Development of a Database for Civil & Structural Construction Works' Production Rates

by

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CERTIFICATION OF APPROVAL

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Approved by,

(Name of Main Supervisor)

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

- kamalu -

KAMALUDIN BIN HASHIM

ABSTRACT

Production rates have been an ambiguous data since the early era of construction. As there are many uncontrollable factors that affect the values of production rates, mathematical solution could not be fully applied in order to obtain the accurate values of the production rates. However, production rates can be categorized as verbal data, which could be obtained from experts' and practitioners' opinions.

The objective of the study is to obtain, compile and develop reliable production rates database for civil & structural construction works. The small amount of studies devoted to this topic and the absence of formal database on Malaysian Civil & Structural construction production rates is one of the main reasons that motivate the study.

Since the study involves collection of verbal data on people's opinion, Survey Research Methodology has been chosen to be the main methods used in the study. Questionnaires and interviews formats are some of the tools used in order to gather the information needed from various respondents. The information was then analyzed by using descriptive analysis method.

The survey produced range of production rates for each activity. The results were then compared to some of the previous study's results which were conducted in Europe. No specific conclusion can be made from the comparison (due to different geological and social factors in Malaysia other countries).As the study is one of the pioneering studies to be conducted in Malaysia, the result of the study may not be universally accepted for construction use. However, it can provide as an indication of the values of production rates data for Malaysian construction industry.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, A.P. I.R. Dr. Arazi bin Idruz, for his continuous supports, guidance, encouragement and concerns throughout the whole process of making this thesis possible.

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Last but not least, thanks to all those companies involved in my questionnaire list for returning the feedbacks to me. Without their feedbacks, there would be no data for me to analysis in order to produce results. Therefore, I would like to thank whoever that was involved in answering my questionnaire.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1. Project Background

Project management is the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time and quality. As the elements are inversely proportional to each other, the main objective of project management can be defined as to achieve an optimum equivalence between time, cost and quality.

Project planning is one of the project management's major activities. It is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. Project planning could be divided into 2 types of orientation, which are the Cost Oriented and Schedule Oriented which respectively focus on cost and time. 'Planning of Work schedule' is a type of project planning which focuses on the element of time.

Planning of work schedule greatly relies on the availability of some fundamentals information such as the scope of work, sequence, quantity, production rates and ultimately durations of each works associated with the project. Among the information prescribed above, discrepancy often happens in predicting the value of production rates for construction works, as it is greatly affected by several factors such as geography, climates, quantity and types of resources and technology used. Furthermore, specific calculation regarding the values of production rates could not be completely derived through mathematical calculation. Thus, acquiring opinions of industry's experts and practitioners by conducting survey would be the best method to obtain reliable value of production rates.

The proposed topic, which is 'The Development of Database for Civil and Structural Works' Production Rates " focuses on establishing and compiling of practical and reliable values of construction production rates from Perak, Selangor and Kuala Lumpur. As the establishment of the database has yet to be formalized in Malaysia, the project's ultimate objective shall be to establish reliable values of construction production rates which are equally applicable for industrial usage in Malaysia.

1.2. Problem Statement:

1. Little work has been conducted nationwide to develop a formal civil & structural production rates database.

2. No formal local software has been developed to estimates the values of construction production rates.

3. As production rates are greatly affected by various factors (controlled and uncontrolled factors), specific calculation could not be derived to calculate the accurate values of construction production rates.

4. Project planners mostly rely on individual experience and judgment in deriving the production rates values.

1.2.1. Significance of the project:

The significance of project could be seen by understanding the problems stated in the Problem Statement section. The project could overcome typical problems in individual estimation, as analyzed values of production rates could be obtained through the study. The outcome of the project could decrease the margin of errors in estimating values of production rates thus would greatly help estimators to choose the correct values of production rates for their planning and scheduling works.

Besides that, the integration of particular information such as location, climates, number of workers and technology used would significantly helps in establishing a good basis in estimating values of production rates. This particular information would be considered in the study and indirectly incorporated within the production rates values, to help estimators to best estimates the appropriate values of production rates to be used in their project.

According to The Business Roundtable[1] , by common consensus and every available measure, the United States no longer gets it's money's worth in construction, the nation's largest industry ... The creeping erosion of construction efficiency and productivity is bad news for the entire U.S. economy. Construction is a particularly seminal industry. The price of every factory, office building, hotel or power plant that is built affects the price that must be charged for the goods or services produced in it or by it. And that effect generally persists for decades ... Too much of the industry remains tethered to the past, partly by inertia and partly by historic divisions...

Referring to the above, one could not deny the fact that improvement of project management would not only aid in the construction industry, but may also be the engine for the national and world economy. This study would be significance in costs point of view, as improvement of production rates values would indirectly improve the project's budget estimation through better work schedule.

Furthermore, the 'The Development of Database for Civil and Structural Works' Production Rates" project is one of the first pioneer project to produce formal production rates database for Malaysian Construction Industry. Although the project's scope is quite limited (covers the area of Perak, Selangor and Kuala Lumpur), the project could act as a stepping stone to the development of production rates database to be use by the Malaysian Construction Industry.

1.3. Aims and Objectives:

- The aim of the research is to initialize the development of Malaysian construction works production rates database. Given this aim, the objective of the research is to:

1. To collect data on construction works from the industry (chosen contractors from Perak, Selangor and Kuala Lumpur).

2. To compile and analyze the database obtained.

3. To develop initial values of construction production rates from the analysis.

1.4. Scope of Study:

The study shall focus on production rates for civil and structural construction works such as reinforced concrete works, and foundation works. The study will implement survey research method which incorporates tools such as questionnaires and interview forms in order to obtain the production rates stated above.

Questionnaire surveys shall be submitted to construction firms located within Perak, Selangor and Kuala Lumpur only. Preliminarily, a minimum of 100 construction firms shall be selected as the study sample, however the total number of the nominated respondents shall be recalculated based on the total number of construction firms in Perak, Selangor and Kuala Lumpur.

The questionnaire shall also covers information related to production rates such as number of workers, area of construction, and references on the building.

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW:

2.1. Background knowledge / Theory:

Production rates could be defined as the amount of works that could be done within a certain period of time. It is one of the most essential information used in scheduling works to determine the duration for specified construction works. Production rates' values are influenced by several factors such as climate, geography, man power and technology applied during construction. The variation of the factors could not be totally controlled, thus producing different values of production rates in every project. However, a basic theory in calculating production rates could be derived by methods shown below.

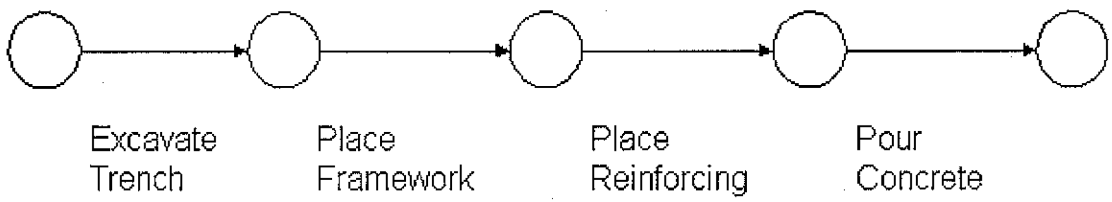

Figure 3.1: Illustrative Set of Four Activities with Precedences

[2] According to Baker (1974)

The *scheduling problem* is to determine an appropriate set of activity start time, resource allocations and completion times that will result in completion of the project in a timely and efficient fashion. Construction planning is the necessary fore-runner to scheduling. In this planning, defining work tasks, technology and construction method is typically done either simultaeously or in a series of iterations. (p. 15)

In most scheduling procedures, each work activity has an associated time duration. These durations are used extensively in preparing a schedule. For example, suppose that the durations shown in Table 1 were estimated for the project diagrammed in Figure 1. The entire set of activities would then require at least 3 days, since the activities follow one another directly and require a total of 1.0 + 0.5 + 0.5 + 1.0 = 3 days. If another activity proceeded in *parallel* with this sequence, the 3 day minimum duration of these four activities is unaffected. More than 3 days would be required for the sequence if there was a delay or a lag between the completion of one activity and the start of another.

Table 3.1: Durations and predecessors for a Four Activity Project illustration

Activity	Predecessor	Duration (Days)
Excavate Trench	-	1.0
Place Formwork	Excavate Trench	0.5
Place Reinforcement	Place Formwork	0.5
Pour Concrete	Place Reinforcement	1.0

All formal scheduling procedures rely upon estimates of the durations of the various project activities as well as the definitions of the predecessor relationships among tasks. The variability of an activity's duration may also be considered. Formally, the *probability distribution* of an activity's duration as well as the expected or most likely duration may be used in scheduling. A probability distribution indicates the chance that a particular activity duration will occur. In advance of actually doing a particular task, we cannot be certain exactly how long the task will require.

A straightforward approach to the estimation of activity durations is to keep historical records of particular activities and rely on the average durations from this experience in making new duration estimates. Since the scope of activities are unlikely to be identical between different projects, unit productivity rates are typically employed for this purpose. For example, the duration of an activity D_{ij} such as concrete formwork assembly might be estimated as:

(1) $$D_{ij} = \frac{A_{ij}}{P_{ij} N_{ij}}$$

where A_{ij} is the required formwork area to assemble (in square yards), P_{ij} is the average productivity of a standard crew in this task (measured in square yards per hour), and N_{ij} is the number of crews assigned to the task. In some organizations, unit production time, T_{ij}, is defined as the time required to complete a unit of work by a standard crew (measured in hours per square yards) is used as a productivity measure such that T_{ij} is a reciprocal of P_{ij}.

A formula such as Eq. (1) can be used for nearly all construction activities. Typically, the required quantity of work, A_{ij} is determined from detailed examination of the final facility design. This *quantity-take-off* to obtain the required amounts of materials, volumes, and areas is a very common process in bid preparation by contractors. In some countries, specialized quantity surveyors provide the information on required quantities for all potential contractors and the owner. The number of crews working, N_{ij}, is decided by the planner. In many cases, the number or amount of resources applied to particular activities may be modified in light of the resulting project plan and schedule. Finally, some estimate of the expected work productivity, P_{ij} must be provided to apply Equation (1). As with cost factors, commercial services can provide average productivity figures for many standard activities of this sort. Historical records in a firm can also provide data for estimation of productivities.

The calculation of a duration as in Equation (1) is only an approximation to the actual activity duration for a number of reasons. First, it is usually the case that peculiarities of the project make the accomplishment of a particular activity more or less difficult. For example, access to the forms in a particular location may be difficult; as a result, the productivity of assembling forms may be *lower* than the average value for a particular project. Often, adjustments based on engineering judgment are made to the calculated durations from Equation (1) for this reason.

In addition, productivity rates may vary in both systematic and random fashions from the average. An example of systematic variation is the effect of *learning* on productivity. As a crew becomes familiar with an activity and the work habits of the crew, their productivity will typically improve. Figure 2 illustrates the type of times that of an unskilled engineer. In the absence of specific knowledge, the estimator can only use average values of productivity.

Weather effects are often very important and thus deserve particular attention in estimating durations. Weather has both systematic and random influences on activity durations. Whether or not a rainstorm will come on a particular day is certainly a random effect that will influence the productivity of many activities. However, the likelihood of a rainstorm is likely to vary systematically from one month or one site to the next. Adjustment factors for inclement weather as well as meteorological records can be used to incorporate the effects of weather on durations. As a simple example, an activity might require ten days in perfect weather, but the activity could not proceed in the rain. Furthermore, suppose that rain is expected ten percent of the days in a particular month. In this case, the expected activity duration is eleven days including one expected rain day.

