REVIEW OF PRODUCTIVITY NORMS IN BUILDING CONSTRUCTION INDUSTRY

MASTER OF SCIENCE IN CONSTRUCTION PROJECT MANAGEMENT

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DECLARATION

I hereby certify that this dissertation does not incorporate any materials without acknowledgement, and materials previously submitted for a degree or diploma in any university to the best of my knowledge , and further I believe it does not contain any materials previously published written or orally communicated by another person except where due reference is made in the text.

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D. K. Walpita **Date**

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This is to certify that this thesis submitted by D. K. Walpita is a record of the candidate's own work carried by him under my supervision. The matters embodies in thesis is original and has not been submitted for the award of any degree.

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Prof. A. D. A. J. Perera (Research Supervisor) 06/05/2015

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ABSTRACT

The construction industry plays vital role in an economy of a given country. In Sri Lanka the construction sector was continuously growing at higher rate and construction industry has a big influence for country' GDP. Materials and labour component are the main inputs to the construction industry. Planning, controlling and monitoring of materials and labour component are the key factors to successfulness of the project. The multi-disciplinary nature of the project development process imposes the need for clear understanding about norms and factors affecting productivity. The stranded labour productivity norms developed many years ago in order to assist labour component. With the technology transferring to the industry, work norms for construction industry are to be review. The main objectives of this research are to revive and develop work norm for building construction activities.

This study investigate and compare the productivity of companies on engineering construction sites in the Sri Lanka to that achieved by companies on comparable sites abroad and it investigate the BSR standard norms on few construction events. This thesis also described the productivity of labour and the mode of payment. The amount of work completed against time were closely examined in different activities in different projects and all data such as mode of payment, tools & machinery availability, work supervision, were recorded with respect to the construction event. The experimental data were analyzed by simple statistical techniques and compared with the standard norms available.

The research findings revealed that the modes of payment are the main striking method to motivate tradesmen. Organization of the work, tools and equipments specifications maintenance, monitoring and supervisions are the other main factors that affect the productivity of labour based projects. It was found that the actual labour output and productivity of labour was higher than the BSR standard values. Furthermore it is recommended to review the total labour cost inorder to assign the work method for better productivity.

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CHAPTER 01 –INTRODUCTION

1.1 Introduction

The current global economic situations and its negative impacts on building construction industry have made construction productivity improvement more and more important (Georage, 2009). Industries recommendations for improving construction productivity are categorized in to the major areas as follows.

1. Labour management,
2. Project front-end planning (loading) and workface planning,
3. Management of construction and support,
4. Constructability in engineering design,
5. Engineering management,
6. Communication,
7. Contractual strategy and contractor selection,
8. Government influence and modularization,

Productivity in construction industry is in central importance to the economic health of the Sri Lanka. The construction industry represents considerable percentage of the economy and large number of workforce is engaging in this industry. Relative productivity performance and any changes within it have significant direct effects on the national productivity and economic well being. (Central Bank Annual Report, 2008).

Labour-based projects however are almost entirely dependent on the productivity of labour. Provided the workers are properly organized and supplied with the correct hand tools, they will be able to carry out most of the activities usually done by machinery. In some construction activities input of labour is still higher than that of machinery, and some activities totally depend on labour. However, it is essential to have realistic estimates of expected labour productivity in order to plan and carry out labour-based work effectively. (Merrow, 2009)

The first action of any planning engineer on a labour-based project should be to determine the quantities and type of work to be carried out. The engineer should then divide this work into activities that can be carried out by individuals or groups of workers, and then, by applying work norms, determine the required labour force and the duration of the project. Choosing the correct work norm is the most critical part of this process.

Estimating the correct productivity is probably the most important decision for the engineer. If the physical quantities are wrongly estimated it can be corrected or re measured. If the numbers of people recruited are insufficient this can also be easily rectified, but altering norms significantly at a later stage involves convincing workers to do more work for the same money, which can be very difficult, and not conducive to success in a labour dependent projects (Georage, 2009).

Many researchers and practitioners have identified poor management practices that lead to poor performance such as scope changes, design errors and omissions, lack of proper planning and scheduling, improper management of tools, equipment, materials, and labor among many other factors.

According to the literature survey, combination of labor issues, project planning, engineering management, leadership, constructability among other issues are the main areas for construction productivity improvement. A summary of a literature survey is presented in the sections and subsections following.

1.2 Research Problem

In Sri Lankan construction industry, 'Building Schedule of Rates' is the mainly available standard document related to the work norm and it is used for planning, estimating and controlling the labour and materials requirement for civil engineering projects. This document was published by the building's department and last full revision made after work studies on July 1988. Available document was obsolete with technology transferring rate and practicing of outdated guidelines in the civil engineering industry and this need to be addressed by the relevant authorities (BSR, 1988). In 2010 Sri Lanka Standard Institute has published the standard rates for construction items and this did not fill the gap.

New technology, tools and equipments and methodologies are being changed day by day and new technology transferring is in a very high rate. In addition new construction methods and innovations to increase the workability are being introduced to enhance the workers performance and productivity. Skill development and training for the workforce is another important feature and such programs are being conducted for the workforce. In addition human resources development activities are being used to increase the productivity by the motivation. Hence productivity of the construction work force is relatively high compared to the BSR standard (Udawatta, 2010).

It is very difficult to predict the human resources performance because it depends on several factors. Especially, the measurement of daily performance of these labours in the construction industry is very difficult task. However it is very important in all the phase in the given project. Although work force offers several benefits, there is no proper method to determine the skill levels. Construction is a labour intensive industry that place heavy reliance its productivity upon the skill level of its workforce. Partially of skill workforce realized poor quality, high wastage and long term productivity decline in the industry (Gunawardana, 2011).

Most of the new jobs (building construction contracts) are offered through competitive biddings. Hence new entrepreneurs are forced to win the bids without own pricing strategy. Most of the new bidders rely on BSR work norms until they develop their own pricing data's. These BSR data was published by the buildings departments and not updated by last twenty years. However construction technique, tools & equipments are changed day by day and hence productivity of labour based construction projects are changed accordingly (Udawatta, 2010).

Presently foreign construction companies are coming in to Sri Lankan construction industry (Specially Chinese construction companies) and they can offer low rates for their bids due to their higher productivity rates & easily win the bid. Then knowing of the work norms in companies on aboard is very important. During the literature review work norms of aboard countries were recorded. However there are no any comparisons found with Sri Lanka standard work norms.

,. Though it is important to study the productivity evaluation of the construction industry labour force, monitoring of the productivity is not accessed. There is no standard method to evaluate the construction labourers performance and productivity at site. Generally labour cost represents 20%-30% from the total construction cost. Hence, knowing correct productivity norms are very important for planning engineers and managers to determine the quantities and types of work to be carried out. The engineer should then divide this work into activities that can be carried out by individuals or groups of workers, and then, by applying work norms, determine the required labour force and the duration of the project. Choosing the correct work norm is the most critical part of this process. During the study considerable effect was taken to identify the key drivers of productivity of civil engineering construction sites and these are discussed in following chapters and sub chapters.

International Labour Organization guidelines (ILO, 2010) stated that, estimating the correct productivity is probably the most important decision of the engineer. Therefore assigning correct labour rates and wages at the beginning of the labour based construction project is very important. In Sri Lankan context different companies have different labour productivity norms. During the literature review, some reasons were discussed for this different in productivity norms among the companies in Sri Lanka.

Non availability of the reliable labour norms in the construction industry is one of the critical issues especially for the contractors, estimators and project managers. This study on ***Reviewing of Productivity Norms in the Construction Industry*** was mainly focused.

1.3 Research Objectives

The main objective of the study is:

> "To make an assessment of labour productivity of construction work and its impact on construction organizations".

The sub objectives are:

1. To make an assessment of productivity of some construction work by comparing they with other countries.
2. To assess the key factors influencing productivity.
3. To analyze the reasons for productivity variations.

1.4 Research Methodology

In order to develop comprehensive literature of productivity improvement and work-study techniques, a detail literature review was carried out through books, journals, articles, publications, and internet & e- resources. A data collection methodology was developed using literatures and data collection and time study methods developed. The developed data collection is filtered & fine tuned as discussed with Senior Engineers, Quantity Surveyors, Managers and Construction Experts & Academics. A quantitative approach is used for this research.

Data collection methodology consists of:

1. Sample time study for construction activities, (Excavation, Back filling, Column concreting, Brick wall construction, Wall plastering & Rubble work).
2. Interview (Personal interview & Telephone interview)
3. Discussion with industrial experts.
4. Historical Data analysis

This study was conducted in Sri Lanka between December 2012 and March 2013 in the construction sites. The time study data was collected by directly observing the quantity done against the time taken for to perform particular work. The factors such as payment mode, work supervision, Tools and materials availability, Safety etc... also taken in to consideration. And for obtaining data from senior level Eng / QS and industrial experts it was required to use personal recommendations, Personal interview etc...

1.5 Main Findings

From the information collected throughout the study, it was found that the motivation of workforce toward construction industry is the driving factor to influence the productivity in labour based construction sites.

During the study it was found that the key motivation factors affecting the productivity of labour based construction projects as the **Mode of Payment**. Among the three mode of payment, 'piece work' are the most striking payment method which will increase the productivity level of construction labours. However during study it was observed that the cost for the works depends on several factors other than the mode of payment even though the piece work method produces better productivity. This is mainly due to Supervisor skill, higher piecework rate, Organization of work etc...

When comparing the productivity with other countries it was found that the level of productivity in Sri Lanka was considerably lower than the other regional countries.

The Key factors which will affect the construction productivity are

1. Motivation and experience of the workforce
2. Organization of the work

3. Type and condition of tools and equipment provided to the worker
4. Skill Development, Training & Continual monitoring of performance.

These factors are discussed in the following sections and sub sections.

1.6. Limitations of the Research

The Research was based on actual data collected from the selected building sites. Amount of labour for the works are the main component of the research and individual measurements were taken as data. Labour norms, performance and productivity of labour force for a particular category in a construction industry were selected and analyzed by taking daily workers performance data.

1. There are plenty of activities in construction sites. For this study it was basically considered only 6 activities due to time constraint.
2. Labour involvement can appear in most of fields such as transport, power, textile, manufacturing, etc... However manpower in building construction sector was taken in to consideration for this study.
3. In some construction activities, number of data gathered was limited due to data availability.
4. Specialized work category such as waterproofing, aluminum & glazing, anti-termite treatment were not considered. Only labour forced based activities were considered for the research.
5. Data collection was carried out in selected site in selected construction organizations and will not representing all local construction organizations.
6. Data collection was limited to a little duration.

1.7 Guides to the Report

This section discusses the structure and the flow of the report. The report consists of following five chapters.

Chapter 01- Introduction:

This chapter described the introduction to the report, Research Problems, research methodology, research objectives and main findings.

Introduction : described the importance of improving the construction productivity to national economy and how to plan the activities & allocations of labour and other resources.

Research problem : described the available standards for work norms analysis and its non compatibility to present condition.

Research objectives : described the consequent objectives which will found during the study.

Research methodology : gives the method of data collection and work study techniques and types of data to be collected

Under the **Main findings,** the factors affecting the construction productive and how to eliminate these barriers have been described.

Chapter 02- Literature Review

This section provides a limited literature review of recent publications relating to Construction Productivity and Labour Productivity Norms.

Under this chapter the research data and literature on following topic are discussed:

a) Contribution to employment in construction industry,
b) Definition of labour productivity norm and unit rates,
c) DACE (Dutch Association of Cost Engineers)labor productivity norms,
d) Productivity norms as per international labour organization,
e) Building schedule of rates (BSR),
f) Method of measurement of buildings works,
g) Work study,
h) Is engineering construction labour productivity improving or declining,
i) Breakdown of work hours,

Chapter 03- Research Methodology

This chapter covers the methodological framework supposed to adopt for the development of the study. Moreover this chapter illustrates the research strategy, research process and limitations which were adopted for this study in details.

Chapter 04- Data Collection and Analysis

Data collection & analysis is the most important step of this research. This chapter presents the analysis and interpretation of findings of the survey. It further discussed the findings of the survey.

Chapter 05- Conclusions, recommendations and Further study

Chapter 05 Summaries the procedure and findings of the research, Its contribution, and offers recommendations for management action to ensure workers motivation and enhancement in productivity.

CHAPTER 02 - LTERATURE REVIEW

2.1 Introduction

Researchers and practitioners around the world have provided several contributions related to improving the various aspects of construction productivity. Research is being performed world-wide in research centers on many areas related to construction productivity. These research centers include industry associations and academic institutions.

