DEVELOPMENT OF DATABASE FOR EXTERNAL WORKS' PRODUCTION RATES

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UNIVERSITI TEKNOLOGI PETRONAS
JANUARY 2009

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by

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(6920)

Dissertation report submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Civil Engineering)

JANUARY 2009

Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

Civil Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(CIVIL ENGINEERING)

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TRONOH, PERAK

January 2009

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.

MUHAMAD SAFFUAN BIN MUHAMAD SALLEH

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, Assoc. Prof. Dr. Ir. Arazi Idrus, for his continuous supports, guidance, encouragement and concerns throughout the whole process of making this thesis possible.

Heartfelt gratitude also dedicated to my tutors, Miss Sanamuqeem and Mr. Christiono and all of my course mates, especially Mr. Faizal Hassan who never hesitated to help when I needed them. Without their guidance and valuable information, this thesis would not be completed in time.

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.

ABSTRACT

Production rates have been an ambiguous data since the early era of construction. 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 investigate the method of determining construction period and production rates practiced in the industry, to collect information and data on external work's production rates from Malaysia's construction industry and to compile and analyze the data obtained. 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. As the study is one of the pioneering studies to be conducted in Malaysia, the result of the study may not be generally accepted for construction use. However, it can provide as an indication of the values of production rates data for Malaysian construction industry.

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CHAPTER 1
INTRODUCTION

1.1 Background Study

A productivity or production rate of the construction labor is of great interest to professionals and researchers because it affects the project schedule and cost. It is the key element or information needed to be determined in order to create an efficient construction schedule program. Definition of production rate is the quantity of work that could be finished within a certain period of time. Inefficiency or low productivity can cause the increase in construction time and cost, which can be reduced by implementing effective planning. The situation can become very difficult and discouraging for many small contractors, especially during economic downturns. As there are many uncontrollable factors that affect the values of production rates, it is impossible 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. In Malaysia's construction industry, the planners or managers determine the production rates based on their experience and previous records of their companies. The industry needs a proper system to determine the production rate such as a database that can be assessed by the industry practitioners around the country.

1.2 Problem Statement

1. Published data is not available on productivity rates of construction in Malaysia especially on the external works.
2. Project planners and managers determine the production rates only by experience and company's previous records.

1.3 Objective of study

1. To investigate the method of determining construction period and production rates practiced in the industry.
2. To collect information and data on external work's production rates from Malaysia's construction industry.
3. To compile and analyze the data obtained.

1.4 Significance of the Project

Construction planning 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. A good construction plan is the basis for developing the budget and the schedule of works. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded.

As practiced in the industry, production rates values has always been based on experience and the company's previous records, which is confidential. Throughout the world and especially in Malaysia, there has been little works on the investigation of construction's production rates. Currently, there is no official construction works production rates database which is available and accessible by everyone. This project will contribute especially on the external works trade to the currently ongoing Development of Database for Construction Production Rates project by Universiti Teknologi PETRONAS. When all the data and findings from different trades are combined, it will be the pioneer project to produce a complete formal production rates database for Malaysia's construction industry. The industry can utilize this database to assist the planning of the project to be completed within time frame and budget.

1.5 Scope of Study

The study shall focus on the production rates of external works such as the drainage, sewerage, hardstand and turfing works. The study shall implement survey research method which using questionnaires and interviews to collect samples of construction production rates from the contractors.

As the budget for this research is limited, the high cost for sending the questionnaire to Sabah and Sarawak shall be avoided. So the sample of this study is limited to contractors from Peninsular Malaysia. A sample of 300 contractors shall be selected randomly to participate in this research.

The questionnaires shall also covers the information on working hours on site and the current method of estimating production rates used by the contractors.

CHAPTER 2
LITERATURE REVIEW

2.1 Effect of Proper Scheduling in Construction Productivity

Scheduling is the process of determining the requirements for each operation to be carried out, such as the start and completion times, and resource allocations [1]. The assembly of these would give the total requirements in completing the job and this has been essential part in construction. With poor scheduling, time and money could be lost due to uncontrolled waiting time and improper allocation of resources. Late delivery of crucial material and equipment to site might result to delays, increased cost and hence, reducing the productivity.

2.2 A Study on Labour Productivity in Turkey

Labour productivity is one of the most important risks in construction projects [2]. Labor represents even the most significant risk to contractors. Construction industries in many developed and developing countries suffer from delays and cost overruns due to labor productivity. Poor labor productivity is accepted as one of the main causes of delays in Turkey as well. On the other hand, project delays were not predictable before. Assignment decisions of resources such as labor, equipment and material control the overall duration and cost of a project. Construction time performance is traditionally identified as one of the three main critical success factors together with cost and quality for a construction project. The application of productivity rate which is an indicator of the construction time performance is in the scope of planning and scheduling of the construction, controlling of the cost and worker performance, estimating and accounting.

A quick and reliable method of estimating the labor resource requirements and cost is desirable at the project inception stage. Labor productivity estimates are often

performed by individuals using combinations of analytical techniques and personal judgment. Namely, the worker hour estimates are usually obtained through direct interaction with a scheduler, the site manager or related sub-contractors who are knowledgeable enough to reject the actual conditions of a project and its constituent activities. These productivity rates planned before form the basis of the estimate. These individuals often have a library of basic productivity rates which are adjusted and recalculated for each project and always modify their productivity rates for each specific estimate. On the other hand, differences in these productivity rates are always likely and normal.

2.3 Labour Productivity in Water Supply Project for Rural Sabah

The study on productivity rates for Sabah was carried out and published by Mohd Ali, H *et al.* (2006); [3]. In this study, the author investigates the labor productivity for different trades in water supply project in Sabah and compares the data from Australia, India and International Labour organization. The work scope of the project involves upgrading the capacity of the water supply from 3 to 6 MLD. The estimated cost of the project is RM 13.6 millions with a contract period of 18 months. The author explains that the methodology used in the study is by direct daily field observation of activities. For each activity, the labor, machinery, period and the output produced were recorded. From the data, the productivity rate was calculated in term of output per hour in relation of resources dedicated to the work such as machinery and manpower. Some examples of data collected and analyzed on this paper are the productivity for 115mm brickwork is about 30% higher compared to India's value and 6% higher than the ILO's. The productivity on fabrication of timber formworks is within the range of Australia's value; 0.91 to 2.0 m^2/hour/carpenter. The productivity for painting of wall per coat is 6.25 m^2/hour/painter compared to the values from Australia, India and ILO that are 4.0, 16.67 and 14.18 m^2/hour/painter respectively. It can be concluded that in general, the productivity rates are competitive compared to the published data. However, there is still a lot of room for improvement, as discussed by the author. This study is useful to the planners and managers that have no previous experience working on similar location.

2.4 Project Measurement Tool for Productivity Assessment

The study to create a project measurement tool called the Productivity Assessment and Schedule Compression Index (PASCI) was carried out by Mansur, S *et al.* (2003); [4]. This tool uses weighted scores from key elements that affect labor productivity and schedule compression methods. The ability to completes the construction can be predicted by comparing the index score to its given contract period at a certain phase of a project. The methodology used are questionnaire surveys (mail and electronic), discussions and interviews with experienced personnel of the industry. The development of this index was presented along with some findings regarding the input and output variables. In order to get the productivity of certain tasks, productivity measurement has to be performed on individual activities, but to get the total productivity; the outcome of the whole process must be taken into account. There are two parts in PASCI that are "Factors Affecting Productivity" (FAP) and "Schedule Compression Methods" (SCM). There are 77 elements in Part 1 and 28 elements in Part 2, which are arranged in a score-sheet format. The weighting sheet was developed based on literature review, direct feedback from the industry's professional, and also from mail questionnaires. There are about 30 contractors, consultants, clients, academicians, engineers and project managers participated and weight the elements. The score-sheet was then used to evaluate the level of FAP and SCM at a point in time. From the analysis, the highest weighted FAP elements are related to contractors. In order to compare the scores with projects outcome the validation process was prepared. The schedule variance (SV) and cost variance (CV) was determined from the survey questionnaire. SV from the questionnaire was converted to suitable schedule variance index (SVI) values. Based on the validation projects, it was found that the PASCI was able to explain quite well the SVI values. For the conclusion, the index could become a useful tool for a planning team to evaluate the odds of avoiding delay based the contract period if it can be applied during planning stage and during construction. The industry can utilize this tool, so the project can be completed within time frame and budget.

