ACCURATE ESTIMATING ON LABOUR PRODUCTIVITY IN SRI LANKAN CONSTRUCTION INDUSTRY

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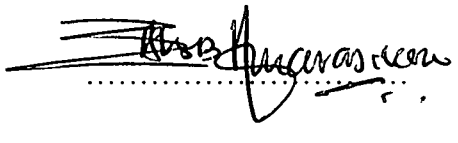
Dedication

To my parents

A Study Submitted in Partial Fulfillment of the Requirements of the Degree of Master of Science in Project Management

Declaration

I hereby declare that this submission is my own work and that, it contains no materials previously published or written by another person nor material which, to a substantial extent, has been accepted for the award of any other degree of diploma of a University of other institution of higher learning, except where an acknowledgement is made in the text.



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I hereby acknowledge that Mr. E. A. L. S. B. Amarasekera has followed the dissertation process set by the Department of Building Economics.

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Prof. R. Rameezdeen

Dissertation Supervisor

Date

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LIST OF ABBREVIATIONS

UPA _ Unit price Analysis

TFP – Total Factor Productivity

UK-United Kingdom

Hrs- Hours

Sqm- Squire Meter

Qty- Quantity

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ABSTRACT

Sri Lankan Construction Industry is greatly concerned about Labour Productivity. Estimating labour accurately has become predominantly a difficult task in the industry. Literature survey was conducted to ascertain indices developed by other countries to measure labour productivity, Factors affecting labour productivity etc..

Case Study research was carried out in Three buildings types Namely **High Rise, Medium Rise and Low Rise** categories in relation to **Cement Block Work, Plastering and Tiling trades.** Hrs per Unit Measurements together with Novel Tool Time Analysis Techniques were used in conducting case studies. All parameters pertaining to the labour study were kept equal in all three building types during the case study research, but the study carried our in open environment where no controls have been introduced.

Research suggests that single labour rate is not meaningful for every eventuality in construction. It was found that the Best Tool time in other words Best Productivity exists in Medium Rise Buildings, and the Least Productivity recorded in High Rise Building projects. Average Productivity was evident in Low Rise Buildings.

Keywords: Labour Productivity, Tool |Time, Construction Industry

INTRODUCTION

Labour productivity is studied in this report in extensive manner by way of case studies in different perspectives focusing the attention on how the labour behaves in different types of projects. Three types of building projects were selected and studied the behavior pattern of very useful construction trades to find out a common relationship of them with respect to the project type. Buildings are categorized into High Rise, Medium Rise and Low Rise in the study and Hollow Cement block work, Cement Plaster and Laying of tiles were studied in relation to labour productivity in the three building types identified.

Hrs per unit measurement of the trades as identified has been studied for a period of six months to devise the behavior pattern on skilled and unskilled labour. Further a novel Tool Time analysis technique too has been conducted in the three building categories in the same trades to further strengthen the research findings of the Hrs per unit measurement if any as an alternative methodology. Tool Time analysis technique is extensively elaborated in this report in Chapter 4

Chapter One while deals with the definitions of the key areas of the study chapter two will elaborate the studies carried out by various other researches on this subject. Chapter Three will illustrate the Case Study elements, research limitations and their characteristics. Organisation culture of which the case study was based on also explained in this chapter. Chapter Four will focus on the two types of case studies carried out and their results in explanative manner. Most of the results have been illustrated in graphical form for easy understating. Research findings and further research hints are explained in the last chapter.

CHAPTER ONE

CHAPTER ONE

1.1 BACKGROUND TO THE STUDY

Construction is a labour intensive business and which is still one of the most unproductive sectors in any economy. In other words, in every construction business one of the largest expenses a construction company has is labour. It represents 20% to 50% of the construction cost. Yet many contractors neglect to invest time and effort necessary to learn exactly what encompasses true labour rate. They merely hope that few extra rupees above what they are already paying their employees will cover everything. They do not recognize the fact that many projects run into cost overruns because the labour cost was not bid accurately.

Labour wage/cost cannot be changed or reduced in a given context. However the burden of labour can be reduced by increasing the productive time of labour and thereby resulting a lower cost per hour of labour. It is not unusual a labour to be productive only 60% of his time, however increasing this percentage by 15% will dramatically and positively influence the labour cost and in return the bottom line of the organization.

Human resource is the most focused factor in any business in the new millennium. Similarly it is vital that a proper study is conducted into the labour in construction industry to identify an accurate labour rate and strategies available to reduce the labour cost and ultimately to increase the productivity of labour. Further workers are not machines which behave similar in same conditions, therefore labour even under apparently similar condition different productivity values could be expected.

Because of the diversity of the construction industry, a single index for the entire industry is neither meaningful nor reliable. Data available in many documents published in Sri Lanka has not been successful in providing a construction estimator a proper guide to accurate estimating of labour. However resolving day today labour issues in various nature is a more common phenomenon in construction industry. Their issue and concerns are variable and situational. Not a single day passes in a construction company not having exposed to a issue with respect to labour. Labour is a subjective factor where no one is able to provide an universal answer to actual labour rate and similarly to labour productivity.

The history of the construction is as old as human being. Every day every year some improvements implemented to how to get a thing done in a more productive way. Good project management in construction must vigorously pursue the efficient utilization of labour, material and equipment. Improvement of labour productivity should be a major and continual concern of those who are responsible for cost control of constructed facilities. To date not a single activity is found to be 100% productive, hence the continual improvements are being taken place. It is common that every time a construction company finds out the best productive way of getting a thing done only when the work is already completed.

Therefore it was felt important that a study on labour to be carried out more extensively to identify and introduce accurate labour productivity norms to the construction industry with specific relevance to the building type.

1.2 SIGNIFICANCE OF THE STUDY

It is evident that the success of any estimator is largely dependant upon the accurate estimate of the labour in any competitive bid. Researching into such a important

phenomena is further strengthen by the absence of a proper estimating guide in the Sri Lankan industry on labour. Every researcher has to devise his or her own method in arriving at an accurate labour productivity estimates. On the other hand some companies think that their labour productivity data are company secrets. As previously explained this is justified by that the 20% to 50% of a cost estimate consists of labour. Keeping this limitation in mind, it was thought necessary to pay emphasis to the subject area to find out what the other developed and developing countries have done on this subject area and relate some of the studies to our context and research and invent a proper guide to an accurate estimating of labour productivity.

Cultural, Technological, Financial, Attitudes or even Supervision could lead to a different labour productivity. Therefore study cannot be confined to one or two situations. If do so the results will not be effective. Therefore it was felt important to study the subject given the certain parameters so that the further use of the study results could be envisaged by modifying it to a given situation. Research and case study will be carried out to have a more logical approach to study labour behavior and productivity related issues in order to devise a framework which will encompasses the decision making platform to improve labour productivity with the given situation. The decision on an accurate labour rate with the given situation will also be derivable through this framework. It was decided that non of these case studies or researches will be done in close environment. They will be uninformed and ad-hoc studies so that the respondents will not have a tendency to provide abnormal results or in other words deviate from their normal behavior. Further the Study environment will be well informed with the study enabling the user of the information to adjust the results into his or her appropriate situation.

1.3 WHAT IS MEANT BY LABOUR PRODUCTIVITY

Productivity in construction is often broadly defined as output per labour hour. Since labour constitutes a large part of the construction cost and the quantity of labour hours in performing a task in construction is more susceptible to the influence of management than are materials or capital, this productivity measure is often referred to as *labor productivity*. However, it is important to note that labour productivity is a measure of the overall effectiveness of an operating system in utilizing labour, equipment and capital to convert labour efforts into useful output, and is not a measure of the capabilities of labour alone. For example, by investing in a piece of new equipment to perform certain tasks in construction, output may be increased for the same number of labour hours, thus resulting in higher labour productivity. (C. Hendrickson, 1998)

When creating job estimates, contractors generally use a true labour rate (including non-productive time) and divide that rate by the hours the employee actually worked that year. If owners haven't been tracking this information, a true labour rate can still be calculated. A normal work year is 2,080 hours (40 hours per week x 52 weeks per year). Although this hourly figure includes the usual 10 days of vacation, various holidays, sick days and compensation days, it doesn't differentiate between productive and non productive time.

If employees are only productive an average of six hours a day, this amounts to 10 hours per week. Excluding the two weeks of vacation, this is 500 hours (10 hours per week x 50 weeks) that employers are paying for non-productive time. Therefore, the true productive rate an owner should be using is 2,580 hours (2,080 work year hours plus 500 unproductive hours). By using this rate when preparing job estimates, an

owner will be better prepared if the job takes more time than anticipated. (Finman. R. 2007)

The productivity of the work force is expressed as the ratio of the actual unit man-hours to those used in the target estimate. For example if an activity is estimated to take 2000 man-hours to install 100 tons of steel, it is based on the unit rate of 20 man-hours per ton. If in reality, the same activity consisted of 120 tons of steel and required 2280 man-hours to complete, then the unit rate actually achieved is 19 man-hours per ton. The productivity of the work crew, in this case, is 19:20 = 0.95. This methodology therefore measures the 'macro' productivity with reference to the target estimate as its base.

Unit man-hours is usually defined as the man-hours needed to install unit quantity of work such as a cubic meters of concrete, a ton of structural steel, a square meter of insulation etc. These rates are available from published data compiled from historical project experience. They represent average values compiled from a number of previously completed projects. These unit rates tend to lump together the direct work hours with the non productive indirect hours such as time spent on walking empty-handed or with tools or materials, waiting for elevators, snack breaks etc. The productivity measured using these unit rates does not therefore address quantitatively the effect of the non-productive indirect work hours. Considering the example cited above, the achieved productivity, although above par, would not give any clue about the extent of indirect and/or wasted hours expended by the work force. As such, if the actually achieved unit rate compares well with the target estimate, such inefficiency may remain masked throughout the project execution unless a technique of a different kind is employed to measure the productivity at the 'micro' level. (P+A Innovators Corp, 2004)

It is convenient to express labour productivity as functional units per labour hour for each type of construction task. However, even for such specific purposes, different

levels of measure may be used. For example, cubic meters of concrete placed per hour is a lower level of measure than killometers of highway paved per hour. Lower-level measures are more useful for monitoring individual activities, while higher-level measures may be more convenient for developing industry-wide standards of performance.