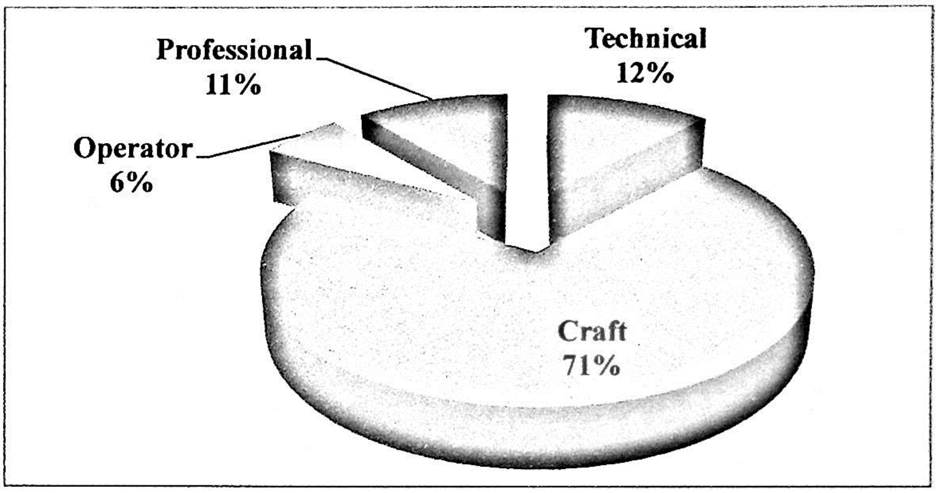
Productivity is a complex issue as many factors influence productivity such as labour, capital, material and equipment. Lack of right materials, tools and equipments, poor communication or relationship between workers and management, disorganized projects, poor supervision, lack of cooperation and communication between different crafts, lack of worker participation in decision making process, and unfair workloads are the some of the factors that affect productivity. Technical problems like inadequate designs or incomplete engineering work can also lead to backlog in productivity. Similarly restrictive and redundant procedures also affect the effectiveness of a project.

2.2 Contribution to Employment

Construction industry contributes 7% to the total Sri Lankan economy. As of 2009, the direct employment in the construction industry was 562,000 persons (ICRA, 2011).This included four categories of employees: professional, technical, crafts, and machine operators. Almost 97% of total persons employed in construction industry were males with 75 per cent falling in the 25-45 age-group. 52 per cent were with experience of less than five years

According to the Fig 2.1, 71% represent the craft category and craftsmen shall represent the labour category in labour based construction project.

Fig 2.1 Construction Workers by Area of Expertise (ICRA Lanka, 2011)



Improvements of productivity in craftsmen are very important since higher amount of construction workers represent the craftsmen category. By knowing the correct work norms in labour based constructions, the quantitative analysis can be performed to improve the productivity in labour based construction projects.

2.3 Definition of Labor Productivity Norm and Unit-Rate:

2.3.1 Labor productivity norm

A labor productivity norm is the number of labor hours (work effort) required to complete a defined construction activity, given the specific qualifications associated with each individual labor productivity norm. By definition, each labor productivity norm is a typical or average number of labor hours required by the collection of all individuals (i.e., crew) associated with the construction activity. For simplicity, we define a labor productivity norm as "a number of hours for an activity per unit of measurement" (Martin, 2011).

2.3.2 Unit-Rate:

A price to be paid and agreed upon for services performed. For example, technical work-hours will be paid for at the unit-rate agreed upon. Often field work is assigned to a subcontractor by the prime contractor on a unit-rate basis. For simplicity, define a unit-rate as "a price per unit of measurement."

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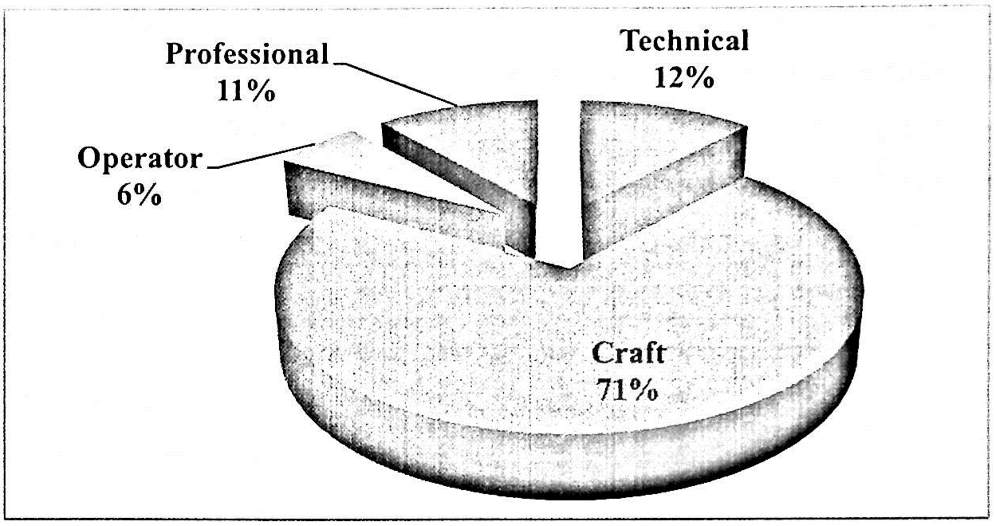

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DACE labour productivity norms (Martin, 2011) described the difference between a labor productivity norm and a unit-rate i.e : there are no costs involved in a labor productivity norm, only work hours. This makes it more usable for different industries and practices because costs are very much related to volumes, economic circumstances, availability, taxes, and etc. labor productivity norms can easily be calibrated to the local circumstances by applying location factors.

Labor productivity norms are used for:

1. Cost estimating, planning and cost control,
2. Tendering and contracting,
3. Standardization and world-wide use,
4. Correct definitions using qualifications and preambles,
5. Appling Location factors,
6. Measurement of productivity,
7. Efficiency evaluation. And,
8. Benchmarking.

2.4 DACE Labor Productivity Norms

In order to introduce a new common labor productivity norms standard for the industry, DACE, 2008: provides a comprehensive quality framework containing definitions, boundaries, practical use, etc. has to be defined. To meet this goal, DACE (Dutch Association of Cost Engineers) has established qualifications and preambles, which describe the overall conditions and the scope descriptions of the labor productivity norms activities.

2.4.1 Qualifications and Preambles

The purpose of the qualifications is to provide guidance in the development and application of labor productivity norms for estimating. In parallel to the development of these labor productivity norms, consideration has been given to the application of location (productivity) factors, indirect costs, overheads, profit and risk, condition factors and/or efficiency factors. Therefore the user should have a common understanding of the terminology used in this process to ensure clarity with regard to what is included in labor productivity norms, labor rates and those items that should be captured as derived costs (applying factors and other adjustments). The preambles and qualifications to the labor productivity norms are intended to provide the basis for completeness and consistency in estimates. The preambles and qualifications are applicable for all types of installation work (Martin, 2011)

Efficiency

According to the DACE, 2011; the worker efficiency is measured in physical terms. Efficiency is measured as "the ratio of planned volume of output to the actual volume of output." The labor productivity norms can also be adjusted by an efficiency factor related to the volume of work that is expected.

2.4.2 Direct vs. Indirect

Direct costs are costs for materials, labor (including working foreman) and allowances that can be assigned to specific activities, including the set of tools and equipment required to execute the work.

Indirect costs are costs occurring during the execution of the work that cannot be assigned directly to specific activities (for example supervision) (Martin, 2011)described the factors that Indirect costs may include:

Site Facilities

Costs for site facilities are costs to prepare the construction site, the lay down areas, construction offices and warehouse. This includes all necessary supplies, including but not limited to: mobile scaffolds, warehouse interior, internal transport, and possible climate regulation. Also included are the costs for exploitation, hiring, maintenance, cleaning, heating, electricity, gas water and telephone costs etc.

Overhead

Overhead costs are costs in the indirect sphere that are relevant to the implementation of the work. This includes costs connected to using supervisory, executive and coordinating staff. In addition, overhead can include costs linked to obtaining required approvals, drawing and calculating work for the implementation, as-built, management, work preparation, permits, reports, material management, quality control and project controls. Initial safety introduction for mobilizing direct labor is also included in overhead costs.

Profit and Risk

Profit is the compensation a contractor receives as a component of the contract price. 'Risk' is the compensation that a contractor receives as a component of the contract price for the uncertainty that the contractor takes with regard to the implementation of the work.

2.5 Measuring Engineering Construction Labour Productivity

Productivity in UK Engineering Construction industry (Merrow, 2009) discussed three approaches to measuring engineering construction labour productivity, each of which has a different meaning and use. First is calling the Economist's Approach. It explains the approach and then explains that it has limited application for their current problem. Second is the Construction Manager's Approach, which measures engineering construction labour productivity at a task level. Finally, there is the Project Approach, which addresses engineering construction labour productivity with the whole project as the unit of observation.

2.6. Work Methods

In all the literature on labour-based construction, there is much reference to day work, task work and piecework. These are very straightforward concepts, but unfortunately they are sometimes defined in different ways by different projects. This can give rise to considerable confusion when comparing data from different places.

International Labour Organization (ILO, 2010) gives important guidance for labour productivity and shows three work methods as Day work, Piece work and Task work which will related to the productivity of labour based construction projects.

Day work means simply that a worker is paid a fixed rate for being present on a site for a full working day, which is usually eight hours of work. The amount of work produced depends entirely on the supervisor's ability to encourage the worker, and the worker's own motivation and sense of responsibility. In many circumstances this can lead to very low productivity, especially with permanent staff that has no particular incentive to work hard. They know they will be paid (generally very poorly) whether they work or not. (ILO, 2010)

Piece work is a method of setting work, usually preferred by the private sector. The worker is allocated an amount of work for an agreed rate of pay. The work they do is measured and the more they do the more they are paid. This approach can give very high productivities, but it can also result in exploitation, especially when the rate for the work is too low. Casual workers are seldom in a good position to negotiate favorable rates. The most dangerous situation is when workers have to put in very long hours to achieve even a subsistence rate of pay. (ILO, 2010)

Task work evolved on projects where the workers were subject to government regulations, which meant they could not be paid more than the prevailing government wage for a day's work. Some other incentive had to be provided. Setting a realistic task, or amount of work to be completed for the day, meant that workers could work as hard as they wanted and then go home to do other things. Tasks are generally set to be achievable in 70 per cent of the working day (a working day being assumed as a period of eight hours), but are often completed in 50 per cent of the working day (*i.e.* in four hours). This approach has proved very successful in practice, often doubling the amount of work achieved in a day; and by inference doubling the productivity of the individual worker, as well as halving the costs. (ILO, 2010)

2.7 Productivity Norms

Some of the productivity norms data published by ILO, (Shieldl, 1998) to compare the productivity of engineering construction companies on comparable sites abroad are discussed in following chapter,

From this data, a median value for each activity has been calculated. To give this value a context, we have included the equivalent standard figure from the Kenyan Rural Access Road Program, 1998. This program was originally one of the most researched programs in the region, and gives a very good idea of what can be achieved with tight supervision and a well motivated work force.

Table 2.1 Site Cleaning norms – Country Data (ILO, 1998)

Average productivity by type of cover m^2 per worker day					
Country	Dense Bush	Medium bush	Light bush	Grubbing	De-stamping
Botswana	-	750	750	150	-
Cambodia	30	60	100	15	75
Ghana	-	-	375	375	-
Indonesia	130	175	-	37.5	1
Kenya	50	150	300	100	-
Lesotho	50	100	250	65	-
Tanzania	50	100	250	150	3.5
Zimbabwe	200	-	300	250	-
WB study	-	-	150	15	-
Median	50	125	275	100	1

Table 2.2 Excavation Norms – Country Data (ILO, 1998)

Average productivity by soil classification m^3 per worker day					
Country	Soft	Medium	Hard	Very Hard	Rock
Botswana	4.25	3.8	2.5	1.9	-
Cambodia	2.75	2	1.25	0.75	-
China	9	7	3	2	-
Ghana	3.75	3.75	3.75	3.75	-
Indonesia	-	-	2.5	-	-
Kenya	5	3.5	2.25	1.75	0.75
Lesotho	4.5	3.5	2.75	1	0.5
Nepal	-	3.3	2.5	-	0.61
Tanzania	5.5	4.5	4	2.5	-
Zimbabwe	5.5	5.5	4	3.5	2
WB study	6.7	2.1	3	2	1.7
Median	**5**	**3.5**	**2.75**	**2**	**0.75**

Table 2.3: Loading, Unloading and spreading norms – Country Data (ILO, 1998)

Average productivity rate m² per worker day			
Country	Loading	Unloading	Spreading
Botswana	12	750	14
Cambodia	8	15.5	5.25
Ghana	6.7	10	-
Kenya	10	9	13.5
Lesotho	5	-	14.25
Tanzania	11	-	15
Zimbabwe	8.5	-	9
World Bank	-	-	11
Median	8.5	10	13.5

Table 2.4: Compaction norms – Country data and recommended values (ILO, 1998:24)

Country Data and Recommended Values m³ per worker day		
Country	Manual Compaction	Equipment Compaction
Botswana	10	-
China	3.2	-
Kenya	7.5	700
Lesotho	15	700
Tanzania	9	700
Median	9	700
Recommended Value	**9**	**700**

2.8 Building Schedule of Rates (BSR)

Building Schedule of Rates (BSR, 1988) is the only available written standard document for local construction industry work norms, which was published by the Buildings Department. It is used to identify the composition of the materials and labour for respective works. The latest revision and necessary adjustments were made by the technical committee appointed by the Ministry of Local Government on 1988 and this document is still being used without any revision (BSR, 1988) Construction technology, methods, tools, equipment etc... are being changed day by day. However reliability of these data and applicability of this document is questionable. The building scheduled of rates is used by the contractor to price their tenders. Well grown companies may have their own norms derived from past experience. However a guiding document may be very useful to the newcomer, whether they are consultants, contractors or project managers (Udawatta, 2010).

