SPATIAL ANALYSIS OF WORK PRODUCTION RATES FOR UTP R&D RESEARCH CENTRE

By

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14894

Dissertation submitted in partial fulfilment of

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(Civil)

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CERTIFICATION OF APPROVAL

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Approved by,

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(ASSOC. PROF DR NASSIR MATORI)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2015

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

JOSHUA TEOH HEIN YK

ABSTRACT

The purpose of this report is to record down all the activities that are directly or indirectly contributed towards completing the author's Final Year Project starting from September 2014 to May 2015. The author's final year project shall show the spatial analysis of the work production rate for the UNIVERSITI TEKNOLOGI PETRONAS (UTP) new R&D Research Centre construction site. In this project, the author shall discuss on the method used to obtain the work production rate *(Work Sampling Method)*, in which the work production is concluded as effective work, contributory work and ineffective work. Then the author had to show how to spatial analysed the data obtained by using the Geographic Information System (GIS). For the study of the work production rate, it was carried out on the three most contributing work forces available on the construction site which were the carpenters, bar benders and general workers. From the result, the author was able to determine the work production for each work force available in terms of effective work, contributory work and ineffective work. Furthermore, the author was able to determine the inter relationship between all the work forces by comparing the entire work production rate. Lastly, the author was able to present the data of work production rate using the ArcGIS 9.3 software by storing all the data and presenting the data using pie chart.

ACKNOWLEDGEMENTS

I would like to take this opportunity to say my thanks to all the involved parties in making the Final Year Project a great educational session and a great success. Hereby I honourably thanking my head supervisor Assoc. Prof Dr. Abdul Nassir Matori and the UTP civil engineering department for giving me their best support, motivation, guidance and advised throughout this whole final year semesters. This had helped me a lot in completing all the task and challenges that I had face so far.

Furthermore, I would like to take this opportunity to express my deep appreciation and gratitude to the KLCC Project team and the main contractor team, Jowahaki for their approval to allow access to the UTP R&D Research Centre construction site in order for me to obtain the result for my final year project. Their kindness and generosity are a great help in part of completing my final year project.

Last and not least, I could like to thank my family and friends in providing me mental support from my back so that I can keep on moving forward. All their advice and courage throughout this course allow me to finish up the student industrial Project period.

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CHAPTER 1

INTRODUCTION

The purpose of this report is to record down all the activities that are directly or indirectly contributed towards completing the author's Final Year Project (FYP1) study throughout the Final Year Semester at UNIVERSITI TEKNOLOGI PETRONAS (UTP) starting from September 2014 until May 2015. The author has decided to do a study on the productivity rate of the work progress for UTP R&D Research Centre which is currently under constructing in the UTP campus by using two methods which are the unit rate method and the work sampling method and lastly by analysed it using Geographic Information System (GIS) software. The date for the whole project was carried out in between the month of September 2014 and May 2015. This chapter shall give a small brief description on the background, problem statement, project objectives and the scope of study.

1.1 Background Study

UNIVERSITI TEKNOLOGI PETRONAS (UTP) has been well known for its strong emphasis on Research and Development. The university has conducts extensive research activities in collaboration with PETRONAS and other institutions and industries locally and abroad focusing on Enhanced Oil Recovery, Carbon Dioxide Management, Deepwater Technology, Nanotechnology, Green Technology, Biomedical Technology, Hybrid Energy Systems, Intelligent Cities and Sustainable Resources. But due to the increasing number of the students, the old buildings for the research facilities have to be converted into classrooms for the students. So, a research centre is being proposed to be built for the future research development of the University.

The UTP R&D Research Centre is design by the GDP Architecture firm and it is targeted to be finished by the year of 2015. It consists of a 4 storey building consisting of laboratories designed for the research and development of CO2

Management, Enhanced Oil Recovery and other Exploration and Production programmes, and it includes a covered outdoor laboratory space for more robust research activities. The project itself has cover up 12.68 acres of land and it is located at south-west of the main campus which is surrounded by heavily forest areas. The gross floor area of the buildings was around 27,871 m^2. The building is laid out in an east-west orientation, the laboratories are not subjected to direct solar heat loads, hence reducing air-conditioning demands. Wide corridors further protect the laboratories from the elements. In the further, this building will be the main attention for all researchers to conduct their experiments or projects for their research titles.

1.2 Problem Statement

The UTP R&D Research Centre has started their construction since last year, May 2013 and currently the project is still in progress. For every construction site, there shall be delays in the actual planning compare to the actual work done. This may be due to certain factors such as accidents on site, weather conditions, Health, Safety and Environmental issues, authorities, workers work permit issues and dealing with new design from the architect or consultant. Furthermore, the skill and discipline of the workers hired also give a huge contribution to the work progress. A good skill workers shall do their job in a short amount without any flaws if compare to unskilled workers in which their work done has many defects and rework has to be done. During rework stage, a lot of the time has been wasted on doing back the same thing without contributing any progress for the whole project.

So, from here the author decide to use two method such as the unit rate method and work sampling method to study and monitor the productivity rate for the UTP R&D Research Centre construction site. Then, by using the Geographic Information System (GIS) the author hopes to analyse the data collected and get a clear view on the conditions of the current project. These two methods can help the author to have a clear view of the work progress on site and help the author to determine the working performance of the workers currently working in the site. Lastly, this also helps the author to make a better decision in planning activities for the future.

1.3 Objectives

The objectives of the extended proposal are as follows:

- To determine the productivity rate of different type of workers using work sampling method
- To compare and study the relationship and difference of each work production rate for each type of worker of work sampling method.
- To analysed the work sampling method spatially using Geographic Information System (GIS)

1.4 Scope of Study

The scope of study for the author's final year project was taken from the construction of the super structural of UTP R&D Research Centre which consists of 4 storey building consisting of laboratories designed for the research and development of CO_2 Management, Enhanced Oil Recovery and other Exploration and Production programmes, and it also includes a covered outdoor laboratory space for more robust research activities. First of all, the scopes of study that the author focuses are the actual work done progress superstructure works by the workers on the site. The period of time for the author to carry out this industrial project starts from the month of September 2014 until May 2015. The author has manages to break down the scopes of study into work sampling method. For the work sampling method, the author needs to determine the performance of the workers on site according to the result of the work sampling method. The author has decided to take a total of 15 workers as the author's references which all these workers includes carpenters, bar benders and general workers. The reason the author has taken the carpenter, bar bender and general worker as the author's project result observation is because these three categories of workers has the most contribution for the project site.

CHAPTER 2

LITERATURE REVIEW

In the literature review part, it consists of the citation and cross referencing part & the critical analysis part. For the citation and cross referencing part, the author shall discuss on the theory for the two method used to obtain the work production rate which is the unit rate method and the work sampling method. Then, the author also shall discuss on the past research from several people on how they carry out the Geographic Information System (GIS). As for the critical analysis part, the author shall discuss on the difference between each of the research method used for the GIS by different researcher.

2.1 Citation and Cross Referencing

First of all, the unit rate method is a ratio of two different units in which the second term is one. According to the website lecture iCoachMath (2004), the two measurement unit involve for unit rate method measurement can be different and not is the same all the time. For an example, iCoachMath has given a question of a unit rate example. In this example, if a girl earns RM180 in 20 hours, than the unit rate of her earning is as 180/20 which is RM9/hour. Next, Shmoop (2014) has stated that the unit rate can be known as the number of cost to the number of units, (cost: number of units). From here, their statement also shows that the ratio is simplified so that the number of units is equal to one. In addition to support the statement, J. Banfill (2012) has stated that the rate in unit rate is used to find and compare all kinds of different quantities. He also added that how many of the first type of quantity can corresponds to one unit of the second type of quantity. The unit rate has some common unit rate such as kilometre per hour, cost per item or work progress per week. He stated that the first quantity is always related to one unit of the second quantity for each of the case. For more detail in about what is unit rate, rate also can be determined through mathematic perspective viewpoint. From this viewpoint, a rate is a ratio between two

measurements with two or more different units. When the unit in respect of was not specified for the things that has change from its original form, it may conclude that it was causes by the rate per unit time. Hence, the most common type of rate that we can see in the field that most people have used is the "per unit time", such as in the medical field in where doctors see the heart rate and flux beats in a minute or second. Lastly, according to Thomas (2013), the rate used in the unit rate can be also known as frequency which we do normally hear in engineering terms. Hence, this helps us to improve our knowledge more on what is all about the unit rate measurements.

On the other hand, the work sampling method best known as the activity sampling method has been carried out too in this study. The work sampling method can be used as a statistic method or technique to determine the different of time spend by the workers on different kinds of activity available. Next, the work sampling method can be important too if we are to determine the manual productivity of a task given. Then, according to D.L. Perkins (2014), he stated that the work sampling method is a series of continuous observations of work in progress being done before finish in any time scale given. Perkins also added that the percentages of the day the workers work done are being compiled through a number of observations which can be known as sample. Furthermore, each of the observation recorded down by the observer can be categorized into three different major categories which known as productive, supportive and recoverable. As for the productive category, it is used to determine the work or job of the workers has been done according to their own field of work. For example, in a construction site the wood cutting and measuring are being done by the carpenter. Next for the supportive category, it can be known as activities used to fully maximize the time use to finish up the job. Lastly for the recoverable category, it can be known as no value added for getting the job done. This is because nothing has been done to proceed with the job. In simple words, it has no production in order to start and finish up a job; stop of work. In order to support Perkins statement that the work are being evaluate based on the three main category such as the productive, supportive and recovery, Ivan (2014) shows that the work sampling method can differentiate into three more methods which can be known as field rating method, productivity rating method and five minutes rating method. From D.L. Perkins (2014) perspective, the way he uses to carry out this work sampling method is fall under the productivity rating method mentioned by

Ivan. Ivan (2014) stated that the productivity rating method can be further categorized into effective work done, contributory work done and ineffective work done which is the synonym to what Perkins had mention. Based on Ivan given theory of work sampling method for the productivity rate, different construction operations will have different list of “effective”, “contributory”, and “ineffective” for each of their work activities. In addition, the work sampling method has an advantage as this method can be conducted for different day of taking the observation sample so that the result that obtained are much more accurate. Ivan (2014) has highlighted that there is a golden rule of thumb that need to be followed when carry out the work sampling method. The golden rules required the observer of the work sampling method to be able to categorise the effectiveness and ineffectiveness of the work according to the category proportion. Then the observer is to be able to determine the confidence level and limit error in order to know the number of actual observation sample needed for his stuidy. The table sample below shows the Sizes required for 95% and 90% confidence level as according to the rule of thumb.

Category Proportion (%)	95% Confidence Level				90% Confidence Level			
	Limits Error (%)				Limits Error (%)			
	1	2.5	5	10	1	2.5	5	10
50:50	9604	1537	384	96	6765	1082	271	68
40:60	9220	1475	369	92	6495	1039	260	65
30:70	8067	1291	323	81	5683	909	227	57
20:80	6147	983	246	61	4330	693	173	43
10:90	3457	553	138	35	2435	390	97	24

Table 1: Rule of Thumb

Work sampling has many benefits and its own characteristics although it does have its own weaknesses as well. One of the benefits of the work sampling method is that it can be carried out on more than one worker because work sampling can be used to monitor up to different numbers of workers. Katyani (2013) stated that the advantages of using work sampling method are because it can help to avoid biased when taking the result. Biased can be avoided when conducting the work sampling method because the workers are not to be alerted that they are under observation. Next, Katyani also mention that the advantage of using the work sampling method is that the study can be interrupted anytime without affecting the result. For example,

the observation sample are carry out in the morning, then at the afternoon the observer has stop to have a lunch break. This won't affect the result as the work sampling method do not taken the time consideration into account. Katyani (2013) also mention the work sampling method can be carried out by anyone by giving a little training on how the work sampling method can be carry out. This makes the work sampling method to be able conducted by anyone at any places. Since the method can be interrupted anytime, there shall be no worries that the results that obtained are useless. Furthermore, with anyone can carry out the work sampling method, it helps to fastened and speeds up the time to carry out the work sampling method. Lastly, Katyani also says that teamwork within a group can be monitored or observed when carry out this work sampling method.