For this general type of productivity measure, it is more convenient to express labour productivity as constant Rupee per labour hours since rupee values are more easily aggregated from a large amount of data collected from different sources. The use of constant rupee allows meaningful approximations of the changes in construction output from one year to another when price deflators are applied to current rupees to obtain the corresponding values in constant rupees. However, since most construction price deflators are obtained from a combination of price indices for material and labour inputs, they reflect only the change of price levels and do not capture any savings arising from improved labour productivity. Such deflators tend to overstate increases in construction costs over a long period of time, and consequently understate the physical volume or value of construction work in years subsequent to the base year for the indices.

CHAPTER TWO

CHAPTER TWO

2.1 HISTORICAL PERSPECTIVE

The use of new equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades. Organizations which do not recognize the impact of various innovations and have not adapted to changing environments have justifiably been forced out of the mainstream of construction activities.

Observing the trends in construction technology presents a very mixed and ambiguous picture. On the one hand, many of the techniques and materials used for construction are essentially unchanged since the introduction of mechanization in the early part of the twentieth century.

In contrast to this view of one large project, one may also point to the continual change and improvements occurring in traditional materials and techniques. Bricklaying provides a good example of such changes:

Bricklaying...is said not to have changed in thousands of years; perhaps in the literal placing of brick on brick it has not. But masonry technology has changed a great deal. Motorized wheelbarrows and mortar mixers, sophisticated scaffolding systems, and forklift trucks now assist the bricklayer. New epoxy mortars give stronger adhesion between bricks. Mortar additives and cold-weather protection eliminate winter shutdowns.

Add to this list of existing innovations the possibility of robotic bricklaying; automated prototypes for masonry construction already exist. Technical change is certainly occurring in construction, although it may occur at a slower rate than in other sectors of the economy.

With a strong technological base, there is no reason why the construction industry cannot catch up and reassert itself to meet competition wherever it may be. Individual design and/or construction firms must explore new ways to improve productivity for the future. Of course, operational planning for construction projects is still important, but such tactical planning has limitations and may soon reach the point of diminishing return because much that can be wrung out of the existing practices have already been tried. What is needed the most is strategic planning to usher in a revolution which can improve productivity by an order of magnitude or more. Strategic planning should look at opportunities and ask whether there are potential options along which new goals may be sought on the basis of existing resources. No one can be certain about the success of various development options for the design professions and the construction industry. However, with the availability of today's high technology, some options have good potential of success because of the social and economic necessity which will eventually push barriers aside. Ultimately, decisions for action, not plans, will dictate future outcomes.

2.2 INDICES DEVELOPED BY OTHER COUNTRIES TO MEASURE LABOUR PRODUCTIVITY

2.2.1 UNIT PRICE ANALYSIS DEVELOPED BY TURKEY

The construction unit price analyses (UPA) are published every year as a book. A considerable modification does not become necessary from year to year; only a few new work items are added and some old and unused ones are removed. All input

prices, indirectly unit prices, changed as well. It is expected that man hours included by UPA differ a little from those in site in normal conditions. But recently, it has been discussed that there is a big difference between man hours in practice and in UPA. Actually, shortening in man hour values is an expected development due to technological improvements, change of construction types, increasing level of labour education, etc. However, any shortening has not been reflected to UPA, and any study has not been carried out related to what the change in quantity is and should be. Recent times the UPA has become inaccurate to some extent.(Ulubeyli. S, Aynur. K, 2003)

2.2.2 TOTAL FACTOR PRODUCTIVITY (TFP) MEASUREMENT IN SINGAPORE

Total factor productivity (TFP) determines long-term economic growth and is a comprehensive industry-level productivity measure. TFP growth is found down by 1.53% per annum over this period, indicating that the performance of TFP in the construction industry lags behind the rest of economy. TFP growth is also found to be fluctuating over time and tends to move in tandem with the construction business cycle. As a monitor of progress towards TFP achievement, factors influencing TFP growth in the construction industry of Singapore over 1984-1997 are identified. Seven factors are found to be significantly related to TFP growth. Among them, economies of scale, R&D by the industry, investment allowance granted and labour unions are leading contributors to TFP growth; while foreign worker, construction accidents and pre-cast are major hampers. (Ofori.G, Shi. M, 2003) The general methodology presented in this study can be applied to other countries. Future studies are required to find appropriate indicators for factors un-quantified.

2.2.3 LABOUR ESTIMATE FACTOR

The method presented achieves this by utilising the productivity rates of contractors' planning engineers for a 'typical' building type (in this instance, a concrete framed high-rise structure is featured). The estimated labour resource requirements for such a building constructed in France, Germany and the UK are calculated. Planned productivity rates form the basis of the estimate, these being used to generate a 'Labour Estimate Factor'. This factor is defined as the man-hour requirements per square meter of the building's gross floor area. Respective national all-in wage rates are then applied to forecast estimated budget costs, for construction in each international location. The calculations are based on a 'typical' design, hence, they are applicable to other buildings of similar type and form. Armed with relevant data, resource estimates could similarly be generated for alternative international locations, and, for different classifications of 'typical' building forms. The process will be of interest to practitioners and clients\customers of the international construction industry (Olomolaiye. P. O, Proverbs D. G,1999)

2.2.4 PRODUCTIVITY TOOL TIME DEVELOPED BY CANADA

"Top Ten Targets for Improving Construction Productivity" project investigates ten strategic areas, including both soft and hard issues of productivity, to develop innovative and sustainable solutions for the construction industry. The ten strategic areas include motivation, supervision, integration, material management, tool time optimization, work practices, communication, schedule optimization, change prediction, and weather impact.(Ruwanpura. J, 2009)

One of the criteria among above as studied in University of Calgary, Canada is **Productivity Tool Time**. This measures the actual time spent by a worker to do a

certain task and it will be compared against the time loss by the worker due to non productive time. So that the necessary changes to the system introduced to reduce the non productive time. Eg. 1. Time taken for waiting for tools and materials to be reduced, Eg.2 Time taken for waiting for instructions to be reduced. So that They measure the improvement in productive time over a period of time. It could be considered as a global measure in all trades or can also be considered as an individual unit rate. This measure is further elaborated in the Chapter 4

2.3 FACTORS AFFECTING LABOUR PRODUCTIVITY AS PERCEIVED BY DIFFERENT COUNTRIES

US industry, The results indicate that cost control, scheduling, design practices, labour training, and quality control are the functions that consistently over the years are perceived as having considerable room for productivity improvement, whereas materials packaging and foreign developments in construction technologies are perceived consistently as functions that do not have much effect on improving construction productivity.(Arditi. D,Mochtar. K, 2000)

Nigeria, Comparative analysis of sites with and without incentives showed that non-financial incentive schemes significantly improved bricklayers' productive time and these schemes accounted for 6% to 26% of the variations in output between the two sets of sites on block laying and concreting activities measured.(Fagbenle. O, Adesanya. D. A, 2004)

Many studies point to the high rates of labour and total factor productivity growth in Japan during the early post-War period as the principle cause of the rise of the Japanese economy. (Bosworth. D, Nakayama. M, 2005)

Study of building projects at Gaza Strip: The analysis of 45 factors considered in a survey indicates that the main factors negatively affecting labour productivity are: material shortage, lack of labour experience, lack of labour surveillance, misunderstandings between labour and superintendent, and drawings and specification alteration during execution.(Enshassi. A, Mayer. P.E,2007)

UK, developed linear regression models show that the concept of multiskilling obeys the 'law of diminishing returns'. That is, a weak relation was found between construction output and a three or more combination of manpower attributes. An optimization model is prescribed for traditional trades. (Ejohwomu. O. A, Olomolaiye, 2008)

Turkey, The results show that monetary factors remain pre-eminent in influencing productivity, but that socio-psychological factors appear to be of increasing importance in this developing economy.(Ulubeyli. S, Aynur. K, 2003)

Owners pay employees for eight hours of work per day, but do they actually do a full day's work for a full day's pay? In some cases, employees might be only 75 percent productive, which computes to six hours of work per day, even though the employee is being paid for eight hours.

Similarly, although some employees may be working the full eight hours per day, their productivity may not be as high as the output of other employees. Therefore, true labour costs need to include unproductive hours or activities, or other personnel inefficiencies.

Research in Singapore reveals that difficulty in the recruitment of supervisors, difficulty in the recruitment of workers, and a high rate of labour turnover, language

barrier of foreign workers, and not significantly the stop-work orders issued because of infringement of government regulations, and work stoppage resulting from disputes with owners/consultants affecting their productivity.(Lim E. C, 1992)

Cultural differences cause productivity ups and down, It can be illustrated by the following example.

French contractors planned to deploy the smallest site management team and labour workforce; which was mainly skilled and directly employed. Their operatives were allocated longer official periods of relaxation and required to work fewer hours. German contractors, while using more managerial staff than French firms, intended to employ the largest workforce, this being predominantly skilled and also directly employed. Working a maximum of five days each week, German firms planned longer working hours, which when considered on a weekly basis were in excess of what is considered (optimally) productive. UK practice included the utilisation of additional managerial staff (compared to France and Germany), combined with subcontract, mainly semi-skilled labour. Planned weekly working schedules were in excess of those elsewhere, and consequently different productivity levels are envisaged. (C. Hendrickson, 1998)

Job-site productivity is influenced by many factors which can be characterized either as labour characteristics, project work conditions or as non-productive activities.

The labor characteristics include:

- Age, skill and experience of workforce
- Lleadership and motivation of workforce

The project work conditions include among other factors:

- Job size and complexity.

- Job site accessibility.
- Labour availability.
- Equipment utilization.
- Contractual agreements.
- Local climate.
- Local cultural characteristics, particularly in foreign operations.

The non-productive activities associated with a project may or may not be paid by the owner, but they nevertheless take up potential labour resources which can otherwise be directed to the project. The non-productive activities include among other factors:

- Indirect labour required to maintain the progress of the project
- Rework for correcting unsatisfactory work
- Temporary work stoppage due to inclement weather or material shortage
- Time off for union activities
- Absentee time, including late start and early quits
- Non-working holidays
- Strikes

2.4 EFFECTS ON JOB SIZE IN PRODUCTIVITY

For very large construction projects, the labour productivity index tends to decrease as the project size and/or complexity increase because of logistic problems and the "learning" that the work force must undergo before adjusting to the new environment.