2.5 Establishing Production Rates

A production rate is the quantity produced or constructed over a specified time period. Estimating realistic production rates is important when determining appropriate contract completion time. Production rates may vary considerably depending on project size, geographic location, and rural or urban setting, even for the same item of work. Production rate ranges should be established in written procedures based on project type (grading, structures, etc.), size, and location for controlling items of work.

In establishing production rates to be used for determining contract time, an accurate database should be established by using normal historical rates of efficient contractors. One method of establishing production rates is to divide the total quantity of an item on previously completed projects by the number of days/hours the contractor used to complete the item. Production rates based upon eight-hour crew days or per piece of equipment are recommended. Production rates developed by reviewing total quantities and total time are not recommended as they may result in misleading rates which tend to be low since they may include startup, cleanup, interruptions, etc.

The most accurate data will be obtained from site visits or review of project records (i.e., field diaries and other construction documents) where the contractor's progress is clearly documented based on work effort, including work crew make up, during a particular time frame. A data file based on three to five years of historical data (time, weather, production rates, etc.) should be maintained.

The production rates used should be based on the desired level of resource commitment (labor, equipment, etc.) deemed practical given the physical limitations of the project. Representatives of the construction industry are also usually willing to assist in developing rates and time schedules. Rates should be updated regularly to assure they accurately represent the statistical average rate of production in the area.

Some jurisdictions apply production rate data taken from some of the published rate guides. This data may be useful as guidance; however, the relationship of these production rates to actual construction projects may be difficult to correlate.

2.6 Adapting Production Rates to a Particular Project

Before time durations for individual work items can be computed, certain project specific information should be determined and some management decisions made. The relative urgency for the completion of a proposed project should be determined. The traffic volumes affected as well as the effect of detours should be analyzed. The size and location of the project should be reviewed, in addition to the effects of staging, working double shifts, nighttime operations, and restrictions on closing lanes. The availability of material for controlling items of work should be investigated. For example, it might be appropriate to consider the need for multiple crews on a specific item to expedite the completion when there are exceptionally large quantities or when there is a large impact on traffic.

Procedures to accelerate project completion should be considered when construction will affect traffic substantially or when project completion is crucial. This is especially important in urban areas with high traffic volumes. When accelerating contract time for time sensitive projects, production rates should be based on an efficient contractor working more than eight hours per day, more than five days per week and possibly with additional workers. The development and application of a separate set of production rates for critical projects is recommended.

2.7 Questionnaire Design

The first step in any survey is deciding what the objectives. The goals of the project determine whom the respondents and what to ask. If the goals are unclear, the results will probably be unclear. Some typical goals include learning more about.

These sample goals represent general areas. The more specific the goals, the easier it will be to get usable answers. There are two main components in determining whom the interviews will be conducted. The first is deciding what kind of people to interview. Researchers often call this group the target population. Correctly

determining the target population is critical. If wrong kind of people been interviewed, the author will not successfully meet the goals.

The next thing to decide is how many people need to interviewed. Statisticians know that a small, representative sample will reflect the group from which it is drawn. The larger the sample, the more precisely it reflects the target group. However, the rate of improvement in the precision decreases as the sample size increases. For example, to increase a sample from 250 to 1,000 only doubles the precision. The author must make a decision about sample size based on factors such as: time available, budget and necessary degree of precision.

CHAPTER 3
METHODOLOGY

3.1 Survey Research Method

In order to achieve the objectives of the project, the author has opted to carry out the survey research method. It is a simple procedure, by collecting the information from a random sample of individuals, by either delivering questionnaires or by conducting interviews to get responds or information from experts and practitioners of the industry. . In this project, the distribution will be done through mails and household drop-off.

3.2 Questionnaire Development

The questionnaires development could be divided into three processes that are question consideration, pilot survey and questionnaire revision. Basically, question consideration is the process of designing the questionnaire by research and literature review. By conducting pilot survey, the author could analyze a set of sample responds thus the questionnaire revision could be carried out.

Constructing valid, reliable, and unbiased questions is necessary but not sufficient for creating a good questionnaire: how the questions are organized and presented also deserves careful consideration [5]. The look and feel of a questionnaire serves as an important cue to respondents as they think about how to react to a request to answer a survey. If it is apparent within the first minute or two that the survey is important and easy to complete, people are highly likely to participate; if instead they are not given compelling reasons to take the time away from other activities to answer the survey or if the questions appear to be too difficult, a lot of people will toss the questionnaire into the trash bin or put it on the bottom of their to-do list,

resulting in a low response rate. If it is apparent from examining the survey that the researchers put in a lot of time and effort to produce a professional-looking and carefully crafted document, people will likely respond with carefully considered, honest answers; if instead, the survey seems to be poorly organized or contains typographical or other careless errors, respondents will be equally as careless when answering the survey.

3.3 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 author has conducted pilot survey on 6 respondents. There are 3 lecturers, 1 contractor in UTP and 2 outside contractors. Basically, the purpose of this pilot survey questionnaire is to ensure the possible respondents in this research can understand the questionnaire and capture their comments. Above all, the understanding of Section C that asking about the production rates is crucial because it will decide whether the research meet its objectives.

In Section C of the questionnaire, the author asked the respondents to fill in the column the estimated production rates for each activities based on the unit / hour that the author suggested. But, the author gives flexibility to the respondents by adding the space for the respondents to state their preferred unit / hour. In this pilot survey, the author tested and asked the respondents whether this system can be easily understand.

3.4 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 all peninsular Malaysia. 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 random sampling shall be done by searching the registered contractor's name list from CIDB. This is one by browsing CIDB's website http://www.cidb.gov.my. The contractors interested to be surveyed in this study are contractors from peninsular Malaysia.

3.5 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.

3.6 30 Respondents

A sample size should not be less than 30. It would be difficult for the researcher to undertake more complex statistical analysis, as most of these analyses require a minimum sample of 30. The 30 respondents or sample size is based on Central Limit Theorem. When the sample size approaches 30, the distribution of data can be assumed to be normal for inference purposes. The standard error is computed from a sampling distribution of the mean. When the sample size approaches 30, the sampling distribution approaches normality. This normal distribution will have the same mean as the parent distribution, and, variance equal to the variance of the parent divided by the sample size.

3.7 Interview

For this project, the author will conduct several interviews to get more precise information and data. Personal interview surveys shall be selected as the author desired sample consists of respondents in a very specific target population. In addition, the author shall have the ability to extensively probe respondents on their impressions and responds.

Advantages of this method include: response rates are very good; respondents have the ability to see; longer interviews are sometimes tolerated; and attitudinal behavior can be best observed. Disadvantages of this method include: it is very expensive; it can be time-consuming if travel is involved; and a non-representative sample may result if the respondents from the location where the interviewing takes place does not match with the desired target population.