Although the work sampling method has its advantages to be shown at the above statement, Katyani (2013) also stated that the disadvantages of using work sampling method are also because it is not economical to be used for short cycle jobs. He stated that is not suitable or uneconomical to study on only a single worker or on a small group of workers. It is much more suitable to use work sampling method to study on a bigger group of workers with more different job scope so that the work sampling method can be carried out effectively. Next, Katyani also said that the disadvantages of using this work sampling method is that when carrying out this method, it do not allow any small break down or delay. Any small delay or breakdown when carrying the method results in postponing of taking the result due to it may affect the number of observations. For example, when accident happen in the middle of taking the result, all the workers shall stop working and look around if compare to when there is no accident to happen. Furthermore, according to Ivan (2014), the speed of the workers has done their job are not recorded down in work sampling method. The work sampling method only records on the percentage of work done and the percentage of ineffective works that the workers has done during their work day.

Pennsylvania Spatial Data Access, PASDA (2013) has stated that the Geographic Information System (GIS) is a system which consists of the computer software, hardware and data which make it easier to manipulate, enter or analysed the present location of the earth surface. In order to support the statement, Korucu, (2012) has also stated that the GIS is a computer system that is designed to show the

current earth surface as well as human characteristic of each kind of data collection in a database with real coordinates in accordance with the purpose of analysis done on them. PASDA also mentioned that the GIS falls into three main categories which are the computer hardware and software, spatial data from the 'real world' and personnel that is well trained. The GIS also helps in the presentation of results on maps, charts and graphs that we obtained from the data. Demirci, (2008) says that in order to achieve the goal above, the users have to store all the data in the GIS separately in different layers and used it according to our purposes. Next, PASDA shows that the GIS can help to visualise our data by providing tools that enable the user to query, manipulate and summarize large quantities of data. Additionally, a GIS enables the user to link the tabular attribute data with the mapped features so that you can visualize patterns in the data across space. Other than visualising the data, we can also combine all the data that we obtained into the GIS software. Kurucu. (2012) on the other hand has added that the GIS has different systems that can be used for various purposes. He stated that based on these interactive information systems, a lot of the GIS application which based on the location, geometry and other attributes also allow questioning of other data. GIS can be known for its usefulness on taking the output according to the aim of used of the user. Kurucu also stated that the GIS can not only be used for such technical issues, nowadays the GIS can help to solve issues in social brunches and in different occupational.

Based on the past research, GIS has been carried out by many researchers to study on different kind of things based on different purposes. First of all Ines, A. V. M., et al. (2002), has stated that GIS can be used to study the crop stimulation model based on the productivity of the water. The map, slope, soil depth, erosion and land used were all converted into digital data and used for the analysis in the GIS. The crops that they used to study are rice, peanut and maize and this entire three are used based on the three cropping season to determine the water productivity rate. Next in their research method for the spatial analysis part of the GIS, they had further classified the criteria of their analysis into physical and ecological attributes. Then, a scoring system was carried out to show a clear view on how the land is separated in the basin. From here, they are able to determine the available region for the crop to grow in the map. On the other hand, Ines, A. V. M., et al. (2002) has uses the crop stimulation model (CERES) and CROPGRO model. The CERES has been used to

predict the growth rate and growth duration of the three crops they studied especially for rice. As an aid to the CERES model, the RUE method has been used to monitor the biomass growth. On the other hand, the CROPGRO model is process oriented and has been used to determine the crop carbon ©, crop and soil nitrogen (N) and the water balances in it. As an addition to Ines, A. V. M., et al. (2002) research, they has concluded that the productivity rate is carried out based on three levels of growth stimulation. This three growth stimulation is the potential, limited and reduced growths. The potential production is the level of yield that the crop can achieve based on a few factors consideration. The limited yield may due to the limited resources that were available such as water and nutrients. The reduced production is usually causes by external forces such as pest, weather condition and disease of the crops. Lastly, the water productivity for their research was carry out based on the equation defined by Molden (1999) to determine the water inflow, water depleted in the process and the water process.

On the other hand, Payn, T. W., et al. (1999) has also carried their research on how productivity of the forest growth can be spatial analysed using GIS and various tools in it. In their research, they had concluded that the geostatic tool is one of the available tools in the GIS software system to analysed and estimate the growth spatial rate index and foliar data of the forest trees. In their research, Payn, T. W., et al. (1999) had mentioned the reason they chose to used GIS for modelling and spatial analysis is due to the GIS is able to deal with a large volume of diversity and spatially oriented the data that geographically anchor processes across space and time. There are two methods of determining the spatial trend within the GIS system and these two methods are the statistical analysis and the soil map units. The statistical analysis is a pure spatial analysis in which the geostatic is applies to map the indicator. As for the soil unit method, it is used to indicate each variable available in the forest and the variable was illustrated using the unit map. Furthermore, Payn, T. W., et al. (1999) has stated that the geostatic is a method to differentiate the data properties according to space and to estimate local value. It is an improvement of the spatial interpolation technique because it helps to interpolate the degree of interdependence of each sample point. In their research, they had used Kriging method for interpolation of data as kriging method give unbiased result and provide estimation the error for non- provided result.

For the next research, Lee, S., et al. (2012) has carried out his study on how the application of weights of evidence and GIS affects the groundwater productivity and the potential mapping of it. In their research, they had mentioned that the Geographic Information System (GIS) has a weakness in which the system lacks a prediction ability due to the GIS has no built in function of multi-dimensional data or have any spatial patterns in which may use to predict the occurrence in the future. So to overcome this weakness of GIS, it is necessary to have other applied technique to find the spatial correlations. Hence, Lee, S., et al. (2012) has decided to use the GPP analysis on the bedrock aquifer using the Weight of Evidence (WOE) method technique as an applied technique to find the spatial correlations so that it can tandem with the GIS and RS technique used to determine the productivity of the groundwater. According to Lee, S., et al. (2012), to obtain the mapping of GPP, data collection was carried out and a databased was constructed by using the WOE method. Then the groundwater productivity (SPT and T) data was obtained soon after the WOE method had carried out. Lastly all the data was validated in the GPP map by using the existing groundwater productivity data for the training in the WOE model.

2.2 Critical Analysis

In this section, all the theory or research studied shall be further discuss and critically analysed on how it can helps the author to carry out the project. The author shall discuss about the author's opinion on how the research benefits the author to carry out the work production rate and the Geographic Information System (GIS) that the author has decided to use for the final year project.

The table below shall show the critical analysis of the *work production rate*.

Name	Year	Title	Description	Findings
Shmoop	2014	Ratios & Percentage	• Mentioned that the unit is a ratio of cost • The ratio is further simplified so that the number of unit is 1	• It gives a simple definition on how to determine the unit rate
D.L. Perkins	2014	Work Sampling: A Method for Assessing and Monitoring	• Work sampling is a series of instantaneous observations of work-in-progress done randomly over a specified period • Work category can be further divided into productive, supportive and recoverable.	• No detail discussion on how the work sampling method is carried out. • Gives a general view on of the work sampling method as an instantaneous observation
Ivan	2014	Work Sampling Method on Bricklaying	• Work sampling method can be further been carry out by field rating, productivity rating and 5 minutes rating • Productivity rating can categorised the work into effective work, contributory work and ineffective work • Setting of limit error, confidence level and pilot study test was carried out • Pilot study is carried out to obtain the actual number of observation sample needed.	• Productivity rating was chosen as on one the method to carry out work sampling method • The work activity for effective work, contributory work and ineffective work are listed out based on the preliminary survey at the site

			• A golden thumb of rule has to be follow in order to get the accurate result	• The importance of the pilot study test is to determine the actual observation sample needed for the work sampling method
Katyani	2013	Advantage and Disadvantage of Work Sampling Method	• Discuss of the advantage and disadvantage of work sampling method as is *Advantages*: - Provide unbiased result - Can be interrupted at any time of the day - People with limited training of the work sampling method are able to carry this method *Disadvantages* - Sudden distraction in the observation may affect the result - Requires the observer to be on site the whole time when collecting data	• Give a clear view on importance factors that need to be consider when taking the observation sample • The pro and con of the work sampling method was discuss thoroughly

Table 2: Critical Analysis of Work Production Rule

The table below shall show the critical analysis of the Geographic Information System (GIS)

Name	Year	Title	Description	Findings
Pennsylvania Spatial Data Access (PASDA)	2013	Introduction to Geographical Information System	• Stated that GIS consists of the computer software, hardware and data which make it easier to manipulate, enter or analysed the present location of the earth surface. • GIS helps in the presentation of spatial data	• PASDA did not mention relation between productivity and spatial analysis • PASDA only give a theory on how to operate the GIS
Kurocu	2012	GIS and Types of GIS Education Programs	• GIS is a system to show the current earth surface • GIS can create different layer for different purposes • GIS in not only for technical used, it can be used to solve issue for different fields	• The usage of creating different layer for each different work was explained • GIS is not mainly to view the earth surface but also can be used for other purpose by using various tools available in the system
Ines, A. V. M., et al	2002	Application of GIS and crop growth models in estimating water productivity	• Uses the crop stimulation model (CERES) and CROPGRO model to get the spatial view of the crops region • GIS is use to study the region for the crops to grow	• GIS has been use to only spatial analysis the region for where the crops grow

			• The productivity rate of water is calculated by using specifics formula	• The productivity rate of water was calculated but did not include together into the GIS software. • No further detail on which tools that has been use to analysed the data
Payn, T. W., et al	1999	Potential for the use of GIS and spatial analysis techniques as tools for monitoring changes in forest productivity and nutrition, a New Zealand example.	• Spatial analysis of the forest growth by using GIS has been carry out • The tools that exists in the GIS software such as geostatic tool has been use to analysed the data obtained • GIS is able to deal with a large volume of diversity and spatially oriented the data that geographically anchor processes across space and time • Statistical analysis and the soil map units has been use to determine the GIS trend analysis • Soil unit method is use to determine the forest productivity and nutrition	• Clearly stated the tools that been use for the GIS analysis • However, the spatial analysis of the geographic and topographic of the forest area is not that clear. • Shows a GIS can have many functions for different purpose.

Lee, S., et al.	2012	Application of a weights-of-evidence method and GIS to regional groundwater productivity potential mapping	• Stated that GIS has a weakness in which the system lacks a prediction ability • GPP analysis has been carry out by using the Weight of Evidence (WOE) to find the spatial correlations so that it can tandem with the GIS and RS technique used to determine the productivity of the groundwater.	• They show that GIS has a weakness in where it cannot be used to predict any further cases that may happen • Additional method has to be used to overcome this weakness of GIS • No clear showing on the uses of GIS

Table 3: Critical analysis of GIS spatial analysis

CHAPTER 3

METHODOLOGY

In this chapter, the author will discuss about the methodology used to determine the work sampling method and the analysis using the Geographic information System software based on the data collected form the UTP R&D Research Centre project site. The flow rate of this whole process will also be shown in the methodology flow chart.

3.1 Work Sampling Method

The work sampling method that the author has used in this project is the productivity rating. Productivity rating has three things that needed to be determined which is the effective work, contributory work and ineffective work. Before carrying out the work sampling method, the author has to come out with an observation sheet which consists of the workers working elements and codes were assign to each of them. The first step to conduct the work sampling method is to obtain the data for the pilot study test. Then from there, the author can determine the required number of observation sample and get the actual result.

3.1.1 *Pilot Study Test*

Pilot study is carry out using random observation as a starting point in order to determine the actual number of observation needed. Before we start the pilot study test, the limit error and confidence level are determined and observation sheet list was prepared beforehand. During the conduct of the pilot study test, for every five minutes interval, the author has to records down the workers job scope according to the observation code list. Based on the pilot study test result, the author has to calculate the observation needed (N) for the actual observation test.

3.1.2 *Actual Observation Test*

After obtained the observation needed (N) from the pilot study test, the actual observation test can be carry out. The sequence of the actual observation test is almost similar as conducting the pilot test. First of all we had to determine the limit of error and level and confident, then for every five minutes interval, the observation of the workers activities was recorded. After obtaining all the data, the frequency (F) of the work is carry out, Percentage of total (P), Accuracy (L)*, the minimum and maximum of the limit of error (%) at the end of the work sampling method. At the end of the project, we can obtain the effective work, contributory work and ineffective work of all the workers based on the observation.

There were a few important notes to be taken seriously when conducting the observation:

- Make sure that the workers we observe are all the same throughout the whole process
- Make sure to take down what the workers are doing at the exact time to avoid any biased.