Finally, the use of average productivity factors themselves cause problems in the calculation presented in Equation (1). The expected value of the multiplicative reciprocal of a variable is not exactly equal to the reciprocal of the variable's expected value. For example, if productivity on an activity is either six in good weather (ie., $P=6$) or two in bad weather (ie., $P=2$) and good or bad weather is equally likely, then the expected productivity is $P = (6)(0.5) + (2)(0.5) = 4$, and the reciprocal of expected productivity is 1/4. However, the expected reciprocal of productivity is $E[1/P] = (0.5)/6 + (0.5)/2 = 1/3$. The reciprocal of expected productivity is 25% less than the expected value of the reciprocal in this case! By representing only two possible productivity values, this example represents an extreme case, but it is always true that the use of average productivity factors in Equation (1) will result in *optimistic* estimates of activity durations. The use of actual averages for the reciprocals of productivity or small adjustment factors may be used to correct for this non-linearity problem.

The simple duration calculation shown in Equation (1) also assumes an inverse linear relationship between the number of crews assigned to an activity and the total duration of work. While this is a reasonable assumption in situations for which crews can work independently and require no special coordination, it need not always be true. For example, design tasks may be divided among numerous architects and engineers, but delays to insure proper coordination and communication increase as the number of workers increase. As another example, insuring a smooth flow of material to all crews on a site may be increasingly difficult as the number of crews increase. In these latter cases, the relationship between activity duration and the number of crews is unlikely to be inversely proportional as shown in Equation (1). As a result, adjustments to the estimated productivity from Equation (1) must be made. Alternatively, more complicated functional relationships might be estimated between duration and resources used in the same way that nonlinear preliminary or conceptual cost estimate models are prepared.

One mechanism to formalize the estimation of activity durations is to employ a hierarchical estimation framework. This approach decomposes the estimation problem into component parts in which the higher levels in the hierarchy represent attributes which depend upon the details of lower level adjustments and calculations. For example, Figure 3 represents various levels in the estimation of the duration of masonry construction. [3] At the lowest level, the maximum productivity for the activity is estimated based upon general work conditions. Table 2 illustrates some possible maximum productivity values that might be employed in this estimation. At the next higher level, adjustments to these maximum productivities are made to account for special site conditions and crew compositions; table 3 illustrates some possible adjustment rules. At the highest level, adjustments for overall effects such as weather are introduced. Also shown in Figure 3 are nodes to estimate down or unproductive time associated with the masonry construction activity. The formalization of the estimation process illustrated in Figure 3 permits the development of computer aids for the estimation process or can serve as a conceptual framework for a human estimator.

TABLE 3.2 Maximum Productivity Estimates for Masonry Work		
Masonry unit size	**Condition(s)**	**Maximum Productivity Achievable**
8 inch block	None	400 units/day/mason
6 inch	Wall is "long"	430 units/day/mason
6 inch	Wall is not "long"	370 units/day/mason
12 inch	Labor is nonunion	300 units/day/mason
4 inch	Wall is "long" Weather is "warm and dry" or high-strength mortar is used	480 units/day/mason
4 inch	Wall is not "long" Weather is "warm and dry" or high-strength mortar is used	430 units/day/mason
4 inch	Wall is "long" Weather is not "warm and dry" or high-strength mortar is not used	370 units/day/mason
4 inch	Wall is not "long" Weather is not "warm and dry" or high-strength mortar is not used	320 units/day/mason
8 inch	There is support from existing wall	1,000 units/day/mason
8 inch	There is no support from existing wall	750 units/day/mason
12 inch	There is support from existing wall	700 units/day/mason
12 inch	There is no support from existing wall	550

TABLE 3.3 Possible Adjustments to Maximum Productivities for Masonry Construction.		
Impact	Condition(s)	Adjustment magnitude (% of maximum)
Crew type	Crew type is nonunion Job is "large"	15%
Crew type	Crew type is union Job is "small"	10%
Supporting labor	There are less than two laborers per crew	20%
Supporting labor	There are more than two masons/laborers	10%
Elevation	Steel frame building with	10%

	masonry exterior wall has "insufficient" support labor	
Elevation	Solid masonry building with work on exterior uses nonunion labor	12%
Visibility	block is not covered	7%
Temperature	Temperature is below 45° F	15%
Temperature	Temperature is above 45° F	10%
Brick texture	bricks are baked high Weather is cold or moist	10%

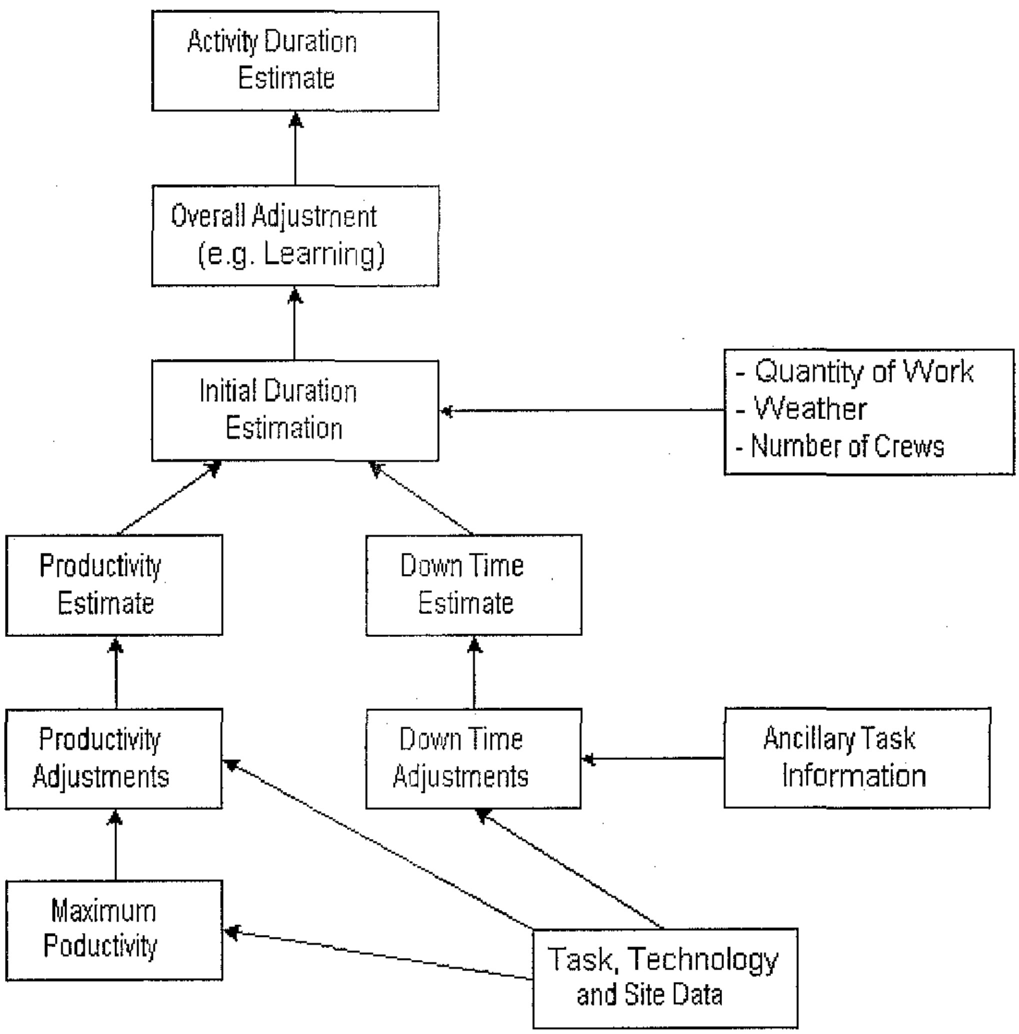

Figure 3.3: A Hierarchical Estimation Framework for Masonry Construction

In addition to the problem of estimating the expected duration of an activity, some scheduling procedures explicitly consider the uncertainty in activity duration estimates by using the probabilistic distribution of activity durations. That is, the duration of a particular activity is assumed to be a random variable that is distributed in a particular fashion. For example, an activity duration might be assumed to be distributed as a normal or a beta distributed random variable as illustrated in Figure 4. This figure shows the probability or chance of experiencing a particular activity duration based on a probabilistic distribution. The beta distribution is often used to characterize activity durations, since it can have an absolute minimum and an absolute maximum of possible duration times. The normal distribution is a good approximation to the beta distribution in the center of the distribution and is easy to work with, so it is often used as an approximation.

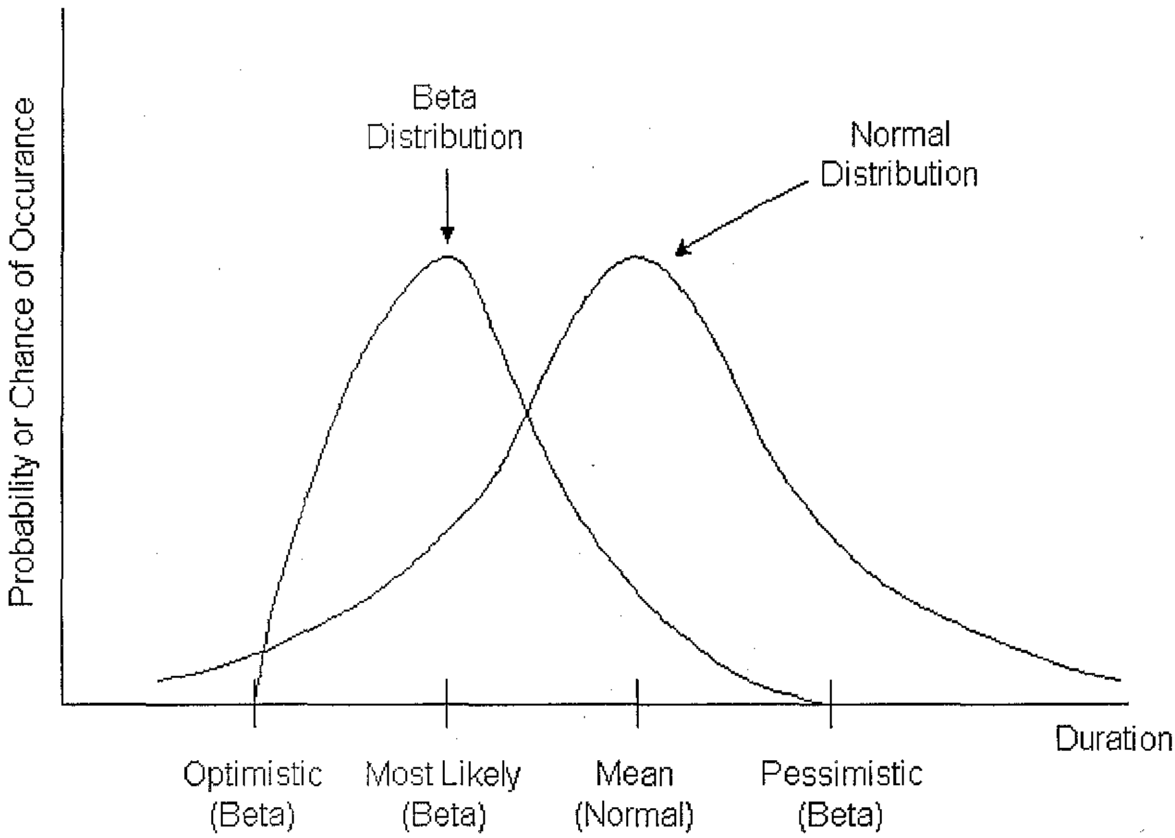

Figure 3.4: Beta and Normally Distributed Activity Durations

If a standard random variable is used to characterize the distribution of activity durations, then only a few parameters are required to calculate the probability of any particular duration. Still, the estimation problem is increased considerably since more than one parameter is required to characterize most of the probabilistic distribution used to represent activity durations. For the beta distribution, three or four parameters are required depending on its generality, whereas the normal distribution requires two parameters.