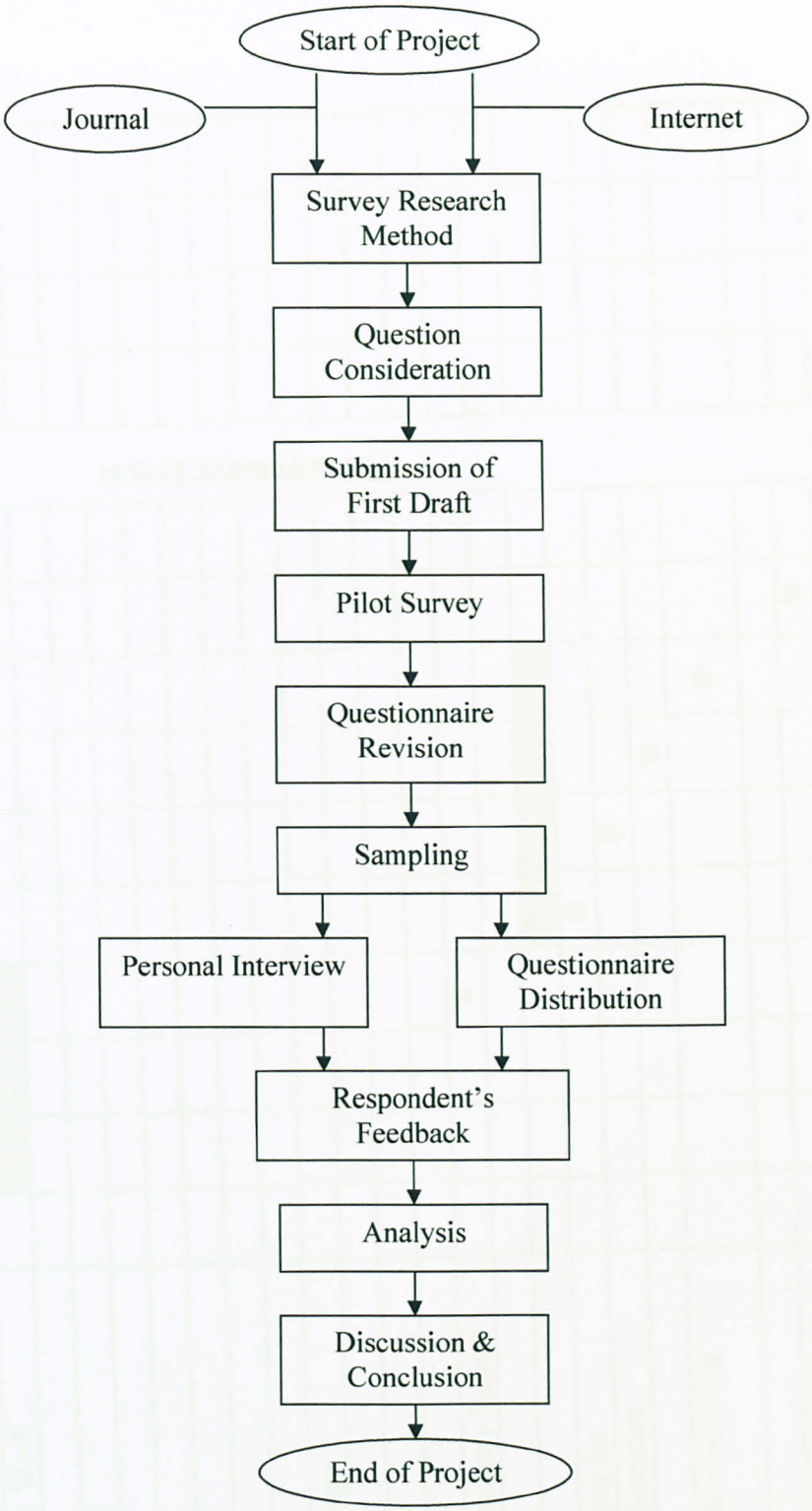

Figure 3.1: Survey Research Flowchart

3.8 Gantt Chart for Final Year Project 1

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	12	13	14
1	Selection of Project Topic	■	■													
2	Preliminary Research Work		■	■	■											
	Introduction															
	-Background Study															
	-Problem Statement															
	-Objective															
	-Scope of Study															
	Literature Review															
	Methodology															
	-Research Methodology															
	-Flow Chart															
	Conclusion															
3	Submission of Preliminary Report				●											
4	Project Work					■	■	■	■							
	- Drafting questionnaire					●										
	- Finalizing questionnaire						●									
	- Pilot Survey							●								
	- Analyzing data & modifying questionnaire								●							
5	Submission of Progress Report									●						

Mid-semester break

6	Seminar (compulsory)									●						
7	Project work continues															
	- Distributing questionnaire to the contractors															
	-Compiling all the feedback from the contractors															
8	Submission of Interim Report Final Draft													●		
9	Oral Presentation														●	

● Suggested milestone

Process

3.9 Gantt Chart for Final Year Project 2

No.	Detail/ Week	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Interviews														
2	Compiling the feedback from contractors														
3	Analyzing Data														
4	Final Report														

Process

3.10 Hazard Analysis

Table 3.1 Job-Safety Analysis

Activity	Potential Hazards	Injury/ Damage	Risk	Controls
1. Computer Analysis	1.1. Neck and Back strain	- May cause pain on the neck and the back	High	1.1.1. Sit-up straight 1.1.2. Posture check 1.1.3. Sit on chairs with cushion that can be tilt back on adjustments. 1.1.4. The monitor screen surface should be approximately 18 – 24 inches away from student torso. 1.1.5. Enough space for desktop and for work papers and other equipment.
	1.2. Eye Strain	- May cause eye fatigue, blurry eyes and even blindness due to imbalance light overexposure.	Medium	1.2.1. Install anti-glare screen. 1.2.2. Do not work in dark. 1.2.3. Adjust brightness control until comfortable with the eye. 1.2.4. The terminal was position at right angles to the window if

				possible and avoids facing directly into bright light (coming from behind computer screen)
	1.3. Carpal tunnel syndrome	- May cause pain to the bone joints.	Medium	1.3.1. The chair or table height was adjusted to have student elbow angle at 90 – 100 degrees. 1.3.2. Clinch the fists, hold on for one second, then stretch the fingers out wide and hold for 5 seconds. 1.3.3. The keyboard was position at correct place so that student doesn't have to bend the hands uncomfortably upwards to reach the keys; place a raised wrist rest on the table in front of the keyboard if necessary.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 General / Background Information

4.1.1 Company's Information

Table 4.1: Company's Location

Location	No of Respondent	Percentage, %
Selangor	10	32
Perak	6	19
Johor	4	13
Negeri Sembilan	4	13
Pulau Pinang	3	10
Kedah	2	7
Kelantan	1	3
Pahang	1	3
Total	31	100

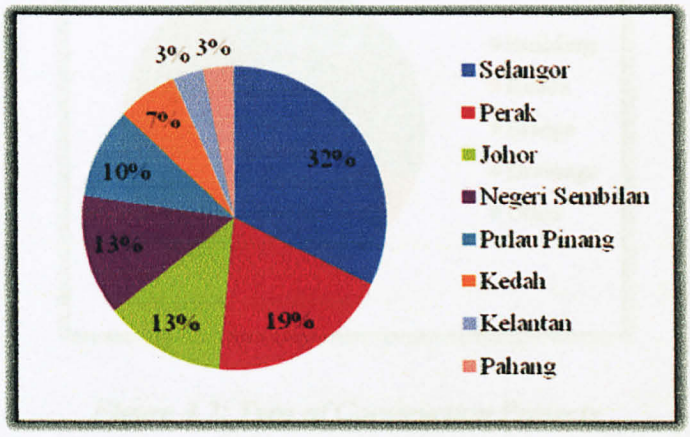

Figure 4.1: Company's Location

The graph shows that the companies responded to the survey come from various part of Peninsular Malaysia. Central Region of Peninsular Malaysia represented by Selangor, Northern Region by Perak, Kedah and Pulau Pinang, Southern Region by Johor and Negeri Sembilan and East Coast Region by Kelantan and Pahang. Therefore, the sample of the study can be declared as representing the contractors in Peninsular Malaysia.

Table 4.2: Type of Construction Projects

Type	No of Respondent	Percentage, %
Building	27	30
Roads	22	25
Bridge	14	15
Drainage	21	24
Other Golf course Sewerage Slope protection Pipe Jacking Piping	5	6
Total	89	100

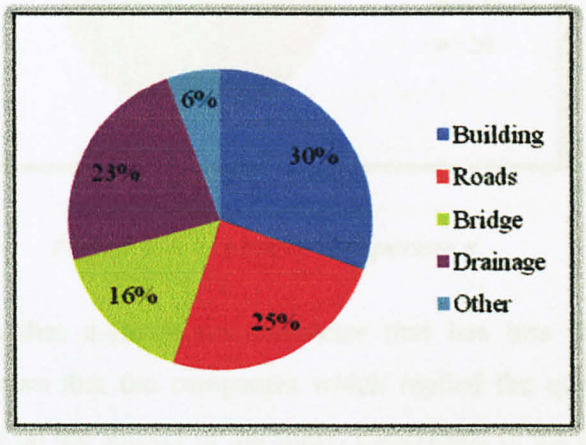

Figure 4.2: Type of Construction Projects

The companies responded to the questionnaire mainly involve in building, roads and drainage projects as the percentage are 30%, 25% and 23% respectively. This shows that there are largely involved in external works as building project need external works such as excavation, water piping, sewerage, and landscaping works. The roads and drainage big percentage is important as the survey includes questions on road hardstand and drainage works. Therefore, the author can conclude that the companies responded to the questionnaire has information and records needed to answer the questionnaire.