A contractor has established that under a set of "standard" work conditions for building construction, a job requiring 500,000 labor hours is considered standard in determining the base labour productivity. All other factors being the same, the labour productivity index will increase to 1.1 or 110% for a job requiring only 400,000 labour-hours. Assuming that a linear relation exists for the range between jobs requiring 300,000 to 700,000 labor hours as shown in Figure 2.1, determine the labour productivity index for a new job requiring 650,000 labour hours under otherwise the same set of work conditions. (C. Hendrickson, 1998)

Figure 2-1: Illustrative Relationship between Productivity Index and Job size

- The labor productivity index I for the new job can be obtained by linear interpolation of the available data as follows:

$$I = 1.0 + (1.1 - 1.0)\left(\frac{500{,}000 - 650{,}000}{500{,}000 - 400{,}000}\right) = 0.85$$

- This implies that labour is 15% less productive on the large job than on the standard project.

2.4.1 PRODUCTIVE LABOUR YIELD

In the construction of an off-shore oil drilling platform, the potential labour hours were found to be L = 7.5 million hours. Of this total, the non-productive activities expressed in thousand labour hours were as follows:

- A = 417 for holidays and strikes
- B = 1,415 for absentees (i.e. vacation, sick time, etc.)
- C = 1,141 for temporary stoppage (i.e. weather, waiting, union activities, etc.)
- D = 1,431 for indirect labor (i.e. building temporary facilities, cleaning up the site, rework to correct errors, etc.)

Determine the productive labour yield after the above factors are taken into consideration.

The percentages of time allocated to various non-productive activities, A, B, C and D are:

$$\frac{A}{L} = \frac{417}{7{,}500} = 6\%; \qquad \frac{B}{L} = \frac{1{,}415}{7{,}500} = 19\%$$

$$\frac{C}{L} = \frac{1{,}141}{7{,}500} = 15\%; \qquad \frac{D}{L} = \frac{1{,}431}{7{,}500} = 19\%$$

The total percentage of time X for all non-productive activities is:

$$X = \frac{A+B+C+D}{L} = 6\% + 19\% + 15\% + 19\% = 59\%$$

The productive labour yield, Y, when the given factors for A, B, C and D are considered, is as follows:

$$Y = \frac{L - A - B - C - D}{L} = 100\% - 6\% - 19\% - 15\% - 19\% = 41\%$$

As a result, only 41% of the budgeted labour time was devoted directly to work on the facility. (C. Hendrickson, 1998)

The non-productive activities associated with a project should also be examined in order to examine the *productive labor yield*, which is defined as the ratio of direct labour hours devoted to the completion of a project to the potential labour hours. For example, in the repaving of highway surface, the flagmen required to divert traffic represent indirect labour which does not contribute to the labour efficiency of the paving crew if the highway is closed to the traffic. Similarly, for large projects in remote areas, indirect labour may be used to provide housing and infrastructure for the workers hired to supply the direct labour for a project. The labour hours spent on rework to correct unsatisfactory original work represent extra time taken away from potential labour hours. The labour hours related to such activities must be deducted from the potential labour hours in order to obtain the actual productive labour yield. (C. Hendrickson, 1998)

2.4.2 UTILIZATION OF ON-SITE WORKER'S TIME

An example illustrating the effects of indirect labour requirements which limit productive labour by a typical craftsman on the job site was given by R. Tucker,1998 with the following percentages of time allocation.

Table 2.1 Percentage of time Allocation Labour

Productive time	40%
Unproductive time	
Administrative delays	20%
Inefficient work methods	20%
Labor jurisdictions and other work restrictions	15%
Personal time	5%

In this estimate, as much time is spent on productive work as on delays due to management and inefficiencies due to antiquated work methods.

Job-site accessibility often may reduce the labour productivity index if the workers must perform their jobs in round about ways.

Labour availability in the local market is another factor. Shortage of local labour will force the contractor to bring in non-local labour or schedule overtime work or both. In either case, the labour efficiency will be reduced in addition to incurring additional expenses.

The degree of equipment utilization and mechanization of a construction project clearly will have direct bearing on job-site labour productivity. (C. Hendrickson, 1998)

2.5 LABOUR PRODUCTIVITY STUDY IN HIGH RISE BUILDING PROJECTS

Study carried our by D G Proverbs*, G D Holt and P O Olomolaiye School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street,Wolverhampton WV1 1SB, UK in 1999 reveals following results. They have researched into firms in German France and UK having following turnover capacity.

Table 2.2 Categorisation of Contractors in each country

	Number and percentage of Contractors					
Annual Turnover Sterling	UK		France		Germany	
	No	%	No	%	No	%
Less than 50 Million	8	25.8	5	35.7	1	10
50 milliom to 450 million	14	45.2	5	35.7	2	20
Above 450 million	9	29	4	28.6	7	70
Totals	31	100	14	100	10	100

Contractor population in each country also given in following table

Table 2.3 – Contractor Population in Each Country

	Number of Contrcators		
Number of Employees	UK	France	Germany
<50	193540	275400	55274
>50>200	765	1400	3310
>200	352	193	120
Totals	194657	276993	58704

Their analysis have been based on following four headings

Analysis one: site managerial personnel

Analysis two: daily working times and break times

Analysis three: working days per week and total working hours

Analysis four: operative employment and utilisation Study reveals significant differences between UK, German and France operative systems.

2.5.1 SITE MANAGEMENT

UK contractors assigned the highest number of site based managers/supervisors for the model project, some 40 and 20% higher than those in France and Germany respectively. The Business Round Table reported that the number of managerial and supervisory levels employed on continental sites was far less than on a typical UK site. Over staffing at the work place can result in serious cost implications and provide increased opportunities for unnecessary worker interference. Over staffing can also be a disruptive condition that can impair construction productivity. The motivation of UK site supervisors may not be what it should due to constraints in

work involvement and career development. Researches revealed that the supervisor morale and motivation levels can impact the productivity of construction firms. In Europe, and particularly in France, an engineering education is considered intellectually prestigious and a foundation for a variety of careers. By adopting the continental strategy of providing site management with a broader educational structure, their roles could be enhanced with greater personal responsibility for projects. This could lead to a reduction in managerial and supervisory levels on site. UK contractors tend to employ a larger proportion of semi-skilled workers than do French and German firms (who employ more skilled workers), and hence for the former there may be a need to employ a greater level of supervision. Furthermore, the common practice in the UK to employ subcontract labour could also impact supervision requirements. Clearly, before it is possible to suggest which supervisory practice (i.e. UK, German or French) is to be preferred, a wider appreciation of the industry, and the factors which impact such strategies is needed. (C. Hendrickson, 1998)

2.5.2 WORKING SCHEDULES

Generally it was found that construction workers in the UK, worked longer hours each week, and had less time allocated for official breaks. In the UK and Germany, actual working time per week was in excess of 45hrs (mean value), while in France, there is a statutory regulation which imposes a limit on working time (French attitudes are also more `militant'; none of the responding companies planned to work more than 43 (hrs per week). However, on a daily basis, German companies intended to work the longest hours (over 10 hrs), the sum total of which was comparable to a UK working week. The harmful effects that excessive working schedules can have on construction productivity have been well researched and documented. Work schedules that extend beyond 40 hrs per week reduce labour productivity and create excessive inflation of construction labour costs, without material benefit to the completion schedule research reported that a 12% reduction in efficiency can be expected for every 10 hrs of overtime worked. Indeed, one investigation reported that

an extension of working time from 40 to 60 hrs per week over a period of 6 weeks, resulted in the project being no further advanced than had a 40 hrs week been adhered to. Evidence provided in the survey suggests the working schedules of UK and German contractors may be excessive, and could impact production performance. French contractors achieve higher levels of productivity and efficiency through an acceptable national standard working time, which when deductions for break allowances are considered, result in an average of 40 hrs, based on a 5 day weekly schedule. Whilst UK and German workers regularly endure grueling weekly schedules, the French appear to benefit from a far shorter week, allowing operatives greater recovery time and a more relaxed working culture. (C. Hendrickson, 1998)

2.5.3 WORKFORCE CHARACTERISTICS

Labour character and attitudes will have an effect on the productivity. The performance analysis is a common tool for assessing worker quality and contribution. Factors that might be evaluated include:

- Quality of Work - caliber of work produced or accomplished
- Quantity of Work - volume of acceptable work
- Job Knowledge - demonstrated knowledge of requirements, methods, techniques and skills involved in doing the job and in applying these to increase productivity.
- Related Work Knowledge - knowledge of effects of work upon other areas and knowledge of related areas which have influence on assigned work.
- Judgment - soundness of conclusions, decisions and actions.

- Initiative - ability to take effective action without being told.

- Resource Utilization - ability to delineate project needs and locate, plan and effectively use all resources available.

- Dependability - reliability in assuming and carrying out commitments and obligations.

- Analytical Ability - effectiveness in thinking through a problem and reaching sound conclusions.

- Communicative Ability - effectiveness in using oral and written communications and in keeping subordinates, associates, superiors and others adequately informed.

- Interpersonal Skills - effectiveness in relating in an appropriate and productive manner to others.

- Ability to Work Under Pressure - ability to meet tight deadlines and adapt to changes.

- Security Sensitivity - ability to handle confidential information appropriately and to exercise care in safeguarding sensitive information.

- Safety Consciousness - has knowledge of good safety practices and demonstrates awareness of own personal safety and the safety of others.

- Profit and Cost Sensitivity - ability to seek out, generate and implement profit-making ideas.

- Planning Effectiveness - ability to anticipate needs, forecast conditions, set goals and standards, plan and schedule work and measure results.

- Leadership - ability to develop in others the willingness and desire to work towards common objectives.

- Delegating - effectiveness in delegating work appropriately.

- Development People - ability to select, train and appraise personnel, set standards of performance, and provide motivation to grow in their capacity.

- Diversity (Equal Employment Opportunity) - ability to be sensitive to the needs of minorities, females and other protected groups and to demonstrate affirmative action in responding to these needs.

The characteristics of the workforce also provided significant levels of discordance. Findings indicated that UK practice was to employ a predominantly subcontract, semi-skilled labour force. French and German contractors preferred to utilise directly employed workers with the emphasis on skilled persons. French companies planned

to employ the smallest workforce, whilst German firms had the largest, although on average just 5% of the German workforce were unskilled operatives.

