OXFORD BROOKES UNIVERSITY

DEPARTMENT OF REAL ESTATE AND CONSTRUCTION

PhD THESIS

SITE LAYOUT: HOW IT IS PERCEIVED TO AFFECT PRODUCTIVITY IN PUBLIC SECTOR CONSTRUCTION PROJECTS IN SRI LANKA

By
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FIG 4.2.3 (UNCREDITED MAP) PG 76 IS EXCLUDED FROM DIGITISED THESIS

PLEASE REFER TO THE ORIGINAL TEXT TO SEE THIS MATERIAL

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I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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ABSTRACT

Improved productivity in the construction industry (CI) can have an important role in improving national competitiveness and achieving a satisfactory growth rate in developing countries. The Sri Lanka (SL) State Engineering Corporation, SL Building Department, SL Port Authority and SL Labour Department have experienced that most of their projects are affected by low productivity. Most projects have also suffered from serious setbacks, and in certain cases even termination, of contracts: productivity is believed to be low compared to other developing countries and the Asian sub-continent in particular. The construction site layout plan (SLP) is one of the focal factors which strongly influence construction productivity.

This research aims to investigate how productivity could be improved in the Sri Lankan public sector building CI through effective SLP. The main objective of this research is to develop an empirically grounded framework for understanding the relationship between SLP and site productivity in the Sri Lankan construction industry (SLCI).

The semi-structured interview was chosen as a main research instrument for data collection. 60 site staff members were randomly selected from 15 construction sites within the context of construction projects commissioned by the Sri Lankan public sector.

The findings from the study show that the employers in Sri Lanka are aware of the supposed advantages of efficient SLP in CI. However, construction SLP in the developed regions in the Sri Lankan CI is not vastly different from SLP in remote regions in the Sri Lankan CI. Effective and efficient SLP in SLCI would contribute to improving their productivity considerably.

The study contributes to the body of knowledge on productive construction site layout and also presents a SLP framework for improving construction productivity in the SLCI. The implementation of this SLP framework could give a new dimension and benefits to the SLCI. If successfully implemented this same framework, could be applied in other industries such as manufacturing. It could also be used in other developing countries - particularly in the Asian sub-region.

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LIST OF ABBREVIATIONS

AD- Anno Domini
AL- Advanced Level
BC- Before Christ
CBSL- Central Bank of Sri Lanka
CGR- Construction output growth
CI- Construction Industry
CP- Construction projects
ERG- Existence-Relatedness-Growth
GDP- Gross Domestic Product
HRM- Human Resource Management
ICTAD- Institute for Construction Training and Development
IE- Industrial Engineering
IMF- International Monetary Fund
IPA- Interaction Process Analysis
IT- Information Technology
NGO- Non Government Organisation
NUDIST- Non-numerical Unstructured Data Indexing Searching and Theorising
Q- Question
SAARC- South Asian Association for Regional Co-operation
SL- Sri Lanka
SLCI- Sri Lankan Construction Industry
SLP- Site Layout Plan
TFP- Total factor productivity
TP- Total productivity
UK- United Kingdom
US- United States
USA- United States of America

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The purpose of this chapter is to provide an introduction to the thesis. The significance of the study is discussed and the importance of site layout plan (SLP) in the context of the Sri Lankan construction industry is addressed. The discussion will be based primarily on an extensive review of the relevant literature. Finally the structure of the thesis is outlined in order to give the reader a general overview.

1.2 STATEMENT OF THE PROBLEM AND SIGNIFICANCE OF THE STUDY

The construction industry (CI) is one of the world's most important industries (Mawdesley *et al*, 1996 and Langston and Wu, 2006). The crucial importance of the construction industry to a sustained development effort in a developing country cannot be overemphasised. Although construction is not an end in itself, it is the means for the achievement of the desired end, which is the development of new production capacity in the economy. However, in developing countries, productivity in construction has remained at a relatively low level compared to other major industries (Zakeri *et al,* 1996, Ofori, 2006 and Alinaitwe *et al*, 2007). Therefore the effect of productivity on a nation's economy is highly significant. Improved productivity in the construction industry can have an important role in promoting national competitiveness and a satisfactory growth rate. The importance of

productivity to any society cannot be over emphasised because it is a valuable measure of how well resources are used in society. There are countless ways to define construction productivity (Pinder, 1984; Olomolaiye *et al,* 1998; Zack, 2004; Saari, 2006A). Researchers have defined productivity differently. The lack of consensus among researchers makes it difficult to evaluate which definition is most appropriate for everyday management. This is considered necessary as a prelude to understanding the link between productivity and the construction site layout plan. Productivity at its simplest is a ratio that compares units of output with units of input, often against predetermined standards (Newstrom and Davis 1997; Saari, 2006B). There is still controversy surrounding the definitions and measurements of productivity.