3.2 Geographic Information System (GIS)

The GIS that the author has used in the project is to analyse the data that obtained from the project site. By using GIS, the author wanted to have a clear view of the layout of the project site by visualising the data and to classified all the data into features for easy analysis on the whole project. GIS can helps the author to understand more about all the complex work on site as it breaks down all the work into small details which is practically easy to understand. In order to use the ArcGIS software, the author has to go through a few tutorial classes to master the software in order to be able to carry out the basic function of GIS.

The GIS is conducted for the UTP R&D Research Centre located inside the UTP main campus. There are 3 categories that has been consider for the GIS analysis which are the carpenters, general workers and the bar benders. So first of all, the location of the project site was to be included into the GIS software which can be

known as the ArcGIS through obtaining from google map services. Then, legends inside the layout were to be determined and illustrated. Then, after obtaining the layout, the author will break down all the workers work activities into ArcGIS so that all the activities can be arranged systematically so that the data can be easy to analyse and understand. Other than that, the work structure for the whole project which is complex can be further be included into ArcGIS so that the data can be arrange according to sequence. For example, the work sequence of the project is at first complex and confusing, but using the GIS we can eliminate all the unnecessary and have a clear view on what the work that can be done on site. Basically GIS helps to determine the work flow and work structure of the whole project.

3.3 Tools Used

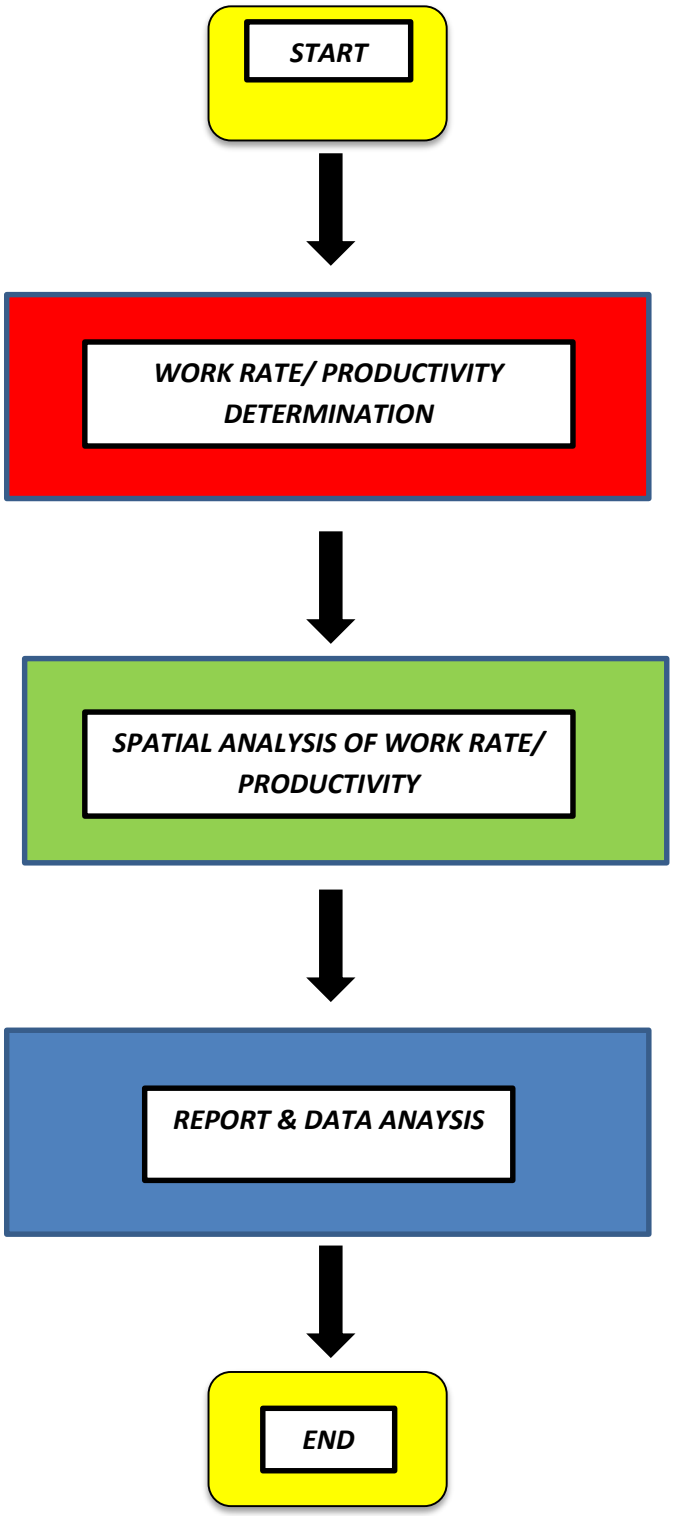
Software

- Microsoft Excel 2010, Microsoft Project 2014, Microsoft Word 2010
- DWG True view 2014, Autocad 2007 & ArcGIS

Hardware

- Timer
- Pen and papers

3.4 Methodology Flow Chart



3.5 Key Milestone& Gantt Chart

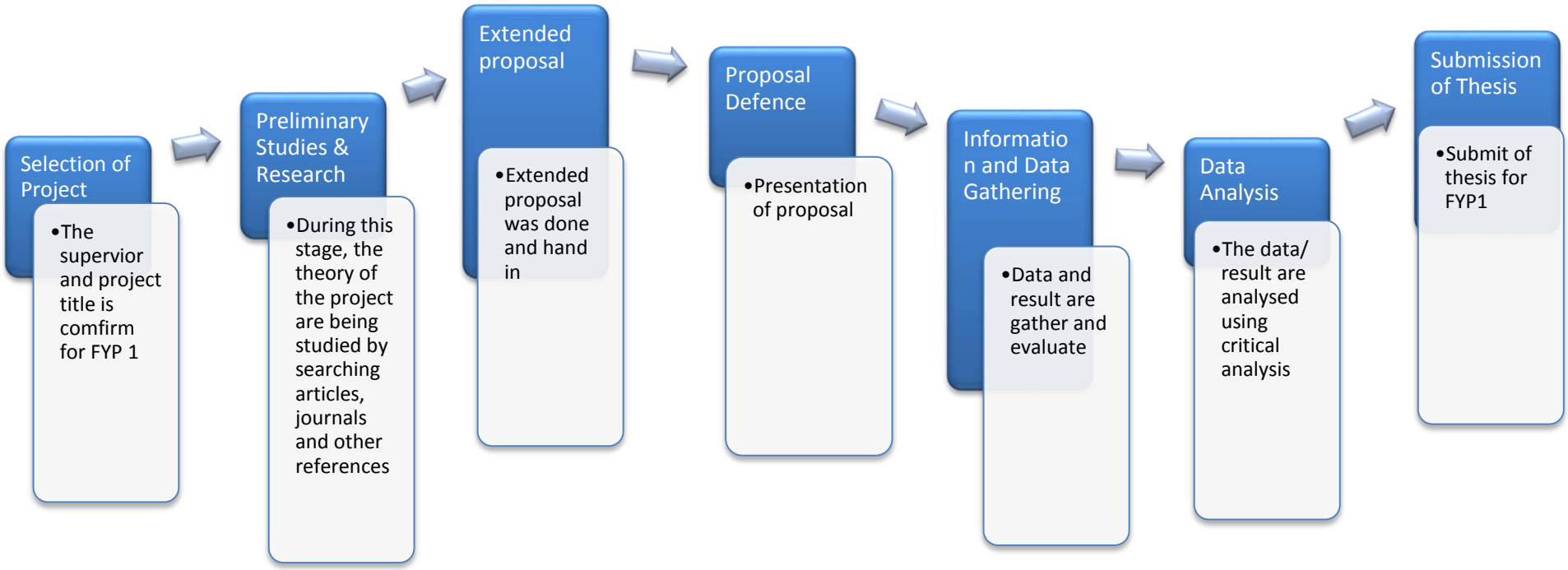


Figure 1: Project Key Milestone

3.6 Gantt chart for FYP 2

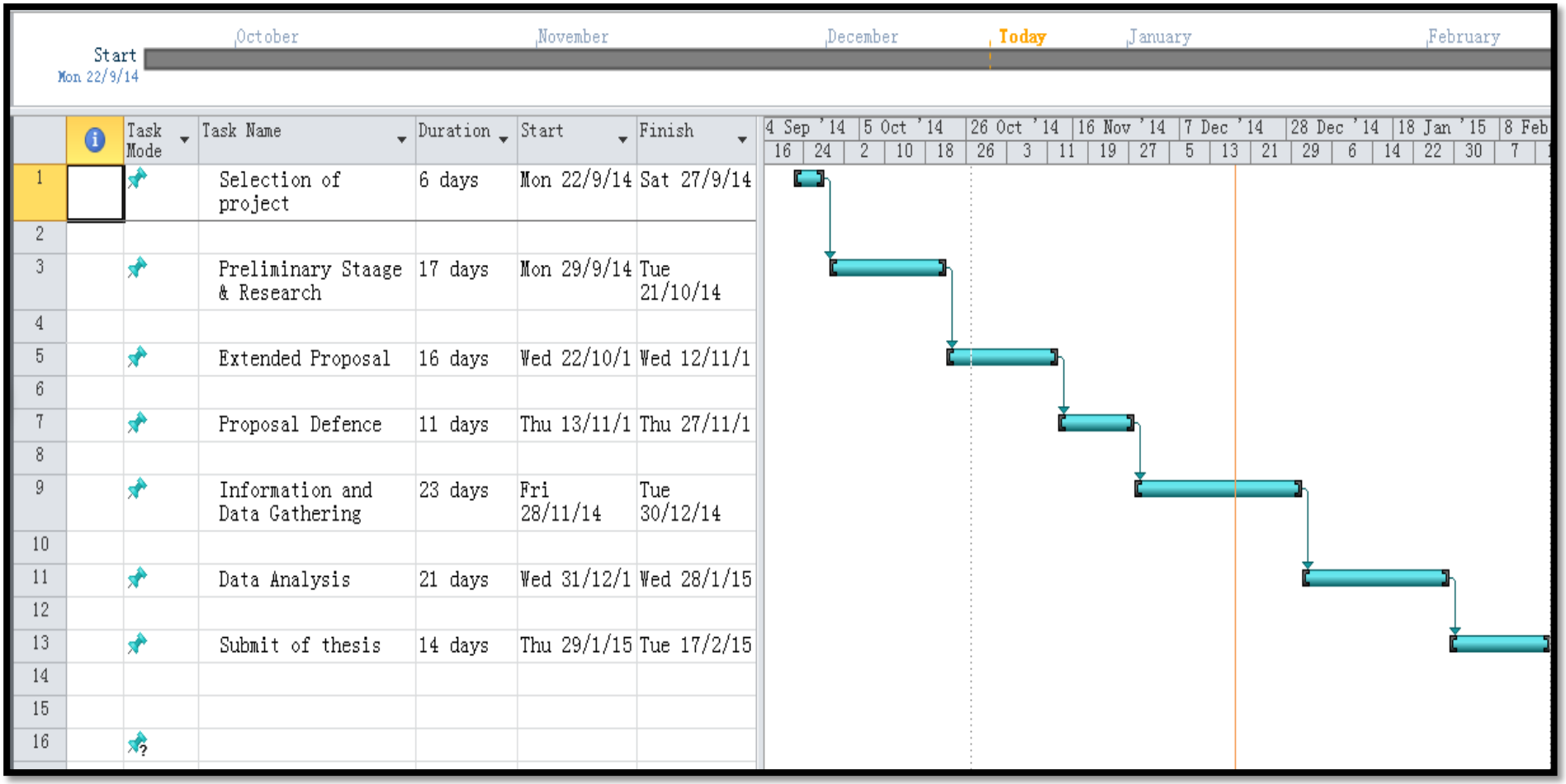


Figure 2: FYP 2 Gantt chart

CHAPTER 4

RESULT & DISCUSSION

4.1 Work Sampling Method (Preliminary Survey)

The results that obtain are mainly from the preliminary survey that the author has observed from the construction site. In order to carry out the work sampling method for the work production rate, an observation sheet list must be prepared before starting the survey. The observation sheet list consists of the code assign for each work category consists of effective work, contributory work and ineffective work of the workers that is available on site: *carpenter, bar bender & general worker*