This schedule is to be read in conjunction with the standard specification for buildings, the special specification for soil, drainage and water supply (ICTAD, 2004) except where they are superseded by note or description in the schedule. During the construction stage, the BSR is useful to calculate the material, plant and labour requirement and it is also useful for financial (SLS573, 1999) planning, scheduling and monitoring purposes.

In this research BSR values are revived by the recording of actual norms on construction activities in different sites. There are plenty of construction activities available in construction sites and various methods available to complete these activities. However BSR does not represent all these activities.

2.9 Method of Measurement of Building Work

The Sri Lanka Standard Method of Measurement of Building Work was first developed on a request made by the National Metric Conservation Authority and was published in 1982 on the recommendation of the Civil Engineering Divisional Committee. Measurement occupied a very important place in planning and execution of any building work from the time of first estimate to final completion of the project and settlement of the payments. This provide guidelines in carrying out this work using only metric units and applies to the preparation of estimate and BOQ' s and to site measurements. In this research, these guidelines were followed mainly for sampling, data collection and analysis (SLS573, 1999).

2.10 Work Study

Work study principles and practice were developed from the early 20th century to improve productivity. Method study and Work measurement which are used in examining human work in all its contexts, and which lead to systematic investigation of all the resource and factors affecting the efficiency and economy of the situation being reviewed, in order to effect improvements. The systematic recording and critical examination of the factors and resources involved in existing and proposed ways of doing work, as a mean of developing and applying easier and more effective methods of reducing costs. Method study is the part of work study which classifies, select and defines operation to be studies, record the procedure currently followed, analyze the methods, and developed alternatives from which the optimal is selected, installed and maintained. The application of techniques is designed to establish the time for a qualified workers to carry out a specified job at a defined level of performance. Work measurement studies the work content of an operation. In order to compare different operations, they are broken in to typical tasks and measured in terms of time. Continuous time study is more appropriate for operation of a cyclic nature involving a few resources. A construction operation usually consists of several activities. The study measures the total time that has elapse in a series of activities. Most often, manual approach allows the stop watch run continually. Time for each observation is recorded and the incremental time may be computed from the consecutive readings (Udawatta, 2010).

The aim of this technique is the evaluation of human work and provides a part of the recording procedure described earlier under method study. However the applications of work measurement data are extensive and can be used in:

1. Determining suitable manning level on construction activities.
2. Setting standard machine utilization and labour performance.
3. Providing the basis for sound financial incentive targets.
4. Providing the basis for cost control by fixing standard performance targets
5. Determine the most economic from alternative methods.

(Haris, 1997)

2.11. Is Engineering Construction Labour Productivity Improving or Declining?

There is an ongoing debate in academic circles as to whether engineering construction labour productivity has been improving or degrading. This debate is largely an issue of definition and measurement. The debate only takes on substance when the methodologies for comparison across time are the same. In modern economies, the relative engineering construction labour productivity on complex project construction has surely declined relative to many other areas of manufacturing and industrial activity simply because engineering construction projects are inherently labour intensive activities, while many rapidly expanding areas of activity are less so. As mentioned above, substitution of machinery and other forms of capital for labour in construction is very dependent on standardization. The nature of most engineering construction projects is that they are specially designed for the particular circumstance and application and therefore not amenable to capitalization. At the same time, the number of labour hours needed to construct a given type of facility has likely improved slowly over the last two decades. That improvement has come from better practices applied to projects rather than changes in construction methodologies. Meanwhile, engineering construction labour productivity in places like China have been improving rapidly because the substitution of modern construction machinery has started to bring engineering construction labour productivity closer to the developed country norms. (Merrow, 2009)

University of Calgary research identified the relative importance of 51 productivity factors which were classified into three groups: **Human, External, and Management**

Human factors;

Such as worker motivation, worker boredom and fatigue, worker attitude and morale, worker's physical limitations, worker absenteeism, worker learning curve, worker experience, and worker skills as well as the team spirit of crew.

External factors;

Such as union rules and influences, adverse weather conditions, noise, dust, radiation, congested work area, change in drawings and specifications, changes in contract, demand for over- quality work, and the nature of project (size and complexity).

Management factors;

Such as protective gear, unrealistic schedules, overtime, multiple shifts, excessive shift length, disrespectful treatment of workers, parking facilities, salary and benefits, site layout, necessity to re-do work, discontinuity in crew makeup, failure to use worker's skill, incompetent personnel, overcrowded work areas, poor inspection programs, unsafe working conditions, inadequate equipment, inadequate supervision, crew composition, constructability, out of sequence survey work, interruption and disruption, adequate site facilities for workers, lack of co-operation between crafts, inadequate communication, lack of worker training and education, cleanliness of construction site, lack of procedures for construction methods, subcontracting, changes in foremen, lack of detailed planning and non availability of information, materials, tools and equipment. (Georage, 2009)

2.12 Breakdown of Work Hours

. The following figures (Figure 2.1 and Figure 2.2) show the detailed breakdown in carpentry work, which basically shows how the time is spent and that there is a room for increasing the working time. (Ruwanpura, 2012)

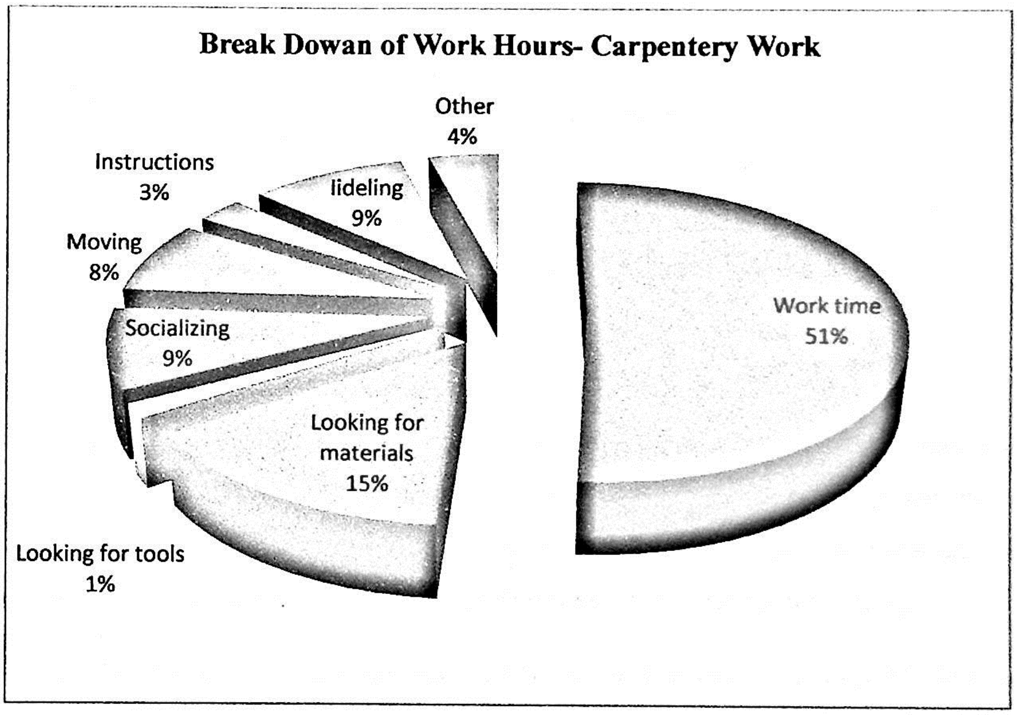

Figure 2.2: Breakdown of work hours (carpentry work)

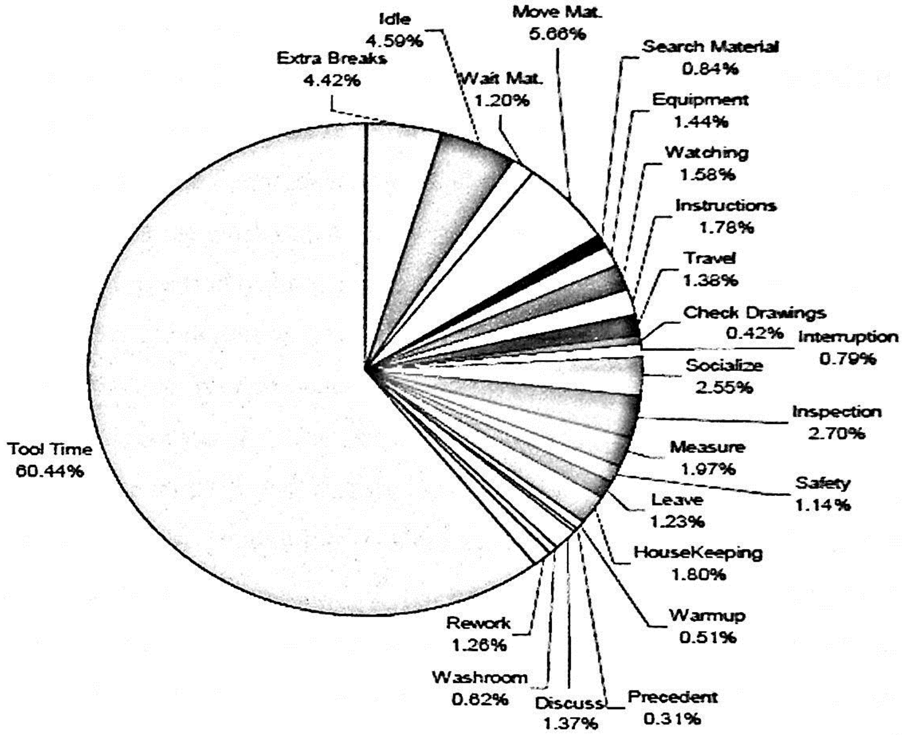

Figure 2.3: Breakdown of work hours

A study to improve productivity of slab concreting operations on four commercial construction sites in Alberta (Silva, 2006), indicated that productivity losses during concreting operations were mainly caused due to variability in the pouring rates and site layout factors restricting the movement of concrete trucks on site during concreting.

(Hewage, 2007)Conducted another research based on Liberda et al.'s (2003) fifty one factors affecting productivity. These factors were prioritized and clustered into nine categories. These categories are: design and changes, worker motivation, inadequate communication, worker skills, non-availability of information, lack of planning, congested work areas, inadequate supervision, and adverse weather conditions.

A research project to develop, test and validate better work practices and tools and to improve the productivity of future construction projects in Alberta and Canada is ongoing at the University of Calgary. The research project is titled "Top Ten Targets for Improving Construction Productivity" (Janaka, 2007). Following are the top ten targets being investigated.

1. Highly motivated, and satisfied workforce
2. Best practices model for supervision
3. Better working relationship model between sub-contractors and the main contractor
4. Efficient materials, tools, and equipment management
5. Tool time optimization by adopting best work practices
6. Optimize work practices and workface planning
7. Information technology based on site communication framework
8. Better integration between site and office management
9. Weather related issues
10. Project stakeholders' issues- owner, architect, changes etc...