This `externalization of labour force' strategy results in firms abnegating responsibility for operative training. UK operatives expect tighter supervision, (as reflected in the managerial numbers reported earlier), and are likely to be semi-skilled, rather than in France and Germany where they are skilled. Subcontracting culture in France is similar to that of the UK, but due to French law structures (subcontractors may bring an action directly against the client in the event of the main contractor not honouring payment), it is not widely used. In contrast, French firms are pursuing new labour strategies, based on `internalisation', and aimed at developing a multi-skilled and autonomous labour force. Research has found that direct labour within construction can be empowered to take full responsibility for their own processes. This seems to be the situation in France, where generally workers are expected to demonstrate the ability to organise, oversee and to control the construction process. The benefits from such labour strategies appear to facilitate the utilisation of a smaller, but more accomplished work force, demanding less supervision, and which succeed in out-performing UK and German companies. In Germany, about a quarter of skilled operatives are over 50 years old and it is estimated that by the turn of the century, about two thirds of the present labour force will have reached, or have passed retirement age. Nevertheless the major employers' associations have introduced new vocational training policies aimed at enhancing recruitment of apprentices, and attempted to upgrade further training schemes to facilitate efficient utilisation of ever more expensive equipment. The major strength of the German construction industry is the quality of the work it produces, which is reliant upon the employment of predominantly skilled operatives. The current employment practices of UK firms manifests skills shortages and inadequate training. A model similar to the French system could provide the basis for `European best practice' recommendations. (C. Hendrickson, 1998)

Above research study found that the comparison of construction practices is onerous and problematical since like-for-like building projects do not exist. Further difficulties were encountered with international comparisons. However the research concluded that following areas has a greater effect on the labour productivity.

- site managerial personnel;
- daily working times;
- break times (relaxation allowances);
- working days per week;
- total working hours;
- . skill levels of workers;
- Size of workforce;
- Modes of employment.

CHAPTER THREE

CHAPTER THREE

3.1 INTRODUCTION TO RESEARCH METHODOLOGY

Labour productivity is an area extensively studied all over the world in different angles. Literature survey revealed that no research has been able to give a panacea for the all the problems encountered in labour productivity. In this study emphasis were made to identify the relationship of the labour productivity with respect to the quantity of work involved and type of building. It is a general belief that the labour rate for a given item of work is constant in any context. Researches too, have not specifically focus on labour productivity related issues in different quantum of work and different types of buildings.

It was decided to deploy a case study research in order to observe the relationships of different building trades with respect to quantum of work and the type of the buildings. Two types of case studies were carried out in selected building projects in order to have a detailed understanding on the subject area.

It was decided to carry out above all studies in open environment where no control has been introduced. Workers were not made to be aware that there was a study being done on their productivity. It was our belief that the workers tend to work slow if they were made to understand that there is a study being carried out to find our actual labour involvement in their trades. They expect a rate hike based on the study. Supervisors of the trades were well informed that the study is purely to find out a practical labour rate for implementation. Research personnel were kept separated

from the site personnel and they were to directly report to the Contract Manager at the head office so that there will not be any influence by the site personnel.

It is important to reveal the culture of the organization before the study. This organization which came under the research has a good control over it's labour issues. There are fixed labour rates for each and every item where site personnel have no jurisdiction to increase on their own. It has to be referred to the Contract Manager for his evaluation before any rate revision. Site personnel are of the view that the control is too much and it ahould not have such control on labour rates because it is minor in nature with respect to the material and other factors. Further they claim that due to this control there are productivity losses and scarcity of labour etc. in sites.

Organisation came under study largely dependant on labour sub contractors and not on direct work force. But study reveals that the subcontractors who generally work in the organization were long standing personnel much attached to the culture of the organization. Sub Contractors were treated well in the organization where one of the sub culture being a annual evaluation of all subcontractors as per their trades and reward them for their outstanding performance. Sub Contract worker training too were extensively practiced. Payments were made to these subcontractors on well informed predetermined dates. Assistance provided in the event a subcontractor need financial assistance for buying new piece of equipments etc.. Due to this scenario although the organization largely dependant on sub contractors it is less evident that the organization faces quality issues, and manpower shortages frequently.

3.2 CASE STUDY RESEARCH ELEMENTS

These data were colleted in three different building trades. They are namely.

- Masonry Block work

- Plastering
- Tiling

3.2.1 MASONRY BLOCK WORK

Masonry block work study was limited to 200 mm thick hollow block work which is used as a partition work for framed construction of buildings. Masonry blocks were of 200mm x 400mm x 200mm in size and approximately 25kg in weight. The walls were erected by bonding these block in cement mortar 1:5 mix. Cement mortar is centrally mixed and provided by a separate gang and the masonry block work erection does not carry the cost of mixing mortar. Cement blocks were provided in a central position in sites and it is the responsibility of the workers to bring them to the work location. In Case of a high rise building they were provided with hoists to lift the material. In a scattered horizontally spread building project these blocks were deployed in close proximity to work site on request by the contractors. Cement mortar too will be distributed to close proximity in such sites so that the masonry subcontractor hauls them using a wheel barrow to the required location.

Scaffolding where if necessary will be erected by a separate gang which can be used by the masonry contractor free of charge. Internal transport of block and mortar are paid separately and this study will not cover them. Therefore this study covers only the following items of work in this masonry block work trade.

- Transporting of blocks and mortar from a 20 meter distance.
- Waiting for instructions
- Getting the lines and levels from a supervisor
- Erecting block work in Cement mortar, including necessary cutting of blocks.
- Make the chases and reveals etc..

- Erecting stiffener columns and beams in required intervals
- Providing for openings if any
- Making good both sides of wall
- Cleaning the area after erection.

3.2.2 PLASTERING

Plastering is done with cement mortar 1:5 with mixing an adhesive called feb mix instead of lime. All plastering will be done in rough nature whether it is internal or external and the smoothing of internal surfaces will be done by the painter using wall putty. Therefore the study only will be limited to rough plastering of surfaces of block or concrete surfaces. Here again the mortar will be centrally mixed and delivered to close proximity through hoist or tractors as the case may be. Limited haulage of approximately 20m distance maximum will be done by the subcontractor by his own labour which shall include in the purview of study. This study of plastering will be therefore limited to

- Transporting of mortar from 20 meter distance
- Waiting for instructions
- Making lines and levels correctly under supervision
- Rough plastering approximately to a thickness of 12-20mm
- Smoothening by a trowel
- Fixing chicken mesh in block work and concrete intersections
- Cleaning the area after work.

3.2.3 TILING

This trade includes cement screed bedding and laying of tiles with necessary cutting including applying of tile grout. Similar to the above two trades here too, the mortar for screed bedding will be centrally mixed and supplied to close proximities. Cement bags, tiles and tile grout too will be supplied to close proximity. Subcontractor's scope covers to transport of these items approximately of 20m. In this trade supervision and quality control is comparatively strict and much emphasis were given to minimize the tile waste. In this connection there will be tile shop drawing drawn and issued to site by the project manager so that the tiller has to adopt the given design on which the tile order has been based on. This work item is different in nature to other two items. Because, the time you lay the screed bed, laying of tile and the applying grout is done in three different occasions. Therefore the researches were advised to take the complete picture by observing each activity in isolation and then integrating at last for the area of tile laying achieved. In this connection the same area comes under survey in three different occasions. But it was always assured that the same contractor is doing the all three operation although it is done in three occasions. Due to the nature of this tiling operation there could be idling of labour while interfacing. Research study were only based on projects which carries larger amount of tiling operation so that the same tiller can do multi operations on then same occasion. In other words, the tiller who lays the screed bed in one location today will do the tiling in another location in the same building and do the grouting in some other location in the same building. So that he will not have any interfacing problems coupled with his productivity. We believe that therefore this study results cannot be implemented in isolated projects which has comparatively low tiling areas. Further this case study is limited to

- Transporting of Tiles and Mortar from 20 meter distance.
- Waiting for instructions
- Making the levels and line under supervision

- Lay Cement sand Screed bedding
- Necessary cutting and grinding of tiles
- Mixing cement paste
- Laying tiles by applying cement paste as per the tile design
- Applying tile grout etc and complete the job
- Cleaning the area after completion.

To carryout above three case studies we have devised a data sheet to be used by the research officers in each site. We have used a computer generated data sheet for this purpose and observe some time to identify the problems which would arise to fine tune the format. With the results we have fine tuned the format and devised a data sheet book to be given to each research officer. Theses data sheets were requested to send duly filled monthly or preferably fortnightly to head office for evaluation. As you would see in the appendix following items are required to be filled by the research officer in the data sheet.

- Project Name
- Research Officer's name
- Month of the study
- Work item
- Achievement in quantity during the period
- Total Skilled Labour hours
- Total Unskilled Labour Hours
- Total Over time Hours of Skilled and Unskilled
- Any Remarks.

Based on the data sheets received above three trades were studied in three different projects in the same organization. They are namely high Rise Residential Building, Medium Rise Hospital Building and Low Rise, horizontally spread housing complex in the view of obtaining the behavior of these trades based on the project type.

Each research officer was advised in site level how to do the study. Environment conditions, nature of operation, level of supervision have been kept equal as much as possible. Research officers were advised to maintain the research norms (prerequisites) in tact in their research items. As mentioned earlier research officers were allowed to study the project operation for two moths before starting the case study, and then on site advices has been provided to each and every problem they encountered. They were given enough freedom to choose the activity most relevant to the study. They were given liberty to discard or discontinue any activity while studying if they were found to be not normal.

Following are the three building categories came under study

3.2.4 HIGH RISE RESIDENTIAL BUILDING

This building is more than 30 storey high, residential building with two basement located in central Colombo having a gross floor area of more than 300,000 sqft. The building construction took place in 30 months for a value of over 2.5 Billion rupees. At the peak of operation there were two tower cranes, one passenger lift and one goods hoist were installed. There were around 600 workers with 60 officers, working in the project at the peak of it's operation. All the attributes relevant to the above three studies were existed in this project, such as centrally operated mortar mixing, Hoisting facilities, and strict quality control measures. Three research officers were deployed in the project to study the trades concern and the study for each activity is carried out for minimum of six months. Some results came abnormal in two stages

due to unnecessary idling time incurred due to stoppage of work being at a high security zone. Therefore the research study has to be extended to eight months in order to get results for six months.

3.2.5 MEDIUM RISE BUILDING

This building is only 5 storey high constructed in Colombo suburb to a private hospital operator having a gross floor area of 50,000 Sqft. Construction took place in 14 months excluding piling works. Extensive areas of block work, plastering and tiling available in the building to be researched. Other attributes considered as prerequisites to the research too were available on the project. Total work force of around 180 and 26 officers were in operation at peak in this project. There was a one tower crane and one passenger hoist deployed in this project. Due to the project being a Colombo suburb it has not encountered any adverse conditions for work. Workers were available in adequate numbers and project ran smoothly without any hindrance.