Table 4.3: Company's Experience

Years	No of Respondent	Percentage, %
<5	0	0
5 - 10	14	45
11- 20	8	26
>20	9	29
Total	31	100

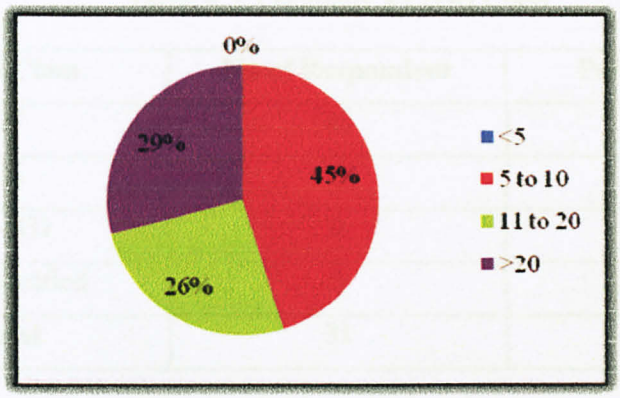

Figure 4.3: Company's Experience

The statistic shows that there is no contractor that has less than 5 years of experience. This shows that the companies which replied the questionnaire have sufficient experience on the subject of the study. Experience of the company is very important because the questions asked in the survey need the respondents to refer their previous project records.

Table 4.4: Company's PKK Class

PKK Class	No of Respondent	Percentage, %
A	21	68
B	5	16
C - F	0	0
Not Specified	5	16
Total	29	100

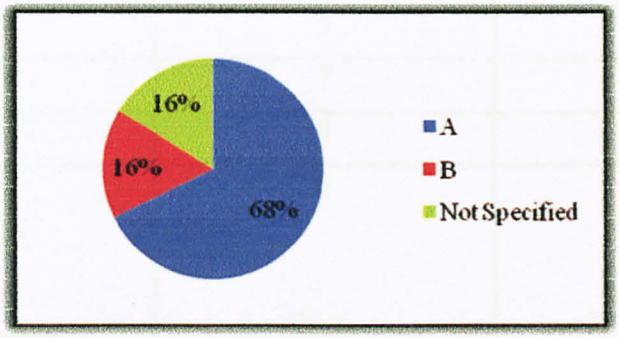

Figure 4.4: Company's PKK Class

Table 4.5: Company's CIDB Class

CIDB Class	No of Respondent	Percentage, %
G7	25	81
G6	1	3
G5 - G1	0	0
Not Specified	5	16
Total	31	100

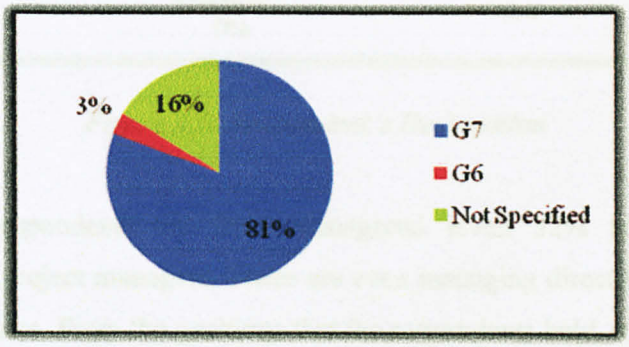

Figure 4.5: Company's CIDB Class

68% and 81% of the contractors responded are from PKK Class A and CIDB Class G7 respectively. This shows that the contractors responded are handling big projects. They have enough manpower and resources to answer the questionnaire.

4.1.2 Respondent's Information

Table 4.6: Respondent's Designation

Designation	No of Respondent	Percentage, %
Project Manager	10	34
Project Engineer	5	14
Quantity Surveyor	7	21
Managing Director	4	
Other Project Director, Technical Contracts Manager HR Executive Operation Manager	5	31
Total	31	100

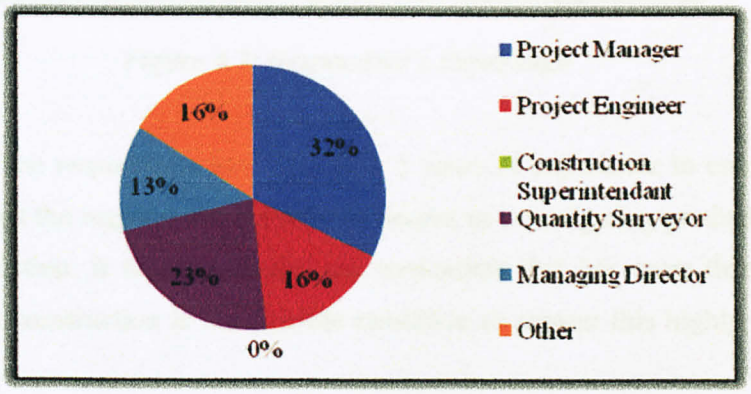

Figure 4.6: Respondent's Designation

Most of the respondents are from managerial level. 32% from the overall respondents are project managers. There are even managing director that responded 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.

Table 4.7: Respondent's Experience

Years	No of Respondent	Percentage, %
<5	5	16
5 - 10	14	45
11- 20	5	16
>20	7	23
Total	31	100

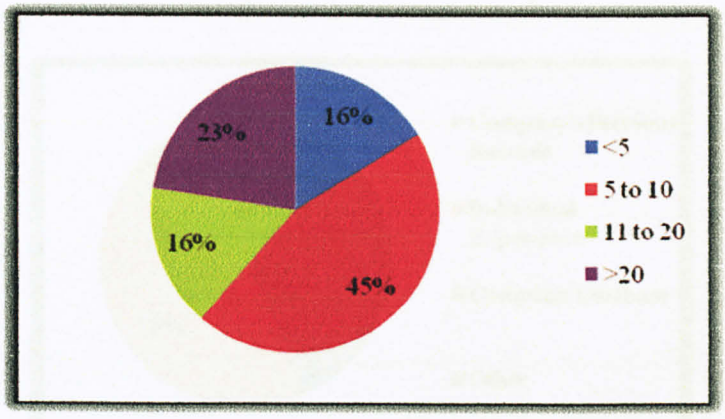

Figure 4.7: Respondent's Experience

Only 16% of the respondents have less than 5 years of experience in construction. This shows that the respondents are reliable source in investigating production rates of the construction. It is assumed that the respondent that has more than 5 years experience in construction is the suitable candidate to answer this highly technical questionnaire.

4.1.3 Current Method of Estimating Production Rates

Table 4.8: Method to Estimate Duration of Work

Method	No of Respondent	Percentage, %
Company's previous record	25	44
Individual experience	22	39
Computer database Microsoft Project	8	14
Other Completion date Consultant Q.S.	2	3
Total	57	100

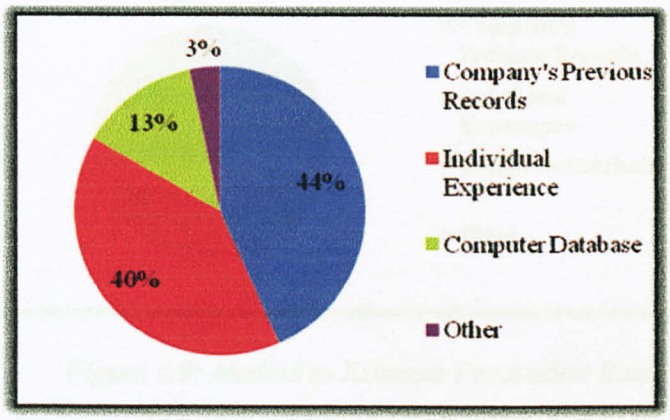

Figure 4.8: Method to Estimate Duration of Work

The graph show that the contractors in Malaysia mainly using company's previous records and individual experience in estimating duration of work. There are 8 respondents that using computer database to estimate the duration of work.