Observation sheet list for carpenter

Classification	Code No.	Element of Carpenters Activities	Remark
Effective Work	E1	Installing Conventional Formwork for Beam and Slab	
	E2	Installing Conventional Formwork for Column	
	E3	Installing Formwork for Staircase	
	E4	Cutting formwork	
	E5	Installing Beam Soft Fit	
	E6	Dismantling Formwork	
Contributory Work	C1	Carrying Formwork Pieces	
	C2	Reading Drawing	
	C3	Marking Setting Line	
	C4	Measuring Formwork Length	
	C5	Hoisting Conventional Formwork	
	C6	Setting up scaffolding	
Ineffective Work	I1	Idle and Away	
	I2	Talking	
	I3	Resting	
	I4	Waiting	
	I5	Rework	
	I6	Walking	

Table 4: Observation Sheet List for Carpenters

Observation sheet list for bar bender

Classification	Code No.	Element of Bar Bender Activities	Remark
Effective Work	E1	Installing Rebar	
	E2	Tying Rebar	
	E3	Installing Links	
	E4	Cutting Rebar	
	E5	Installing Block Spacer	
	E6	Installing BRC Wire Mesh	
Contributory Work	C1	Carrying Rebar	
	C2	Reading Drawing	
	C3	Confused	
	C4	Measuring Rebar Length	
	C5	Hoisting Rebar/ BRC Wire Mesh	
Ineffective Work	I1	Idle and Away	
	I2	Talking	
	I3	Resting	
	I4	Waiting	
	I5	Rework	
	I6	Walking	

Table 5: Observation Sheet List for Bar Bender

Observation sheet list for general worker

Classification	Code No.	Element of Generals Workers Activities	Remark
Effective Work	E1	Hacking	
	E2	Larvae Ciding	
	E3	Housekeeping	
	E4	Cleaning / Blowing	
	E5	Installing Beam Soft Fit	
	E6	Cement Rendering Work	
Contributory Work	C1	Pushing Wheelbarrow	
	C2	Carrying Things	
	C3	Marking Setting Line	
	C4	Hoisting Materials	
	C5	Taking Levelling	
	C6	Giving Instructions / Coordinating with operator	
Ineffective Work	I1	Idle and Away	
	I2	Talking	
	I3	Resting	
	I4	Waiting	
	I5	Rework	
	I6	Walking	

Table 6: Observation Sheet List for General Workers

Next for the limit error, category proportion and the confidence level, the author has chosen to use the figures that been highlighted in the tables shown below. The value is chosen based on the observation that the author has made based on the performance of the worker on site.

Category Proportion (%)	95% Confidence Level				90% Confidence Level			
	Limits Error (%)				Limits Error (%)			
	1	2.5	5	10	1	2.5	5	10
50:50	9604	1537	384	96	6765	1082	271	68
40:60	9220	1475	369	92	6495	1039	260	65
30:70	8067	1291	323	81	5683	909	227	57
20:80	6147	983	246	61	4330	693	173	43
10:90	3457	553	138	35	2435	390	97	24

Table 7: Chosen Rule of Thumb

From the table above it clearly shows that the category proportion that the author has chosen to use in the study is 20:80 for the ineffective work to the effective work ratio based on the work performance of the workers on site. Then, a 90% of confidence level and limit error of 10% was chosen from the author opinion about his skill and confidence when taking the observation sample. So, when carry out the pilot study, it is to make sure that the actual sample that obtained must be higher than 43 samples so that we can obtained the percentage of effective work, contributory work and ineffective work of the workers evaluated.

4.2 Work Sampling Method (Pilot Study & Actual Observation)

Pilot test was conducted after the preliminary survey. The main purpose of the pilot study is to make that the identified activity elements are sufficient to record all the activities involved in the operation for each work category. It also used to modify if necessary and also to calculate the required number of observations to obtain an acceptable accuracy.

In the pilot test conducted, ten observations are decided to take for each work category which consists total of 50 observations taken. Then, it is to taken to calculate the required number of observation to delineate an acceptable accuracy. The number of observation must be more than 43 if limit of error of 10% and confidence level 90% were used, and if we assumed that the category proportion is 80:20. However, to enhance the creditability and reliability, we opted for 100 observations. For all the work category of carpentry work, bar bender and general work, we applied random observation method which records the first observation at immediate time in the 5 minutes interval

After getting all the data needed to carry out the work sampling method, it is best to carry out the result for the pilot test in order to find the actual observation needed to do the work sampling method for each work category. So, first of all we will start with the carpenters, bar benders and lastly on general workers. The data gather are all being shown as below.

4.2.1 Carpenters Works

Classification	Code No.	Element of Carpenters Activities	Number Of Observation
Effective Work	E1	Installing Conventional Formwork for Beam and Slab	24
	E2	Installing Conventional Formwork for Column	0
	E3	Installing Formwork for Staircase	0
	E4	Cutting formwork	1
	E5	Installing Beam Soft Fit	0
	E6	Dismantling Formwork	6
	Total		31
Contributory Work	C1	Carrying Formwork Pieces	5
	C2	Reading Drawing	0
	C3	Marking Setting Line	0
	C4	Measuring Formwork Length	1
	C5	Hoisting Conventional Formwork	2
	C6	Setting up scaffolding	4
	Total		12
Ineffective Work	I1	Idle and Away	0
	I2	Talking	1
	I3	Resting	2
	I4	Waiting	3
	I5	Rework	0
	I6	Walking	1
	Total		7

Table 8: Raw Data for Carpenter (pilot test: First 50 observations)

The first 50 pilot study results are recorded and summarised as below:

Observation	Frequency	Percentage of total, P
Effective Work	31	62
Contributory Work	12	24
Ineffective Work	7	14

Table 9: Summarise Carpenter Data (pilot test)

From the values revealed above, we can obtain the number of observations required by:

$$N = \frac{4P\ (1-P)}{L^2}$$

$$= \frac{4(0.62)(1-0.62)}{0.1^2}$$

= 95 observations

The total observations required for the observations were 95 observations which is more than 43 observations, hence it is acceptable to be used to obtain the actual number of sample observation. However, to further enhance the credibility and reliability of the results that will be tabulated later, a total of 100 observations were constructed for the carpenter workers.

The final 100 actual observations samples are recorded and summarised as below:

Classification	Code No.	Element of Carpenters Activities	Number Of Observation
Effective Work	E1	Installing Conventional Formwork for Beam and Slab	41
	E2	Installing Conventional Formwork for Column	0
	E3	Installing Formwork for Staircase	0
	E4	Cutting formwork	5
	E5	Installing Beam Soft Fit	0
	E6	Dismantling Formwork	0
	Total		46
Contributory Work	C1	Carrying Formwork Pieces	15
	C2	Reading Drawing	0
	C3	Marking Setting Line	0
	C4	Measuring Formwork Length	5
	C5	Hoisting Conventional Formwork	0
	C6	Setting up scaffolding	4
	Total		24
Ineffective Work	I1	Idle and Away	2
	I2	Talking	2
	I3	Resting	15
	I4	Waiting	6
	I5	Rework	0
	I6	Walking	5
	Total		30

Table 10: Carpenter Raw Data

The 100 actual observation samples for carpenters are summarised as below:

Observations	Frequency	Percentage of total, P (%)	Accuracy, L	Minimum (%)	Maximum (%)
Effective Work	46	46	± 9.968	36.032	65.968
Contributory Work	24	24	± 8.542	15.458	32.542
Ineffective Work	30	30	± 9.165	20.835	39.165

Table 11: Summarise Carpenter Data

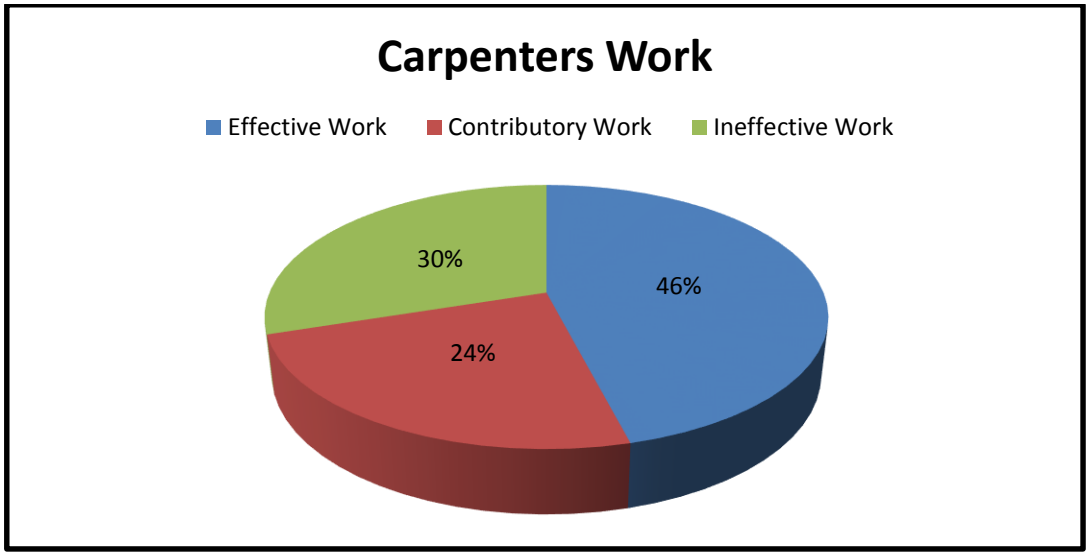


Figure 3: Carpenter Pie Chart

Percentage of total (P) for each operation is calculated:

For effective work, P = 46/100 x 100%

= 46%

For contributory work, P = 24/100 x 100%

= 24%

For ineffective work, P = 30/100 x 100%

= 30%

Acceptable accuracy (L*) for each operation is calculated as below:

For effective work, L = √ {[4 (0.46) (1-0.46)]/100}

= ± 9.968 %

For contributory work, L =√ {[4 (0.24) (1-0.24]/100}

= ± 8.542 %

For ineffective work, L =√ {[4 (0.30) (1-0.30)]/100}

= ± 9.165 %

According to Pilcher (1992),

Labour utilisation excluding contributory activities (%)

= (Effective work observations)/ (Total observations) = 46/100 x 100% = 46 %

Partially including contributory activities

= (Effective observation+ 1/4 Contributory)/(Total observations)

= [46+ (1/4 x 24)]/100 x 100%

= 52%

As delimitated from calculation, the overall performance for carpenter work at UTP R&D Research Centre is 52%.

Overall Analysis for Pilot and Actual Observation

There are 50 observations taken as the pilot study to determine the required number of observation. From the pilot study, a total of 100 observations are taken for the actual observation. From the actual observation result, 46 % of the 100 observation is effective work, 24% of the 100 observation is contributory work and 30 % of the 100 observation is ineffective work. According to Pilcher (1992) formula, the overall productivity performance on the UTP R&D Research Centre site is 52%

4.2.2 *Bar Bender Works*

Classification	Code No.	Element of Bar Bender Activities	Number Of Observation
Effective Work	E1	Installing Rebar	1
	E2	Tying Rebar	15
	E3	Installing Links	2
	E4	Cutting Rebar/ Bending	9
	E5	Installing Block Spacer	0
	E6	Installing BRC Wire Mesh	0
	Total		27
Contributory Work	C1	Carrying Rebar	0
	C2	Reading Drawing	0
	C3	Confused	0
	C4	Measuring Rebar Length	2
	C5	Hoisting Rebar/ BRC Wire Mesh	0
	Total		2
Ineffective Work	I1	Idle and Away	0
	I2	Talking	0
	I3	Resting	21
	I4	Waiting	0
	I5	Rework	0
	I6	Walking	0
	Total		21

Table 12: Raw Data for Bar Bender (pilot test: First 50 observations for bar bender's worker)

The first 50 pilot study results are recorded and summarised as below:

Observation	Frequency	Percentage of total, P
Effective Work	27	54
Contributory Work	2	4
Ineffective Work	21	42

Table 13: Summarise Bar Bender Data (pilot test)

From the values revealed above, we can obtain the number of observations required by:

$$N = \frac{4P\ (1-P)}{L^2}$$

$$= \frac{4(0.54)(1-0.54)}{0.1^2}$$

= 99.36 observations

The total observations required for the observations were 100 observations which are more than 43 observations; hence it is acceptable to be used to obtain the actual number of sample observation for bar bender works.