As an example, the normal distribution is characterized by two parameters, μ and σ representing the average duration and the standard deviation of the duration, respectively. Alternatively, the *variance* of the distribution σ^2 could be used to describe or characterize the variability of duration times; the variance is the value of the standard deviation multiplied by itself. From historical data, these two parameters can be estimated as:

(2) $$\mu \approx \bar{x} = \sum_{k=1}^{n} \frac{x_k}{n}$$

(3) $$\sigma^2 \approx \sum_{k=1}^{n} \frac{\left(x_k - \bar{x}\right)^2}{n-1}$$

where we assume that n different observations x_k of the random variable x are available. This estimation process might be applied to activity durations directly (so that x_k would be a record of an activity duration D_{ij} on a past project) or to the estimation of the distribution of productivities (so that x_k would be a record of the productivity in an activity P_i) on a past project) which, in turn, is used to estimate durations using Equation (4). If more accuracy is desired, the estimation equations for mean and standard deviation, Equations (2) and (3) would be used to estimate the mean and standard deviation of the reciprocal of productivity to avoid non-linear effects. Using estimates of productivities, the standard deviation of activity duration would be calculated as:

(4) $$\sigma_{ij} \approx \frac{A_{ij}\sigma_{1/P}}{N_{ij}}$$

where $\sigma_{1/P}$ is the estimated standard deviation of the reciprocal of productivity that is calculated from Equation (3) by substituting 1/P for x.

2.2. Previous Related Works

2.2.1. Books

Throughout this study, most of the books related to the production rates topic are done by foreign researchers. Little works has been done by local researchers regarding this topic. Basically, most of the theory and basic idea in this study have been established by referring to the foreign researchers' journals and books. One of the books that have been thoroughly used in this study is the book written by Chris Hendrickson, the 'Fundamental Concepts for Owners, Engineers, Architects and Builders' [5] which covers topics such as construction planning, fundamental scheduling procedures and advance scheduling techniques. According to Chris Hendrickson (1989)

"Productivity improvements are always of importance and value. As a result, introducing new materials and automated construction processes is always desirable as long as they are less expensive and are consistent with desired performance. (p.2)"

By referring to the book, the author could better understand the characteristics and importance of production rates in construction planning works.

2.2.2. Journals and other research publication:

The journals "A Comparative Evaluation of Concrete Placing Productivity Rates amongst French, German and UK Construction Contractors" written by D.G. Proverbs, G.D. Holt & P.O. Olomolaiye from School of engineering and the Built Environment, University of Wolverhampton which related to the differences of production rates values between French, German and UK construction contractors had proven that there are significant factors such as location and labor expertise. The Journal concluded that German contractors achieved the most efficient levels of labour productivity for the concrete placement operation whilst among the sample surveyed.

Another related published researched is the observation study of Cardington project (construction of seven storey reinforced concrete frame building) by A.P. I.R. Arazi Idrus. The published research had determined some production rates values for common in-situ concrete and general construction works. Speed of the construction works was measured by recording the time and noting the number of workers involved in the operation. The Cardington project was one of the very few full scale 'real' projects in which speeds were systematically observed, monitored and recorded throughout the whole construction period. The result of the observation study is included in the result and discussion session for comparison purposes.

2.2.3. Websites:

Besides books and journals, there are also studies being made and published through websites. Websites could not be taken as the main reference for this study as anyone could publish a site on their own and the degree of accuracy of the information is quite ambiguous. Realizing this fact, the author has decided to take websites information as a second source of information for this study. Some of the websites which offers various values of construction production rates are such as www.constructionlibrary.com and www.planningplanet.com. The Construction Library is founded on a unique interactive database of production rates, based on Work Study research conducted on real construction sites since the 1950s. This database itemizes each construction activity in terms of the amount of work a single production unit – from a bricklayer to a piling rig – should be accomplishing in a given time. The basis for the Rates is a body of work created by leading contractors and clients from the early 1950s. The value of these rates has been proven and they were a de facto standard in leading contractor organizations in years gone by. All Production Rates are published in both metric and imperial formats. A calculator appears on each rate card to allow users to calculate resource hours, planning hours, planning days, material and labour costs. Rate cards allow the user to input volumetric data from a drawing or Bill of Quantities and instantly calculate the resource and anticipated cost requirements for each activity. The rates, however, will always be used as an input to some secondary process, usually within discipline-specific planning/scheduling software such as Primavera, Microsoft Project or an estimating package. Regarding the geographical problem, construction library claims that it provide a Universal Benchmark values of production rates. The exact deviation shall be decided by the user himself.

The planning planet is founded on database development through internet application. Users from all over the world would subscribe to the website, and input or suggest production rates for various construction works. However, the method in deriving or choosing the production rates given by the users is yet to be known as there is no explanation given on that topic. Furthermore, the website does not give any justification on the production rates based on the number of workers associated to the works.

CHAPTER 3

METHODOLOGY

3. METHODOLOGY:

3.1. Introduction:

As discussed in the literature review section, production rates could not be simply calculated by mathematical modeling. There are many uncontrollable factors which occur randomly and can't be incorporated in the mathematical model. Thus calculation or theoretical method which is normally being applied in engineering works could not be implemented in the study. However, there are several other methods which could be applied such as observation method and survey research method.

Observation method requires the author to observe the works in a real-life project. Stop clock and video camera are some of the basic tools required to record the time needed to accomplish the works which are being observed. Obviously, this method consumed a lot of time to be implemented. It is not time efficient for a student to conduct this method for the study.

Another method which could result in an equally quality with the observation method is the survey research method. Survey research method can be defined as a method of gathering information of verbal data from a sample of individuals. Usually the works associated with survey research method are delivering questionnaires and conducting interviews to get responds or information from experts or publics on a specified subject.

From the methods described above, survey research method seems to best suits the requirements and constraint applied within this study. As production rate is a verbal data, questionnaire seems to be the most efficient method in obtaining those data. Furthermore, less time but high quality information could be retrieved from survey research method.

3.2. Processes:

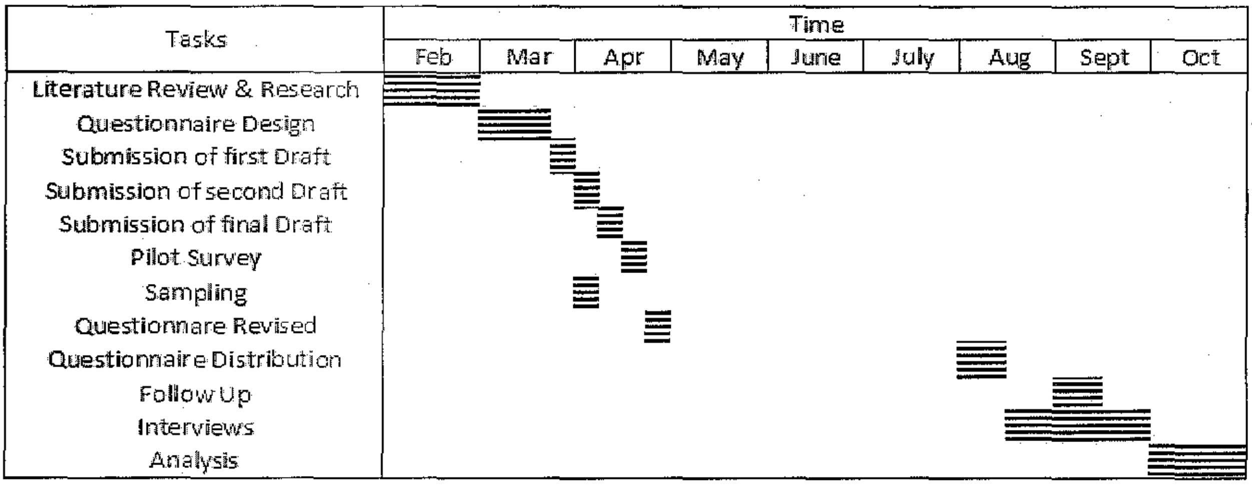

Figure 4.1: Detail schedule for FYP 1 and FYP 2

3.2.1. Literature Review

Literature review is an important process in the project, as it provides the author with the general idea on the project. The methodologies involved in this process are mainly research on internet, library and discussion with Supervisor and Tutor.

3.2.2. Questionnaire Design

Generally, the process in designing a questionnaire could be divided into 3 major steps which are considerations & rule of thumb, pilot survey and questionnaire revisions. The methodology in considering the considerations and rule of thumbs in designing the questionnaire are generally adopted by literature review and research. Pilot survey is one of the major processes in the project; however it could be included as one of the steps in the designing process as it serves as a tool to aid in the questionnaire modifications. Questionnaire revision is one of the steps, carried out after the pilot survey in order to further enhance the questionnaires from various aspects.

In designing the questionnaire, several considerations need to be considered such as the respondent's level of knowledge, biases and respondent's attitude. Respondent's level of knowledge basically involved the general terms and definition used by the respondents. This criteria need to be considered in the designing process, so that the questionnaire designed could easily be understood by the respondents. Besides that, it is also important so that the respondents would not answer the questionnaire on a misconception. Bias is one of the parameter need to be well understood in designing a questionnaire. Without proper thought on this parameter, the respondents would give bias results from the questionnaire. Two of the main 'location' where bias result usually occurs is the sample and the nature of the questionnaires itself. Respondent's attitude is also one of the parameter which leads to bias results in the survey.

Besides the considerations discussed above, a rule of thumb also applied in the designing process. KISS - Keep It Short and Simple is one of the rule of thumb in designing the questionnaire. Rules of thumb in designing the questionnaire is being studied through the literature review process. Apart from that, references on previous questionnaire developed which is significant to the project is also one of the methodology in studying the "do's and don't in designing the questionnaire".

Pilot survey is essentially a small scale replica of the actual survey and it is carried out before the actual survey is undertaken. A pilot survey is very useful when the actual survey is to be on a big scale as it may provide data which will allow costs to be trimmed. Also, a pilot survey will give an estimate of the non-response rate and it will also give a guide as to the adequacy of the sampling frame chosen. The methodology in this step shall be discussed on the pilot survey section below.

Questionnaire review shall again follow the cycle of the questionnaire design steps. However, the designer should decide whether to incorporate the pilot survey again in the revised questionnaire or not. For a serious survey, usually designer shall again conduct pilot survey on the revised questionnaire to further improve the quality of the questionnaire designed.

3.2.3. Pilot Survey

Pilot survey is essentially a small scale replica of the actual survey and it is carried out before the actual survey is undertaken. For this study, Pilot survey shall be conducted after the final draft of the questionnaire has been completed. The pilot survey shall be conducted both internally and externally. Three internal respondents (UTP's lecturer) and three external respondents (contractor) shall be chosen randomly for the survey. The respondents shall be given a period of time to complete the questionnaire. The questionnaire will then be collected to be analyzed.

3.2.4. Sampling

Sampling could be defined as collecting data from a representative sample of the population they are interested in. There are two different types of sampling procedures--probability and nonprobability. Probability sampling methods ensure that there is a possibility for each person in a sample population to be selected, whereas nonprobability methods target specific individuals. The project shall implement a probability sampling methods in order to avoid biases in the results with an area covering Perak Darul Ridzuan, Selangor Darul Ikhsan and Kuala Lumpur. Cluster sampling which divides the population into smaller groups, and only sampling from one of the groups shall be implemented in the project. Contractor from Perak, Selangor and Kuala Lumpur shall be divided into each area, and shall be selected randomly in order to provide better distribution of results.

The process of random sampling conducted for this project consists of 4 main tasks. The first task is to search the registered contractor's name list from CIDB. This is one by browsing CIDB's website http://ww3.cidb.gov.my/corporate/index-my.html . The contractors interested to be surveyed in this study are contractors from Perak, Selangor and Kuala Lumpur.