Table 4.9: Method to Estimate Production Rates

Method	No. of Respondent	Percentage, %
Company's previous record	25	46
Individual experience	20	36
Computer database	7	13
Other Completion date Quotation Supplier	3	5
Total	55	100

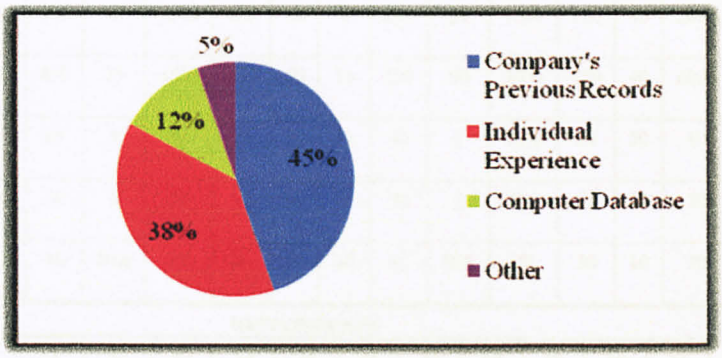

Figure 4.9: Method to Estimate Production Rates

Most of the respondents have suggested that company's previous records and individual experience are the current method of estimating production rates of the construction. There are 45% answers for company's previous records and 38% answers for individual experience. There are 7 respondents that answered computer database. However, they did not specify the name of the database that they are using. One of the respondent stated that they are using completion date of the project as the reference to estimate the production rates. From this, the author can state that there are contractors in Malaysia that change the production rates for each project depending on when they must finish or complete that project.

From these statistics, the author can conclude that current method of estimating duration of works and production rates are by company's previous records and individual experience.

4.2 Production Rates Raw Data

Table 4.10: Quantity of Work

ACTIVITIES	RESPONDENTS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Excavation	99	100	60	15	600	53	50	11	160	30	40	60	40	500	40	30	320	60
Backfilling	112	40	40	N/A	450	75	50	16	80	20	100	200	25	400	40	20	1000	55
Hardstand	1114	100	20	240	15	50	50	0.3	600	10	1000	180	5	10	80	50	700	90
PC Drain 12 inch	52	5	30	10	60	100	50	1	40	50	30	45	5	50	25	20	60	60
PC Drain 18 - 36 inch	46	3.5	25	3	60	70	50	0.5	40	30	30	30	3	50	20	10	25	20
Vitrified Clay Pipes	15	20	30	5	30	200	50	1	80	10	30	30	8	20	8	20	10	40
Water Pipe	30	60	15	7	30	150	50	1	100	12	50	180	15	20	35	30	22	50
Close Turfing	55	140	300	40	2500	120	50	6	200	20	1000	150	40	2000	100	100	100	40
Spot Turfing	82	200	450	75	6500	200	50	15	200	50	2000	180	40	6000	225	200	150	80
Tree Planting < 5 feet high	4	6	80	8	40	15	50	12	30	5	N/A	30	20	40	8	40	5	50
Tree Planting > 5 feet high	2	3	50	6	20	10	50	7	30	2	N/A	20	15	20	10	20	7	20
Chain Link Fencing	60	70	10	N/A	35	80	50	20	50	N/A	50	30	10	30	15	50	100	100

ACTIVITIES	RESPONDENTS												
	19	20	21	22	23	24	25	26	27	28	29	30	31
Excavation	40	50	80	80	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Backfilling	65	50	N/A	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hardstand	10	100	20	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC Drain 12 inch	45	50	60	60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC Drain 18 - 36 inch	30	25	50	50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vitrified Clay Pipes	150	30	60	60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Pipe	230	60	70	75	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Close Turfing	200	100	800	850	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spot Turfing	300	200	1500	1500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree Planting < 5 feet high	25	12	50	50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree Planting > 5 feet high	13	6	30	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chain Link Fencing	70	45	150	155	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The data was collected through questionnaires submissions and also interviews. Twenty eight of the data were from questionnaires submission, whereas three more data were from interviews. However, some data been indicated as N/A because the respondents leave the space blank without answering. It is assumed that those respondents does not sure the answer or confuse with the questionnaire format.

The data of quantity of work will be used to calculate the production rates that will be explained later.

Table 4.11: Unit of Work

ACTIVITIES	RESPONDENTS																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Excavation	m^2	m^2	m^3	m^3	m^2	m^3	m^2	m^3	m^2	m^3	m^3	m^2	m^2	m^2	m^3	m^2	m^3
Backfilling	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3
Hardstand	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
PC Drain 12 inch	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
PC Drain 18 - 36 inch	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
Vitrified Clay Pipes	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
Water Pipe	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
Close Turfing	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
Spot Turfing	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
Tree Planting < 5 feet high	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Tree Planting > 5 feet high	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Chain Link Fencing	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run

ACTIVITIES	RESPONDENTS													
	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Excavation	m^2	m^3	m^2	m/run	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
Backfilling	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3
Hardstand	m^2	m^2	m^2	m/run	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
PC Drain 12 inch	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
PC Drain 18 - 36 inch	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
Vitrified Clay Pipes	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
Water Pipe	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run
Close Turfing	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
Spot Turfing	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2	m^2
Tree Planting < 5 feet high	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Tree Planting > 5 feet high	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Chain Link Fencing	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run	m-run

The questionnaire gives the respondents option whether answering with the suggested or alternative unit of work. Then, the author will convert all unit of work to one unit for each work or activity. The aim of this strategy is to give respondents freedom to choose unit of work depending on the unit that they are more familiar.

Table 4.12: Unit of Time

ACTIVITIES	RESPONDENTS																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Excavation	H	D	H	H	D	D	H	H	H	H	D	H	H	D	H	H	D
Backfilling	H	D	H	H	D	D	H	H	H	H	D	D	H	D	H	H	D
Hardstand	H	D	D	D	D	D	D	H	D	H	D	D	H	D	H	H	D
PC Drain 12 inch	D	D	D	H	D	D	D	H	D	H	D	D	H	D	H	H	D
PC Drain 18 - 36 inch	D	D	D	H	D	D	D	H	D	H	D	D	H	D	H	H	D
Vitrified Clay Pipes	D	D	D	H	D	D	D	H	D	H	D	D	H	D	H	H	D
Water Pipe	D	D	D	H	D	D	H	H	D	H	D	D	H	D	H	H	D
Close Turfing	H	D	D	H	D	D	H	H	D	H	D	D	H	D	H	H	D
Spot Turfing	H	D	D	H	D	D	H	H	D	H	D	D	H	D	H	H	D
Tree Planting < 5 feet high	H	D	D	H	D	D	D	H	D	H	D	D	H	D	H	H	D
Tree Planting > 5 feet high	H	D	D	D	D	D	D	H	D	H	D	D	H	D	H	H	D
Chain Link Fencing	D	D	D	D	D	D	D	H	D	H	D	D	H	D	H	H	D

ACTIVITIES	RESPONDENTS															
	18	19	20	21	22	21	22	23	24	25	26	27	28	29	30	31
Excavation	D	H	D	D	D	D	D	D	N/A	D	H	N/A	N/A	D	D	N/A
Backfilling	D	H	D	D	D	D	D	D	N/A	D	H	N/A	N/A	D	D	N/A
Hardstand	D	H	D	D	D	D	D	D	N/A	D	D	N/A	N/A	D	D	N/A
PC Drain 12 inch	D	D	D	D	D	D	D	D	N/A	D	D	N/A	N/A	D	D	N/A
PC Drain 18 - 36 inch	D	D	D	D	D	D	D	D	N/A	D	D	N/A	N/A	D	D	N/A
Vitrified Clay Pipes	D	D	D	D	D	D	D	D	N/A	D	D	N/A	N/A	D	D	N/A
Water Pipe	D	D	D	D	D	D	D	D	N/A	D	D	N/A	N/A	D	D	N/A
Close Turfing	D	D	D	D	D	D	D	D	N/A	D	H	N/A	N/A	D	D	N/A
Spot Turfing	D	D	D	D	D	D	D	D	N/A	D	H	N/A	N/A	D	D	N/A
Tree Planting < 5 feet high	D	D	D	D	D	D	D	D	N/A	D	H	N/A	N/A	D	D	N/A
Tree Planting > 5 feet high	D	D	D	D	D	D	D	D	N/A	D	H	N/A	N/A	D	D	N/A
Chain Link Fencing	D	D	D	D	D	D	D	D	N/A	D	D	N/A	N/A	D	D	N/A

Table 4.13: Company's Working Hour on Site

	RESPONDENTS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
COMPANY'S WORKING HOUR ON SITE (HOUR)	8	8	8	9	9	8	8	8.5	9	9	8	8	8	8	11	9

	RESPONDENTS														
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
COMPANY'S WORKING HOUR ON SITE (HOUR)	9	9	9	8	13	8	9	9	8	9	8	7.5	8	8	8

Two previous tables show the unit of time and company's working hour as stated by the respondents. For Table 4.12, H indicates 'per hour' and D indicates 'per day'. There are some respondents that do not answer the unit of time which are Respondent 24, 27, 28 and 31. Most of the respondents prefer 'per day' unit of time. All of this unit will be converted to 'per hour' value which then will be used to calculate the production rates.