The final 100 actual observations samples are recorded and summarised as below:

Classification	Code No.	Element of Bar Bender Activities	Number Of Observation
Effective Work	E1	Installing Rebar	10
	E2	Tying Rebar	49
	E3	Installing Links	4
	E4	Cutting Rebar/ Bending	0
	E5	Installing Block Spacer	0
	E6	Installing BRC Wire Mesh	0
	Total		63
Contributory Work	C1	Carrying Rebar	2
	C2	Reading Drawing	0
	C3	Confused	0
	C4	Measuring Rebar Length	0
	C5	Hoisting Rebar/ BRC Wire Mesh	17
	Total		19
Ineffective Work	I1	Idle and Away	2
	I2	Talking	5
	I3	Resting	6
	I4	Waiting	3
	I5	Rework	0
	I6	Walking	2
	Total		18

Table 14: Bar Bender Raw Data

The 100 actual observation samples for bar benders are summarised as below:

Observations	Frequency	Percentage of total, P (%)	Accuracy, L	Minimum (%)	Maximum (%)
Effective Work	63	63	± 9.656	53.344	72.656
Contributory Work	19	19	± 7.846	11.154	16.846
Ineffective Work	18	18	± 7.684	10.316	15.846

Table 15: Summarise Bar Bender Data

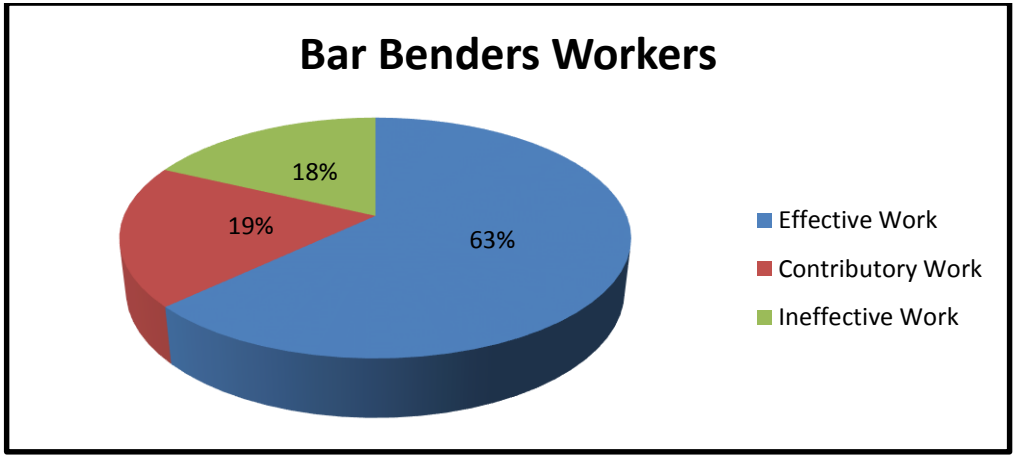


Figure 4: Bar Bender Pie Chart

Percentage of total (P) for each operation is calculated:

For effective work, P = 63/100 x 100%

= 63%

For contributory work, P = 19/100 x 100%

= 19%

For ineffective work, P = 18/100 x 100%

= 18%

Acceptable accuracy (L*) for each operation is calculated as below:

For effective work, L = √ {[4 (0.63) (1-0.63)]/100}

= ± 9.656%

For contributory work, L =√ {[4 (0.19) (1-0.19]/100}

= ± 7.846%

For ineffective work, L =√ {[4 (0.18) (1-0.18)]/100}

= ± 7.684%

According to Pilcher (1992),

Labour utilisation excluding contributory activities (%)

= (Effective work observations)/ (Total observations) = 63/100 x 100% = 63 %

Partially including contributory activities

= (Effective observation+ 1/4 Contributory)/ (Total observations)

= [63+ (1/4 x 19)]/100 x 100%

= 67.75%

As delimitated from calculation, the overall performance for bar bender work at UTP R&D Research Centre is 67.75%.

Overall Analysis for Pilot and Actual Observation

There are 50 observations taken as the pilot study to determine the required number of observation. From the pilot study, a total of 100 observations are taken for the actual observation. From the actual observation result, 63 % of the 100 observation is effective work, 19% of the 100 observation is contributory work and 18 % of the 100 observation is ineffective work. According to Pilcher (1992) formula, the overall productivity performance on the UTP R&D Research Centre site is 67.75%

4.2.3 *General Workers*

Classification	Code No.	Element of Generals Workers Activities	Number Of Observation
Effective Work	E1	Hacking	0
	E2	Larvae Ceding	0
	E3	Housekeeping	0
	E4	Cleaning / Blowing	0
	E5	Installing Beam Soft Fit	0
	E6	Cement Rendering Work	18
	Total		18
Contributory Work	C1	Pushing Wheelbarrow	0
	C2	Carrying Things	4
	C3	Marking Setting Line	0
	C4	Hoisting Materials	0
	C5	Taking Levelling	0
	C6	Giving Instructions/ Coordinating with Operator	0
	Total		4
Ineffective Work	I1	Idle and Away	11
	I2	Talking	2
	I3	Resting	4
	I4	Waiting	8
	I5	Rework	0
	I6	Walking	3
	Total		28

Table 16: General Worker Raw Data (pilot test: First observations for general worker)

The first 50 pilot study results are recorded and summarised as below:

Observation	Frequency	Percentage of total, P
Effective Work	18	36
Contributory Work	4	8
Ineffective Work	28	56

Table 17: Summarise General Worker Data (pilot test)

From the values revealed above, we can obtain the number of observations required by:

$$N = \frac{4P\ (1-P)}{L^2}$$

$$= \frac{4(0.36)(1-0.36)}{0.1^2}$$

= 92.16 observations

The total observations required for the observations were 93 observations which are more than 43 observations; hence it is acceptable to be used to obtain the actual number of sample observation for bar bender works. However, to further enhance the credibility and reliability of the results that will be tabulated later, a total of 100 observations were constructed for the carpenter workers.

The final 100 actual observations samples are recorded and summarised as below:

Classification	Code No.	Element of Generals Workers Activities	Number Of Observation
Effective Work	E1	Hacking	4
	E2	Larvae Ceding	0
	E3	Housekeeping	1
	E4	Cleaning / Blowing	3
	E5	Installing Beam Soft Fit	0
	E6	Cement Rendering Work	31
	Total		39
Contributory Work	C1	Pushing Wheelbarrow	14
	C2	Carrying Things	6
	C3	Marking Setting Line	0
	C4	Hoisting Materials	2
	C5	Taking Levelling	0
	C6	Giving Instructions/ Coordinating with Operator	4
	Total		26
Ineffective Work	I1	Idle and Away	15
	I2	Talking	2
	I3	Resting	2
	I4	Waiting	15
	I5	Rework	0
	I6	Walking	1
	Total		35

Table 18: General Worker Raw Data

The 100 actual observation samples for general workers are summarised as below:

Observations	Frequency	Percentage of total, P (%)	Accuracy, L	Minimum (%)	Maximum (%)
Effective Work	39	39	± 9.755	29.245	48.755
Contributory Work	26	26	± 8.773	17.227	34.773
Ineffective Work	35	35	± 9.539	25.461	44.539

Table 19: Summarise General Worker Data

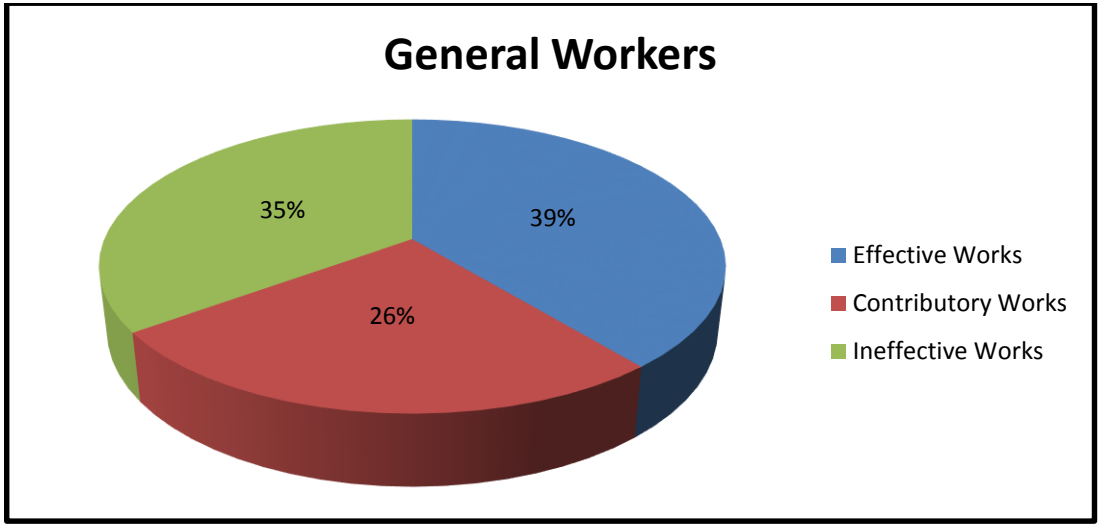


Figure 5: General Worker Pie Chart

Percentage of total (P) for each operation is calculated:

For effective work, P = 39/100 x 100%

= 39%

For contributory work, P = 26/100 x 100%

= 26%

For ineffective work, P = 35/100 x 100%

= 35%

Acceptable accuracy (L*) for each operation is calculated as below:

For effective work, L = √ {[4 (0.39) (1-0.39)]/100}

= ± 9.755%

For contributory work, L =√ {[4 (0.26) (1-0.26]/100}

= ± 8.773%

For ineffective work, L =√ {[4 (0.35) (1-0.35)]/100}

= ± 9.539%

According to Pilcher (1992),

Labour utilisation excluding contributory activities (%)

= (Effective work observations)/ (Total observations) = 39/100 x 100% = 39 %

Partially including contributory activities

= (Effective observation+ 1/4 Contributory)/ (Total observations)

= [39+ (1/4 x 25)]/100 x 100%

= 45.5%

As delimitated from calculation, the overall performance for general worker's work at UTP R&D Research Centre is 45.5% which is not more than 50%.

Overall Analysis for Pilot and Actual Observation

There are 50 observations taken as the pilot study to determine the required number of observation. From the pilot study, a total of 100 observations are taken for the actual observation. From the actual observation result, 39 % of the 100 observation is effective work, 26% of the 100 observation is contributory work and 35 % of the 100 observation is ineffective work. According to Pilcher (1992) formula, the overall productivity performance on the UTP R&D Research Centre site is 45.5%

4.3 Spatial Analysis of work production rate using ArcGIS 9.3

Based on the result that obtained from the work production rate, it was required to be spatial analysed it by using the GIS software so that the data that obtained can be presented in the form of data in the GIS software.

Hence, in order to show the data in the GIS software, first of all the map or the topography of the current location of the UTP R&D Research Centre are being located and save using the Google Earth software.

Figure 6: UTP R&D Research Centre Location

Next, in order to create three different layers for each type of work category *(carpenter, bar bender & general workers)* three different "***polygons***" were drawn on the map of the current building location to show the different type of work available.