The second task in collecting the samples is to choose the appropriate contractors for the study. The contractors which are from grade G5-G7 and specialized and experienced in building construction are chosen in the survey. Three hundred contractors are chosen in this stage which consists of one hundred contractors for every state (Perak, Selangor and Kuala Lumpur).

After finalizing the name list, the author then rearrange the name list according to alphabets (from A-Z), and choose the contractors in incremental order. For this study, the author has decided to choose the contractors from the name list in increment of two, because the total contractors which are three hundreds divided by one hundred fifty is equal to two. However the starting point where the author decided to choose is decided randomly. The author shall take ten Ping-Pong ball, and numbered them from one to ten. Randomly, he shall pick one of the Ping-Pong balls in order to decide what number shall be the starting point in choosing the contractors incrementally. Through these steps, fifty contractors shall be selected for each state (Perak, Selangor and Kuala Lumpur).

3.2.5. Questionnaire Distribution

After sampling processes, the revised questionnaire shall be distributed to the randomly selected samples. In this project, the distribution would be done through mails and household drop-off. Questionnaires shall be mailed to the companies located far from UTP. For companies nearer to UTP, the questionnaire shall be distributed personally to the companies' site offices or head quarters. A cover letter shall be included within the questionnaire's envelope, in order to introduce the project to the respondents.

3.2.6. Follow Up

Once the expected reply date for the respondents (3rd September 2007) has passed, author shall contact the respondents by means of telephone or email. The follow up process shall be done in one week duration. This process is done to increase the chance that the respondents would respond to the questionnaire sent to them. The author shall call or email the respondents in order to ask the respondents whether they received the questionnaire and also to remind them about the questionnaire.

3.2.7. Interviews

Generally, there are two methods to interview respondent namely personal interview and telephone interview. Personal interview requires the author to go to the respondents' place, and conduct a direct interview with the person. Extra interpersonal communication skills are required in order to gain good impression from the respondents. It is important that the respondents do not feel uncomfortable during the interview session, as it would greatly impact the result of the interview session. However, respondents are most likely to welcome the interviewee once they agreed to be interview.

Telephone interview is easier and faster to be conducted as the author is not required to travel a lot. Comparatively, it is cheaper than personal interview. However, most of the time, telephone interview could not establish a good relationship from both of the parties (the interviewee and the respondents) as they are no direct communication from both of them.

For this study, the author decided to use the direct interview method, as the desired answer (production rates) from the respondents is in numerical form. Logically, it is quite hard to make the respondents understand the desired answer needed by only talking in the telephone. Furthermore, the respondents would most likely try to answer the questions asked by the author as fast as he/she can in order to end the conversation. Therefore, personal interviews seemed to suit the need in this study the most compared to telephone interviews.

3.2.8. Analysis

Analysis involved in the study is analytical and descriptive analysis. Analytical analysis shall be carried out if the responds is 30 or more. However, if lower responds is obtained, descriptive analysis shall be carried out. Descriptive statistics "describe" data that have been collected. Commonly used descriptive statistics include frequency counts, ranges (high and low scores or values), means, modes, median scores, and standard deviations.

3.3. Tools

3.3.1. Final Year Project 1

Basically, the Final Year Project the author only requires simple tools on both hardware and software. As there are not much physical works should be done in the FYP 1 scope of works, materials used are only papers whereas software used are such as Microsoft word and Microsoft excel.

3.3.2. Final Year Project 2

For FYP 2, the process of distributing the questionnaire via mail requires lots of envelopes and stamps. About one hundred fifty envelopes are required to be sent and another hundred fifty for the respondent to send back to the author for the study. Each of the envelopes (going and returning) shall be stamped. After distributing the questionnaire, the author shall need communication tools such as telephone and internet for follow up process. Certain software such as Microsoft Excel, Microsoft Project and Primavera System shall be used to conduct analysis and software development process.

CHAPTER 4

RESULTS & FINDINGS

4. RESULTS:

4.1. General / Background information:

4.1.1. Company's Location:

Table5.1: Company's Location:

Company's Location	No. of Respondents
Perak	1
Selangor	11
Kuala Lumpur	2

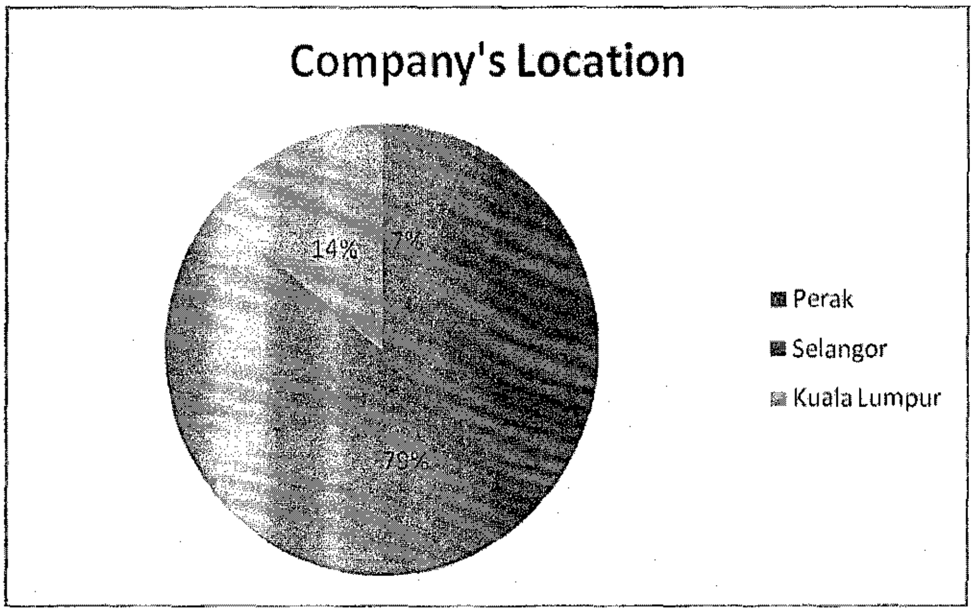

Figure 5.1: Company's Location

The above pie chart visually explains that most of the respondents are from Selangor Darul Ehsan. Initially, the purpose of knowing the respondent's company's location is to distinguish whether there is any significance difference in the three states civil and structural production rates. However, no indication can be made since so little respondents replied the questionnaire.

4.1.2. Respondent's Class

4.1.2.1. PKK class:

Table 5.2: Respondent's PKK Class:

PKK Class	No. of Respondents
A	11
B	1
Unknown	2

Most of the respondents are from Class A PKK contractor which deals with mega projects.

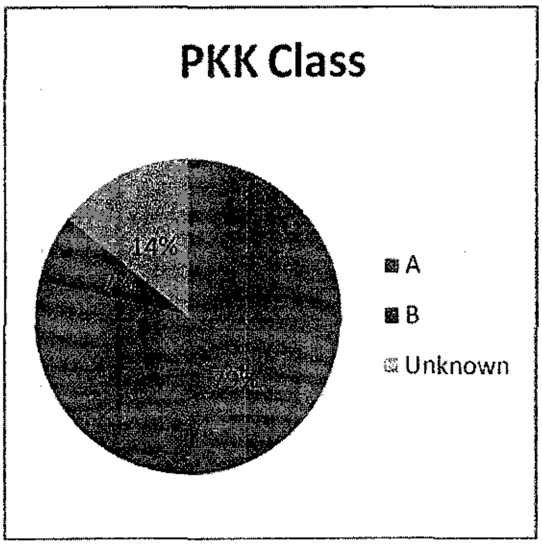

Figure 5.2: Respondent's PKK Class

4.1.2.2. CIDB class:

Table 5.3: Respondent's CIDB Class:

CIDB Class	No. of Respondents
G7	11
G4	1
Unknown	2

For CIDB class, most of the respondents are from G7 Class, which is the highest class in CIDB class.

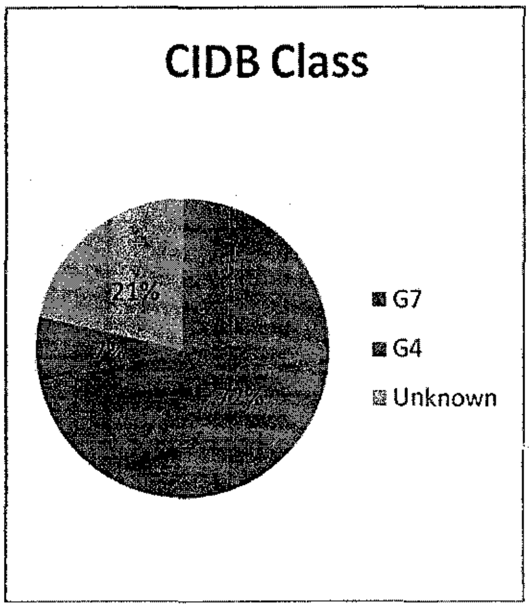

Figure 5.3: Respondent's CIDB Class

4.1.1. Company's experience in building construction:

Table 5.4: Company's Experience:

Company's Experience (Years)	No. of Respondents
Less than 5	3
5 – 10	6
10 - 20	5

Most of the respondents' company's experiences have 5-10 years experience. This shows that the companies which replied the questionnaire have sufficient knowledge on building construction.

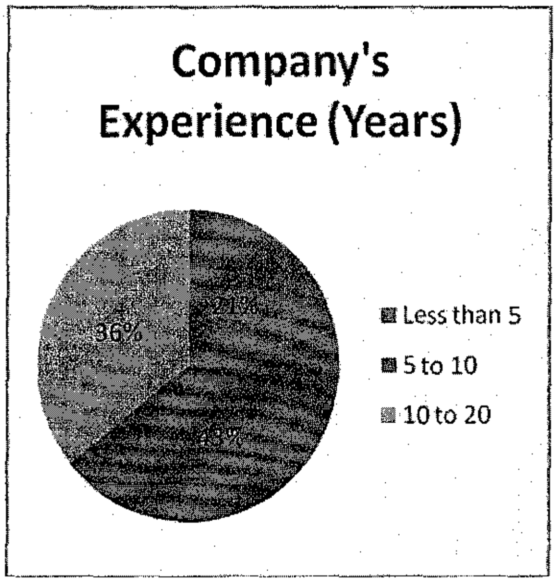

Figure 5.4: Respondent's CIDB Class:

4.1.2. Respondent's experience in building construction:

Table 5.5: Respondent's Experience:

Experience (Years)	No. of Respondents
Less than 5	7
5 – 10	4
10 – 15	2
More than 15	1

Half of the respondents have less than 5 years experience in building construction. However, it is assume that the respondents could rely on the company's intellectual property regarding building construction, in answering the questionnaire.