3.2.6 LOW RISE HOUSING COMPLEX

Our third research entity was a condominium housing complex situated in hill country having more than 320 individual housing units in a 60 acre land with extensively uneven ground surfaces. Housing units are single and two storey made out of concrete frame construction with hollow block infill, plastered and painted with tiled floors. Each house contains a gross floor area of 1500 to 2300 sqft. Nature of the project is such that the substructure work of each building has a huge variation due to ground condition being uneven. Our research items only confined to superstructure and therefore they can be considered and as an ordinary housing complex. At peak there were 800 work force with 50 over officers in operation. Cement mortar is centrally batched and distributed using tractors to work sites.

Cement block, cement, tiles too are distributed to different location by tractors. Subcontractor had to haul them to maximum of 20m using wheel barrow to his work place. Therefore it can also be considered as similar working environment to other two buildings. Scaffoldings are erected by a separate gang without cost burden to the subcontractor. Heavy quality control measures were existed in the project while two storey house in this project to be completed in maximum of 8 months. There were three research officers deployed in this project to carry out this study.

CHAPTER FOUR

CHAPTER FOUR

4.1 CASE STUDY ONE- MONITORING OF HRS PER UNIT ON TRADES

This case study research is design in such a manner that the research teams were given a data sheet to be filled monthly basis or if possible in fortnight and sent to head office for evaluation. Data so received are carefully short listed to find out the data which involve considerable quantity under study as revealed in table 4.1. As ahown in the table data have been gathered with respect to trades and types of building designed according to the research design.

4.1.1 RESEARCH RESULTS -CASE STUDY ONE

Data obtained from each of above trades in three different projects were tabulated to find out the relationship of each in relation to the project type. Raw results obtained through case study are tabulated in Table 4.1. Quantity involve too have been gathered in order to make sure that there have been some uniformity in the quantity studied and to make sure very small quantities were not subjected this study.

Data gathered by the research officers were number of labour hours consumed in skilled and unskilled basis for an amount of quantity identified. Indirect labour involvements were not taken into account. Total hrs recorded include not only the effective working time of the labour and it include total time the labourer is on at site. In other words total time labour is considered for payment of his wage is taken

into consideration. Time to time supervision made by the Sub Contractor (Gang leader) not considered for the time records.

Table 4.1 – Quantity and Hrs per Unit Measurement Results

Legend

M1
Sk / Unsk
Qty in Sqm
Hrs/Sqm / Hrs/Sqm

	M1		M2		M3		M4		M5		M6	
	Sk	Unsk	Sk	Unsk	Sk	Unsk	Sk	Unsk	Sk	Unsk	Sk	Unsk
200 Thick Block work												
High Rise	60		110		52		121		82		95	
	1.87	1.63	1.43	1.85	0.9	2.1	1.63	1.63	1.68	1.85	1.43	1.63
Medium Rise	285		712		250		85		180		450	
	1.15	1.09	1.19	1.06	1.36	1.2	1.28	1.05	1.28	1.01	1.23	0.98
Low rise	288.31		45		2853		491		717		302	
	0.99	1.02	0.69	0.91	0.49	0.46	1.804	1.338	1.16	0.8	1	0.65

Plaster

High Rise	95		822		210		112		55		325	
	0.93	0.87	0.78	0.93	0.82	0.7	0.88	0.96	0.72	0.83	0.95	1.1
Medium Rise	802		452		218		385		924		354	
	0.71	0.54	0.85	0.67	0.78	0.58	0.89	0.66	0.83	0.6	0.92	0.66
Low rise	240		844		889		110		350		426	
	0.37	0.43	1.11	0.77	1	0.61	0.73	0.73	0.4	0.4	1.74	1.3

Tiling

High Rise	24.6		20		265		215		90		65	
	1.89	0.98	0.9	2.7	1.68	1.1	1.56	0.9	1.83	1.1	1.43	1.68
Medium Rise	65		55		22		85		115		203	
	1.61	0.81	1.63	0.93	1.53	0.98	1.45	0.93	1.43	0.85	1.43	0.98
Low rise	70		26		145.92		595		110		38	
	1.86	1.24	1.58	0.96	1.82	0.73	1.68	1.1	1.36	0.98	1.43	0.86

By just looking at the above results one could not sense the relationship of each trade in the project type. Therefore each trade has been graphed in the light of different building type in order to visualize the relationships. Therefore skilled labour in one graph and unskilled labour in another graph is plotted as in figure 4.1 to 4.6