Another study found that the average direct effective working time (tool time) of two commercial construction job sites in Calgary was just 53.17%, (Fig. 2.3). Moving around the site was the largest portion of non-tool time activities. The category "walking" includes looking for materials, looking for foremen, carrying tools and equipment, just walking in it, and walking to the office, wash rooms, and stopping to chat with fellow co-workers. After working continuously for a long time, it is necessary to have short breaks for smoking, idling, using washroom facilities, but if these breaks last more than 10 minutes then the productivity at that period can be seriously affected (Gannoruwa, 2008)

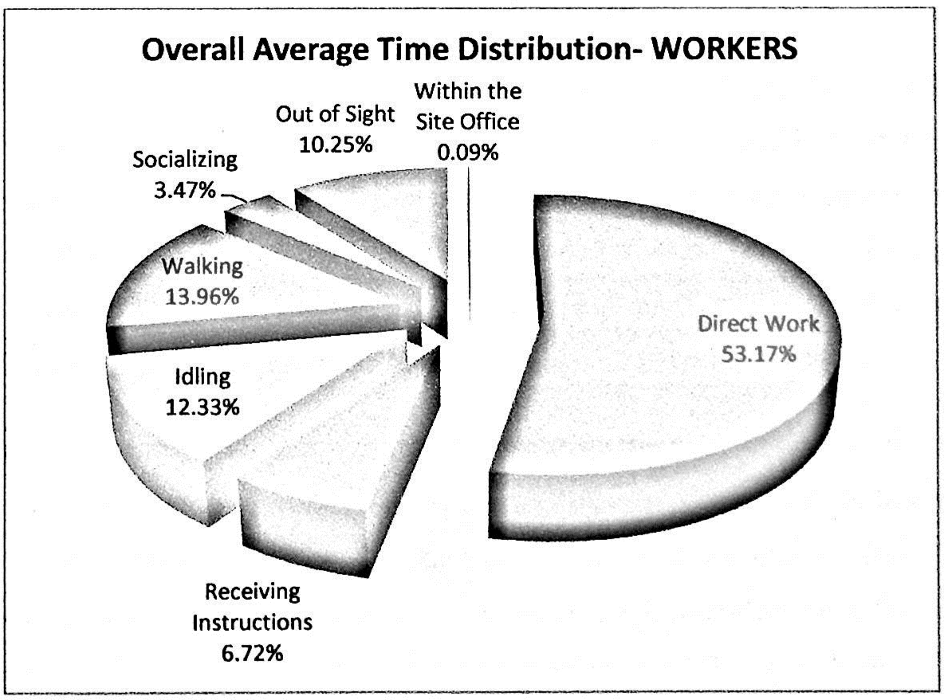

Figure 2.4: Workers' total working time distribution

Liu and Ruwanpura developed a "Ten-Week Testing Model" to improve tool time and construction productivity on a high-rise building site by reducing waste in on-site resource management. (Liu, 2007)

Aduagyei and Ruwanpura, identified some of the significant situations that create congestion and reduce the productivity of resources in the work area. Some of the critical situations were over stacking of trades, improper activity sequencing, excessive on-site prefabrication & storage of material in the work area and improper planning of the activities with regards to movement of resources in the work area with the progression of the work.

In the United Kingdom, the Building Research Establishment Ltd. (BRE) has produced many publications relating to construction productivity. BRE also organizes training courses and workshops aiming to improve the technical performance of workers in the construction industry. Additionally the post secondary institutions in the UK have contributed to numerous published research relating to construction productivity improvements. Combining the knowledge and experience of the construction industry with the research expertise of academics, the European Construction Industry Institute (ECI) based in the UK, has published in areas such as design effectiveness, fast tracking, benchmarking, leadership and innovation and procurement strategy and time skills, knowledge and competence among other publications (Udawatta, 2010).

In the United States, the Construction Industry Institute (CII) has developed 14 Best Practices to enhance the business effectiveness and sustainability of the capital projects. Some of these practices directly or in directly affect construction productivity. Relevant CII Best Practices are Alignment, Benchmarking and Metrics, Change Management, Constructability, Lessons Learned, Materials Management, Planning for Startup, Pre-Project Planning, Quality Management, Team Building and Zero Accidents Techniques.

The Center for Construction Industry Studies (CCIS) also in the US has published many studies relating to improve construction productivity. These studies relate to workforce challenges, assignment and allocation optimization of workforce. The Construction Users Roundtable (CURT) publications, on the other hand, included the following relevant works dealing with many aspects of construction productivity. (Georage, 2009)

1. Construction Productivity Measurement
2. Construction Labour Motivation

3. Improving Construction Safety Performance
4. First & Second Line Supervisory Training
5. Project Management Education & Academic Relations
6. Application of Modern Management Systems
7. Contractual Arrangements
8. Integrating Construction Resources & Tech.
9. Construction Technology Needs & Priorities
10. Exclusive Jurisdiction in Construction
11. Scheduled Overtime Effect on Construction Projects
12. Contractor Supervision in Unionized Construction
13. Constraints Imposed by Collective Bargaining Agreements
14. Local Labour Practices
15. Absenteeism & Turnover
16. Impact of Local Union Politics
17. Use of Journeymen in the Union Sector
18. Government Limitations on Training Innovations
19. Utilization of Vocational Education in Construction Training
20. Training Problems in Open Shop Construction
21. Labour Supply Information
22. Administration & Enforcement of Building Codes & Regulations

The study in South Gujarat region of India (Mistry & Rajiv, 2013) identified total 27 critical factors which were affects labour productivity in construction projects, the main factors they identified as (1) Payment Delay, (2) Skill of labour, (3) Clarity of technical specification, (4) Shortage of Materials, (5) Motivation of Labour. Then the contractors should act on these actors to improve labour productivity which ultimately can help to get higher profits from the projects.

Olomolaiye et al (1998) briefly studied labour productivity on construction sites in Nigeria. Their study concluded that there was a need for establishing output figures on various construction sites through time study techniques. It was concluded that the method studies and research results should be disseminated not only to large firm but also to small firm so the most productive working methods (or best practice) could be adopted by operatives, resulting in increase output without necessarily increasing physical efforts.

Lim et al (1995) studied the factors affecting productivity in the construction industry in Singapore. Their findings indicated that the most important problems effecting productivity were: difficulty with recruitment of supervisor, difficulty with recruitment of workers, high rate of labour turnover, absenteeism for the work sites and communication problem with foreign workers. Olomolaiyeet al (1996) studied factors affecting productivity of craftsmen in Indonesia, with their findings indicating craftsmen in Indonesia spent 75% of their time working productively. Five specific productivity problems were identified as lack of materials, reworks, absenteeism, lack of equipment and tools

Gunawardana (2011) had done the study on the labour productivity in building construction industry to reveal the top ten motivation factors affecting on labour productivity as Medical care, supervision, on-time payment, overtime, canteen for employee, social activity opportunities, job security, accommodation, communication and love & belongingness.

Majority of the construction workers who are working in the building construction industry in Sri Lanka are highly de-motivated due to the difficulties faced by them to fulfill their basic need in that poor working environment. It is evidence that the industry has totally forgotten the value of these people while providing good working environment. (Gunawardana, 2011)

2.13 Summary

The literature review presents previous studies and the reference on research problem and its nature. Recent studies to compare the BSR and actual norms (Udawatta, 2010) shows the output of workers in several construction activities and his study limited only to compare BSR & Actual norms. Study (Gunawardana, 2011)for Labour Productivity in Construction Industry is mainly based on the questioner survey and the main objective is to identify the motivation factors of the workers. In this study data collection based on the pre determined motivation factors and concluded that the de motivational factors in poor working environment. Study on Total Factor Productivity (Nawarathna, 2006)was to study on various tools & techniques available to measure the productivity in construction industry. During the literature review there was no any study found on direct quantitative analysis of the construction workers performance & analysis of the major factors directly affect the workers performance.

Hereby major focus was given for the variation of labour productivity norms and key factors affecting the productivity of labour based construction projects. It has been identified the mode of payment are the major governing factor which will affect the productivity. The international norms for labour productivity as per the International Labour Organization were review and these factors can be compared with local norms. Building Schedule of Rates (BSR) was taken as the standard for construction industry and it shows labour , materials and plant consumption for construction activity. Standard Method of Measurement of Building Work was guideline for carrying out the estimation work. These documents were reviewed and figures use to check the current situation whether the engineering construction labour productivity improving or declining?

Labour Productivity analysis was the major element of research and Sri Lanka Labour performance was mainly concentrated. The breakdown of work hours shows the % of time taken for work (tool time) and other activities. Then the experimental data collected from industrial expertise to maximize the tool time for better productivity.

Many researches were carried out to identify & maximize the productivity of labour. These previous studies were very useful to develop the research background and well supported for detail analysis. The Research methodology was developed by considering the factors identified during the literature review. Survey method has been designed to collect the time study data and to identify the major factors affect the labour productivity as discussed in literature review.

CHAPTER 03 RESEARCH METHODOLOGY

3.1 Introduction

A list of motivation and demotivation factors were identified during the literature review. The review of literature also indicated the significance of the motivational factors on productivity and hence data collection methodology was designed by considering these factors.

Accordingly, methodology was developed to make an assessment of construction labour productivity. The methodology used in this study is the collection of time study data, which can be categorized as quantitative research. Quantitative approaches are more specific and result oriented and it involved the collection of numerical data in order to explain, predict and or control phenomena of interest (Mojaheed , 2005)

3.2 Survey

The most common survey methods are literature searches, taking with people or focus groups, personal interviews, telephone survey, mail surveys and internet surveys. Following surveys methods were used to collect information and data for this research.

Time study data collection is the one of the best way to get correct information during the initial stage of the research project. It can be used to gather information that is not commonly available or that is too new to be found in the literature. Although often valuable, the information has questionable validity because it is highly subjective and might not be representative of the population if not selected correctly.

Personal interviews are a way to get in-depth and comprehensive information. They involved one person interviewing another personal or detailed information. Typically, the interviewer will ask questions from a written questionnaire and record the answers verbatim

In this research above two methods is used to identify the influencing factors and analyze the reasons for labour productivity variations and its impact on construction organization.

3.3 Research Design

The research design can be considered as the overall picture of the research which is presented in this section. The design is used to structure the research, to describe how all of the major part of the research project works together tries to address the central research question. This quantitative research was design as an empirical study rather than a theoretical study. Data collection approaches, research sampling, data collection technique, data analysis technique and comparison with standard norms were design as compatible with the particular research. Figure 3.1 shows the important steps to be carried out on the research process.

The research design basically focuses on to the research problem and objectives.

In the construction industry, plenty of independent activities are available. With the time restriction of the research few construction activities were focused to carry out the detail analysis. As initial step, some activities on building construction were selected among the various civil engineering fields. In building construction industry, different scales of projects are available from single unit to multistoried. For the collection of time study data different scale of projects were selected based on the availability of construction activities as per the research requirement. Six different independent activities were selected to collect the data. Detail analysis was carried out for selected activities and final comparison with BSR standard, international standard and experimental was done for individual activity basis. Final conclusion and recommended were based on the detail analysis.

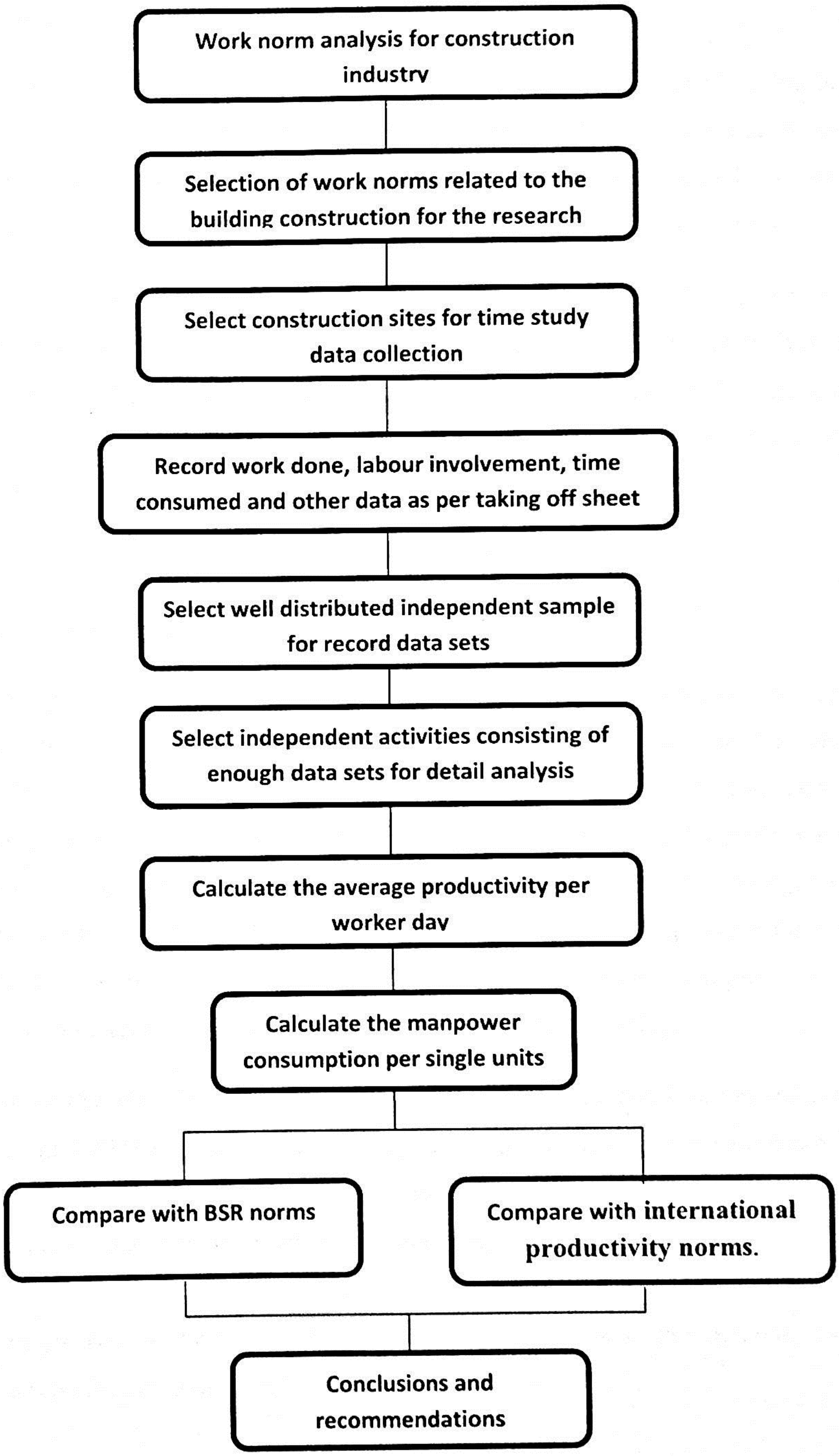

Fig 3.1 Important Steps for Research and Analysis

3.3.1 Design of time study data collection format

Time studies are the application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance (Haris, 1997). First, the work norm parameters to be analysis in this study were identified. The work to be observed should be broken down into elements to facilitate subsequence synthesis.