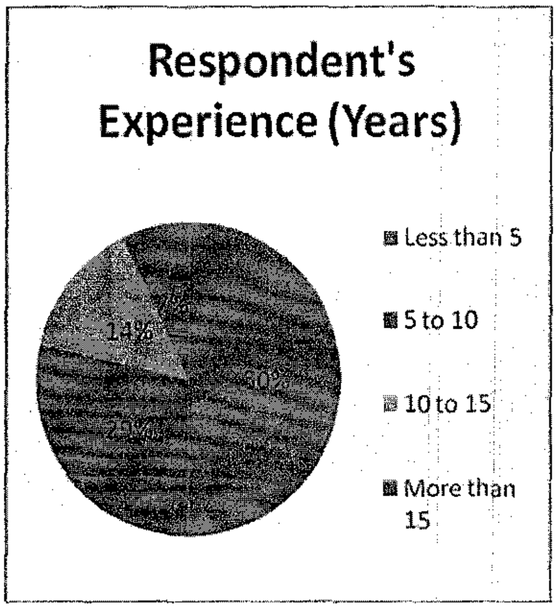

Figure 5.5: Respondent's CIDB Class:

4.1.3. Respondent's designation:

Table 5.6: Respondent's Designation:

Respondent's Designation	No. of Respondents
Managing Director	1
General Manager	1
Project Manager	5
Construction Manager	3
QaQc Manager	1
Planner	2
Project Engineer	1

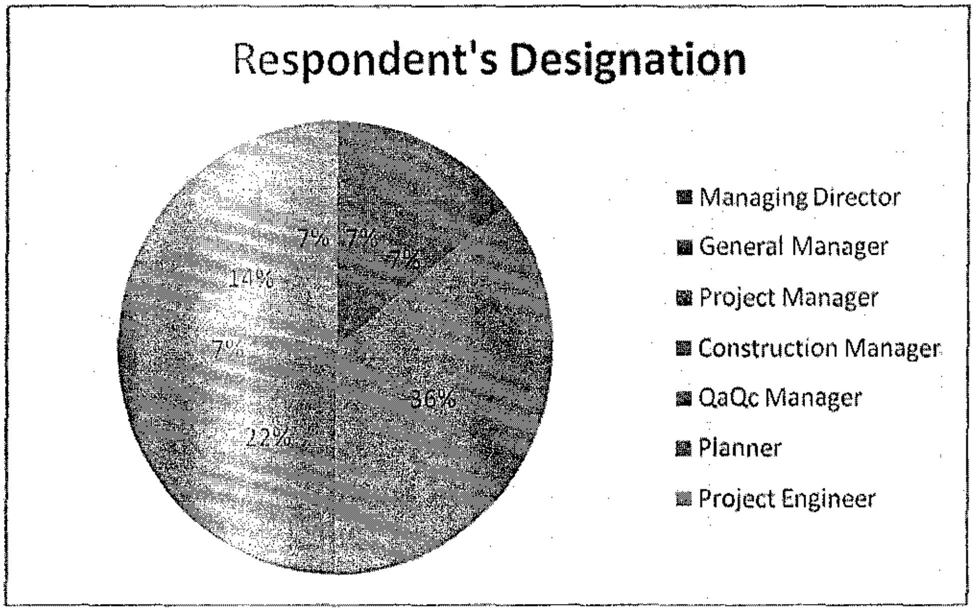

Figure 5.6: Respondent's Designation

Most of the respondents are from managerial level. 36% from the overall respondents are project managers. There are even managing director and general manager that respond to the questionnaire. From the positions that the respondents held, it can be logically assumed that the answers given is from experienced workers. Furthermore, it can also be assumed that the experience and high level of technical knowledge is required to answer the questionnaire.

4.2. Production Rates Results:

Table 5.7: Raw Data:

Task	Unit	Production Rates												
		Questionnaire					Interviews							
		1	2	3	4	5	6	7	8	9	10	11	12	13
ing	m/day	680	288	300	300	100	300	450	300	400	300	700	357	15[illegible]
cavation	m³/day	200	360	200	200	50	50	150	200	150	150	225	220	5[illegible]
lsework Installation	m³/day	50	500	60	50	50	40	80	70	100	80	50	50	14[illegible]
rmwork Installation														
Soffit Formwork	m²/day	148	100	100	150	20	70	100	96	70	60	150	75	1[illegible]
Edge Formwork	m²/day	110	50	60	120	20	50	60	104	40	60	120	43	1[illegible]
einforcement Fixing														
Main bar	ton/day	3	1.5	2	3	0.7	1.5	2.4	1.1	0.6	1	2.5	1	0.[illegible]
Links	ton/day	1	0.5	1	1	0.7	1	0.5	0.7	0.3	1	1	0.8	0.[illegible]
BRC (Mesh)	m²/day	900	400	600	1000	150	200	400	500	100	500	850	250	15[illegible]
Loose Bar	ton/day	1	0.3	0.5	1	0.7	0.4	0.5	1	0.3	1	1	0.5	0.[illegible]
oncrete Placement:														
Skip & Bucket	m³/day	160	50	50	150	16	60	50	36	100	30	200	75	1[illegible]
Pumping Chute	m³/day	300	150	180	275	16	180	150	320	180	160	280	200	1[illegible]
alsework Dismantling	m³/day	150	1000	150	150	100	80	160	100	130	160	150	125	10[illegible]
ormwork Dismantling	m²/day	320	50	150	300	40	120	150	120	100	120	300	165	2[illegible]
ickwork	m²/day	190	40	100	150	18	50	30	32	40	80	200	80	1[illegible]

The data was collected through questionnaires submissions and also interviews. Five of the data were from questionnaires submission, whereas nine more data were from interviews. However, 1 data could not be shown in the table as the respondent only gives duration for the activities, instead of production rates.

4.3. Analysis:

As the number of responds is below 30, analytical analysis couldn't be carried out. Thus, descriptive analysis is used to analyze the raw data. The analysis done is based on the raw data's modus. The analysis covered Variance Analysis based on contractors' class and respondents' experience, Mean and Variance analysis and also modus analysis. Variance analysis discussed on the significant and differences of production rates, based on contractors' class and respondents' experience. Mean and Variance analysis discussed the mean and variance values, calculated from the raw data and modus analysis is done to select the best production rates values, in the study scope.

Table 5.8: Variance Analysis Based on Contractor Class

Task	Unit	Production Rates												
		Contractor Class												
		A										B	Unknown	
	m/day	300	100	300	288	300	400	300	700	357	150	450	680	300
tion	m³/day	200	50	50	360	200	150	150	225	220	50	150	200	200
ork Installation	m³/day	50	50	40	500	70	100	80	50	50	140	80	50	60
ork Installation														
it Formwork	m²/day	150	20	70	100	96	70	60	150	75	12	100	148	100
e Formwork	m²/day	120	20	50	50	104	40	60	120	43	12	60	110	60
cement Fixing														
ı bar	ton/day	3	0.7	1.5	1.5	1.1	0.6	1	2.5	1	0.7	2.4	3	2
s	ton/day	1	0.7	1	0.5	0.7	0.3	1	1	0.8	0.7	0.5	1	1
; (Mesh)	m²/day	1000	150	200	400	500	100	500	850	250	150	400	900	600
se Bar	ton/day	1	0.7	0.4	0.3	1	0.3	1	1	0.5	0.7	0.5	1	0.5
te Placement:														
) & Bucket	m³/day	150	16	60	50	36	100	30	200	75	16	50	160	50
ıping Chute	m³/day	275	16	180	150	320	180	160	280	200	16	150	300	180
ork Dismantling	m³/day	150	100	80	1000	100	130	160	150	125	100	160	150	150
ork Dismantling	m²/day	300	40	120	50	120	100	120	300	165	24	150	320	150
ork	m²/day	150	17.5	50	40	32	40	80	200	80	18	30	190	100

By observing the above data, no conclusion could be made based on the class of the contractor's production rates. A, B and unknown class give more or less the same production rates with respect to each other. Furthermore, the presence of the unknown class further denies the author to makes any conclusion from this analysis.

Table 5.9: Variance Analysis Based on Respondent's Experience

Task	**Unit**	**Production Rates**												
		Respondent's Experience (Years)												
		Less than 5							5 to 10				11 to 15	More than 15
	m/day	288	300	100	300	300	400	150	300	450	300	357	700	680
on	m³/day	360	200	50	50	200	150	50	200	150	150	220	225	200
k Installation	m³/day	500	50	50	40	70	100	140	60	80	80	50	50	50
k Installation														
Formwork	m²/day	100	150	20	70	96	70	12	100	100	60	75	150	148
Formwork	m²/day	50	120	20	50	104	40	12	60	60	60	43	120	110
ement Fixing														
oar	ton/day	1.5	3	0.7	1.5	1.1	0.6	0.7	2	2.4	1	1	2.5	3
	ton/day	0.5	1	0.7	1	0.7	0.3	0.7	1	0.5	1	0.8	1	1
Mesh)	m²/day	400	1000	150	200	500	100	150	600	400	500	250	850	900
Bar	ton/day	0.3	1	0.7	0.4	1	0.3	0.7	0.5	0.5	1	0.5	1	1
Placement:														
Bucket	m³/day	50	150	16	60	36	100	16	50	50	30	75	200	160
ing Chute	m³/day	150	275	16	180	320	180	16	180	150	160	200	280	300
k Dismantling	m³/day	1000	150	100	80	100	130	100	150	160	160	125	150	150
k Dismantling	m²/day	50	300	40	120	120	100	24	150	150	120	165	300	320
k	m²/day	40	150	18	50	32	40	17.5	100	30	80	80	200	190

By observing the above results, there are some patterns of data that distinguish the production rates data given by different respondents' experience. Most of the lowest production rates were given by respondents that have less than five years of experience, followed by five to ten years and eleven years and above. Respondents that have eleven years and above experience basically provide more or less the same production rates which are the maximum or highest production rates compared to the other. This shows that experience respondents who have observed several construction works knows that the construction works production rates values can be as high as written in the table whereas little experience respondents tend to be in a safer side in predicting the production rates value.

Table 5.10: Mean and Variance

No	Task	Mean	Variance
1	Piling	355.70 m/day	30,197
2	Excavation	169.60 m^3/day	7,469
3	Falsework Installation	101.54 m^3/day	15,081
4	Formwork Installation		
	Soffit Formwork	88.54 m^2/day	1,982
	Edge Formwork	65.31 m^2/day	1,339
5	Reinforcement Fixing		
	Main bar	1.62 ton/day	1
	Links	0.78 ton/day	0
	BRC (Mesh)	461.54 m^2/day	91,731
	Loose Bar	0.68 ton/day	0
6	Concrete Placement:		
	Skip & Bucket	76.38 m^3/day	3,474
	Pumping Chute	185.15 m^3/day	9,089
7	Falsework Dismantling	196.54 m^3/day	58,997
8	Formwork Dismantling	150.69 m^2/day	9,775
9	Brickwork	79.00 m^2/day	4,042

By observation, it is quite obvious that there is large variance between the data, thus mean could not be accepted as the ultimate results of the study. However, there are some values that occurred quite often in the raw data, thus modus of range data was taken as the result of the study.

Table 5.11: Production Rates (after analysis):

No	Task	Unit	Production Rates	% of differences between max and mix
1	Piling	m/day	220-340	35%
2	Excavation	m^3/day	175-236	25.8%
3	Falsework Installation	m^3/day	40-132	70%
4	Formwork Installation			
	Soffit Formwork	m^2/day	70-96	27%
	Edge Formwork	m^2/day	35-56	37.5%
5	Reinforcement Fixing			
	Main bar	ton/day	0.6-1.1	45.5%
	Links	ton/day	0.87-1.0	13%
	BRC (Mesh)	m^2/day	100-280	64.3%
	Loose Bar	ton/day	0.87-1.0	13%
6	Concrete Placement:			
	Skip & Bucket	m^3/day	16-53	70%
	Pumping Chute	m^3/day	140-200	30%
7	Falsework Dismantling	m^3/day	145-160	9.4%
8	Formwork Dismantling	m^2/day	84-142	40.8%
9	Brickwork	m^2/day	17.5-54	67.6%

From the analysis, ranges of values are made and the best ranges are selected based on the occurrence frequency of the raw data. One of the reason to use ranges of values as the end product is because the data's variance are very high. Single values result could not be extracted from the raw data due to small number of responds and also the large variance that occurred.

From the above results, it is observed that the ranges are large for falsework installation, BRC (Mesh) fixing, Skip & bucket concrete placement and brickwork. One of the reasons that lead to the big differences between the max and min values in the above range is the large variance in the raw data. However, small differences of max and min values for links and loose bar fixing are also observed.