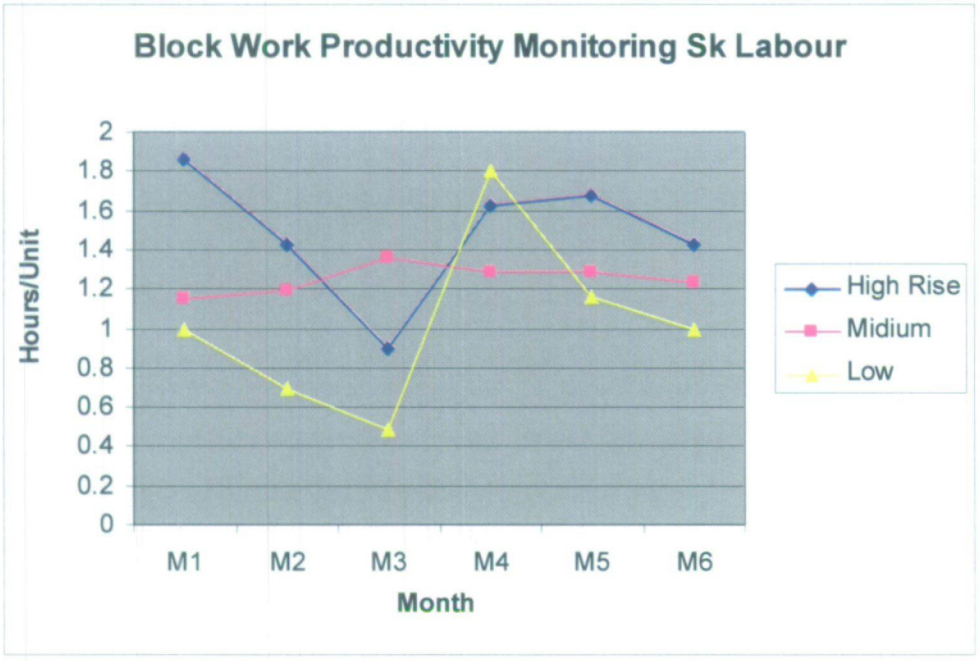

Figure 4.1 – Skilled Labour Hrs/Unit Block Work

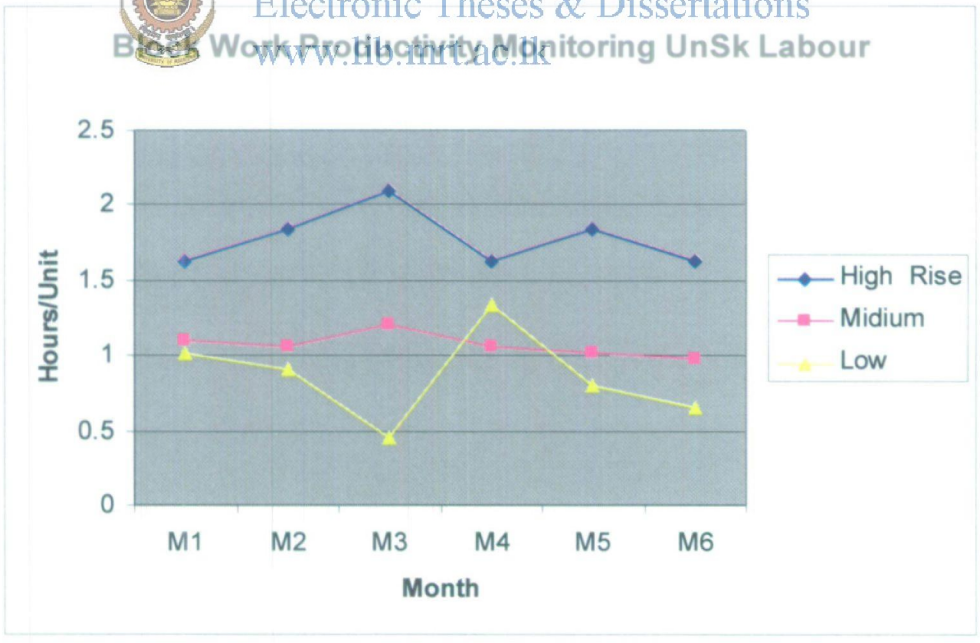

Figure 4.2 – Un Skilled Labour Hrs/Unit Block Work

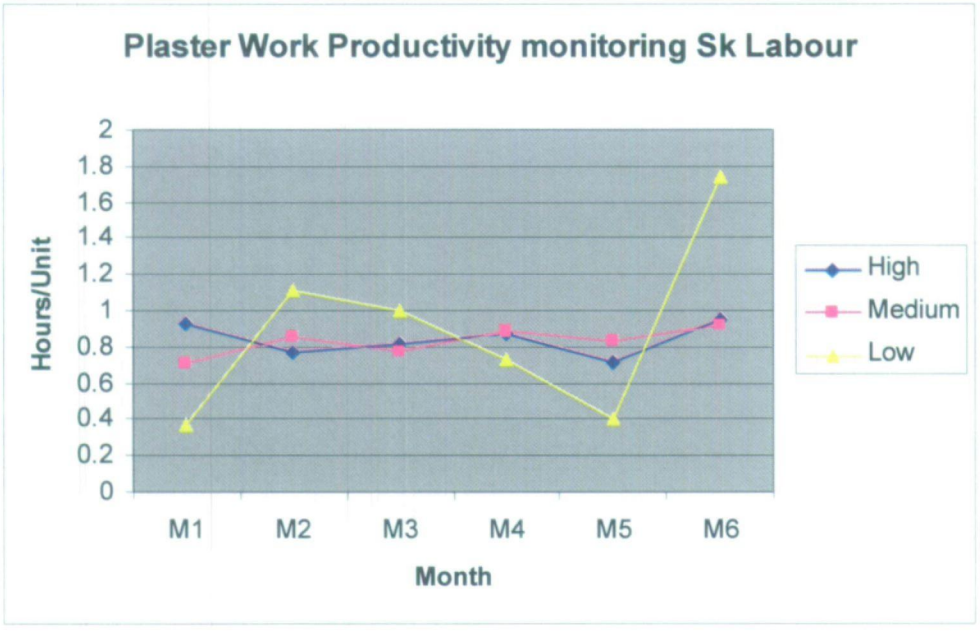

Figure 4.3 – Skilled Labour Hrs/Unit Plaster Work

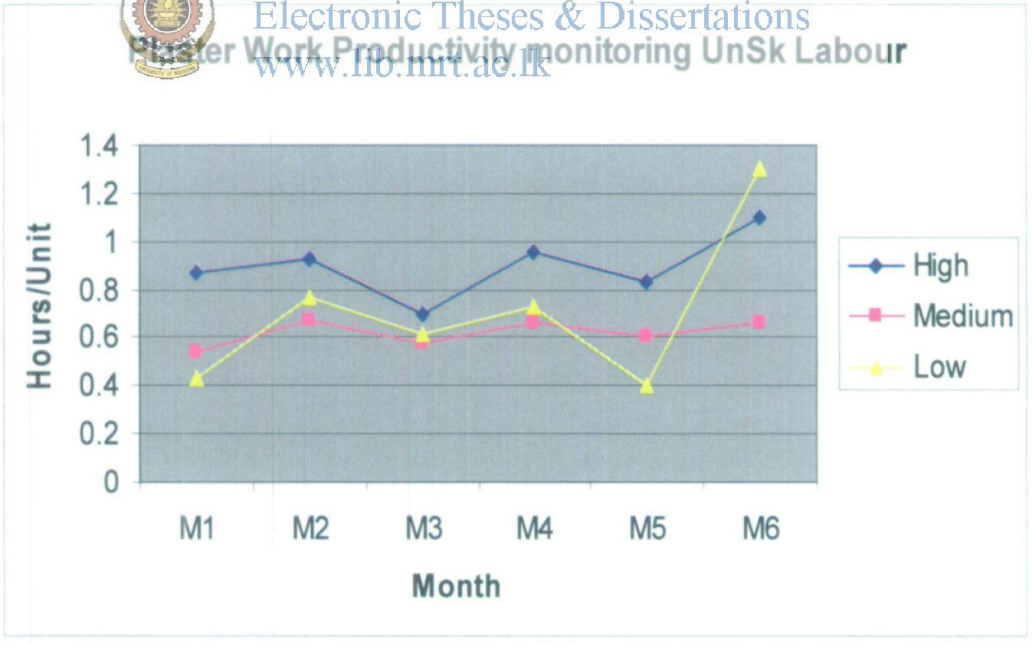

Figure 4.4 – Un Skilled Labour Hrs/Unit Plaster Work

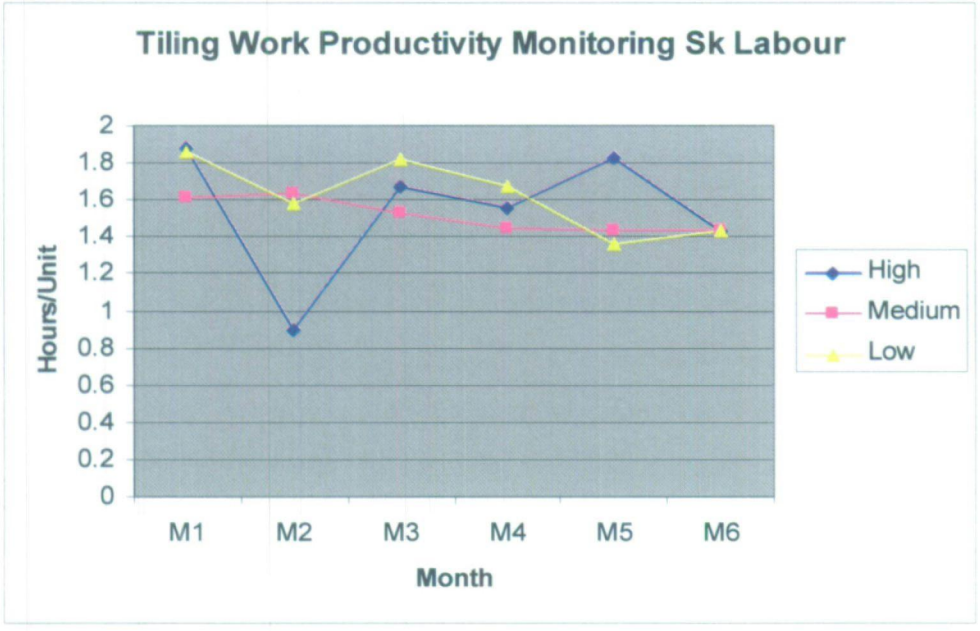

Figure 4.5 – Skilled Labour Hrs/Unit Tiling Work

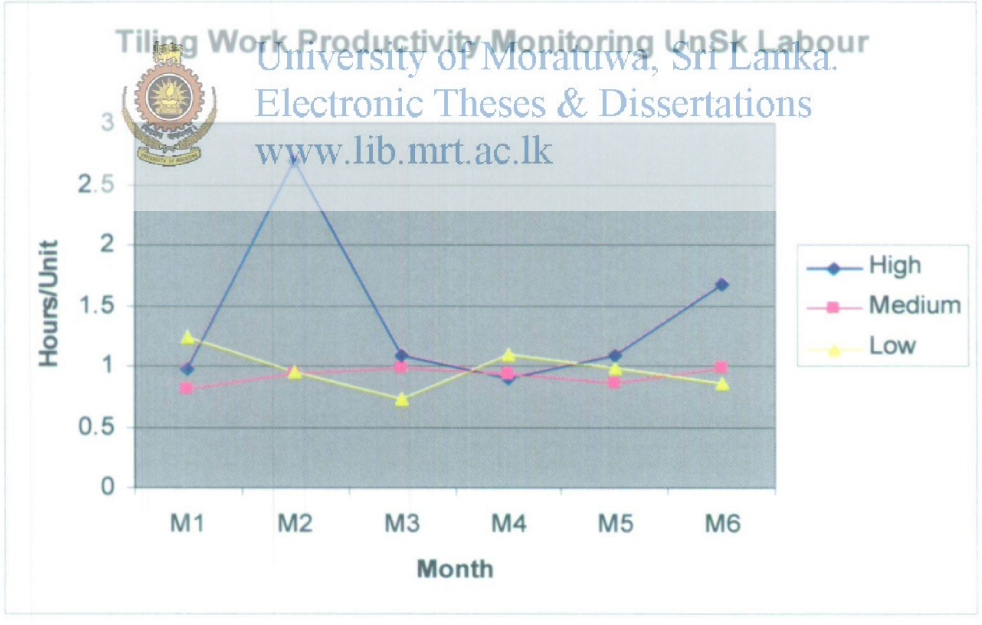

Figure 4.6 – Un Skilled Labour Hrs/Unit Tiling Work

It appears that similar performance levels are not seen both in Skilled and Unskilled categories in trades. While skilled and unskilled were showing lowest labour hours per unit in Block work, Skilled worker shown low and equal labour hrs per unit in plaster with other trades where unskilled perform badly in high rise than in medium

rise. Quite uniquely tiling skilled and unskilled results were shown opposite results in each building type where in high rise building, skilled consume low number of hrs per unit and unskilled consumed high number of hrs compared to other two building types.

Although charts in figure 4.1 to 4.6 shows some relationship of how each trade perform in different project type, it was felt important to find out this relationship as a one unit without differentiating into skilled labour and unskilled labour. Therefore these results researched through the case studies were converted to a unit rate using following daily wages. Skilled labour hour is taken as Rs 93.75 and unskilled labour hour taken as 56.25. This is not an accepted practice in a research because these labour rates are time driven and it can escalate or diminish with time. But in order to observe this relationship clearly this exercise has been performed. Graphs were developed based on above scenario shows in figure 4.7 to 4.9.

Figure 4.7 – Labour Rate Analysis Block Work

Figure 4.8 – Labour Rate Analysis Plaster Work

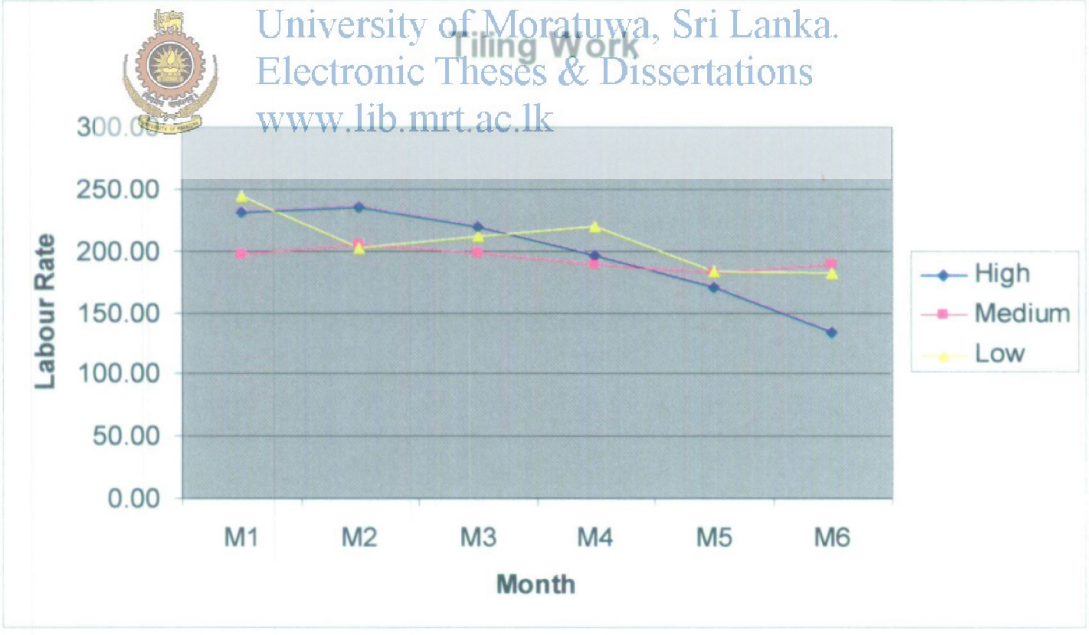

Figure 4.9 – Labour Rate Analysis Tiling Work

Above graphs revealed that in most cases high rise building requires a higher labour hours to do one unit than in low rise. Exceptionally some results show different opinion. In the block work exercise it is clearly evident that low rise performs higher productivity of labour than the high rise. But in other two trades they are somewhat

similar except for one or two results. Further it is evident from the results that the medium rise performs average in productivity in every case.