The construction site layout plan (SLP) is one focal factor that strongly influences construction productivity (Olomolaiye, 1990; Jayewardene, 1992; Demir, 1996; James and Lagro, 2001; Hesham *et al*, 2003; Haytham *et al*, 2008). In particular, on construction sites, management deficiencies, inexperienced workers – as well as workers who are de-motivated – have a huge impact on the productivity of the site workforce. Therefore, it is envisaged that, with proper site layout planning, most of these factors would be minimised for a particular construction sector (e.g. public sector). The Sri Lanka State Engineering Corporation, Sri Lanka Building Department, Sri Lanka Port Authority and Sri Lanka Labour Department have experienced that most of their projects are affected by low productivity (Perera, 1999; Rajasiri, 1999; ICTAD, 2008). Most projects have also suffered from serious setbacks and even termination of contracts: productivity is believed to be low compared to other developing countries and to the Asian sub-continent in particular (Jayawardane and Gunawardena, 1998; ICTAD, 2008; ILO, 2011). Ineffective SLPs are responsible for

increasing wastage of construction material, equipment manpower and time; there is also a relationship between SLP, labour and material productivity (Jayewardene, 1992 and 1994; James and Lagro, 2001; Da Silva and Rwanpura, 2006; Aduagyei and Ruwanpura, 2008). Therefore it can be argued that one of the key factors contributing to such low productivity in Sri Lanka is that of inefficient SLP. In the ancient and colonial eras, the Sri Lankan CI was well established (Mahavamsa, 1950; Paranawithana, 1946), although there is no evidence of the methods they used to manage construction sites. On the other hand, in Sri Lanka Western management approaches have been employed in CI over the past few decades, without an assessment of the appropriateness of such approaches (Jayawardane, 1992).

This has raised some crucial problems. The employers in CI in Sri Lanka are aware of the supposed advantages of efficient SLP. Effective and efficient SLP, therefore, would improve productivity in the Sri Lankan CI.

This research contributes to a greater understanding of productivity, particularly in respect of SLP, in the Sri Lankan CI. It develops a coherent framework for analysis that may be applied to similar studies in other developing countries, particularly in the Asian sub-region. In addition to the empirical evidence generated, this study will be of benefit to Sri Lankan policy makers in respect of facilitating a more effective and efficient CI, contractors and clients. Most previous studies looked at productivity (Olomolaiye, 1988; Price, 1992; Smithers and Walker, 2000; Teicholz, 2004) by referring to factors such as employees' motivation. However, in Sri Lanka no one has conducted productivity studies with special reference to effective SLP within the CI.

This study will thus fill a gap and also develop new research ideas in the area of construction management.

1.3 RESEARCH STATEMENT AND JUSTIFICATION

The following considerations were made when taking the final decision on the topic.

Whether or not:

(a) The topic is researchable, given time, resources, and availability of data

(b) The study will fill a void in the construction industry and also develop new ideas in scholarly literature

(c) The topic is essential to increase productivity of Sri Lankan construction industry

(d) The topic is too narrow for a study of this nature

(e) The results from the study will be of interest to others, (e.g. Government decision makers, constructors, contractors, professionals such as officials of the Sri Lanka Ports Authority (SLPA), the Ministry of Housing and Constructions, the Urban Development Authority of Sri Lanka, the State Engineering Corporation and private contractors).

After giving careful consideration to all the above, the researcher decided on the topic for the study.

1.4 AIMS OF THE STUDY

The research aims to investigate how productivity could be improved in the Sri Lankan public sector construction industry by using effective and efficient site layout plans (SLP).

1.5 OBJECTIVES

(a) To review the theoretical basis of existing concepts relating to construction site productivity.

(b) To ascertain, to what extent employers in the construction industry (CI) in Sri Lanka are aware of the supposed advantages of effective SLP.

(c) To identify the perceived productivity benefits realised through the implementation of the above SLP practices

(d) To ascertain if there are significant differences between SLP amongst developed regions and remote regions in SLCI.

(e) To develop an empirically grounded framework for understanding the perceived relationship between SLP and site productivity of the Sri Lankan CI.

1.6 RESEARCH PROPOSITIONS

To obtain the above objectives the research propositions are as follows:

(a) The employers in Sri Lanka are aware of the supposed advantages of efficient SLP in CI

(b) Construction SLP in developed regions in the SLCI is different to SLP in remote regions in the SLCI.

(c) Effective and efficient SLP in Sri Lankan CI would contribute to improve their productivity.

1.7 METHODOLOGY

Research data was collected by means of a survey of site staff (e.g. site engineers) in Sri Lanka with particular emphasis on the public sector CI. Public sector is chosen as the focus of this research because most of the factors affecting construction productivity can be assumed to be constant within the public sector. This condition emanates from the fact that they are direct labour organisations and employ labour on a long-term basis.