Table 5.12: Comparison of the study's result with previous study results:

Task	Unit	FYP II	Price Books			Published - Proverb 1998	Published -Price 1984	Observed-Cardington 1998	Planning Planet	Average
			Wessex 2000	Laxtons 2000	Spons 1999					
	m/day	220-340								280
ı	m3/day	175-236							200	218
Installation	m3/day	40-132						133.33	140	119.8
Installation										
ɪt Formwork	m2/day	70-96	42.1	38.1		57.1			9.6	46
ɜ Formwork	m2/day	35-56	36.36		29.6	72.7			12	39.23
nent Fixing										
ar	ton/day	0.6-1.1	1.6		1.52	1.26		4.2	0.7	1.69
	ton/day	0.87-1.0	1.07		0.84				0.7	0.8863
ᴍesh)	m2/day	100-280			266.7			266.7		241.13
Bar	ton/day	0.87-1.0								0.935
'lacement:										
Bucket	m3/day	16-53	38.1		33.33	34.78		133.33	44	53
ɪg Chute	m3/day	140-200					114.3	160	320	191.1
Dismantling	m3/day	145-160					88.9	200		147.13
Dismantling	m2/day	84-142					57.14			85.07
	m2/day	17.5-54								35.75

The above table compared the result of the study to other previous studies (conducted in Europe). Unfortunately, no local previous study could be compared with the study. Although the comparison could not be accepted as an 'apple to apple' comparison (due to differences in geological and social factors), still it could be used as an indication to the differences and similarities of the study and the previous studies. The yellow cell highlighted, shows the similarities of the study's result with the other results. By comparing the values above, the results of the study could be accepted as 'on the right track' for a preliminary study, however more studies need to be conducted to further reduce the result ranges' margins thus improve the accuracy of the production rates values.

4.4. Discussion:

4.4.1. Small Number of respondents:

a. From 190 questionnaires sent, only 6 questionnaires are answered which is 3.16% from the total questionnaires. Another 8 data are obtained through interviews. The reasons that lead to such small number of respondents could be explained by:

   i. The high level of knowledge and experience needed to answer the questionnaire. Technical estimation is needed to estimates the production rates asked within the questionnaire.

   ii. Only experienced workers could responds to the questionnaire. Not all of the workers in the construction industry could give the estimation of the civil and structural production rates.

   iii. The questionnaire requires the respondents to put more effort in order to answer it. The respondents need to imagine and estimates before answering the question. This may lead to procrastination and lowering down the respondents' motivation in answering the questionnaire.

   iv. From the interviews, the author discovers that most of the contractors in Malaysia prefer using past project duration record rather than detail production rates data. As this being said, it could be logically assumed that some of the respondents couldn't convert the duration into production rates due to some differences from their past project with the references included in the questionnaire.

4.4.2. The reliability of the results:

a. Large variance of the raw data:

   i. It is observed that there is large variance on the raw data.

   ii. The large variance of the data could be explained by:

- Different imagination and estimation by different respondents. The respondents have their own perception on how fast a work could be done (based on their own experiences) thus resulting into very large differences in estimating production rates.
- Re-estimation of the production rates from actual project's gang size into the questionnaire's reference on the gang size. The respondent would have different way of re-estimating the gang size, thus lead to differences in the raw data.
- The questionnaire has not restricted the machineries used and method of construction to the respondents. Thus every respondent estimates the production rates based on their own experience and preferences on the above factors.

iii. Although the raw data have a very large variance, it could be accepted as there are many other uncontrollable variables that are not restricted in the study. Thus the fact that the raw data have a very large variance indicates the appropriateness of the data itself.

b. Method of analysis:

i. The study analyzed the data by ranging the data and then selecting the range that have the highest frequency of the raw data.

ii. However, it is observed that the method produced a significantly large range of results (i.e. piling have a range of 220-340 m/day).

c. Most of the results of the study were answered by respondents that have less than ten years of experience. From the variance analysis, it was observed that there were large margin's differences between the answers from respondents that have less than ten years and more than that. Thus it can be assumed that there are some degree of error in the less experienced respondents answer as logically, the experienced respondents should have higher technical knowledge thus enabling their estimation to be more accurate.

d. From the above discussion, it can be concluded that the results may not be immediately used for construction purposes. However it could be accepted as an indication to the characteristics of civil & structural production rates in Malaysia and used for development of more reliable database in the future.

4.5. Findings:

a. Some of the contractors in Malaysia prefer to use past project duration records which are then re-estimated, rather than detail production rates for planning and scheduling works.
b. Most contractors in Malaysia are familiar with speed of structural construction in terms of summation of duration which a storey of building could be build, rather than figures of production rates for each construction trades.
c. Some of the PKK Class A contractor (main contractor) relies on their sub-contractor experience in estimating production rates as it is their sub-contractor which will do the construction works, whereas the main-contractor usually manage the project from a higher level.
d. In Malaysian construction project, it is common to have many revisions of project schedule, thus the accuracy of the first project schedule is not highly emphasize as eventually the schedule will need to be changed.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5. CONCLUSION & RECOMMENDATIONS:

5.1. CONCLUSION

The study can be concluded as a preliminary research in the development of the Malaysian production rates database. The study successfully reached two of its main objectives, which is to initialize the development of the Malaysian construction works production rates database and obtaining and analyze the production rates' values from the study sample. However, development of reliable construction production rates could not be fully achieved, as the result of the study can only be taken as an indication to the pattern or characteristics of the local production rates data. Although currently the study couldn't produce reliable data for construction works, the study have reveal several findings that may be use for future research such as the tendency of local contractor to refer to past project's duration record than developing detail production rates for scheduling purposes. Thus future research should focus on obtaining the duration records first and calculating the production rates based on the duration given by the respondents.

5.2. RECOMMENDATION:

a. Future research should concentrate on obtaining duration's data rather than production rates data.

   Method:

   i. Detail drawing of the project (i.e.: building detail drawing) should be provided, to further assist the respondents in answering the questionnaire.

   ii. By obtaining durations data, the researcher could calculate the production rates by dividing the amount of works to be done (based on the drawing) with the duration provided by the respondents.

b. Besides questionnaire distribution, researcher can also create a website, so that contractors can easily share and discuss their production rates data with each other

c. Cooperation with CIDB is one of the best methods to further develop the research. (CIDB can provide fund and manpower to conduct observation study)

d. Integration of the database with software such as Microsoft Project or Primavera Systems should be implemented to enhance the quality of local's project scheduling works.

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APPENDIX

APPENDIX A: Questionnaire – First Draft

APPENDIX B: Questionnaire - Second Draft

APPENDIX C: Questionnaire – Final Draft

APPENDIX D: Interview's Questionnaire

APPENDIX E: Data & figures which helps in estimating production rates.

APPENDIX A: QUESTIONNAIRE FIRST DRAFT

Purpose

The purpose of this questionnaire is purely for academic used in order to conduct a research on 'Development of a Database for Civil & Structural Works Production Rates'.

Instruction

Before proceeding with the questionnaire, please refer to the attachment, to enhance your understanding on the questionnaire's focus. Please fill in the blanks or tick in the [ ] provided. Kindly return the survey form which has been answered in the envelope enclosed.

Section A: General / Background info

Company:

1. Name of Company: ____

2. Class:

   a. PKK __________

   b. CIDB _________

3. Company's experience in building construction?

   _________ years

4. Does the company implement any construction planning & Scheduling method?

   [ ] Yes

   [ ] No

Respondents:

1. What is your designation with the company

   [ ] Project Manager [ ] Construction Manager [ ] Quantity Estimator

   [ ] Others: ____________________________________

2. Respondent's experience in building construction?

   _________ years

Section B: Production Rates

1. Foundation:

No	Task / Description	Slow	Ave	Fast	Units	Machinery/Equipment Used
1	Piling				No/days	
2	Excavation				m^3 /day	
3	Pile Test: 1) PDA Test 2) Kent Leg					

2. Reinforced Concrete Works:

No	Task / Description	Slow	Ave	Fast	Units	Machinery/Equipment Used
1	Falsework Installation				m^3 /day	
2	Formwork Installation 1) Soffit Formwork 2) Edge Formwork				m^2 /day	
3	Reinforcement Fixing 1) Loose Bar 2) BRC				 Tonnes/day m^2 /day	
4	Concrete Placement: 1) Skip & Bucket 2) Pumping 3) Chute				m^3/hr	
5	Falsework dismantling				m^3 /day	
6	Formwork Dismantling				m^2/day	
7	Roof trusses: 1) Pre-Frabricated Timber/Steel 2) Insitu Concrete				 No/hr m^3/day	
8	Brick work				m^2/hr	

Section C: Additional Information

1. Where do you get the production rates' value in scheduling works:

   ____

2. Do the production rates value used often meet the schedule's target?

   [ ] Yes

   [ ] No

3. If you have a similar building such as in the appendix (5 storeys), please give the actual duration needed for the building completion (up to roof tiles and brickwork, without any architectural work)

   ____

   ____

4. Is there any other additional information to help in the study?

   ____

Attachment:

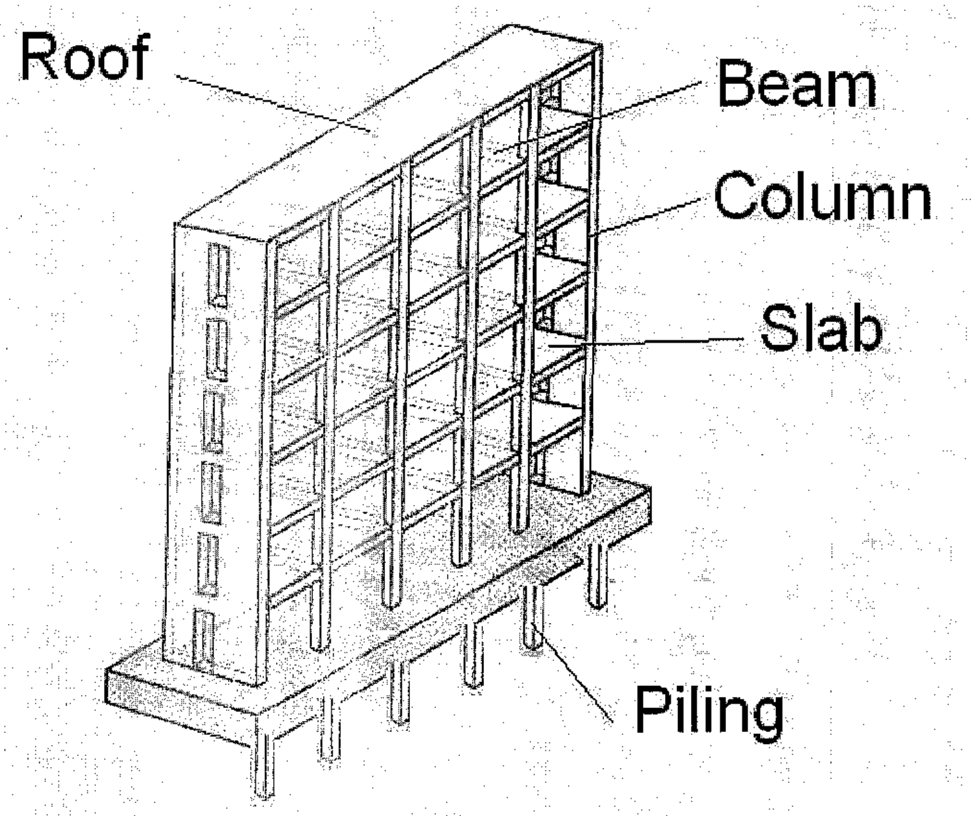
Gang Size Assumption:

No	Task Description	Gang Size (Person)
1	Concreting	7 (Including Foreman)
2	Erecting Falsework	4
3	Erecting Formwork	4
4	Reinforcement Fixing	4
5	Dismantling Falsework	4
6	Dismantling Formwork	4
7	Brickwork	??