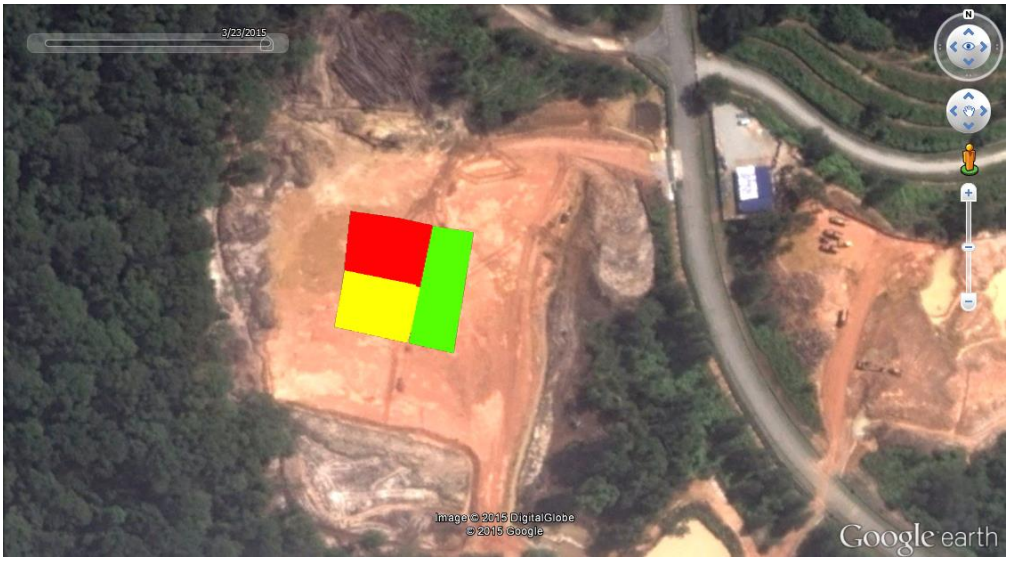


Figure 7: 'Polygons" created

The file was safe as *("kmz")* type of file to allow the ArcGIS 9.3 software to open and run the file as it was one of the requirements. As soon as the file was open in the ArcGIS 9.3, the colours of the polygon drawn shall change a little due to the limited colour provided in the ArcGIS 9.3 software and the polygon shall appeared to be in a kind of layout sheet each with the work category labelled on it.

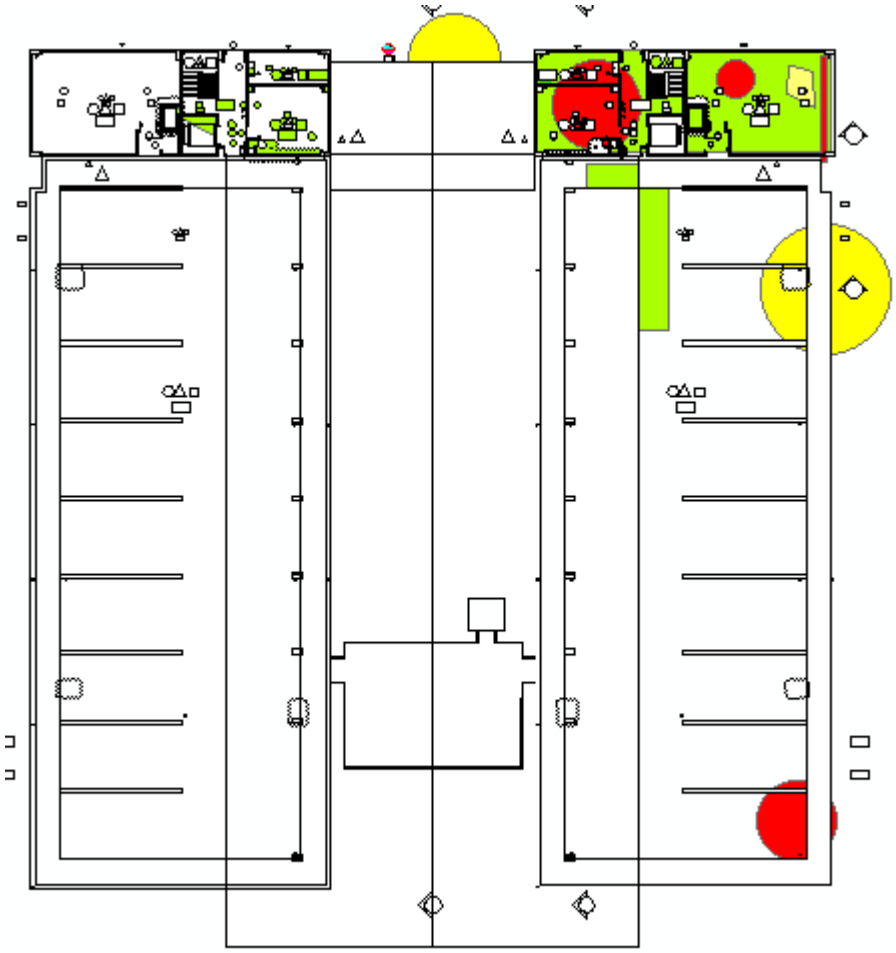


Figure 8: Building Layout Exists in ArcGIS 9.3 Software

Lastly, all the raw data that obtained from the work production rate are able to be included into the ArcGIS 9.3 software according to each layer consisted of carpenter (green), bar bender (red) and general workers (yellow). The *'list of table'* tools were used in the ArcGIS 9.3 software to store all the raw data for each category of work in terms of effective work, contributory work and ineffective work. Then, by using the ArcGIS 9.3 software, pie charts were generated to shows the percentage of the work efficiencies for each type of work available on the construction site.

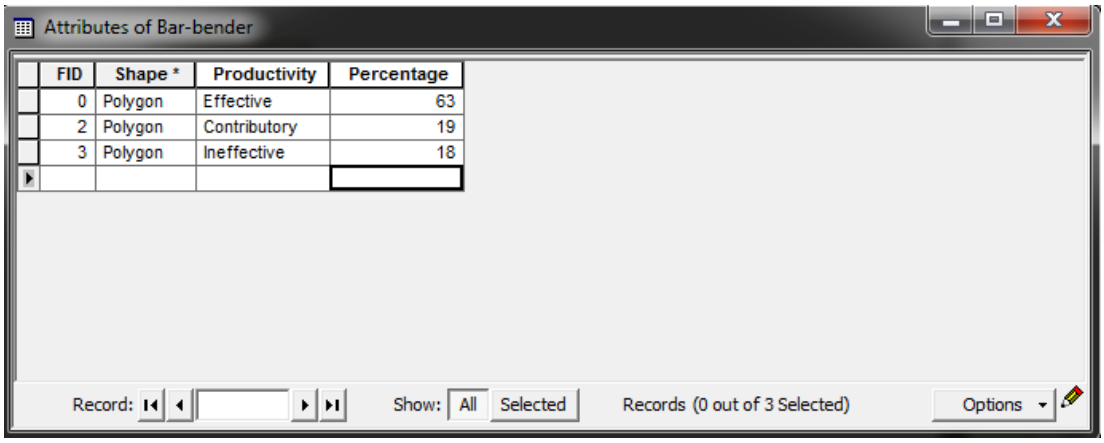


Figure 9: Bar Bender 'List of Tables'

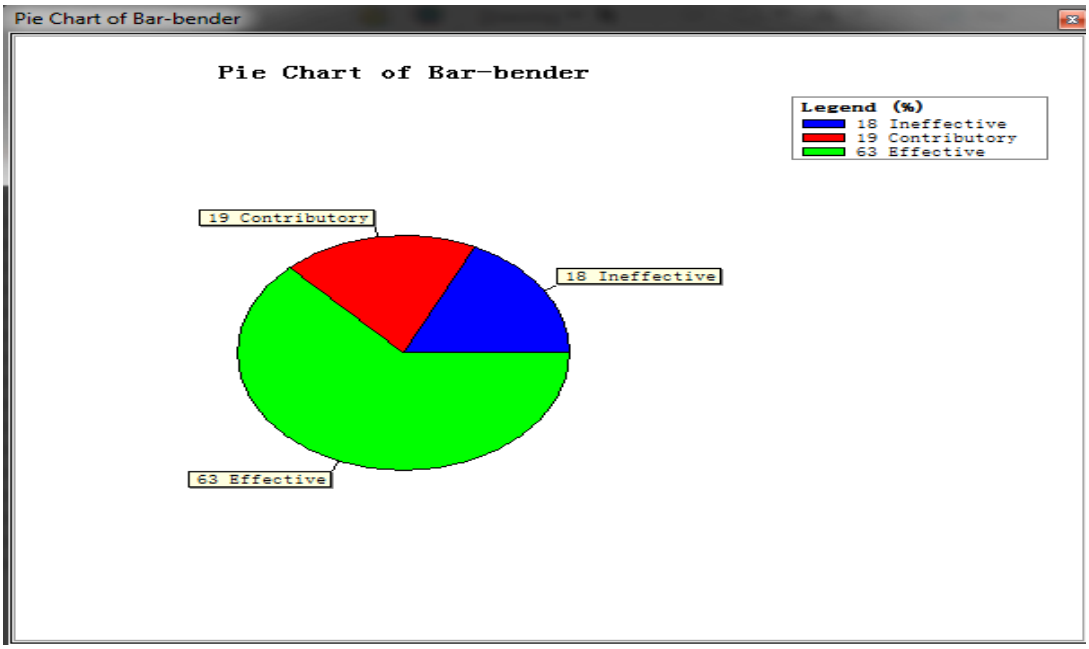


Figure 10: Pie Chart produced using ArcGIS for Bar Bender

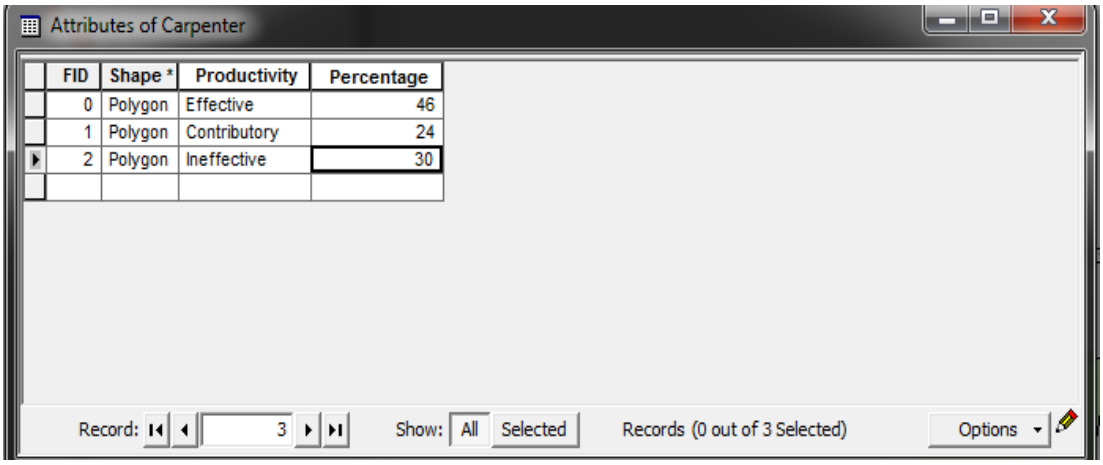


Figure 11: Carpenter 'List of Tables'

