technique). Microsoft project is graphically understood by most practitioners and schedule can be produced faster than any of the other scheduling method. The total duration to complete the main tasks can be swiftly obtained. Besides, it is simple to understand and interpret a Microsoft project Gantt chart as it covers target dates and times for the all the activities from major to lower levels. Besides, critical jobs are displayed and highlighted and non-critical jobs with their float values are easily shown. Tracking Gantt can be used easily to show the difference between actual and baselines.

However, it does not clearly show the sequential relationships and interdependencies of the various tasks to be accomplished. It does not also take into consideration of the production rate, site investigations and other aspects of time consideration. Duration estimation very much is at the discretion of the estimator.

For Earned Value Technique, all the information including start and finish date, duration, schedules progress, actual progress, time lapping were inputted into the table by using excel similar to that of a Gantt chart and then applied to be calculated into S-curve. From the S–curve, the progresses of the project could be examined as the X-axis represent time and Y-axis represent percentage of progress. It can easily compare the schedule and actual progress of the project. For this purpose, such curves can be very useful in affording a quick grab of the overall time condition of the work. Hence for the purpose of controlling and taking the remedial actions, it can be quite useful. For detection of problems root causes, the actual critical activities and the floats, this method will not be sufficient.

It is noted that CPM or PERT is entirely not used in all the case studies. Albeit, it's usefulness in detecting critical activities and the floats, this method is mind-boggling for many practitioners and estimators. Thus, it is being ignored in many projects.

However, scheduling methods are just way a mean or an aide when calculating the activities's duration and presenting the projects' activities' durations and their total durations. Estimators should not depend solely on programs/methods to achieve a good time estimate but have a systematic mean of determining time that could wholly look into activities types, durations of each individual activity with the consideration of the dynamism of civil engineering construction works and the many factors which can influence them to do otherwise.

6. PROPOSED MODEL FOR TIME DETERMINATION

The following is a proposal of a time determination model, which was designed to incorporate the various issues from the outcome of this research project

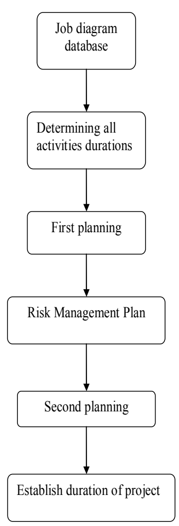

Figure 1: Proposal for Time Determination Model

6.1 Develop a Job Diagram Database

A design called job diagram database can be created to systematically develop weekly job plans. Such plans can be used by estimator in the scheduling process and allocating available labor and equipment resources. Job diagram should guide the user in a clear, step-by-step fashion from the process of listing out work posting, identifying constraints, checking constraint satisfaction, and allocating resources; then later, collecting field progress data and reasons for work failure. This systematic approach helps the user create quality work plans and learn and understand potential reasons for failures. A database can be created using Microsoft Excel and will be sufficient for this model.

(a) Features of Job Diagram

A work plan consisting of constraint and factors must be considered in order to avoid the interruptions on site. Information regarding these constraints is as important as the early and late start and finish date. Since constraints are specific to each work plan, they should be tracked as part of the work plan information. These constraints can be categorized in four types, which are:

a. **Weather**
b. **Materials**
c. **Labor and equipment**
d. **Site conditions**

b) Implementation of Work Plan

In the application process, the work plan can be generated using certain database. This database must have information about the work packages to be done and resources that can be used, i.e., the laborers and the equipment. This can be done in the worksheet that is prepared by the estimator. In Work Plan, this information can be previewed and used throughout the project.

Once all features for a job diagram identified, numbers of laborers and equipment to be assigned to a specific work plan are selected. After that, duration of every job is preliminarily determined and input in the selected scheduling method.

6.2 Determination of Activities Durations

Next, it is necessary to estimate all activities durations before come out with total project duration. The duration estimation requires accurate estimation to keep the project complete on time. Therefore, designers or construction professionals who have worked on past similar projects can be consulted, as they have experience to estimate quite closely the length of the time required to complete an item of work. Moreover, project team can organize a group meeting which request for member's opinions. The team will perform individual roles according to their knowledge and experience. Besides, every team member will be responsible to gain or collect information through the historical data on time variants. Data collection will be useful to review and evaluate. At the end, estimation of duration can be clearly achieved.

6.3 First Planning

After obtained the duration through the reliable sources and data, time could be applied into every work task. In the first planning, the start and completion date for every activity can be fixed. This stage did not include expected situation problems/risky situations related to factors such as equipment, material, labor or others. The duration only focuses on the time needed to complete each portions of works.

6.4 Risk Management Plan

The first thing that must be recognized is that risks, especially in construction, do exist but are not necessary fairly distributed. It may contribute to delay on the project. Therefore, a risk management should concentrate on managing the risk effectively through various ways. It can be done by implemented a set of risk management plan. Throughout this provision, allocation of risk will be clear and straightforward. The plan can be categorized into 5 or more types of expected situations or risks. There are weather, labor, equipment, material and others. Once the risk is identified, others related criteria can be analyzed. After evaluating the information from the plan, the estimator can take corrective action to minimize or covering the risk. As the result, such a plan constitutes an effective early warning device for detecting when the project may be falling behind the schedule. Besides, it also provides specific guidance for the efficient and accomplishment of the work

6.5 Second Planning

After an analyzed risk management plan, second planning on activities duration can be carried out. This is an extension from the first planning. Estimators must take other factors into consideration such as bad weather, lack of manpower, equipment and other conditions. Therefore, time for every activity to complete may be lengthened from first planning. As certain risks may cause serious delay on certain activities, more days will be estimated to finish the particular work. Overall, second planning provides more accurate and safe time estimation than first planning. It is better to prevent than overcome the problem when it occur.

6.6 Establish Duration of Project

The final step is to develop a project schedule to determine duration of project. Additionally, a proper thought-out schedule allows estimators to properly coordinate the work and resources that are needed to timely complete the work.

By following the steps in the model, the project will likely to have reasonable time duration and hence, facilitate manageable and efficient time management.

7. CONCLUSION

From this research project, it was strongly indicated that accurate estimation of project duration is very important in order to come out with a project scheduling. To estimate the duration for any site activity, the estimator must first clearly understand the nature of construction activity, its expected production rate, which can be relatively constant for particular type of activity or basing on the estimator's experience. Once the duration of activities are identified, total duration of the project can be calculated through different methods

However, delayed on the time estimation could obviously see in the case studies which consisted of as much as 80% of the projects behind the schedule. This pointed towards a better and more effective time estimation model apart from the traditional methods of calculations.

From the study of the reasons and causes of delays, this project had proposed a time determination model, which incorporates the introduction of risk analysis and management. In essence, it is believed that good manipulation of project management tools can help in getting effective in project time planning. The model consists of a job diagram, 1st time planning, and 2nd time planning and a risk management plan.

It is hopeful that with detail expansion of various types of civil engineering projects and the respective activities and risky situations, a proper system can be created to estimate construction more effectively.

ACKNOWLEDGEMENT

A sincere acknowledgement to Universiti Malaysia Sarawak for the opportunity and facilities of this research project. The Universiti together with the faculty and department had provided many support for this project in terms of resources and material.

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