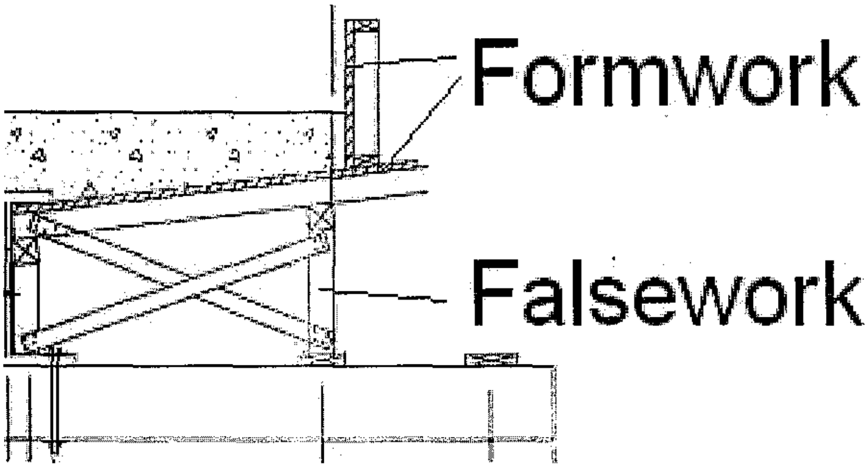
Terms of Reference:

Project Assumption Detail:

1) Cost 1M – 20M
2) 5 Storey building
3) Project focus – Civil & Structural Construction Works.



Structural Figure:



Falsework & Formwork

APPENDIX B: QUESTIONNAIRE SECOND DRAFT

Development of a Database for Civil & Structural Construction Works' Production Rates

Project scheduling works is one of the important works in construction works. In order to have a quality construction schedule, reliable values for construction production rates is needed. Thus, the purpose of this study is to conduct a research to develop a database for civil & structural works Production Rates.

The questionnaire is divided into three sections which are section A, B and C. Please answer the questionnaire by referring to every section's instructions and also by referring to the references attached on the last page of the questionnaire.

Section A: General / Background information

Please fill in the blanks and tick in the [ ] provided.

I. Company:

1. Name of Company: ____
2. Class:
    a. PKK __________
    b. CIDB __________
3. Company's experience in building construction? __________ years

II. Respondents

1. What is your designation with the company

    [ ] Project Manager [ ] Construction Manager [ ] Quantity Estimator

    [ ] Others: ____

2. Respondent's experience in building construction? __________ years

Section B: Production Rates

Please refer to the reference page attached before filling in the average production rates for the construction works stated below by using the units given and/or by using your own preferred alternative units.

No	Task / Description	Units	Average Production Rates	Alternative Units	Average Production Rates
1	Piling	No/days			
2	Excavation	m^3 /day			
3	Falsework Installation (Aluminium Scaffolding)	m^3 /day			
4	Formwork Installation (Plywood) 1) Soffit Formwork 2) Edge Formwork	m^2 /day			
5	Reinforcement Fixing: 1) Main Bar 2) Links 3) BRC (Mesh) 4) Loose Bar	Tonnes/day			
6	Concrete Placement: 1) Skip & Bucket 2) Pumping 3) Chute	m^3/hr			
7	Falsework dismantling	m^3 /day			
8	Formwork Dismantling	m^2/day			
9	Brick work	m^2/hr			

*Falsework here means the scaffolding whereas formwork is the structure of boards that makes up a form for pouring concrete in construction.

Section C: Additional Information

Please fill in the blanks and tick in the [ ] provided.

1. Where do you get the production rates' values in scheduling works?

   ____

2. Does the given production rates values in section B always meet the schedule target when being applied in a reality construction project?

   [ ] Yes

   [ ] No

3. Is there any other additional information to help in the study?

   ____

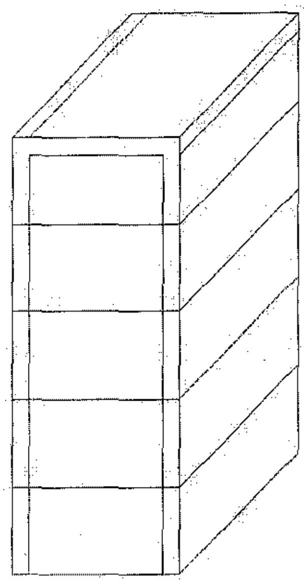
References:

a) Gang Size Assumption:

No	Task Description	Gang Size (Person)
1	Concreting	7 (Including Foreman)
2	Erecting Falsework	4
3	Erecting Formwork	4
4	Reinforcement Fixing	4
5	Dismantling Falsework	4
6	Dismantling Formwork	4
7	Brickwork	4

b) Building Reference:

i. Type of Structure: Concrete Structure
ii. No. of storey: 5
iii. Cost: 5M – 15M
iv. Floor Area per storey: $40m^2$/storey
v. Usage type: Office building



Structural Figure

Thank you for your time and cooperation in completing the questionnaire. It would be highly appreciated if you could send back the questionnaire by **** 2007.**

APPENDIX C: QUESTIONNAIRE FINAL DRAFT

Development of a Database for Civil & Structural Construction Works' Production Rates

Production rate (also known as construction rate or productivity rate) is a measure on how fast a articular task in construction work can be carried out. It is one of the important data needed for project :heduling works. The purpose of this study is to conduct a research to develop a database for civil & tructural works production rates. The database can be use as a basis for planning and scheduling of civil and tructural construction works.

The questionnaire is divided into four sections which are section A, B, C and D. Please answer the uestionnaire by referring to the instructions given in each section also by referring to the assumed ıformation on the last page of the questionnaire.

;ection A: General / Background information

'lease fill in the blanks or tick in the [ ] provided.

.. **Company:**

1. Name of Company: ______________________________
2. Class:
   a. PKK   A[ ] B[ ] BX[ ] C[ ] D[ ] E[ ] F[ ]
   b. CIDB   G1[ ] G2[ ] G3[ ] G4[ ] G5[ ] G6[ ] G7[ ]
3. Company's experience in building construction? (Years)
   <5[ ]   5-10[ ]   10-20[ ]   >20[ ]

[. **Respondents**

1. What is your designation with the company?
   [ ] Project Manager [ ] Construction Manager [ ] Planner [ ] Quantity Surveyor
   [ ] Other: ______________________________

2. Respondent's experience in building construction? __________ years

Section B: Production Rates

Please refer to the assumption in the attachment page before filling in the production rates in Section B1 and Section B2 (if available) by using the units given or using your own preferred units.

B1-Planned Production Rates	
Task/Description	Production Rates
Piling	____m/day or ____/__
Excavation	____m^3/day or ____/__
Falsework Installation (Turbular Scaffolding)	____m^3/day or ____/__
Formwork Installation (Plywood) 1)Soffit Formwork 2)Edge Formwork	 ____m^2/day or ____/__ ____m^2/day or ____/__
Reinforcement Fixing: 1)Main Bar 2)Links 3) BRC (Mesh) 4) Loose Bar	 ____ton/day or ___/__ ____ton/day or ___/__ ____m^2/day or ___/__ ____ton/day or ___/__
Concrete Placement: 1)Skip & Bucket 2)Pumping Chute	 ____m^3/day or ____/__ ____m^3/day or ____/__
Falsework dismantling	____m^3/day or ____/__
Formwork dismantling	____m^2/day or ____/__
Brickwork	____m^2/day or ____/__

B2-Actual Production Rates (optional/if available)		
No	Task/Description	Production Rates
1	Piling	____m/day or ____/__
2	Excavation	____m^3/day or ____/__
3	Falsework Installation (Turbular Scaffolding)	____m^3/day or ____/__
4	Formwork Installation (Plywood) 1)Soffit Formwork 2)Edge Formwork	 ____m^2/day or ____/__ ____m^2/day or ____/__
5	Reinforcement Fixing: 1)Main Bar 2)Links 3) BRC (Mesh) 4) Loose Bar	 ____ton/day or ___/__ ____ton/day or ___/__ ____m^2/day or ___/__ ____ton/day or ___/__
6	Concrete Placement: 1)Skip & Bucket 2)Pumping Chute	 ____m^3/day or ____/__ ____m^3/day or ____/__
7	Falsework dismantling	____m^3/day or ____/__
8	Formwork dismantling	____m^2/day or ____/__
9	Brickwork	____m^2/day or ____/__

Definition:

1) Planned Production Rates are the rates being used for scheduling purposes before the construction work begin.
2) Actual Production rates are the rates obtained after the actual works have been carried out.
3) Falsework means the scaffolding whereas formwork is the structure of boards that makes up a form for pouring concrete.

Section C: Additional Information

Please feel free to write any comment related to the topic of the study.

____

____

____

____

____

Section D: Feedback

1) Please indicate whether you wish to receive a copy of the result of this study by ticking the appropriate box below:

   [ ] Please send me a copy of the result

   [ ] Please do not send me the copy of the result.

2) If you need further information, please contact Kamaludin's mobile number at 012-3892548 or email at re3f@hotmail.com.

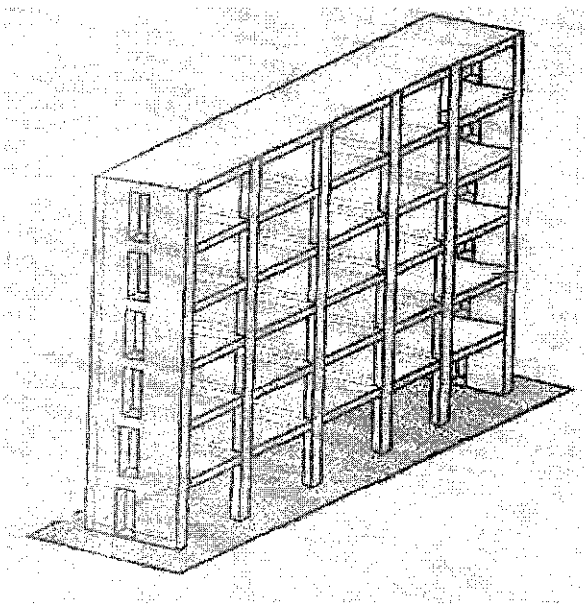
Attachment

a) Gang Size Assumption:

No	Task Description	Gang Size (Person)
1	Concreting	7 (Including Foreman)
2	Erecting Falsework	4
3	Erecting Formwork	4
4	Reinforcement Fixing	4
5	Dismantling Falsework	4
6	Dismantling Formwork	4
7	Brickwork	4

b) Reference Building (Typical)

i. Type of Structure: Concrete Framed
ii. No. of storey: 5
iii. Building Cost: 5M – 20M
iv. Floor Area per storey: $40m^2$/storey
v. Usage type: Office building



Building Reference

Thank you for your time and cooperation in completing the questionnaire. It would be highly appreciated if you could send back the questionnaire by 3rd September 2007.

APPENDIX D: INTERVIEW QUESTIONNAIRE

Development of a Database for Civil & Structural Construction Works' Production Rates

Production rate (also known as construction rate or productivity rate) is a measure on how fast a articular task in construction work can be carried out. It is one of the important data needed for project :heduling works. The purpose of this study is to conduct a research to develop a database for civil & ructural works production rates. The database can be use as a basis for planning and scheduling of civil and ructural construction works.

The questionnaire is divided into four sections which are section A, B, C and D. Please answer the uestionnaire by referring to the instructions given in each section also by referring to the assumed ıformation on the last page of the questionnaire.

ection A: General / Background information

lease fill in the blanks or tick in the [ ] provided.

. Company:

1. Name of Company: ______________________________
2. Class:
   a. PKK A[ ] B[ ] BX[ ] C[ ] D[ ] E[ ] F[ ]
   b. CIDB G1[ ] G2[ ] G3[ ] G4[ ] G5[ ] G6[ ] G7[ ]
3. Company's experience in building construction? (Years)
   <5[ ] 5-10[ ] 10-20[ ] >20[ ]

[. Respondents

1. What is your designation with the company?
   [ ] Project Manager [ ] Construction Manager [ ] Planner [ ] Quantity Surveyor
   [ ] Other: ______________________________
2. Respondent's experience in building construction? __________ years

ection B: Production Rates

lease refer to the assumption in the attachment page before filling in the production rates in Section B1 and ection B2 (if available) by using the units given or using your own preferred units.