To convert the 'per day' value to 'per hour' value, the author need to know the company's working hour on site. The 'per day' value will be divided by the company's working hour on site. For example:

> *Respondent 22 states the excavation rates is 80 m^2 per day. The company's working hours on site is from 8 am to 5pm. It is assumed that there is one hour for lunch break for all companies. So the total working hours on site is 8 hours. Then, 80 m^2 been divided with 8 hours which gives the production rate of 10 m^2 of excavation per hour.*

Table 4.13: Production Rates from Each Respondent

ACTIVITIES	RESPONDENTS																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Excavation	99	12.5	60	15	66.7	6.6	50	11	160	30	5	60	40	50	40	30	35.6
Backfilling	112	5	40	N/A	50	9.4	50	16	80	20	12.5	25	25	50	40	20	111
Hardstand	140	12.5	2.5	26.7	1.7	6.3	6.3	0.3	66.7	10	125	22.5	5	1.3	80	50	77.8
PC Drain 12 inch Dia.	6.5	0.6	3.8	10	6.7	12.5	6.3	1	4.4	50	3.75	5.6	5	6.3	25	20	6.7
PC Drain 18 - 36 inch Dia.	5.8	0.4	3.1	3	6.7	8.8	6.3	0.5	4.4	30	3.8	3.8	3	6.3	20	10	2.8
Vitrified Clay Pipes	1.9	2.5	3.8	5	3.3	25	6.3	1	8.9	10	3.8	3.8	8	2.5	8	20	1.1
Water Pipe	3.8	7.5	1.9	7	3.3	18.8	50	1	11.1	12	6.3	22.5	15	2.5	35	30	2.4
Close Turfing	55	17.5	37.5	40	278	15	50	6	22.2	20	125	18.8	40	250	100	100	11.1
Spot Turfing	82	25	56.3	75	722	25	50	15	22.2	50	250	22.5	40	750	225	200	16.7
Tree Planting < 5 feet high	4	0.75	10	8	4.4	1.9	6.3	12	3.3	5	N/A	3.8	20	5	8	40	0.5
Tree Planting > 5 feet high	2	0.4	6.3	0.7	2.2	1.3	6.3	7	3.3	2	N/A	2.5	15	2.5	10	20	0.8
Chain Link Fencing	7.7	8.8	1.3	N/A	3.9	10	6.3	20	5.6	N/A	6.3	3.8	10	3.8	15	50	11.1

ACTIVITIES	RESPONDENTS													
	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Excavation	6.7	40	6.3	6.2	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Backfilling	6.1	65	6.3	N/A	2.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hardstand	10	10	12.5	1.5	2.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC Drain 12 inch	6.7	5	6.3	4.6	7.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PC Drain 18 - 36 inch	2.2	3.3	3.1	3.8	6.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vitrified Clay Pipes	4.4	16.7	3.8	4.6	7.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Pipe	5.6	25.6	7.5	5.4	9.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Close Turfing	4.4	22.2	12.5	61.5	106	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spot Turfing	8.9	33.3	25	115	188	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree Planting < 5 feet high	5.6	2.8	1.5	3.8	6.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tree Planting > 5 feet high	2.2	1.4	0.7	2.3	4.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chain Link Fencing	11.1	7.8	5.6	11.5	19.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The table shows the calculated production rates from every respondent. Note that production rates from Respondent 23 to 31 (nine respondents) could not be calculated as they did not fully answer the questions.

4.3 Analysis

Descriptive analysis is used to analyze the raw data. 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 4.14: Variance Analysis Based on Contractors Class

ACTIVITIES	PKK CLASS												
	A												
Excavation	99	12.5	60	15	6.6	50	160	60	40	50	40	35.6	10
Backfilling	112	5	40	N/A	9.4	50	80	25	25	50	40	111	2.5
Hardstand	140	12.5	2.5	26.7	6.3	6.3	66.7	22.5	5	1.3	80	77.8	2.5
PC Drain 12 inch	6.5	0.6	3.8	10	12.5	6.3	4.4	5.6	5	6.3	25	6.7	7.5
PC Drain 18 - 36 inch	5.8	0.4	3.1	3	8.8	6.3	4.4	3.8	3	6.3	20	2.8	6.3
Vitrified Clay Pipes	1.9	2.5	3.8	5	25	6.3	8.9	3.8	8	2.5	8	1.1	7.5
Water Pipe	3.8	7.5	1.9	7	18.8	50	11.1	22.5	15	2.5	35	2.4	9.4
Close Turfing	55	17.5	37.5	40	15	50	22.2	18.8	40	250	100	11.1	106
Spot Turfing	82	25	56.3	75	25	50	22.2	22.5	40	750	225	16.7	188
Tree Planting < 5 feet high	4	0.75	10	8	1.9	6.3	3.3	3.8	20	5	8	0.5	6.3
Tree Planting > 5 feet high	2	0.4	6.3	0.7	1.3	6.3	3.3	2.5	15	2.5	10	0.8	4.4
Chain Link Fencing	7.7	8.8	1.3	N/A	10	6.3	5.6	3.8	10	3.8	15	11.1	19.4

ACTIVITIES	PKK CLASS								
	B				NOT SPECIFIED				
Excavation	11	6.7	40	6.3	66.7	30	5	30	6.2
Backfilling	16	6.1	65	6.3	50	20	12.5	20	N/A
Hardstand	0.3	10	10	12.5	1.7	10	125	50	1.5
PC Drain 12 inch	1	6.7	5	6.3	6.7	50	3.75	20	4.6
PC Drain 18 - 36 inch	0.5	2.2	3.3	3.1	6.7	30	3.8	10	3.8
Vitrified Clay Pipes	1	4.4	16.7	3.8	3.3	10	3.8	20	4.6
Water Pipe	1	5.6	25.6	7.5	3.3	12	6.3	30	5.4
Close Turfing	6	4.4	22.2	12.5	278	20	125	100	61.5
Spot Turfing	15	8.9	33.3	25	722	50	250	200	115
Tree Planting < 5 feet high	12	5.6	2.8	1.5	4.4	5	N/A	40	3.8
Tree Planting > 5 feet high	7	2.2	1.4	0.7	2.2	2	N/A	20	2.3
Chain Link Fencing	20	11.1	7.8	5.6	3.9	N/A	6.3	50	11.5

By observing the above data, no conclusion could be made based on the class of the contractor's production rates. A, B and unspecified class give more or less the same production rates with respect to each other. Furthermore, the presence of the

unspecified class further denies the author to makes any conclusion from this analysis.

Table 4.15: Variance Analysis Based on Respondent's Experience

ACTIVITIES	RESPONDENT'S EXPERIENCE (YEARS)												
	< 5			5 to 10									
Excavation	60	40	40	99	12.5	15	50	11	30	35.6	40	6.3	6.2
Backfilling	25	25	40	112	5	N/A	50	16	20	111	65	6.3	N/A
Hardstand	22.5	5	80	140	12.5	26.7	6.3	0.3	50	77.8	10	12.5	1.5
PC Drain 12 inch	5.6	5	25	6.5	0.6	10	6.3	1	20	6.7	5	6.3	4.6
PC Drain 18 - 36 inch	3.8	3	20	5.8	0.4	3	6.3	0.5	10	2.8	3.3	3.1	3.8
Vitrified Clay Pipes	3.8	8	8	1.9	2.5	5	6.3	1	20	1.1	16.7	3.8	4.6
Water Pipe	22.5	15	35	3.8	7.5	7	50	1	30	2.4	25.6	7.5	5.4
Close Turfing	18.8	40	100	55	17.5	40	50	6	100	11.1	22.2	12.5	61.5
Spot Turfing	22.5	40	225	82	25	75	50	15	200	16.7	33.3	25	115
Tree Planting < 5 feet high	3.8	20	8	4	0.75	8	6.3	12	40	0.5	2.8	1.5	3.8
Tree Planting > 5 feet high	2.5	15	10	2	0.4	0.7	6.3	7	20	0.8	1.4	0.7	2.3
Chain Link Fencing	3.8	10	15	7.7	8.8	N/A	6.3	20	50	11.1	7.8	5.6	11.5