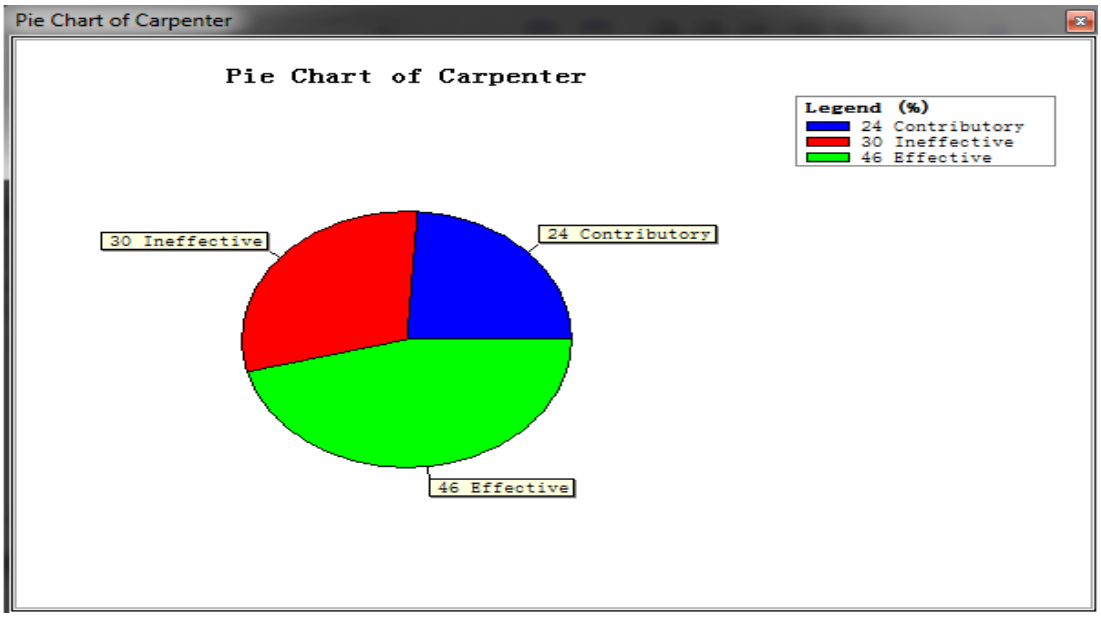


Figure 12: Pie Chart Produced using ArcGIS for Carpenter

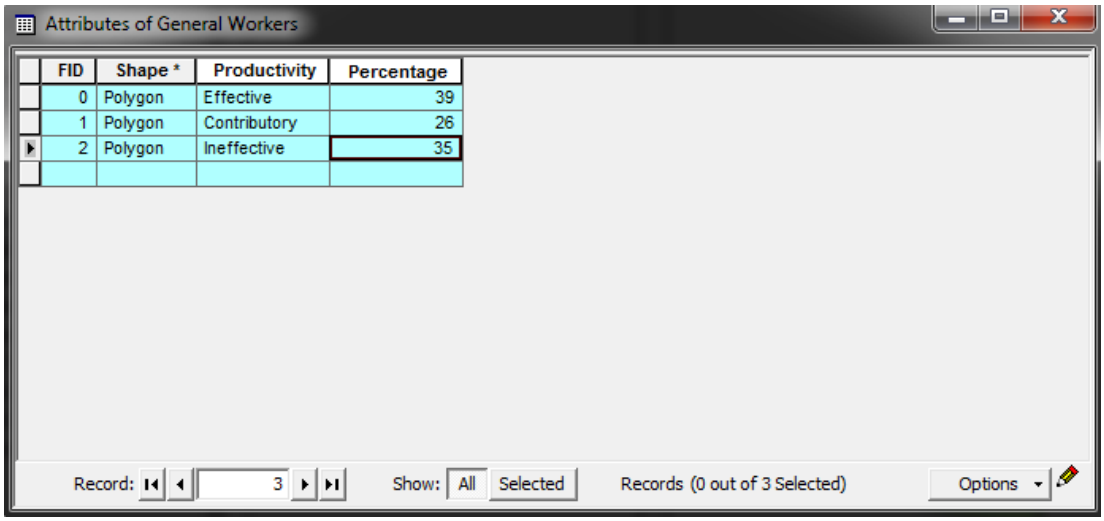


Figure 13: General Worker 'List of Tables'

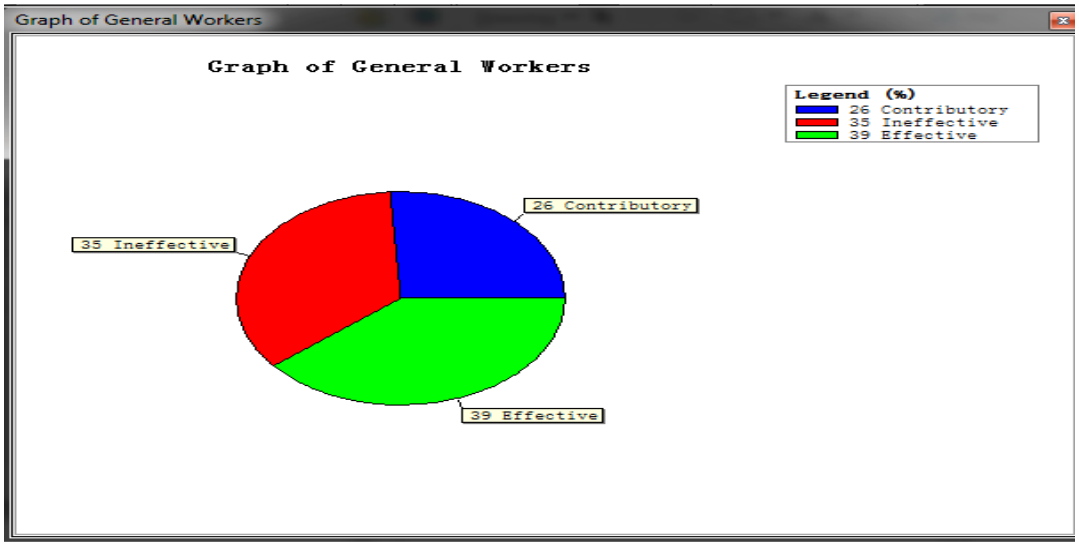


Figure 14: Pie Chart Produced using ArcGIS for General Worker

4.4 Discussion of Overall Analysis

From the results, it showed that the work production rate at the UTP R&D Research Centre for the three major types of workers; carpenter, bar bender and general worker mainly consisted of effective work. This information gives a definite result that the work productivity rate of the construction site is having progress as the amount of percentage of the effective work rate is higher than the contributory work rate and the ineffective work rate. By using the GIS software, all the productivity data can be presented easily by looking at the design layout drawing.

Although all the three major work force for the UTP R&D Research Centre consisted of effective work, but all both three work forces each have different value of effective work, contributory work and ineffective work percentage. The carpenters has shown that their effective work, 46%; contributory work, 24%; ineffective work 30%. As for the bar benders, their effective work was 63%; contributory work, 19%; ineffective work, 18%. Lastly for the general workers, their effective work was 39%; contributory work, 26%; ineffective work, 35%. As seen from the summary of the work productivity percentage, it shows that the bar bender working in the site has the highest amount of the effective work and with the least amount of ineffective work. While on the other hand, the effective work for the carpenters and general workers are not that high as compare to the bar bender and the general workers have the worst effective work as their ineffective work is the highest among the three types of workers.

The different in the percentage of work in these three workers are caused by a few factors after a few details analysis from the site survey and results obtained. First of all is due to the timeline of the project as when the time the work sampling method was carried out the project was almost completed towards the end and the work method of each workers were different. Hence the effective works for the carpenters were not high as there is much less work for them since they are installing for the last formwork design for the roof and dismantling formwork at the 3rd floor and 2nd floor. Furthermore, the carpenters have to measure the length and width of the formwork according to each drawing design and this took quite some time. Next for the bar bender, their work consisted the highest effective rate because most of the formwork has been installed by the carpenter and the bar bender must quickly installed the

rebar's into the formwork for casting. The bar bender also doesn't need to waste their time in bending rebar or looking at the design drawing because the rebar for the beam was installed at the ground floor and hoisted to the top of building for installation. Hence, the effective work that the bar bender showed are mostly consisted of tying rebar and installation of links for rebar reinforcement. Lastly, for the general workers their effective work was not that high if compared to carpenter and bar bender was within expectation. This was because the work of the general workers mostly consisted of simple general work and supportive work in the site. Furthermore, the general worker in the site has to render cement by using manual work force; hence most of their times were used in waiting and talking while waiting for the time to pass for the cement to uniformly mix.

In addition, the ethnics of the workers were one of the main factors that determined the effectiveness rate of the works. In the site, most of the carpenters, bar benders and general workers are made up from foreign workers came from Indonesia and Bangladesh. From the site preliminary survey, it can be shown that most of the Indonesian workers are much committed into their works as compare to the Bangladesh workers. Indonesian workers do spend most of their time focusing in their works and taking a break at the appointed time. As for the Bangladesh workers, a part of them likes to chit chatting during the work hours and they tend to leave their job 10 minutes before the appointed break time. This causes most of the work sampling data recorded the activities to be ineffective rate as it is almost near the break time. On the other hand, the day of the week also play a major role in determining the workers productivity rate. Usually most of the workers tend to work harder on Monday as Monday is the first day of work. Psychologically all the workers shall give all their best on the first day of work. But, as Monday move on to Friday, the workers shows that their working productivity may start to decrease especially on Friday. The workers mentioned that they has a feeling of going home as compare to Monday, hence the productivity rate of the workers usually are high on Monday and tends to decrease as they work till the end of the week.

CHAPTER 5

CONCLUSION

In summary, the author has used the UTP R&D Research Centre as one of the author project analysis. For this project, there were three objectives; to determine the work production rate of three type of major work (carpenter, bar bender, general worker) by using the work sampling method, and then the difference in the effective work for these three major works were compared and discussed. Lastly, the data were to be spatial analysed by using the ArcGIS software. Hence, from the results it shows that the bar bender activities has the highest effective work rate following by the carpenter work and lastly the general worker work rate. Each of them have different qualities of work rate due to several factors such as the different in working method, the timeline of the construction period and the attitude of the workers. Next, the data obtained from the work sampling method were to be spatial analysed using the ArcGIS 9.3 software by creating 'polygons' of different layers according to each work forces. The data was store in each layer and presentable by using a pie chart to show the effectiveness rate of each work forces. As a conclusion, all three objectives of the project were achieved.

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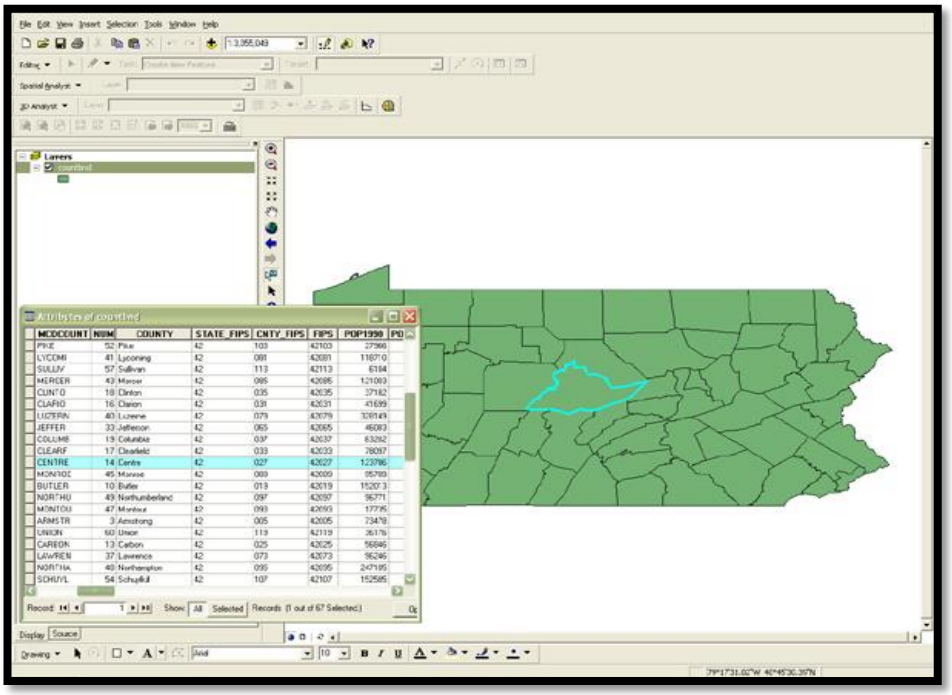
APPENDIX I

UTP R&D Research Centre finishing design



Mapping using GIS software

Workers rendering cement

Carpenters and bar benders focusing on lower roof area

APPENDIX II
Raw Data

Classification	Code No.	Element of Bar Bender Activities	Remark
Effective Work	E1	Installing Rebar	
	E2	Tying Rebar	
	E3	Installing Links	
	E4	Cutting Rebar / Bending	
	E5	Installing Block Spacer	
	E6	Installing BRC Wire Mesh	
Contributory Work	C1	Carrying Rebar	
	C2	Reading Drawing	
	C3	Confused	
	C4	Measuring Rebar Length	
	C5	Hoisting Rebar/ BRC Wire Mesh	
Ineffective Work	I1	Idle and Away	
	I2	Talking	
	I3	Resting	
	I4	Waiting	
	I5	Rework	
	I6	Walking	

E6 Rendering work

Classification	Code No.	Element of Generals Workers Activities
Effective Work	E1	Hacking
	E2	~~Larvae Ciding~~ Formwork
	E3	Housekeeping
	E4	Cleaning / Blowing
	E5	Installing Beam Soft Fit
Contributory Work	C1	Pushing Wheelbarrow
	C2	Carrying Things
	C3	Marking Setting Line
	C4	Hoisting Materials
	C5	Taking Leveling
Ineffective Work	I1	Idle and Away
	I2	Talking
	I3	Resting
	I4	Waiting
	I5	Rework
	I6	Walking

C6 - Giving instructions / coordinating with operators.