4.2 CASE STUDY TWO – MEASURING TOOL TIME IN BUILDING TRADES

4.2.1 INTRODUCTION TO TOOL TIME

Measurement of **Tool Time** technique was firstly introduced by Prof. Janaka Ruwanpura Associate professor University of Calgary Canada. This technique was used to measure the productive time as a percentage of total time in projects. It is therefore necessary to identify what could be considered as Tool Time and what could be considered as Non Tool Time in building trades. Therefore following were identified as Non Tool Time in any labour trade. They have been categories under three headings in relation to Sri Lankan Construction Industry as follows.

4.2.1.1 Supportive Non Tool Time

- Measurement
- Checking of drawings
- Interruptions to work due to quality issues etc..
- House Keeping
- Discussions related to work
- Inspections

4.2.1.2 Non Supportive Non Tool Time

- Waiting or search materials
- Waiting or search equipments
- Watching others works
- Waiting for Instructions
- Traveling within the site

4.2.1.3 Non Tool Time Due To Idling

- Tea Breaks/ Lunch Breaks
- Answering calls
- Socialising
- Leave
- Wash room
- Interruption of work other than quality issues

Same projects considered in the case study one have been considered for this study as well. We have conducted this study for ten months and the period which the study one was conducted falls within these ten months. Therefore the environmental conditions prevails in the projects can be considered similar for both the studies.

For the purpose of the research total productive time of the worker day is calculated by reducing the main three rest time of the worker, i.e Lunch hour and two tea breaks. This is 1.5 hrs out of total labour day. Other factors affect this productive time is considered as non tool time. Following example will elaborate how the case study was carried out to obtain the tool time percentage as tabulated in the Table 4.2

Eg. Worker Start Time = 8 hr

Worker finish time = 18 hr

Total Worker hours = 18 hr-8 hr =10 hrs

Total standard Non Productive time of the worker

Tea Break= 10 hr-10.15 hr= 0.25 hrs

Lunch Hour = 12 hrs- 13 hrs= 1.0 hrs

Tea Break = 15.00 hr- 15.15 hr= 0.25 hrs

Total Standard non Productive time = 1hrs +0.25 hrs +0.25 hrs= 1.50 hrs

Therefore Total Standard productive time = 10hrs- 1.5 hrs= 8.5hrs

If the worker's productive time is affected by following per day

Waiting = 23 minutes

Inspection = 17 minutes

Calls = 3 minutes

Wash room = 17 minutes

Socialising = 6 minutes

Traveling = 22 minutes

Total Non Productive time = 88 minutes = 1.47 hrs

Therefore His productive time = 8.5 hrs – 1.47 hrs = 7.03hrs

Therefore his tool time would be 7.03/8.5 x 100 = 82.71%

Overtime too is considered in calculating the total labour hours. Total of day's results were observed over a month and average month results received at head office for evaluation. However the studying personnel were kept free in identifying the type of non tool time they encountered without restricting to a standard schedule of non tool time.

Project Management introduced some improvements time to time to enhance the productivity of the labour by observing the results in all three building projects. Therefore the results have seen improvement towards the end. Following are the results obtained thorough the Tool Time study in each building type.

4.2.2 RESEARCH RESULTS- CASE STUDY TYPE TWO

Table 4.2- Tool time Results

Division	Trade	G Avg	Avg Tool time	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
High Rise	Block Work	60.07%	52.[illegible]9.00%	[illegible]6.00%	[illegible]48.00%	[illegible]51.00%	[illegible]46.00%	[illegible]48.00%	[illegible]48.00%	[illegible]49.00%	60.00%	62.00%
	Plastering		62.[illegible]	61.20%	58.00%	64.50%	68.00%	69.00%	67.00%	57.00%	58.00%	61.20%	62.00%
	Tilling		64.9[illegible]	62.23%	66.[illegible]%	58.20%	65.00%	66.50%	68.50%	70.00%	72.00%	69.00%	71.00%
Medium Rise	Block work	74.91%	66.01%	65.78%	72.48%	70.14%	73.71%	68.00%	65.00%	54.00%	63.00%	62.00%	66.00%
	Plastering		75.96%	77.60%	76.55%	78.84%	76.00%	78.00%	73.00%	70.00%	78.00%	76.40%	75.20%
	TIling		82.77%	84.71%	87.40%	86.99%	84.00%	82.50%	81.20%	79.00%	83.00%	80.20%	78.70%
Low Rise Housing	Block work	69.18%	69.15%	73.10%	68.50%	65.30%	68.00%	65.50%	68.05%	68.45%	67.42%	74.00%	73.15%
	Plastering		69.03%	69.90%	70.70%	70.85%	67.59%	68.71%	68.90%	69.53%	69.44%	64.81%	69.91%
	Tiling		69.37%	61.55%	62.05%	67.10%	72.22%	71.62%	68.90%	71.92%	72.53%	73.14%	72.68%