ACTIVITIES	RESPONDENT'S EXPERIENCE (YEARS)								
	11 to 20				> 20				
Excavation	160	50	6.7	10	60	66.7	6.6	30	5
Backfilling	80	50	6.1	2.5	40	50	9.4	20	12.5
Hardstand	66.7	1.3	10	2.5	2.5	1.7	6.3	10	125
PC Drain 12 inch	4.4	6.3	6.7	7.5	3.8	6.7	12.5	50	3.75
PC Drain 18 - 36 inch	4.4	6.3	2.2	6.3	3.1	6.7	8.8	30	3.8
Vitrified Clay Pipes	8.9	2.5	4.4	7.5	3.8	3.3	25	10	3.8
Water Pipe	11.1	2.5	5.6	9.4	1.9	3.3	18.8	12	6.3
Close Turfing	22.2	250	4.4	106	37.5	278	15	20	125
Spot Turfing	22.2	750	8.9	188	56.3	722	25	50	250
Tree Planting < 5 feet high	3.3	5	5.6	6.3	10	4.4	1.9	5	N/A
Tree Planting > 5 feet high	3.3	2.5	2.2	4.4	6.3	2.2	1.3	2	N/A
Chain Link Fencing	5.6	3.8	11.1	19.4	1.3	3.9	10	N/A	6.3

By observing Table 4.15, 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. 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 4.16: Mean and Variance

ACTIVITIES	MEAN	MEDIAN	UNIT / HOUR	VARIANCE
Excavation	38.2	32.8	m^2	1362
Backfilling	37.3	25	m^3	1108
Hardstand	30.5	10	m^2	1720
PC Drain 12 inch	9.3	6.3	m-run	114
PC Drain 18 - 36	6.2	3.8	m-run	45
Vitrified Clay Pipes	6.9	4.5	m-run	39
Water Pipe	12.9	7.5	m-run	160
Close Turfing	63.3	38.75	m^2	5473
Spot Turfing	136.2	50	m^2	43040
Tree Planting < 5	7.3	5	No.	75
Tree Planting > 5	4.4	2.3	No.	26
Chain Link Fencing	11.0	8.3	m-run	109

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.

To determine the distribution nature of data, the author has conducted investigation by developing histograms of data frequency. From this histogram analysis, the shape of data frequency and characteristic of data distribution would be revealed. Figure below shows an example of histogram analysis conducted in this study.

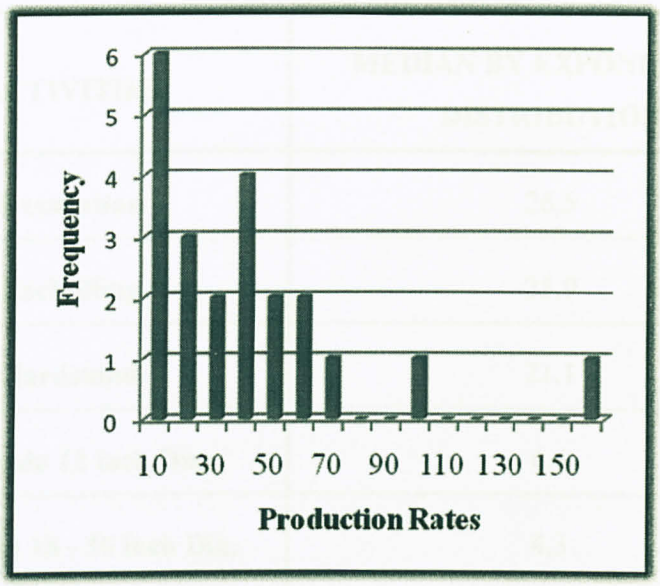

Figure 4.10: Frequency vs. Production Rates of Excavation

From the histogram, it clearly shows that the data distribution is positively skewed. The right tail is longer and the mass of the distribution is concentrated on the left of the figure. The data set has relatively few high values. The nature of data distribution is also similar to other set of data from different external works investigated in this study. In a skewed distribution, the mean is farther out in the long tail than is the median.

The number of respondents that answered completely the questionnaire is 22. Thus, the data distribution cannot be assumed to be normal as the sample size is below 30.

So, median is preferred rather than mean to be the representative value of data set and the distribution type is exponential distribution [6]. In exponential distribution, the calculation of mean and median is as per formulas below.

Mean, E [X] = 1 / λ

$Median = ln(2) / \lambda$

From calculation by exponential distribution formulas, the new medians are as in table below.

Table 4.17: Median by Exponential Distribution

ACTIVITIES	MEDIAN BY EXPONENTIAL DISTRIBUTION
Excavation	26.5
Backfilling	25.9
Hardstand	21.1
PC Drain 12 inch Dia.	6.4
PC Drain 18 - 36 inch Dia.	4.3
Vitrified Clay Pipes	4.8
Water Pipe	8.9
Close Turfing	43.9
Spot Turfing	94.4
Tree Planting < 5 feet high	5.1
Tree Planting > 5 feet high	3.0
Chain Link Fencing	7.6

These median is the most representative value of the data sets from the survey. Thus, these values can be concluded as the values of production rates for external works in Malaysian construction industry.

4.4 Discussion

4.4.1 Problem Occurred During Study

From 300 questionnaires sent, only 31 contractors responded including 3 that been interviewed by the author. In other word, 10.3% of the contractor replied the questionnaire. This is quite a small number but it can be explained by the fact that:

i. It requires decent technical knowledge to answer the questionnaire. The production rates that asked in the questionnaire require the respondent to make technical estimation that usually through respondent's knowledge in construction. Non-technical person such as Human Resource Manager is not suitable to answer the questionnaire.

ii. The respondents need vast amount of experience to answer the questionnaire. Not all of the workers in the construction industry could give the estimation of the civil and structural production rates.

iii. It requires much effort to answer the questionnaire. The respondents need to visualize the external works asked before estimate the production rates. The respondents could become demotivated as it requires them to focus and consume much of their time.

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. 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.

v. The contractors have difficulty in answering the questionnaire because the contractors usually use data of duration instead of production rates value. It can be assumed that they couldn't convert the data on duration of works into detailed production rates value.

vi. Answering the questionnaire is not compulsory. The questionnaire comes from a university with purpose of doing research instead of questionnaire

from a body like CIDB or authorities. The contractor may feel that it is a waste of time to respond or participate in this survey.

vii. The respondent may feel the format of questionnaire confusing and complicated especially in Section C of the questionnaire. This can make the respondents give the wrong production rates or in worse case, leave the space blank without answer.

The production rates data collected has large variance. This could be explained by:

i. 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.

ii. The respondents have different estimation of the gang size or number of worker needed to execute the external works asked in the questionnaire. The questionnaire itself does not state the gang size or number of worker and this could make the production rates given by the respondents to be based on different estimation thus leading to a large variance of data.

iii. Different respondent has different experience and projects involved. Every project is unique and there are many factors that can influence how fast certain work can be finished. So, different respondent tend to give different production rates.

iv. The questionnaires are not detail regarding the method of construction and machineries used for most of the external works asked thus make the respondents to give the answer based on their own preferences.

Although the raw data have a 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 large variance indicates the appropriateness of the data itself.

4.4.2 Findings

The findings below show that the sample represents the entire population:

i. The data collected comes from various parts of Peninsular Malaysia such as Kedah, Kelantan, Selangor and Johor. This makes the data represents the construction industry of Peninsular Malaysia.

The findings below shows that the companies responded are creditable to answer the questionnaire:

i. 68% of the contractor responded the questionnaires are Class A (PKK) contractor and 81% are Class G7 (CIDB) contractor. From this, it is found that the respondents comes from big company and are responsible for many of the construction activities in the country. The respondents can be concluded as the people who are responsible and are the major player of Malaysian construction industry.

ii. 84% of the respondents involves in the external works such as hardstand construction, drainage, slope protection and piping. This information shows that the respondents have knowledge and understanding to answer the questionnaire.

iii. All the companies responded to the questionnaire have at least five years of experience in construction. 45% has 5- 10 years experience, 26% has 11 – 20 years of experience and 29% has more than 20 years of experience. This shows that the company responded has enough information and experience needed to answer the questionnaire.