Classification	Code No.	Element of Carpenters Activities	Remark
Effective Work	E1	Installing Conventional Formwork for Beam and Slab	
	E2	Installing Conventicnal Formwork for Column	
	E3	Installing Formwork for Staircase	
	E4	Cutting formwork	
	E5	Installing Beam Soft Fit	
	E6	Dismantling Formwork	
Contributory Work	C1	Carrying Formwork Pieces	
	C2	Reading Drawing	
	C3	Marking Setting Line	
	C4	Measuring Formwork Length	
	C5	Hoisting Conventional Formwork	
	C6	Setting up scaffolding	
Ineffective Work	I1	Idle and Away	
	I2	Talking	
	I3	Resting	
	I4	Waiting	
	I5	Rework	
	I6	Walking	

WORK SAMPLING OBSEIRVATION SHEET (PILOT)

Contract: 12th Floor Office Block B	Time started: 11.05am Time finished: 11.50am	Sheet No: 1 Date: Observer: Joshua
Job Description: Bar bender		
Location: ~~Oasis Corporate Park (OCP)~~		
Activity Code: As stated above	Notes: Bright & Sunny.	

Round Number	Time	Workers					Remarks
		W1	W2	W3	W4	W5	
1	11.05	E2	E2	E2	E4	E4	
2	11.10	E2	E2	E2	E3	I3	
3	11.15	E2	I3	E2	I3	E4	
4	11.20	I3	E2	E2	E4	E4	
5	11.25	E2	E2	E2	E3	E4	
6	11.30	C4	C4	E1	E4	E4	
7	11.35	E2	E2	I3	E4	I3	
8	11.40	I3	I3	I3	I3	I3	
9	11.45	E4 I3	E6 I3	I3	I3	I3	
10	11.50	I3	I3	I3	I3	I3	

WORK SAMPLING OBSERVATION SHEET

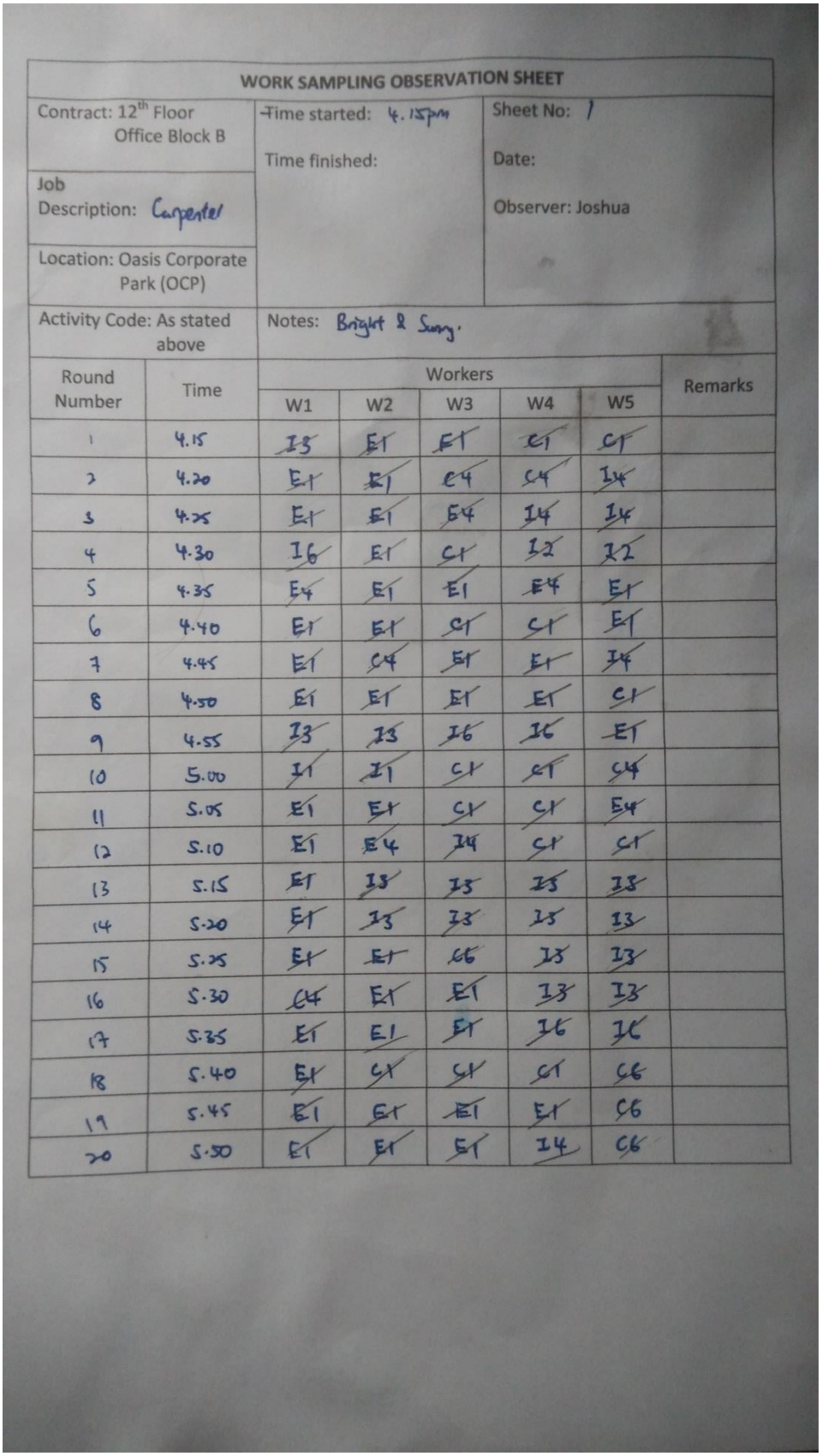
Contract: 12th Floor Office Block B	Time started: 4.15pm Time finished:	Sheet No: 1 Date: Observer: Joshua
Job Description: B-B		
Location: Oasis Corporate Park (OCP)		
Activity Code: As stated above	Notes: Bright & sunny.	

Round Number	Time	Workers					Remarks
		W1	W2	W3	W4	W5	
1	4.15	E1	E2	E2	E1	E1	
2	4.20	E3	E2	E2	E3	E3	
3	4.25	E3	E2	E2	I6	I2	
4	4.30	C1	E1	E2	E2	E1	
5	4.35	E2	E2	I2	I2	E2	
6	4.40	E1	E2	C1	E2	E2	
7	4.45	E2	E2	I4	E2	E2	
8	4.50	E2	I3	E1	E2	E2	
9	4.55	C5	C5	C5	C5	C5	
10	5.00	E2	E2	I2	I2	E2	
11	5.05	I3	I3	I3	I3	I3	
12	5.10	I4	C5	C5	C5	I1	
13	5.15	I4	E2	E2	E2	E2	
14	5.20	E2	E2	E2	E2	E2	
15	5.25	E2	E2	E2	E2	E2	
16	5.30	E2	E2	I6	E2	E2	
17	5.35	E2	E2	C5	C5	E2	
18	5.40	E2	E2	E2	I1	E2	
19	5.45	C5	C5	C5	C5	C5	
20	5.50	E1	C5	C5	E1	E1	

WORK SAMPLING OBSERVATION SHEET (Pilot)

Contract: 12th Floor Office Block B	Time started: 1.45pm Time finished: 2.30pm	Sheet No: 1 Date: Observer: Joshua
Job Description: Carpenter		
Location: Oasis Corporate Park (OCP)		
Activity Code: As stated above	Notes: Bright & Sunny.	

Round Number	Time	Workers					Remarks
		W1	W2	W3	W4	W5	
1	1.45	E6	E6	E1	E1	E1	
2	1.50	E6	I3	E1	E1	E1	
3	1.55	E6	E6	C1	E1	E1	
4	2.00	E1	E6	I4	E1	E1	
5	2.05	E4	E1	C5	C5	E1	
6	2.10	C1	C6	E1	I4	I4	
7	2.15	E1	E1	C1	E1	E1	
8	2.20	E1	I3	C4	C1	E1	
9	2.25	I6	E1	E1	I2	C6	
10	2.30	E1	E1	C1	C6	C6	



WORK SAMPLING OBSERVATION SHEET

Contract: 12th Floor Office Block B	Time started: 4.15pm	Sheet No: 1
	Time finished:	Date:
Job Description: Carpenter		Observer: Joshua
Location: Oasis Corporate Park (OCP)		
Activity Code: As stated above	Notes: Bright & Sunny.	

Round Number	Time	Workers					Remarks
		W1	W2	W3	W4	W5	
1	4.15	I3	E1	E1	C1	C1	
2	4.20	E1	E1	C4	C4	I4	
3	4.25	E1	E1	E4	I4	I4	
4	4.30	I6	E1	C1	I2	I2	
5	4.35	E4	E1	E1	E4	E1	
6	4.40	E1	E1	C1	C1	E1	
7	4.45	E1	C4	E1	E1	I4	
8	4.50	E1	E1	E1	E1	C1	
9	4.55	I3	I3	I6	I6	E1	
10	5.00	I1	I1	C1	C1	C4	
11	5.05	E1	E1	C1	C1	E4	
12	5.10	E1	E4	I4	C1	C1	
13	5.15	E1	I3	I3	I3	I3	
14	5.20	E1	I3	I3	I3	I3	
15	5.25	E1	E1	C6	I3	I3	
16	5.30	C4	E1	E1	I3	I3	
17	5.35	E1	E1	E1	I6	I6	
18	5.40	E1	C1	C1	C1	C6	
19	5.45	E1	E1	E1	E1	C6	
20	5.50	E1	E1	E1	I4	C6	

WORK SAMPLING OBSERVATION SHEET (PILOT)

Contract: 12th Floor Office Block B	Time started: 11.05am Time finished: 11.50am	Sheet No: 1 Date: Observer: Joshua
Job Description: G.W		
Location: ~~Oasis Corporate Park (OCP)~~		
Activity Code: As stated above	Notes: Right & Sway	

Round Number	Time	Workers					Remarks
		W1	W2	W3	W4	W5	
1	11.05	~~E6~~	~~E6~~	~~I4~~	~~I2~~	~~I2~~	
2	11.10	~~E6~~	~~E6~~	~~C2~~	~~I4~~	~~I4~~	
3	11.15	~~E6~~	~~E6~~	~~E6~~	~~I4~~	~~E6~~	
4	11.20	~~I1~~	~~I1~~	~~E6~~	~~E6~~	~~E6~~	
5	11.25	~~I4~~	~~I4~~	~~E6~~	~~E6~~	~~I1~~	
6	11.30	~~I4~~	~~I1~~	~~I1~~	~~I1~~	~~I1~~	
7	11.35	~~C2~~	~~C2~~	~~E6~~	~~E6~~	~~I1~~	
8	11.40	~~I4~~	~~C2~~	~~I1~~	~~I1~~	~~I1~~	
9	11.45	~~E6~~	~~E6~~	~~I6~~	~~I6~~	~~I6~~	
10	11.50	~~E6~~	~~I3~~	~~I3~~	~~I3~~	~~I3~~	

WORK SAMPLING OBSERVATION SHEET

Contract: 12th Floor Office Block B	Time started: 1.55pm Time finished:	Sheet No: 1 Date: Observer: Joshua
Job Description: G W		
Location: Oasis Corporate Park (OCP)		
Activity Code: As stated above	Notes:	

Round Number	Time	Workers					Remarks
		W1	W2	W3	W4	W5	
1	1.55pm	E6	E6	C1	I1	I1	
2	2.00	E6	C2	C2	C1	C1	
3	2.05	E6	C6	E6	C1	C1	
4	2.10	E6	E6	I4	C2	C6	
5	2.15	E6	C6	C2	E6	E6	
6	2.20	E6	E3	I4	C1	E6	
7	2.25	I1	C1	C1	C2	C2	
8	2.30	E6	I4	I4	I4	I1	
9	2.35	E6	E4	I4	E6	I1	
10	2.40	C4	I4	I4	C6	E6	
11	2.45	I3	C1	C1	I4	I1	
12	2.50	I1	C1	C1	E6	I1	
13	2.55	I1	C1	I1	I1	I3	
14	3.00	I1	C1	I1	I1	I1	
15	3.30	E6	E6	I4	I4	I4	
16	3.35	E6	E6	I4	E6	I4	
17	3.40	E6	C1	I1	I1	E1	
18	3.45	E6	E6	I4	I6	E1	
19	3.50	E6	E6	E6	E6	E1	
20	3.55	E6	E6	I4	E6	E1	