B1-Planned Production Rates	
Task/Description	**Production Rates**
Piling	____m/day or ____/__
Excavation	____m³/day or ____/__
Falsework Installation (Turbular Scaffolding)	____m³/day or ____/__
Formwork Installation (Plywood)	
1)Soffit Formwork	____m²/day or ____/__
2)Edge Formwork	____m²/day or ____/__
Reinforcement Fixing:	
1)Main Bar	____ton/day or ___/__
2)Links	____ton/day or ___/__
3) BRC (Mesh)	____m²/day or ___/__
4) Loose Bar	____ton/day or ___/__
Concrete Placement:	
1)Skip & Bucket	____m³/day or ____/__
2)Pumping Chute	____m³/day or ____/__
Falsework dismantling	____m³/day or ____/__
Formwork dismantling	____m²/day or ____/__
Brickwork	____m²/day or ____/__

B2-Actual Production Rates (optional/if available)		
No	**Task/Description**	**Production Rates**
1	Piling	____m/day or ____/__
2	Excavation	____m³/day or ____/__
3	Falsework Installation (Turbular Scaffolding)	____m³/day or ____/__
4	Formwork Installation (Plywood)	
	1)Soffit Formwork	____m²/day or ____/__
	2)Edge Formwork	____m²/day or ____/__
5	Reinforcement Fixing:	
	1)Main Bar	____ton/day or ___/__
	2)Links	____ton/day or ___/__
	3) BRC (Mesh)	____m²/day or ___/__
	4) Loose Bar	____ton/day or ___/__
6	Concrete Placement:	
	1)Skip & Bucket	____m³/day or ____/__
	2)Pumping Chute	____m³/day or ____/__
7	Falsework dismantling	____m³/day or ____/__
8	Formwork dismantling	____m²/day or ____/__
9	Brickwork	____m²/day or ____/__

Definition:

1) Planned Production Rates are the rates being used for scheduling purposes before the construction work begin.
2) Actual Production rates are the rates obtained after the actual works have been carried out.
3) Falsework means the scaffolding whereas formwork is the structure of boards that makes up a form for pouring concrete.

Section C: Additional Information

Please fill in the blanks.

1. Where do you get the planned and actual (if any) production rates' values in scheduling works?

   ____

2. What is the methodology applied in measuring the planned and actual (if any) production rates?

   ____

3. Do you have any production rates database that is used in the company's scheduling work? If yes, can it be shared with the research to further enhance the reliability of the research?

   [ ] Yes, and it can be shared.

   [ ] Yes, but it can't be shared.

   [ ] No.

4. Please feel free to write any comment related to the topic of the study.

____

____

____

Section D: Feedback

1) Please indicate whether you wish to receive a copy of the result of this study by ticking the appropriate box below:

   [ ] Please send me a copy of the result

   [ ] Please do not send me the copy of the result.

2) If you need further information, please contact Kamaludin's mobile number at 012-3892548 or email at re3f@hotmail.com.

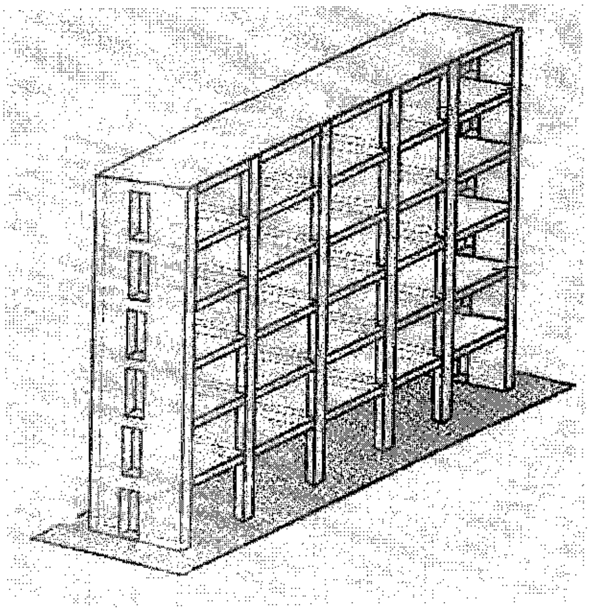
Attachment

a) Gang Size Assumption:

No	Task Description	Gang Size (Person)
1	Concreting	7 (Including Foreman)
2	Erecting Falsework	4
3	Erecting Formwork	4
4	Reinforcement Fixing	4
5	Dismantling Falsework	4
6	Dismantling Formwork	4
7	Brickwork	4

b) Reference Building (Typical)

i. Type of Structure: Concrete Framed
ii. No. of storey: 5
iii. Building Cost: 5M – 20M
iv. Floor Area per storey: $40m^2$/storey
v. Usage type: Office building



Building Reference

Thank you for your time and cooperation in completing the questionnaire. It would be highly appreciated if you could send back the questionnaire by 3rd September 2007.

FIRST 2 1/3 SPAN (P5E TO P3E-)	**76 days**	**24-05-06**	**21-08-06**																			
P3E- To P4E+ (25m + 6m = 31m)	**66 days**	**24-05-06**	**09-08-06**																			
Heavy Duty Shoring on site	7 days	24-05-06	31-05-06	100	100	100	100	100	100	100	100	100	100	100	100	100		100		100		
Installation of shoring to Voided Slab	41 days	25-05-06	12-07-06	95	90	97	100	99	100	100	100	100	100	100	100	100		100		100		
Soffit formwork to Voided Slab	8 days	01-07-06	17-07-06	59	60	64	65	70	95	76	99	82	99	94	100	100		100		100		
Inclined side formwork to Voided Slab	6 days	07-07-06	20-07-06	28	30	35	35	42	48	49	50	56	57	70	70	77		83		90		
Install rebar to Voided Slab stage 1	10 days	10-07-06	20-07-06	9	15	18	30	26	36	35	40	44	46	62	63	70		79		88		
Install 1 m dia. concrete pipe as permanent form	6 days	21-07-06	27-07-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Support to cantilevel slab	6 days	19-07-06	25-07-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		14		
Soffit to deck slab	8 days	22-07-06	31-07-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to deck slab	10 days	29-07-06	09-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
P4E+ to P5E (25m)	**70 days**	**29-05-06**	**18-08-06**																			
Installation of shoring to Voided Slab	37 days	29-05-06	11-07-06	97	90	99	100	100	100	100	100	100	100	100	100	100		100		100		
Soffit formwork to Voided Slab	10 days	30-06-06	13-07-06	78	80	86	95	93	98	100	98	100	99	100	100	100		100		100		
Inclined side formwork to Voided Slab	11 days	12-07-06	24-07-06	0	15	0	30	7	30	15	45	22	60	37	73	45		52		60		
Install rebar to Voided Slab stage 1	11 days	10-07-06	21-07-06	8	15	16	30	24	32	32	50	40	60	57	70	65		73		81		
Install 1 m dia. concrete pipe as permanent form	5 days	28-07-06	02-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Support to cantilevel slab	9 days	25-07-06	03-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Soffit to deck slab	8 days	02-08-06	10-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to deck slab	10 days	08-08-06	18-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
CONCRETE POURING TO VOIDED SLAB	**2 days**	**19-08-06**	**21-08-06**																			
Final Inspection	1 day	19-08-06	19-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Concrete to deck slab	1 day	21-08-06	21-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
SUBSEQUENT 2 2/3 SPAN (ABUT A TO P3E-)	**65 days**	**01-08-06**	**14-10-06**																			
P3E- To P2E (25m - 6m = 19m)	**36 days**	**01-08-06**	**11-09-06**																			
Heavy Duty Shoring on site	7 days	01-08-06	08-08-06	0	0	0	0	0	0	0	5	0	5	0	5	0		0		0		
Installation of shoring to Voided Slab	7 days	02-08-06	09-08-06	0	0	0	0	0	0	0	20	0	20	0	25	0		0		0		
Soffit formwork to Voided Slab	5 days	12-08-06	17-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Inclined side formwork to Voided Slab	6 days	16-08-06	22-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to Voided Slab stage 1	8 days	18-08-06	26-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install 1 m dia. concrete pipe as permanent form	3 days	28-08-06	30-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Support to cantilevel slab	4 days	23-08-06	26-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Soffit to deck slab	6 days	28-08-06	02-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to deck slab	7 days	04-09-06	11-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
P2E+ to P1E (25m)	**51 days**	**10-08-06**	**07-10-06**																			
Installation of shoring to Voided Slab	7 days	10-08-06	17-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Soffit formwork to Voided Slab	5 days	18-08-06	26-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Inclined side formwork to Voided Slab	6 days	28-08-06	02-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to Voided Slab stage 1	10 days	28-08-06	07-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install 1 m dia. concrete pipe as permanent form	4 days	08-09-06	12-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Support to cantilevel slab	5 days	13-09-06	18-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Soffit to deck slab	7 days	19-09-06	26-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to deck slab	10 days	27-09-06	07-10-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
P1E+ to ABUT A (25m)	**48 days**	**18-08-06**	**12-10-06**																			
Installation of shoring to Voided Slab	7 days	18-08-06	25-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Soffit formwork to Voided Slab	5 days	26-08-06	31-08-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Inclined side formwork to Voided Slab	6 days	30-08-06	05-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to Voided Slab stage 1	10 days	04-09-06	14-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install 1 m dia. concrete pipe as permanent form	4 days	15-09-06	19-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Support to cantilevel slab	5 days	20-09-06	25-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Soffit to deck slab	7 days	23-09-06	30-09-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Install rebar to deck slab	10 days	02-10-06	12-10-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
CONCRETE POURING TO VOIDED SLAB	**2 days**	**13-10-06**	**14-10-06**																			
Final Inspection	1 day	13-10-06	13-10-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		
Concrete to deck slab	1 day	14-10-06	14-10-06	0	0	0	0	0	0	0	0	0	0	0	0	0		0		0		

Legend: Sch - Scheduled; Act - Actual

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
IRVEYING														
TIFICATION														
ING														
ING														
T'S WORKS														
s														
llation														
D														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

LANT DEPLOYMENT PLAN

Quantity	1	2	3	4	5	6	7	8	9	10	11	12	13	14
30hp														
250 kg														
175 cfm														
3.7 kw														
3.7 kw														
25 ton														
2 ton @ 50m														
60 m3/hr														
52 hp														
10 ton														
1 ton														
5 t														
2 ton														
150 kva														

LANT DEPLOYMENT PLAN

	1		2		3		4		5		6		7		8		9		10		11		12		13		14	
men																												
	10	10	25	25	30	30	30	20	10	10																		
	5	10	20	20	20	20	20	20	20	20	20	20	20	20	5	5	6	5	5	5	6	5	6	5				
	10	10	50	50	70	70	70	70	70	70	70	70	50	50	10	10	10	10										
	10	10	60	50	50	50	60	50	50	50	60	50	30	30	10	10	5	5	5	5								
							10	10	30	30	30	30	30	30	30	30	30	30	20	20	10	10						
											10	10	10	10	10	10	10	10	10	10	10	10						
																	5	5	10	10	30	30	30	30	30	20	20	20
											10	10	10	10	10	10							10	10	10	10	10	
																							10	15	15	20	20	10
																					10	10	10	10	10	10	10	
																								10	20	20	20	20
	5	5	10	10	10	10	10	10	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	30	30
											10	10	10	10	30	30	30	30	30	40	40	40	40	40	30	30	10	10
								5	5	5	10	10	10	10	30	30	30	30	30	40	40	40	40	40	30	30	10	10
																			10	10	10	10	30	30	50	50	50	50
											30	30	30	30	30	30	50	50	50	50	50	50	40	40	40	40	20	20