The findings bellows shows that the person responded to the questionnaire are suitable to answer the questionnaire:

i. Only 5 respondents (16%) have less than 5 years of experience in construction. Experience is very important in answering or participating in this survey as the questionnaire involves many high technical items and requires good judgement based on the experience of the practitioners of construction in Malaysia. Person that has at least 5 years of experience is considered good and suitable to answer the questionnaire.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 CONCLUSION

The study can be concluded as a pioneer research in the development of the reliable Malaysian production rates database. The study was able to provide an indicative production rates for external works. The study reached its objectives which are to investigate the method of determining construction period and production rates practiced in the industry, to collect information and data on external work's production rates from Malaysia's construction industry and to compile and analyze the data obtained.

From the study, the author can conclude that among the contractors in Peninsular Malaysia, the method of estimating duration of works and production rates are by company's previous records and individual experience. The study also has proposed some indicative value of external works' production rates which can be used to develop a database for construction production rates in Malaysia. The study has revealed several findings and observations that may be use for future research.

5.2 RECOMMENDATION

i. The researcher should cooperate with CIDB to develop the research. CIDB can provide funds and manpower to conduct case study which can produce more accurate data.

ii. The researcher should attach drawings with the questionnaire sent. The drawings can clarify and avoid misunderstanding to the respondents.

iii. 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.

iv. The researcher can present and attach gift to the questionnaire such as book mark or tie pin to the respondents. This should motivate the respondent to answer and reply the questionnaire.

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APPENDICES

APPENDIX A

PILOT SURVEY QUESTIONNAIRE ON CONSTRUCTION PRODUCTION RATES: EXTERNAL WORKS

SECTION A: GENERAL / BACKGROUND INFORMATION

Please fill in the blanks and tick in [ ] provided. Respondents can thick more than one [ ].

Company Information:

1. Name of Company: _____
2. Type of Construction Projects :
   [ ] Building [ ] Roads [ ] Bridge [ ] Drainage [ ] Other: _____
3. Company experienced in construction (years) :
   [ ] < 5 [ ] 5-10 [ ] 11-20 [ ] > 20
4. Class of Contractor :
   a) PKK [ ]A [ ]B [ ]C [ ]D [ ]E [ ]F
   b) CIDB [ ]G1 [ ]G2 [ ]G3 [ ]G4 [ ]G5 [ ]G6 [ ]G7

Respondent's Information

1. What is your designation with the company?
   [ ] Project Manager [ ] Construction Superintendent
   [ ] Project Engineer [ ] Quantity Surveyor
   [ ] Other: _____
2. Respondent's experienced in construction(years):
   [ ] < 5 [ ] 5-10 [ ] 11-20 [ ] > 20

SECTION B: CURRENT METHOD OF ESTIMATING PRODUCTION RATES

Respondent can tick more than one for each [ ] provided or fill in the blanks.

1. How do you estimate the duration of work activities in a project?
   [ ] Company's previous records [ ] Software
   [ ] Individual experience / judgment [ ] Other: _____
2. How do you estimate the production rates?
   [ ] Company's previous records [ ] Software
   [ ] Individual experience / judgment [ ] Other: _____

SECTION C: PRODUCTION RATES OF EXTERNAL WORKS

Please give the production rates **(per hour)** for each of the activities in the table below using the unit suggested or using your own preferred unit.

Activities	Production rates	Unit / hour	Alternative unit / hour by respondent
Excavation		m^3	
Backfilling and compaction		m^3	
Road / hardstand construction with typical specification (including excavation, laying sub-base, base, binder and wearing course and compaction)		m^2	
Installation of PC drain based on 12 inch / 30mm diameter (including excavation by hand, blinding, jointing and rendering)		m-run	
Installation of PC drain based on 18 inch - 36 inch / 455mm - 915mm diameter (including excavation by hand, blinding, jointing and rendering)		m-run	
Laying 9 inch / 225mm diameter vitrified clay pipes (including excavation, backfilling and compaction)		m-run	
Installing 4 inch /100mm diameter water pipe (including excavation, backfilling and compaction)		m-run	
Turfing works		m^2	
Tree planting (5 feet / 1.5 meter and higher)		No.	
Tree planting (5 feet / 1.5 meter and lower)		No.	
Constructing R.C. fencing		m-run	

SECTION D: FEEDBACK

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

1. Do you prefer to know result of research?
   [ ] Yes [ ] No

2. Would you willing to be contacted to provide additional information to support this research?
   [ ] Yes, my contact telephone number is _____ ext: _____
   [ ] No.

Thank you for your time and cooperation in completing the questionnaire. Your response will be used for research purpose only. It would be appreciated if you could return this questionnaire as soon as possible.

SECTION E: SUGGESTION

Please give any suggestions to improve this questionnaire. To simplify and save time, point forms are encouraged.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

APPENDIX B

SURVEY QUESTIONNAIRE ON CONSTRUCTION PRODUCTION RATES: EXTERNAL WORKS

SECTION A: GENERAL / BACKGROUND INFORMATION

Please fill in the blanks or tick in the space [ ] provided. You can tick more than one space [ ].

Company Information:

1. Name of your company: _____

2. Type of construction projects : (you can tick more than one)
   [ ] Building [ ] Roads [ ] Bridge [ ] Drainage [ ] Other: _____

3. How many years experience does company have? :
   [ ] < 5 [ ] 5-10 [ ] 11-20 [ ] > 20

4. Class of Contractor :
   PKK [ ] A [ ] B [ ] C [ ] D [ ] E [ ] F
   CIDB [ ] G1 [ ] G2 [ ] G3 [ ] G4 [ ] G5 [ ] G6 [ ] G7

5. What is the company's working hours on site?
   _____ am to _____ pm

Respondent's Information

1. What is your designation in the company?
   [ ] Project Manager [ ] Construction Superintendent
   [ ] Project Engineer [ ] Quantity Surveyor
   [ ] Other: _____

2. How many years of experience in construction do you have?
   [ ] < 5 [ ] 5-10 [ ] 11-20 [ ] > 20

SECTION B: CURRENT METHOD OF ESTIMATING PRODUCTION RATES

For each question below, you can tick more than one space [ ] provided or fill in the blanks.

1. How do you estimate the duration of work activities in a project?
   [ ] Company's previous records [ ] Computer database (please state: _____)
   [ ] Individual experience / judgment [ ] Other (please state: _____)
2. How do you estimate the production rates?
   [ ] Company's previous records [ ] Computer database (please state:_____)
   [ ] Individual experience / judgment [ ] Other (please state: _____)

SECTION C: PRODUCTION RATES OF EXTERNAL WORKS

Please give the production rates **(quantities of work per hour or day)** for each of the activities in the table below using the unit suggested or using your own preferred alternative unit. An example for excavation is given as a guide.

Activities	Quantity of Work	Unit of Work		Unit of Time (please tick one)	
		Suggested (default)	Your Alternative	Per Hour	Per Day
Excavation 1m deep excavation of normal soil by machine	**40**	m^2		√	
Excavation 1m deep excavation of normal soil by machine		m^2			
Backfilling and compaction		m^3			
Road / hardstand construction with typical specification (including excavation, laying sub-base, base, binder and wearing course and compaction)		m^2			
Installation of PC drain based on 12 inch / 300mm diameter including excavation by hand, blinding, jointing and rendering		m-run			
Installation of PC drain based on 18 inch - 36 inch / 455mm - 915mm diameter including excavation by hand, blinding, jointing and rendering		m-run			
Laying 9 inch / 225mm diameter vitrified clay pipes including excavation, backfilling and compaction		m-run			
Installing 4 inch /100mm diameter water pipe including excavation, backfilling and compaction		m-run			
Turfing works: close turfing cow grass		m^2			
Turfing works : spot turfing cow grass		m^2			
Tree planting (less than 5 feet / 1.5 meter high)		No.			
Tree planting (5 feet / 1.5 meter and higher)		No.			
Constructing chain link fencing 5 ft/1.5m and above high		m-run			

SECTION D: FEEDBACK

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

1. Do you prefer to know result of research?
   [ ] Yes [ ] No

2. Are you willing to be contacted to provide additional information to support this research?
   [ ] Yes, my contact telephone number is _____ ext: _____
   [ ] No

Thank you for your time and cooperation in completing the questionnaire. Your response will be used for research purpose only. It would be appreciated if you could return this questionnaire as soon as possible.