As identified during the literature review, the condition of different tools and equipments used for specific construction activities were recorded. Time study abstract sheet shows in Modern Construction Management, Third edition (Haris, 1997) were considered when designing the data collection format. These data collection format are shown in appendix 01 to appendix 06.

3.3.2 Sampling technique and Sampling size

A Purposive sampling method was used to select the sample from the contractors who are having ICTAD classification C1 to C6. It can definitely say that the selection of participants is a very vital part of planning a research. Without careful planning and choosing an appropriate methods for sampling, it is very easy to obtain a biased sample that does not represent the population. When this happens, it is difficult to extend findings to a wider population and the validity of the experiment decreases. In order to produce influential and meaningful results, researchers must ensure that they have chosen an appropriate sampling method to select a representative sample of participants (David, 2006).

Study the Population: - The current employment in construction industry of Sri Lanka is about 609480 in year 2012 (Central Bank Annual Report, 2008) as shown in Figure 3.1 this includes categories of technical, professional, operator and craft (ICRA, 2011). Then the total population in craftsmen represents about 432730.

Sample size: - Out of this 432730 number of craftsmen, 260 (Krejcie, 1970) were selected as representative sample.

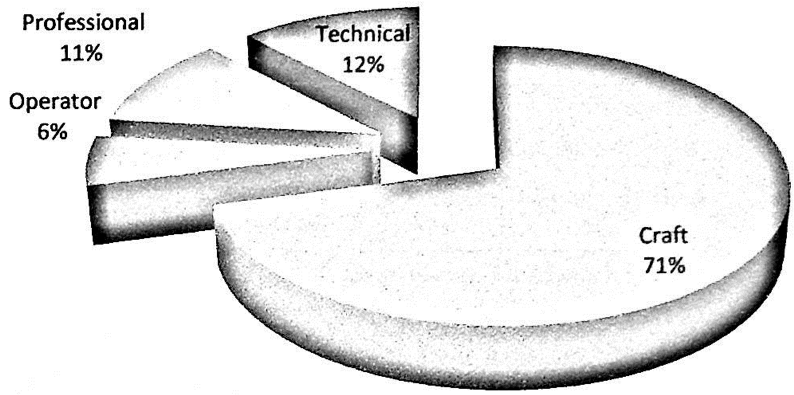

Figure 3.2-Distribution of Employment Category in Construction Industry

3.3.3 Data analysis tools

As in figure 3.1, firstly, we identify the work norm parameters to be analyzed in this study. Basically research was carried out by using collected daily records from selected sites. Building construction sites were selected in order to collect data according to the availability. Most essential parameters which can be collected from the site were defined at the research design stage. In construction projects, there are plenty of activities can be found during the construction phase. For this research, activities related to civil works were selected and some special works as aluminum work, waterproofing, electrical work etc... were not selected for the same because these specialized works are usually carried out by using out sourced specialized sub contractors. Some are proprietary system and cannot use for comparison. Another reason is that civil work is the main body of the construction industry and it covers more than 50% of the contract sum and more labour intensive job compared to the other activities (Udawatta, 2010).

Having prepared data collection templates, the basic introductions were given to technical and supervision staff and it was covered taking off measurements, grouping the activities, measure the working hours and entering the data to templates. Initially collected data was filtered with respect to the activity basis and entered to the electronic format.

Meanwhile daily work done per skill labour per day was calculated. For this analysis simple statistical formulas and graphs were used for interpretation

Productivity of each activity can be defined as follows

$$Pr = \frac{\text{Output}}{\text{Input}}$$

Inputs include Labour , Plant & equipment ,Capital

Output is typically measured in revenues and other components such as quantity of work done, quality & stranded.

In this study, input is generally taken as labour hours and output is the quantity of work done within the selected period.

Comparison index can be defined as follows

$$D = \frac{V_{Actual} - V_{BSR}}{V_{BSR}} \times 100$$

(Udawatta, 2010)

Where, D is the percentage index of a selected activity, **'V Actual'** is the actual data measured from respective sites and **'V_{BSR}'** is the corresponding Building Scheduling of Rates.

In addition to the numerical analysis and data collection from interviews, discussion with industry expertise and historical data analysis were taken in to consideration. Output from these data are discussed in conclusion

3.4 Parameter Selection

To fulfill the objectives of the research, defining of parameters is one of the important tasks. Daily work done on specific task is measured in order to analyze the performances of the workers. In this research, the labour components were measured for different construction activities. Each construction activity has different parameters with the nature of event and such parameters were monitored separately. Condition of different tools and equipments used for specific construction activities were recorded to analyze the data.

According to the research topic, the key parameter was the work norms in labour based construction projects. During the literature review so many factors which will affect the labour productivity were identified. Table 3.1 given below represents the parameters and relevant variables

Table 3.1 Parameters and Variables

#	Activity	Unit	*Parameter to be Measured*				
			Labour consumption	***Payment Mode***	***Tools & machinery allocation***	***Work Supervision***	***Others***
1	Manual Excavation	m^3	Unskilled labour	day work, piecework, task work	Mamoty, shovel, Throw bar, pitchas	Technical supervision,	Type of soil
2	Soil Back filling & compaction	m^3	Unskilled labour	day work, piecework, task work	Mamoty, shovel, Throw bar, pitches	Technical supevision,	Hauling distance
3	Column Concreting	m^3	Skilled, Unskilled labour	day work, piecework, task work	Crane & Bucket	Technical supevision,	
4	9" thick brick wall cement: sand 1:5 in superstructure	m^2	Skilled, Unskilled labour	day work, piecework, task work	Mamoty, shovel, Trowel, level bar	Technical supervision,	
5	16mm thick cement: sand 1:5 plaster in walls	m^2	Skilled, Unskilled labour	day work, piecework, task work	Mamoty, shovel, Trowel, level bar	Technical supervision,	
6	random Rubble masonry in cement and sand 1:5 using 6"x9", 6"x4" broken stones in foundation	m^3	Skilled, Unskilled labour	day work, piecework, task work	Mamoty, shovel, Trowel, level bar	Technical supervision,	

3.5 Sample Design

Sample design was very important and characteristics of the sample represent the population of the event. The sampling method used to select the organization, activities and set of data was non probability purposive sample. This means that there is no chance to each and every sample for inclusion in population. Purposive means the sample is selected merely for the purpose of the research.

Labour consumption and productivity are vast areas because it extends to various types of labouring activities in the construction and other fields. Hence the construction field has been selected to carry out the research. There has been various construction sites spread all around the country such as irrigation, highway, building, water supply etc... Among the above mention specialized different fields, building construction was selected for the research. Evaluation of labour productivity and actual norms is covered very board area and consider only the labour involvement of the construction industry.

There are number of building construction projects going on in Sri Lanka, However as a sample of this research, two sites from Tudawe Brothers (pvt) limited, two sites from Access Project (pvt) limited, One site from Maga Engineering (pvt) Limited and one site from S & S Engineering (pvt) Limited were selected. In addition to time study data telephone interview had been held with industrial expertise and all conversations have been recorded.

3.6 Summary

This chapter described how the research design was done owing to the research problem and it further indicates how the parameter selection and sample design was done. The Survey method indicates type of the data collection and how importances of the data are. Research design can be consider as the overall picture of the research and it shows the important steps of the research, selection of activities for data collection and selection of work sites for data collection. It also described the derivation of time study data collection formats and sampling techniques. Simple statistical formula is used for data analysis. Parameter selection was another important event of the research. Relevant data were defined as parameter of the activity. Finally these parameters were compared with BSR standard values and international work norms. In addition samples were defined representing the population of the event. Six construction sites representing four leading construction companies were selected as samples for detail analysis.

Next chapter described how the data collection was done and detail data analysis to achieve the research objectives as per the methodology discussed in Chapter 3

CHAPTER 04 DATA COLLOLECTION AND ANALYSIS

4.1 Introduction

The previous chapters described the research problems, research design, and selection of parameters and sample design. In this study, data from selected construction sites were taken in to consideration. All the time study data was collected by directly supervising the work and entered in to prepared format. This process was a new experience for the site staff and some difficulties were found in identifying the events through collection and recording the data in each site. Mode of payment for the particular activities were recorded and tools & machinery availability, work supervision, details availability, type of work and other required data was collected. The simplified template was very useful for the data collection and analysis. These data collection templates are shown in Appendix 1 to Appendix 6.

4.2 Preliminary Data Collection

This research mainly based on quantitative method to gather data and all the data was measured independently. Data collection procedure was very long and different kind of difficulties faced during data collection. However it was done successfully.

To produce this Brief, a time study was carried out to selected active labour-based projects in Colombo & suburb to obtain data on their current norms. In addition, a number of documents were consulted to obtain data from completed projects and projects in other regions. The summary of these sources of additional information are included in Appendix 7 to Appendix 12

One of the sub objectives was to compare the productivity of companies in engineering construction sites in Sri Lanka to that achievements of the companies on comparable sites in abroad. For that purposed it was required to collect productivity data in excavation and back filling since International Labour Organization has done the analysis and published the comparable data related to excavation and back filling (ILO, 2010). For the time study data, it was assume the materials are available at site and waiting time for materials and tools are not taken in to consideration during data collection. However this issue was raised during the interview & discussion had with industrial experts and their feedback was recorded. According to the issues identify during the literature review, the data collection was mainly focused to record time study data with the mode of payment, Work Supervision, Organization of work and Tools availability.

Data collection period was limited and work norms data related to the construction activities within the period were recorded for the study. It was found that few data sets were becoming detached from the average due to error in recording. Hence incomplete and unrealistic data were eliminated from the data set. In addition some of the labor groups has being involving in several task during the recording and such data was not encountered to the data analysis.

4.2.1 Excavation

This is common labour-based activity that can be applied to many items in a construction program.

Excavation is required:

- To produce pit and trenches for lay column/ wall foundation in virgin terrain
- To obtain material for filling
- In producing road side drains,
- In quarries to obtain gravel for surfacing
- To form the embankments
- To obtain material for small earth dams.

Even the activity of breaking up rock boulders is strictly speaking an excavation.

This activity can usually be carried out by hoe or shovel, but as the material hardens, a mattock, pickaxe or even a heavy crowbar will be needed. For fractured rock, chisels and hammers can be utilized, but for very hard rock, drilling and blasting will be Necessary. For soft material, the worker will only require one hand tool such as a hoe or shovel, but for harder materials each worker will need to be equipped with two tools, typically a pick to loosen the material, and a shovel to remove it.

The method of disposal of the excavated material needs to be well defined in how the activity is specified. Many project expect the excavator (the person who does the excavating) to load material into a head basket, wheelbarrow or trailer as part of the operation. In other cases the excavator is expected to "throw" the material away, or into the required place and country data received from various projects confirms that this extra operation does not seem to add significantly to the effort required. Thus the excavation parameter for this study is defined as including, loading or throwing, providing this does not include a lift of more than one meter, or a throw of more than two meters.

The most important parameter for excavation is the hardness of the material. This can alter the expected productivity by a factor of four or greater. Materials are typically described as soft, medium, hard, very hard or rock and these terms are used in the comparison of different project data. This is set out in Table 4.1 below in a simplified form as a useful way for projects to assess their individual situation. All excavation is measured in cubic meters of in situ material.