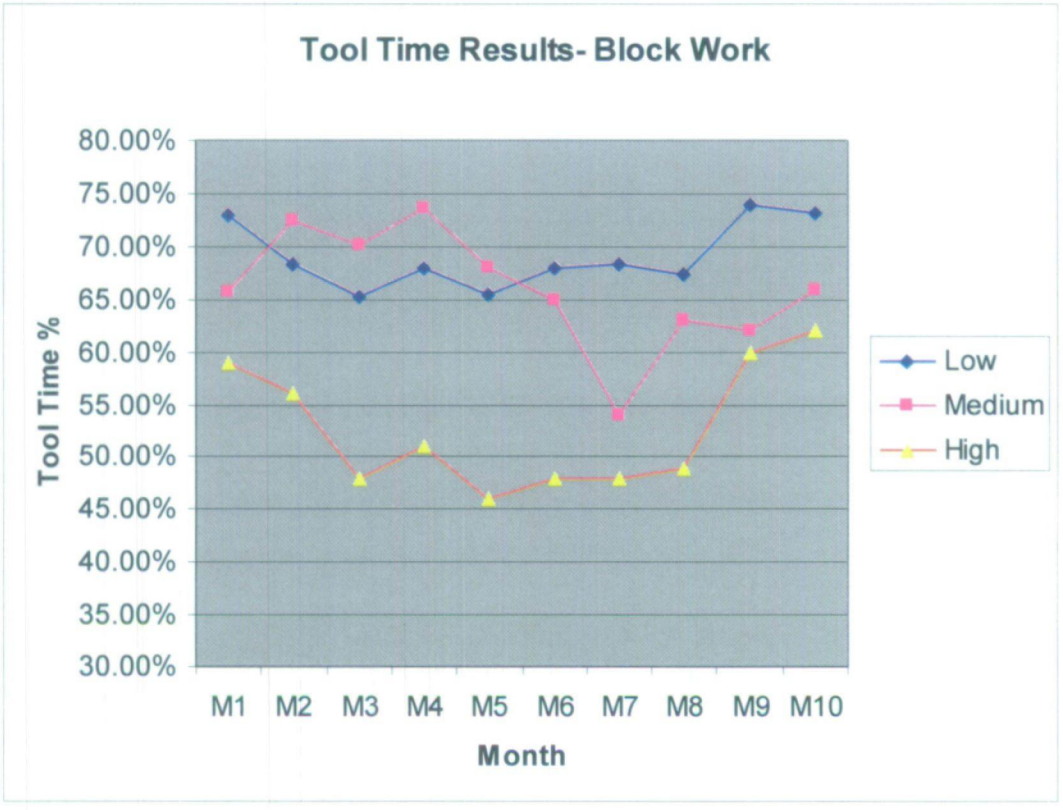

Figure 4.10 – Tool Time Results-Block Work

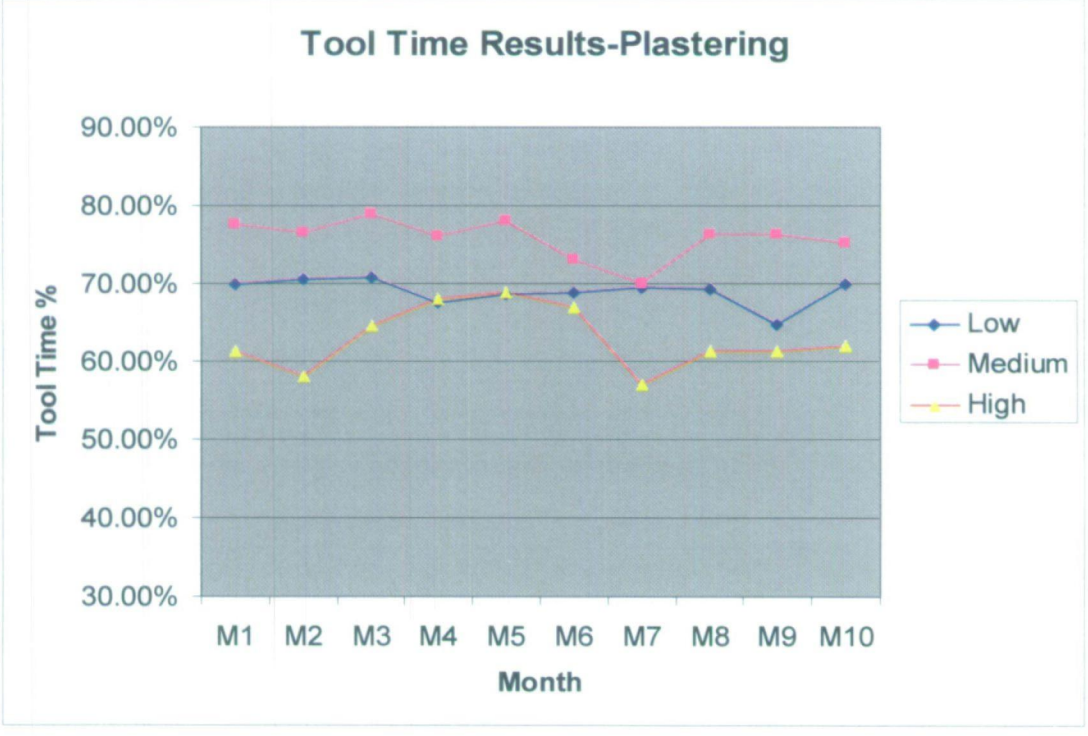

Figure 4.11 – Tool Time Results Plaster Work

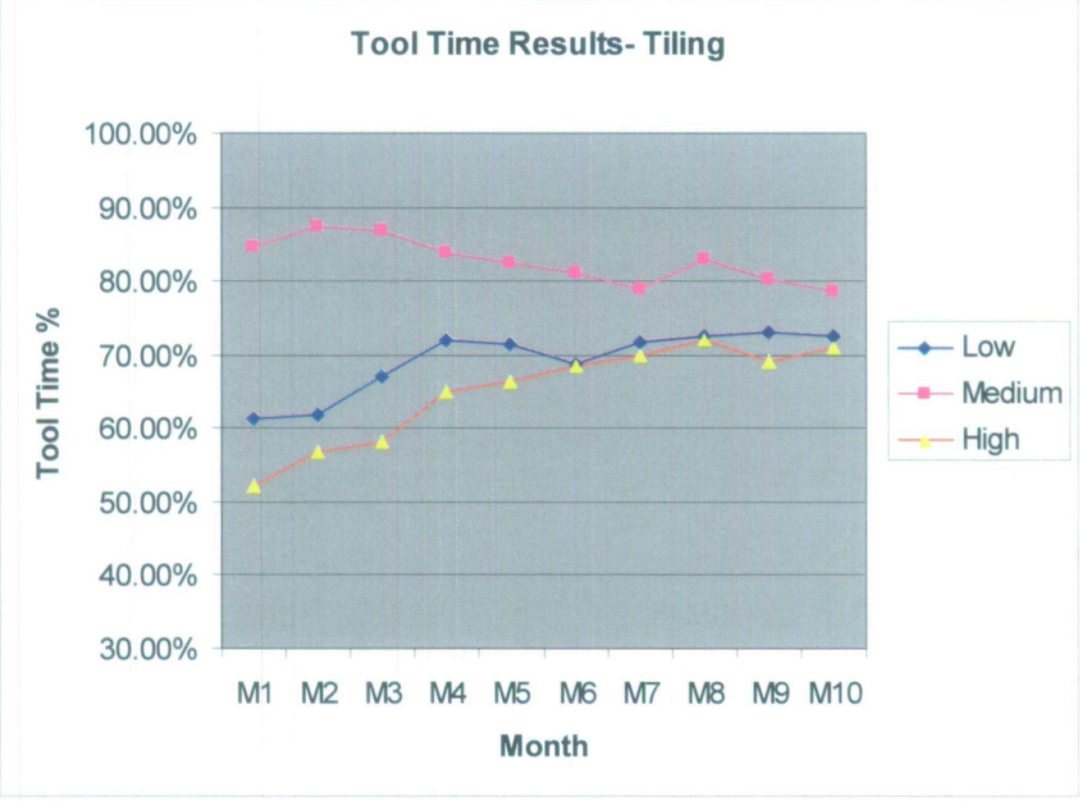

Figure 4.12 – Tool Time Results-Tiling Work

Results tabulated in table 4.2 is presented in graphical form in figure no 4.10-4.12. When analyzing block work item in the high rise building shows a very low tool time. The reason behind this was that at the time of study, the block work item was only confined to internal cladding of toilet and bed rooms where only minor quantity of work is involved at a given time. Therefore it has much waiting time coupled with stiffeners in close proximity. Therefore the results of the block work study in high rise need to be considered in isolation.

In average among three categories of buildings studied, the best tool time recorded in medium rise buildings. Next is the Low rise and then the high rise. Due to various reasons high rise building recorded a very low Tool Time. Similar to the case study One it shows that high rise building works involves higher labour hrs per unit than the others. In other words it shows a low productivity. Case study Two also reveals the similar results by showing higher Tool Time in high rise buildings.

Due to the above found low periodicity issue in high rise, some emphasis has been made to identify the reasons for high rise buildings to show low productivity. Following are some of them as identified by observing the nature of work in the high rise building studied.

- Limited availability of hoisting equipments
- Traveling delays of workers to required levels
- Limited availability of canteen and sanitary facilities to workers in different levels
- Limited store facilities in other levels than the lowest level
- Interruption due to interfacing issues.

CHAPTER FIVE

CHAPTER FIVE

5.1 FINAL RESEARCH FINDINGS

Two case study types were carried out in three different projects to study the labour productivity relationship in different types of buildings. As shown, two types of study namely Hrs per Unit measurement and Tool Time study reveals similar results with minor deviations. Since these exercise were carried out in open environment these kinds of miner exceptions are unavoidable. Therefore research findings must be generalised in this instance. While generalizing these results it is important to highlight that due to environmental factors these results could have a variation. Therefore the project environment has been initially elaborated to the reader to get and idea about the culture of the organization on which the above results were based upon. Following can be summarized as the final research findings.

- **One cannot have a single labour rate for a trade to suit every environment.**

  Single labour rate is given in every instances for anyone uses the BSR or standard norms available in the industry. Due to various reasons this is not possible and it has to be subjective and decided on the type of building you are estimating.

- **Higher productivity can be obtained in medium Rise Buildings;**

  One cannot imagine how far this is truth. But both the research case study reveals that the maximum productivity can be obtained in medium rise

buildings. Second is the Low rise building or horizontally scattered buildings. It should be noted that this particular low rise building category studied was a major housing complex consisting of more than 300 housing units.

- **Least productivity is recorded in High Rise Buildings.**

  Due to the various reasons identified in this research the lowest periodicity has been recorded in high rise buildings. These are ways and means of improving this productivity. Towards the end of the tool time records, it is observed that the tool time of the high rise building project has been increased. But it has not managed to reach the level of medium rise. This improvement was achieved by the project team by introducing various means of reducing non productive time or tool time of workers. However it was evident that this is not possible to have a higher productivity than a medium rise or low rise building projects.

- **Accurate labour rate can be devised Based in Tool Time results**

  Assume one knows the average labour rate of a trade, and if the estimator knows how this average labour rate is arrived. He could increase or decrease the labour rate to adjust the type of project based on the tool time results. This is a simple exercise to work out the most appropriate labour rate for a project. Thus, it must stop believing the BSR norms any further blindly.

- **Best Worker performance analysis could be obtained through Tool Time records**

  Since Tool time study reveals the draw back of the existing operating system by way of non productive time one can find ways and means of improving the system to have improved tool time and thereby improved productivity. Just analysis of Hrs per Unit as conducted in the case study no One has not revealed reasons for the low or high productivity. Although it is not the

preview of the Tool time analysis of this research, the data obtained could be further analysed to advice project on drivers to improve productivity. Similarly with the start of the Tool Time analysis the high rise building came under this case study introduced an additional passenger hoist in light of low productivity encountered by the Tool time analysis of the first three months.

5.2 FURTHER RESEARCH

More rates needs to be analysed based on tool time technique to devise industry wide data base for the tool time factor in each building. So that statistical model can be developed to devise labour rates for different types of buildings with a base rate to be used by the construction industry.

Tool time analysis can be further used to asses the factors affecting the improved productivity. With the limited time available in the research study this tool was only utilised to analyse the tool time of activities. But this was felt as a very important tool to analyse the productivity looses in work methods and address them to improve. Sometime the non tool time activities when analysed shows the corrective action straight away so that the improvement could be easily identified.

During the research it was found that the interfacing of trades becomes an important productivity hamper in every building. That can be illustrated by this example. Interfacing time is the time lap between start of paint after the completion of plaster work. Generally in Sub Contracts, these two trades were done by two different Sub Contractors. There is always a time lap for the painter to start after the block layer finishes his work for many reasons. This is a very important area to be researched and find out methods of overcoming delays due to interfacing.

Entire research case study in this report has been piled up based on open environment. It would be advisable to do the same case study on close environment which will control the effects of external factors and environmental issues. This will enable to find out the productivity changes by controlling external factors time to time. Of course this is a difficult study to do in a project environment because this kind of study will need to be separately handled with controls disturbing the natural flow of the progress.

5.3 CONCLUSIONS

The study conducted in this research was a very successful and fruitful exercise both for the individuals involve in estimating construction works and also to the construction industry as a whole. Study reveals valuable information as explained in the relevant chapters.

Now we can conclude that industry wide single labour rate is neither possible nor meaningful in this context. They are correlated and subject to various factors at all the time. Two case studies conducted showed evidence that labour behaves quite differently in three building types studied. It is also important to highlight the fact that these researches were carried out in open environment and therefore the results of the study is not uniformed to have a firm belief on any of the findings identified in this report. But Since the two sets of case studies focus on the same labour productivity in two different angles the general opinion was emerged on certain research findings comparing the two study results. They can be considered as concrete findings which can be further implemented undoubtedly.

|Findings Suggest that the highest productivity on labour could be obtained in medium rise buildings, and the least productivity could be found in High Rise buildings. Average productivity is observed in Low rise horizontally scattered

buildings. Please refer the definitions of the these three building categories in chapter 3. Hrs per unit measurements revealed in this research could also be considered firm and could be used by estimators confidently.

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APPENDICES

Appendix One

Data Sheet used to obtain Results for Case Study One

PRODUCTIVITY MONITORING REPORT

OFFICER'S NAME ..... PROJECT ..... DATE .....

OFFICER'S DESIGNATION ..... PROJECT MANAGER'S/OIC NAME .....

MONTH ..... FORM ..... TO ..... P.M.'S / OIC SIGNATURE .....

(A) DATE	
QUANTITY	
SKILLED WORKERS	UNSKILLED WORKERS
TOTAL WORKING HRS	TOTAL WORKING HRS
TOTAL O.T. HRS.	TOTAL O.T. HRS.

	WORK ITEM	MONTHS TARGET	A	TOTAL ACHIEVED	REMARKS
1					
2					
3					
4					
5					
6					

Appendix Two

Data Sheet used to obtain Results for Case Study Two

Tool Time Observation Sheet

Observer ..... Activity..... Site.....

Date of Observe: ....(1st Date)

Non Tool Time Catogary	NON PRODUCTIVE TIME MINUTES									
	AM .8-9	AM .9-10	AM .10-11	AM .11-12	AM / PM .12-01	PM .01-02	PM .02-03	PM .03-04	PM .04-05	PM .05-06
Total Non Productive Time										

Total Work Time = (Number of workers involved to the activity X 8)

Productive Time = (Total Work Time - Total Non productive Time)

$$\text{Productive Time \%} = \frac{\text{Productive Time}}{\text{Total Work Time}} \times 100$$

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