Table: 4.1 Soil Excavation Characteristics

Activity definition	Soil Description		Suitable tools
	Cohesive	Non- Cohesive	
Soft	Soft	Very loose	Easily excavated with a shovel or hoe
Medium	Firm	Loose	Can be dug with a shovel
Hard	Stiff	Compact	Mattock, pick or other swung tool required
Very Hard	Very Stiff or Hard	Dense or Very dense	Crowbar required in addition to pick
Rock		Rock	Sledge hammer and chisels required

With the availability of high performance machineries most of the excavations were mechanized excavations in large scale projects. However to collect time study data for manual excavations, small scale construction projects, House construction and pits excavation were selected.

4.2.1.1 Specimen Calculation

Consider the sample time study data collected for manual Soil Excavation shown in Table 4.2 This form was derived as explained in chapter 3.3.1. This data set is only for sample calculation and data required for the study (sample size) was explained in chapter 3.3.2. The summary of whole data collected is given in Appendix 7 to Appendix 12 and used for analysis in coming chapters

Table 4.2 Time Study Data for Manual Excavation

M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of "**Review of Productivity Norms in the Construction Industry**".											
Company Name											
Project Name											
Date											
Time study for excavation for foundation(manual)											
Element	**Basic time**								**Total**	**Frequency**	**Average ft³/ hour**
Start time	8.1	8.2	11	11	14	14.2	16.4	16.4			
End time	10.4	10.3	13	13	16.4	16.3	18.3	18.3			
Duration	2.3	2.1	2	2	2.4	2.1	1.5	1.5	15.9	8	14.2
Volume excavated	66	62	56	52	67	61	43	45	452	8	
No of workers allocated	2	2	2	2	2	2	2	2			
Tools/Machinery allocated	Mamoty, Showel , Crow Bar										
Type of soil	Loose soil										
Supervising oficer (designation)							Mode of Payment				
Other Observations											

According to the data collected, the average value was calculated for each time study data sets and the calculated average value for each work item are given in Appendix 7 to Appendix 12. Based on this average value, median productivity value for each work item under different category was calculated

$$\text{Productivity Value (Country Median)} = \frac{\sum \textit{Average Producgtivity as per Appendix } 7}{\text{Frequency}}$$

This median productivity values calculated for excavation as per the experimental data are shown in Table 4.3

Table 4.3 Average (Median) Productivity of Soil Excavation as per Experimental Data

Average Productivity by Soil Classification Excavated Qty m³ per workers day (8 working hours)				
Soft	Medium	Hard	Very Hard	Rock
3.82	3.4	2.12	0.6	

The Table 4.3 gives average quantity of soil excavated per workers day (8 working hours) are shown therein. For this average time study, 12 data sets were selected and these sources of additional information are included in Appendix 7 (Appendix 7 - summary of time study data for excavation)

Table 4.4 **Comparison of BSR Value & Experimental Data - Average Productivity of Soil Excavation.**

	Average Productivity by Soil Classification Excavated Qty m³ per workers day (8 working hours)				
	Soft	Medium	Hard	Very Hard	Rock
Experimental	3.82	3.4	2.12	0.6	
BSR Value	2.83	1.26	0.81	1.13	
% Variation	26%	63%	61%	(78%)	

Comparison of actual and BSR labour productivity norms for excavation are described in Table 4.4. This shows that the large variation between Experimental and BSR value.

The median results can be compared with the results from recent trials and the original productivity norms from the other countries. To compare the productivity of companies on engineering construction sites in the Sri Lanka to that achieved by companies on comparable sites in abroad, the productivity norm data given in *ILO/ASIST Technical Brief No. 2* can be used

Table 4.5: Recent Trials and the Original Productivity Norms from the other Countries

Country	Average Productivity by Soil Classification m^3 per workers day (8 working hours)				
	Soft	Medium	Hard	Very Hard	Rock
Botswana	4.15	3.8	2.5	1.9	-
Cambodia	2.75	2	1.25	.75	-
China	9.0	7.0	3	2.0	-
Ghana	3.75	3.75	3.75	3.75	-
Indonesia	-	-	2.5	-	-
Kenya	5.0	3.5	2.25	1.75	0 .75
Lesotho	4.5	3.5	2.75	1.0	0.5
Nepal	-	3.3	2.5	-	0.61
Tanzania	5.5	4.5	4.0	2.	-
Zimbabwe	5.5	5.5	4.0	3.5	2.0
Sri Lanka	3.82	3.40	2.12	0.6	-

The highest productivity norms for excavation were in China with productivity rates up to 9 and 7m^3 per day respectively for soils classified as of soft or medium workability. However, China is very well organized in this sort of activity, and its workers are accustomed to work levels which may not be acceptable in other regions of the world.

Zimbabwe's productivity norms were up to 6m^3 per day and consistently higher than other countries in all activities. Some of the rock excavation figures are high and may reflect a lack of data in this area for manual methods, apart from Lesotho and Nepal.

According to the experimental data, Sri Lankan productivity norm for soft soil excavation was 3.82 m^3 per workers day. This is considerably lower than other countries. That for medium soil was 3.4 m^3 per workers day and equal to the country medium for medium soft soil as per Table 2.2. The country median of productivity data for very hard soil is 0.6 m^3 per workers day as per the experimental data this value was very much lower than the international norms

4.2.1.2 Cost Impact Analysis

Table 4.6 - Cost for Excavate 1 m³ of Soil as per Experimental Data

Company / Site Name	Average cost per 1 m³ of excavation	
	Day work	Piece work
Company - 01 (very hard soil)	381.00	
Company - 02	298.00	
Company - 05	318.00	883.00
Company - 06		776.00

According to the ILO data median value for soft soil excavation is 3.5 m³/day. Then the cost for 1m³ of is Rs. 285.00 (1000.00/3.5). However average Sri Lanka experimental value is Rs 332.00 and BSR Value is Rs. 353. The major factors affecting this variation are discussed under conclusion.

4.2.2 Back Filling

This activity is often combination of loading. Unloading and spreading

Loading refers to loading from a pre-excavated stockpile.

Unloading is probably unique to labour-based activities in civil engineering. It does not refer to wheelbarrows or head baskets, but to emptying non-tipping trailers or trucks.

Spreading refers to the general activity of converting loosely dumped soil or gravel into a smooth and even road surface. It includes moving material by shovel, hoe, rake, and the use of leveling devices such as the chamber board and string lines.

Table 4.7 Average Productivity Data for Back Filling

Average Productivity of back filling by haul distance in Sri Lanka m³ per workers day (8 working hours)			
0-20m	20-40m	40-60m	60-80m
6.74	4.81		

Table 4.8 Comparison of BSR Value & Experimental Data – Back Filling

	Average Productivity of back filling by haul distance in Sri Lanka m³ per workers day (8 working hours)			
	0-20m	20-40m	40-60m	60-80m
Experimental	6.74	4.81		
BSR	2.83	2.83		
Variation %	57%	41%		

This data shows that the BSR data are obsolete. However BSR does not describe the most important parameters such as haul distance, compaction methods which will affect the productivity of work. Hence the BSR norms cannot use as it is for the estimating purpose

These median results can be compared with the results from recent trials and the original productivity norms from the other countries.

Table 4.9 Average Productivity Data for Back Filling by Haul Distance

Country	Average Productivity of back filling by haul distance m³ per workers day(8 working hours)			
	0-20m	20-40m	40-60m	60-80m
Botswana	8.4	7	6.7	5.6
Kenya	10.5	10.5	8	6.5
Lesotho	8	6	5	4.5
Tanzania	11	11	8.25	6.25
Zimbabwe	5	5	5	5
Sri Lanka	6.74	4.81	-	-

For better productivity the recommended norms to be keep at the higher end of the range. These figures are achievable but require the operation to be well set up, particularly with regard to the condition of the haulage route. World Bank data has demonstrated that a poor haul route can halve productivity. Productivity depends to a large extent on the efficiency of the loading teams. However, haulage route condition and type of haulage equipment also play a large part, as well as the organization of the loading and unloading areas.

4.2.2.2 Cost & Impact Analysis

Table 4.10 Cost Per Unit of Work Item (back filling)

Company / Site Name	Average Cost per 1 m^3 of Back filling	
	Day work	Piece work
Company - 01	331.00	
Company - 02	162.00	
Company - 05		706.00

According to the Table 4.10, Cost for 1 m^3 of back filling is different for the each company. This is mainly because of the hauling distance, Loading method etc...

4.2.3 Column Concreting

For the time study data column concreting using concrete skipper and crane at upper floor levels are taken in to consideration

In this study it has been notice that the time taken to perform job will depends on some major factors

- Location and elevation of column
- Bucket capacity
- Scaffolding arrangement
- Crane operator's skill
- Column size

Output is highly varied depending on these factors and hence these data cannot take in to comparison with other data. Mode of payment for all the observations were day work and therefore the productivity of most of activities were depends on supervisor's skill and above listed factors.

Table 4.11: Average Productivity Data for Column Concreting Using Skipper

Output (m^3/ Hrs) From Time study data	Output (m^3/ Hrs) from total job
3.9	1.25
3.7	2.6
2	1.9
5.56	4.16
1.51	1.2

Data shows the considerable different in outputs, and this is due to time taken to transfer from one column to other, idle time during concreting, time for scaffolding and other safety arrangements,

Concreting operations in most of construction sites are ready mixed concrete. BSR does not give any productivity norm or guidance for ready mixed concreting work.

4.2.4 Brick work

Productivity of Construction of brick walls are depends on several factors (other than workers performance)

- Location
- Supply of materials
- Size & Quality of bricks
- Payment mode

In this research, time study data was collected based on the payment mode and it was observed the considerable productivity gap between day work and piece work. Task work construction activities not much common in brick work construction. Median values of productivity data for brick wall construction are shown below.

Table 4.12 Average Productivity Data for Brick Wall Construction

Company Name	Average Productivity Rate			
	day work		Piece work	
	ft²/ day	m²/ day	ft²/ day	m²/ day
Company 01	56	5.21	71	6.60
Company 02	58	5.40	85	7.91
Company 03	46	4.28	65	6.05
Company 04	49	4.56	68	6.33

In Table 4.5, brick work process data were shown in different sites in different payment modes. These figures show the considerable difference in productivity data between day work and piece work, during the study, supervisor's motivation level, company profile. Tools availability was also noted. On this selection, time taken to complete the selected quantity were taken and based on that, the amount of work to be completed for 8 hours period was calculated.

Table 4.13 Comparison of Labour Involvement for Brick Work with Actual and BSR Norms.

Item	Experimental Norms per square		BSR Norms per square		% of Variation from BSR Norm	
	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled
1	2.05	3.32	2.25	3.75	8%	11%
2	1.72	2.85	2.25	3.75	24%	23%
3	2.17	3.25	2.25	3.75	4%	13%
4	1.47	2.8	2.25	3.75	34%	25%
5	1.17	2.82	2.25	3.75	48%	24%
6	1.53	3.12	2.25	3.75	32%	17%
7	1.41	3.05	2.25	3.75	37%	19%

According to the experiment data first three figures are related to the day work payment and next four figures are piece work payment. According to this figures it can be assumed that the base for BSR were the basic day work norms and BSR does not represent the correct values for estimation.

4.2.4.2 Cost impact

Table 4.14 Cost Per 1 m² of 9" Brick Wall

Company / Site Name	Average cost per 1 m² of 9" Brick wall	
	Day work	Piece work
Company - 01	512.00	480.00
Company - 02	568.00	490.00
Company - 03	571.00	590.00
Company - 04	482.00	430.00
Company - 06	569.00	430.00

This experimental data shows the considerable different in cost per 1 m2 of brick work in some companies. When the company gives higher piecework rate for the work then the cost per 1 m² of brick work lesser in day work basis.

. 4.2.5 Wall Plastering Work

Definition:

Cement sand plaster is a layer of cement and sand mortar which is applied over walls made of brickwork, cement block work, RCC walls or RCC columns and beams.

The plaster can be divided into 2 basic categories:

1. Interior plaster (as specified by interior designers) is usually smooth finish and 16mm thick (can have rough keyed surface to receive another material like tile or stone cladding)
2. Exterior plaster which is applied on building facades, compound walls etc. is usually 20 mm thick. The top coat is usually rough finish with a sand grain texture.

Same as the brick wall construction, productivity of plastering works also depends on some major factors other than workers performance.

- ➢ Location & height
- ➢ Supply of materials
- ➢ Plumbness of the existing wall
- ➢ Payment mode

In this research, time study data was collected based on the payment mode and it was observed the considerable productivity gap between day work and piece work. Median values of productivity data for wall plastering are shown in table 4.9

Table 4.15 Average Productivity Data for Wall Plastering

Company Name	Average Productivity Rate			
	Day work		Piece work	
	ft²/ day	m²/ day	ft²/ day	m²/ day
Company 01	126	11.72	145	13.49
Company 02	100	9.30	195	18.14
Company 03	70	6.51	140	13.02
Company 04	108	10.05	158	14.70

As usual, work durations were measured hourly basis and finally it was converted to the daily work output.

Table 4.16 Comparison of Labour Involvement for Wall Plastering - Actual and BSR Norms.

Item	Experimental Norms per square		BSR Norms per square		% of Variation from BSR Norm	
	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled
1	0 .93	1.4	1.0	1.25	10%	-12%
2	1.0	1.3	1.0	1.25	0%	-4%
3	1.4	1.96	1.0	1.25	-40%	-51%
4	0.63	1	1.0	1.25	37%	20%
5	0.51	0.8	1.0	1.25	49%	36%
6	0.71	1.3	1.0	1.25	28%	-4%
7	0.69	1.0	1.0	1.25	31%	20%

Same as brick work, piece work figures has considerable variation from BSR values.

4.2.5.2. Cost Impact

Table 4.17 Cost for 1 m² of Plastering

Company / Site Name	Average cost per 1 m² of Wall Plastering	
	Day work	Piece work
Company - 01	188.00	240.00
Company - 02	235.00	279.00
Company - 03	337.00	279.00
Company - 04	218.00	258.00

According to the experimental data day work cost for 1m2 of wall plastering in company 02 is lower than that of piece work cost. Even though piece work method produced better productivity, cost wise day work method is economical for the construction company. This phenomenon happens due to higher piece work rate offering for the labour sub contractors by considering his profit and overhead.

4.2.6 Rubble Masonry Work

Table 4.18 Average Productivity Data for Rubble Masonry Work

Company Name	Average Productivity Rate			
	Day work		Piece work	
	ft^3/ day	m^3/ day	ft^3/ day	m^3/ day
Company 01	64	1.82	74	2.10
Company 02	38	1.08	64	1.82
Company 03	48	1.36	62	1.76

Rubble work and its labour component were taken in to consideration. Cement, sand & rubble stone are used for construction. Generally rubble walls used for wall foundations are less than 600mm width. For the earth retaining structures with of the rubble wall varied from 1800mm to 450 mm. Productivity construction of wider rubble walls are considerably higher than the of thinner walls.

Table 4.19 Comparison of Actual and BSR Productivity Norms for Rubble Work

Item	Experimental Norms		BSR Norms		% of Variation from BSR Norm	
	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled
1	2.6	4.0	4.0	6.0	10%	-12%
2	2.1	4.0	4.0	6.0	0%	-4%
3	1.5	2.4	4.0	6.0	-40%	-51%
4	1.5	2.45	4.0	6.0	37%	20%
5	1.6	2.65	4.0	6.0	49%	36%
6	1.4	2.05	4.0	6.0	28%	-4%

Same as the productivity norms for brick work and plastering discussed above, rubble work also shows the considerable deviation from BSR values. Hence the use of BSR norms for the estimation is not recommended.

4.2.6.2 Cost Impact Analysis

Table 4.20 Cost Per 1 m³ of Rubble Masonry Work

Company / Site Name	Average cost per 1 m³ of Rubble masonry work	
	Day work	Piece work
Company - 01	1,507.00	1,295.00
Company - 02	2,142.00	1,591.00
Company - 03	1,696.00	1,665.00

This data shows the cost different between day work and piece work, Different in productivity is very high though the different in cost is very low.

4.3 Methods Used for Data Collection

Collection of raw data was the most important part of the research, because the research was based on experimental data. Hence extra attention was granted at the data collection stage. Data collection part was done by well trained technical staff at each site. Data collection process was basically divided in to three categories and they were day work labours, piece work labours and task work labours. It was given an extra attention to quantify the direct and indirect labour involvement for respective event. Indirect labour involvements, such as material transport etc were not taken in to final figures. Skill and unskilled labour component were measured on hourly basis and it was converted to the daily rate. It was assumed that normal working day consisting of the eight hours working period. Next step was the work done of the event and it was physically measured as per the guidelines described in the standard method of measurements. All the data was entered in to the template by the technical staff and hard copies of template have been distributed among the officers and end of the day completed records were collected. Finally data sheet were entered in to the electronic format and it was used for detail analysis.

4.4 Data Preparation for Analysis with BSR Norms

All recorded daily data sheet were checked with basic requirement for the detail analysis. Incomplete and unrealistic data were removed from the data sample due to arithmetic mistakes.

Table 4. 21 Summary of Experimental Labour Consumptions and BSR Norms

Activity	States	Day work		Piece work		Task work	
		Skill	Unskilled	Skill	Unskilled	Skill	Unskilled
Excavation per m³	Actual Norms		0.3				
	BSR		0.79				
Back filling per m³	Actual Norms		0.15				
	BSR		0.35				
Brick work per square	Actual Norms	1.98	3.14	1.40	2.95		
	BSR	2.25	3.75	2.25	3.75		
Wall Plastering per square	Actual Norms	1.11	1.55	0.64	1.03		
	BSR	1.0	1.25	1.0	1.25		
Rubble work per m³	Actual Norms	2.07	3.47	1.5	2.38		
	BSR	4.0	6.0	4.0	6.0		

According to the above Table six construction activities which were Excavation, Back filling, Brick work, Wall plastering and Rubble work were selected for detail analysis. This table shows that the main two figures which related to BSR standard and experimental data were considered for different events. Mainly the labour components were divided in two major components which are skill and unskilled labour. First data sets of the table 4.8 were described as labour consumption for excavate 1 m³ of soil as per the actual research data and BSR norms. Similarly work norms for other activities were described on table 4.8.

4.5 Analysis of Labour Consumption and Deviation from BSR

In this research, deviation of labour consumption was calculated and it was notice that less labour component was used in each construction activity. As described under research design in section 3, the analysis simple statistical formulas and graphs were used for interpretation. BSR is used to compare the standard norms with actual norms and comparison index was defined and formula as follows (Udawatta, 2010)

$$D = \frac{V_{Actual} - V_{BSR}}{V_{BSR}} \times 100$$

Where, D is the percentage index of a selected activity, 'V_{Actual}' is the actual data measured from respective sites and 'V_{BSR}' is the corresponding Building Scheduling of Rates. As per the comparison index defined above, the percentage deviations of each activity with respect to the different parameters were calculated and details were described.

Table 4.22 Comparison of Skill Labour Consumption and Deviation

Activity	V_{Actual}	V_{BSR}	$V_{Actual}-V_{BSR}$	D
Excavation	-	-	-	-
Back filling	-	-	-	-
Brick work	1.98	2.25	-0.3	-13%
Wall Plastering	1.11	1.0	0.11	11%
Rubble work	2.07	4.0	-1.93	-48%

In this study, productivity norms were recorded based on day work and piece work. The average value of this day work and piece work has been taken for 'V_{Actual}.'

Table 4.23 Comparison of Unskilled Labour Consumption and Deviation

Activity	V_{Actual}	V_{BSR}	$V_{Actual}-V_{BSR}$	D
Excavation	0.3	0 .79	-0.49	-62%
Back filling	0.15	0.35	-0.2	-57%
Brick work	3.14	3.75	-0.61	-16%
Wall Plastering	1.55	1.25	0.3	24%
Rubble work	3.47	6.0	-2.53	-42%

The comparison between the actual labour involvement and BSR standard in different construction activities was compared in Table 4.21 and Table 4.22.

The first raw illustrates the actual labour usage for excavation of cubic meter of soil and BSR standard. As per the experimental data (Skilled labour usage to finish square of brick work is 3.14 and BSR standard value was 3.75. in addition percentage deviation of these two was 16% and negative sign represent the less time taken in actual situation.)

Likewise the D value was calculated for other activities.

Table 4.24 Summary of Average Daily Work Done of the Skilled Labour

#	Construction Activity	Unit	Daily Work Done			
			Actual Qty			BSR Qty
			Day work	Piece work	Task work	
1	Excavation (medium hard)	m^3/Day	3.4	-	-	1.26
2	Back Filling	m^3/Day	6.74	-	-	2.83
3	Column Concreting	m^3/Day	17.84	-	-	-
4	9" Brick work	m^2/Day	4.8	6.7	-	1.13
5	Wall Plastering	m^2/Day	9.4	14.9	-	9.3
6	Rubble Work	m^3/Day	1.35	1.8	-	0.71

Table 4.23 described the summary on research findings and comparison with BSR relative values. These figures were shown in the actual quantity column with respect to the construction activities. Owing to the time restriction of the research period, six activities were selected for final analysis and respective BSR values were shown separately. Normally BSR is used to develop the construction rates for filling the BOQ at budding stage.

4.6 Summary

This chapter illustrates the survey findings which includes the number of time study data collected for the survey and their response. Productivity variation under mode of payment such as day work, piece work and task work were deeply analyzed to justify the best way to get work done efficiently and economically. Productivity and its cost impact analyzed separately and cost impact for the construction organization was tabulated. Experimental data and BSR data were tabulated and analyzed separately to identify the variation of experimental data with BSR norms.

To compare the local productivity level with international norms, experimental data from excavation and back filling were used due to the data availability. This comparison shows lesser productivity level in Sri Lanka compared with other regional countries.

The analysis of these factors clearly stated that the importance of these factors in order to enhance the productivity in construction industry. Next chapter describe how these factors affect the productivity and more about the research findings

CHAPTER 05 - CONCLUSIONS RECOMMONDATIONS & FURTHER STUDY

5.1 Conclusion,

The main objective of the research was to make an assessment of labour productivity of construction work and its impact on construction organization and it was carried out by collecting the actual data from different sites.

The previous sections have set out the average amount of work that can be expected from an average worker in reasonable health, however, this average figure can be affected by many factors, the most important are:

1. Motivation and experience of the workforce
2. Organization of the work
3. Type and condition of tools and equipment provided to the worker
4. Continual monitoring of performance.

5.1.1. Motivations & Experience of Work Force

Labor productivity is the amount of services that a craftsmen produces in a given amount of time (labor productivity norm), also referred to as the measured time required to execute a specified amount of work. In this study, it has been identified that the motivation and experience of the work force as a key factor to affect the construction productivity.

In the study, it has been identified the mode of payment as the main striking method to motivate tradesmen. **Day work, Piece work** and the **Task work** are the three payments methods in labour based construction projects.

When setting the task work experienced personal should be set the task accurately. Tasks are generally set to be achievable in 70 per cent of the working day (a working day being assumed as a period of eight hours), This approach has proved very successful in practice when experience work group are engaging with the work, Some occasion highly skilled work groups are often completed the set daily task in 50 per cent of the working day (*i.e.* in four hours) depending of the ability of worker. Often doubling the amount of work achieved in a day; and by inference doubling the productivity of the individual worker, as well as halving the costs. The most common work methods are the day work and piece work.

According to the experimental data, it is observed that the productivity of day work group is lower than that of piece work or task work labours since the worker's own motivation and sense of responsibility is very low in day work group. They know they will be paid whether they work or not. In many day work cases the amount of work produced depends entirely on the supervisor's ability to encourage the workers,

However, for piece work to function correctly, it is essential to establish the correct piece rate. If the work done within the day is much lower than the prevailing cash wage for similar work in the area, then there is a danger that an insufficient number of workers will be attracted, and the attendance of those that do come will be unreliable, sometimes null. If there is very high unemployment, or more commonly if there are few alternative chances of getting waged employment, it has been found that, although workers will be recruited, they will be lack motivation and be resentful of normal piece work. Then the workers will tend to work under day work or request claim for the lost.

Responsible management must avoid the situation where below-poverty-line-rates are being given to the people. Conversely it is important that rates are not so high as to distort the local economy.

Although piecework demonstrably gives the highest output. *t* does have its own problems such as quality of work, higher rate to complete the work lead higher construction cost etc… .

Depending on the training and experience of the site supervisory staff, and work arrangement within the organization the productivity will vary. Without the continued presence of trained supervision, outputs will drop substantially specially in day work groups.

During the studies it was indicate that blunt or worn excavating tools can reduce worker output considerably. Badly made or poorly fitted handles also have a significant negative effect. Standard norms are established with good quality tools at the start of a project. As tool quality decreases, the workers have to compensate by putting in longer hours to achieve their daily task. Tool management must achieve two things to ensure maximum productivity. Firstly a hand tool of the **correct strength** and secondly a **system of routine maintenance and tool replacement** must be in place on any site to ensure that workers always have good tools.

5.1.2 Comparison of Productivity with Other Countries

To compare the productivity of companies on engineering construction sites in the Sri Lanka to that achieved by companies on comparable sites abroad the productivity norm data given in *ILO/ASIST Technical Brief No. 2* is used. The median results compared with the results from recent trials and the original productivity norms from the other countries. With the data availability, only excavation and back filling norms were considered.

The highest productivity norms for excavation were in China with productivity rates up to 9 and 7m^3 per day respectively for soils classified as of soft or medium workability. However, China is very well organized in this sort of activity, and its workers are accustomed to work levels which may not be acceptable in other regions of the world.

According to the experimental data, Sri Lankan productivity norm for soft soil excavation was 3.82 m^3 per workers day. This is considerably lower than other countries. That for medium soil was 3.4 m^3 per workers day and equal to the country medium for medium soft soil as per Table 2.2. The country median of productivity data for very hard soil is 0.6 m^3 per workers day as per the experimental data this value was very much lower than the international norms.

At present construction industry is having a huge market competition and tries to develop its own pricing strategy to become a competitive source in the market. Moreover BSR was not revised during past few decades and new comers still use this as a guide to develop the rates. Hence this research is very appropriate to understand the industry behavior. In this research some of construction activities were represented at the finishing stage of the construction process and today all the stakeholders are more concern about the final quality of the product. Hence contractors have to spend more time and money to meet the desired quality standards. This was the main reason to use highly skilled workers and trained supervision staff for the labour based construction projects.

5.2 Recommendations and Further Study

This thesis is focus to develop the work norms for medium scale building construction site and research findings were based on the experimental data. This research was targeted mainly to find out the daily work done, Labour Consumption and key drivers affecting the productivity of engineering construction sites. The daily work done was measured for each activities and it was directly proportionate to the labour performance. After detail analysis and comparison with BSR & International norms, the daily work output were satisfactorily good when compared with BSR norms and but the daily work output is considerably less when compared with international norms. With the technology improvement it is necessary to improve and maintain the workers daily performance at recommended international level to fight with international bidders.

The research finding revealed that the four main factors which will affecting the labour based construction projects as Motivation and experience of the workforce, Organization of the work, Type and condition of tools and equipment provided to the workers, Skill Development, Training & Continual monitoring of performance. As a result of poor management of these factors, the cost is automatically gone up and this may pave the way to major issue or failure to the project. Hence all the construction organizations need to review and adhere to these findings to fill the loopholes in their system.

In construction industry, Standard norms for labour are used for planning and monitoring work and it is very important document in civil engineering field. However available document was developed more than twenty years back and reviewing process was also not done during this period. With the technology transfer during last two decades, it was observed that standard norms were slightly different from the actual norms. In this study, basically it was targeted to revive the standard norms with the actual situations. With the time restriction of the research period, data collection and analysis was limited to six construction activities; however this process can be applied for all the construction activities after that new work norms can be developed to suit to the present work conditions. This is the prime requirement on construction industry and it is recommended to carry out the further study or separate investigation on the particular sector.

In the industry, standard norms were developed with the respect to the field of specialization such as building, road, irrigation, etc. This analysis was based only on medium scale building projects; however it should be covered all the industries in civil engineering field.

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M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of **"Review of Productivity Norms in the Construction Industry".**

Company Name	
Project Name	
Date	

Time study for excavation for foundation(mannul)																			
Element	**Basic time**																**Total basic time**	**Frequency**	**Unit basic time**
Start time																			
End time																			
Duration																			
Volumn excavated																			

No of workers allocated	
Tools/Machinary allocated	
Type of soil	

Supervising oficer (designation)		Payment mode(day work, piece work, task work etc...)	

M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of **"Review of Productivity Norms in the Construction Industry".**

Company Name	
Project Name	
Date	

Time study for filling and compaction(mannul)

Element	Basic time																Total basic time	Frequency	Unit basic time
Start time																			
End time																			
Duration																			
Volumn filled																			

No of workers allocated	
Tools/Machinary allocated	
Haul Distance	

Supervising oficers		Payment mode(day work, piece work, task work etc...)	

M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of **"Review of Productivity Norms in the Construction Industry".**

Company Name	
Project Name	
Date	

Time study for column concreting using ____ m^3 concrete skipper

Element	Basic time																Total basic time	Frequency	Unit basic time
Truck mixture arrival																			
Fill Skip from Truck Mixture																			
Crane lifts, Slews, Travel																			
Unloding in to shutter																			
Concrete gang vibrate concrete																			
Crane return to position																			

No of workers allocated	
Tools/Machinary allocated	
Type of soil	

Supervising oficer (designation)		Payment mode(day work, piece work, task work etc...)	

M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of **"Review of Productivity Norms in the Construction Industry".**

Company Name	
Project Name	
Date	

Time study for construction of 9" brick wall

Element	Basic time																Total basic time	Frequency	Unit basic time
Observation start time																			
Observation end time																			
Duration																			
Qty done																			
No of workers allocated																			
Tools/Machinary allocated																			

Supervising oficer (designation)		Payment mode(day work, piece work, task work etc...)	

M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of **"Review of Productivity Norms in the Construction Industry".**

Company Name	
Project Name	
Date	

Time study for wall plastering

Element	Basic time																Total basic time	Frequency	Unit basic time
Observation start time																			
Observation end time																			
Duration																			
Qty done																			

No of workers allocated	
Tools/Machinary allocated	

Supervising oficer (designation)		Payment mode(day work, piece work, task work etc...)	

M. Sc in Construction Project Management at University of Moratuwa, Data collection on the topic of **"Review of Productivity Norms in the Construction Industry"**.

Company Name	
Project Name	
Date	

Time study for Rubble work

Element	Basic time																Total basic time	Frequency	Unit basic time
Observation start time																			
Observation end time																			
Duration																			
Qty done																			

No of workers allocated	
Tools/Machinary allocated	
Type of soil	

Supervising oficer (designation)		Payment mode(day work, piece work, task work etc...)	

Summary of Time Study for Excavation

It No	Date	Company	Payment mode	Out put (m^3/ Day)	Remarks
	27-Nov-12	**Company 01**	Day work	3.94	Loose soil
	28-Nov-12	**Company 01**	Day work	4.31	Loose soil
	28-Nov-12	**Company 01**	Day work	3.96	Loose soil
	30-Nov-12	**Company 01**	Day work	3.07	Loose soil
	15-Dec-12	**Company 01**	Day work(Piece work)	0.59	Very hard soil
	16-Dec-12	**Company 01**	Day work(Piece work)	0.61	Very hard soil
	24-Nov-12	**Company 01**	Day work(Piece work)	2.22	Hard Soil
	26-Nov-12	**Company 01**	Day work(Piece work)	2.08	Hard Soil
	20-Dec-12	**Company 01**	Day work(Piece work)	2.2	Hard Soil
	30-Dec-12	**Company 01**	Day work(Piece work)	1.98	Hard Soil
	24-Nov-12	**Company 05**	Day work	3.25	Medium
	2-Dec-12	**Company 05**	Day work	3.48	Medium
	4-Dec-12	**Company 05**	Day work	3.65	Medium
	4-Dec-12	**Company 05**	Day work	3.54	Medium
	26-Nov-12	**Company 07**	Day work	3.2	Medium
	28-Nov-12	**Company 07**	Day work	2.98	Medium
	2-Dec-12	**Company 07**	Day work	3.56	Medium
	4-Dec-12	**Company 07**	Day work	3.55	Medium

It No	Date	Company	Payment mode	Out put (m^3/ Day)	Remarks(Hauling Distance, m)
	2-Jan-13	Company 01	day work	7.74	5.6
	3-Jan-13	Company 01	day work	6.84	4
	4-Jan-12	Company 01	day work	5.95	3
	5-Jan-12	Company 01	day work	5.82	6.5
	12-Jan-13	Company 01	day work	6.95	5
	13-Jan-13	Company 01	day work	7.14	4
	16-Jan-13	Company 01	day work	6.74	11
	5-Jan-13	Company 02	Day work	4.81	22
	12-Jan-13	Company 02	Day work	7.83	1.2
	16-Jan-13	Company 02	Day work	6.2	3
	18-Jan-13	Company 02	Day work	5.84	2
	19-Jan-13	Company 02	Day work	7.09	1

Time Study For Column Concreting

Time Study for Column Concreting

It No	Date	Company	Payment mode	Out put (m^3/ Hrs)	Out put (m^3/ Hrs) from total job	Remarks
	23-Dec-12	Tudawe Brothers (pvt) Ltd	Day work	3.9	1.25	
	28-Dec-12	Tudawe Brothers (pvt) Ltd	Day work	3.7	2.6	
	28-Dec-12	Tudawe Brothers (pvt) Ltd	Day work	2	1.9	
	29-Dec-12	Tudawe Brothers (pvt) Ltd	Day work	5.56	4.16	
	18-Nov-12	Tudawe Brothers (pvt) Ltd	Day work	1.51	1.2	

Time Study For 9" Brick wall Construction

It No	Date	Company	Payment mode	Out put (m^2)	Out put (ft^2)	Remarks
	5-Dec-12	Commpany 01	Task Work	7.07	76	
	6-Dec-12	Commpany 02	Task Work	6.05	65	
	12-Dec-12	Company 02	Piece work	7.95	85	
	29-Dec-12	Company 02	Day work	8.38	90	
	30-Dec-12	Company 02	Day work	4.46	48	
	6-Jan-13	Company 02	Day work	3.28	35	
	8-Jan-13	Company 03	Piece work	4.99	54	
	10-Jan-13	Company 03	Piece work	5.31	57	
	10-Jan-13	Company 03	Piece work	6.31	68	
	13-Jan-13	Company 03	Piece work	6.2	67	
	13-Jan-13	Company 03	Piece work	5.8	62	
	14-Jan-13	Company 03	Piece work	6.3	68	
	16-Jan-13	Company 03	Piece work	7.3	79	
	4-Jan-13	Company 04	Day work	4.56	49	
	4-Jan-13	Company 04	Piece work	6.15	66	
	4-Jan-13	Company 04	Piece work	7.58	82	
	7-Jan-13	Company 04	Piece work	5.3	57	

Time Study For Wall Plastering

It No	Date	Company	Payment mode	Out put (m^2)	Out put (ft^2)	Remarks
	16-Nov-12	Company 01	Piece work	13.53	146	
	17-Nov-12	Company 01	Piece work	12.84	138	
	18-Nov-12	Company 01	Piece work	12.9	139	
	18-Nov-12	Company 01	Piece work	14.56	156	
	16-Nov-12	Company 01	Day Work	11	118	
	17-Nov-12	Company 01	Day Work	12.3	133	
	18-Nov-12	Company 01	Day Work	11.8	127	
	24-Nov-12	Company 02	Piece work	17.93	193	
	24-Nov-12	Company 02	Piece work	18.46	198	
	25-Nov-12	Company 02	Day work	11.6	125	
	18-Nov-12	Company 02	Day work	11.01	118	
	8-Jan-13	Company 02	Day work	10.15	109	
	8-Jan-13	Company 02	Day work	5.1	55	
	11-Jan-13	Company 02	Day work	7.92	85	
	13-Jan-13	Company 02	Day work	10.2	110	
	11-Jan-13	Company 03	Day work	5.21	56	
	13-Jan-13	Company 03	Day work	7.26	78	
	14-Jan-13	Company 03	Day work	7.35	79	
	16-Jan-13	Company 03	Day work	6.23	67	
	11-Jan-13	Company 03	Piece work	14.51	156	
	13-Jan-13	Company 03		12.28	132	
				13.3	143	
				12	129	
	11-Jan-13	Company 04	Day work	11.26	121	
	13-Jan-13	Company 04	Day work	9.58	103	
	25-Nov-12	Company 04	Day work	9.4	101	
	16-Nov-12	Company 04	Piece work	15.16	163	
	17-Nov-12	Company 04	Piece work	14.51	156	
	24-Nov-12	Company 04	Piece work	13.86	149	
	24-Nov-12	Company 04	Piece work	15.26	164	

Time Study for Rubble Work

It No	Date	Company	Payment mode	Out put (m^2)	Out put (ft^2)	Remarks
	16-Nov-12	Company 01	Piece work	2.11	78	
	17-Nov-12	Company 01	Piece work	1.97	73	
	18-Nov-12	Company 01	Piece work	2.14	79	
	18-Nov-12	Company 01	Piece work	1.78	66	
	22-Nov-12	Company 01	Day Work	1.78	66	
	23-Nov-12	Company 01	Day Work	1.65	61	
	26-Nov-12	Company 01	Day Work	1.76	65	
	24-Nov-12	Company 02	Piece work	1.86	69	
	24-Nov-12	Company 02	Piece work	2.14	79	
	25-Nov-12	Company 02	Day work	1.14	42	
	18-Nov-12	Company 02	Day work	1.11	41	
	8-Jan-13	Company 02	Day work	0.81	30	
	8-Jan-13	Company 02	Day work	1.05	39	
	11-Jan-13	Company 02	Day work	1.16	43	
	13-Jan-13	Company 02	Day work	0.89	33	
	13-Jan-13	Company 03	Piece work	1.7	63	
	13-Jan-13	Company 03	Piece work	1.65	61	
	16-Jan-13	Company 03	Piece work	1.84	68	
	17-Jan-13	Company 03	Piece work	1.51	56	
	11-Jan-13	Company 03	Day work	1.27	47	
	12-Jan-13	Company 03	Day work	1.32	49	