Data was collected to investigate the characteristics of site layout plan factors (e.g. location of site office, stores, rest rooms etc), interpret the research objectives and to test the above propositions.

The data-gathering techniques will be:

- Interviews (one-to-one)

Interview sessions were the main research instrument in the study. 60 semi-structured interviews were conducted and these were fully tape recorded. This interview schedule was pilot tested prior to the main research work. Most of the interviews were conducted in Sinhala, which is the lingua franca of the Sri Lankan operatives.

- Observation sessions

15 observation sessions were conducted in 15 construction sites within the public sector in Sri Lanka. A pre-structured observation schedule was used for each observation session. This schedule was also pilot tested. The findings of the observations were triangulated with findings from the interview sessions.

Data Analysis

Quantitative data was directly analysed using SPSS statistical data analysis software. Qualitative data was categorised using content analysis categorised techniques and analysed using SPSS statistical data analysis software.

1.8 THE SCOPE OF THE RESEARCH

Due to the time scale of the research, the cost and the practicality of the work to be undertaken in Sri Lanka, the following sample was randomly selected for this study:

15 project managers, 15 site engineers, 13 architects, 2 quantity surveyors and 15 foremen drawn from 15 construction sites in the public sector. These 60 interviews are deemed sufficient in terms of the qualitative methodology of this research.

1.9 THE STRUCTURE OF THE THESIS

The thesis is structured into seven chapters.

1.9.1 CHAPTER ONE: Introduction

In this chapter, an introduction to the thesis is given. A description of the research significance, research problem and its justification are also presented. It also describes the research aims objectives and propositions of the study. Synopses of the remaining chapters are also presented.

1.9.2 CHAPTER TWO: Productivity and Site Layout Factors in Construction Industry

This chapter provides an overview of the productivity concept. The chapter examines the definition and measurement of productivity issues with particular reference to construction sites. It draws on construction site layout plans and its influence of productivity in construction sites.

1.9.3 CHAPTER THREE: Sri Lankan Construction Industry

This chapter gives a historical perspective of the Sri Lankan construction industry its past, present and future and also the factors that are shaping the industry. Finally the chapter tests the need to develop a better framework for productivity in the industry.

1.9.4 CHAPTER FOUR: Methodology

This chapter discusses the methodology of the study: the development of research techniques and procedures for data collection and analysis. It includes the sample selection, research paradigms, development of research techniques, pilot study.

1.9.5 *CHAPTER FIVE:* Research results

This chapter contains the analysis of the data and the interpretation of the results with respect to site layout practices in Sri Lankan public sector building construction projects. To recap, the site layout factors are materials, equipments, waste management system, stores, site office, rest room and sanitary facilities, security systems of the site and health and safety systems

1.9.6 CHAPTER SIX: Discussion

This chapter contains the discussion of background demographic information concerning the sample and the results with respect to site layout factors (e.g. materials, equipment). It also seeks to interpret the propositions of the research.

1.9.7 CHAPTER SEVEN: Conclusion and recommendations

This chapter begins with a summary of the findings of the study and a new framework regarding for site layout in the Sri Lankan construction industry. Furthermore this chapter contains a discussion of the limitations of the study, the contribution of the research to construction management knowledge and a conclusion and recommendations to the industry as well as scope for future research are presented

The references and appendixes will be presented at the end of the thesis.

CHAPTER TWO

PRODUCTIVITY AND SITE LAYOUT FACTORS IN THE CONSTRUCTION INDUSTRY

2.1 Introduction

This chapter is divided into nine sections. Sections two, three and four look at the description of the productivity concept, a discussion on definition and measurement issues. Construction site layout is covered in section five followed by the factors influencing construction site layout. Section seven deals with the different approaches to planning the construction site layout. Section eight discusses the critiques of different approaches to site layout studies followed by the summary and discussion of the chapter.

2.2 Definition of Productivity

There are many ways to define productivity; a lack of consensus creates difficulty in selecting the most appropriate. Definitions by Pinder, 1984; Olomolaiye *et al*, 1988; Zack, 2004; Saari, 2006A are among those considered to see if they are appropriate for day-to-day management

Productivity, at its simplest, is a ratio that compares units of output with units of input, often against predetermined standards: If more output can be produced from the same amount of input, productivity is improved (Newstrom and Davis, 1997; Saari, 2006B).

In other words, if more output is produced using less input, it can be considered as an increase in productivity. Pinder (1984) and Valentine (2001) define productivity as the value of industry economic output per unit of human and fixed capital required to attain it.

The Concise Oxford Dictionary (9th edition) defines productivity as:

> *"The capacity to produce; the state of being productive; effectiveness of productive effort, especially in industry; the production per unit of effort."*

This definition has identified three major productivity concepts, namely:

- "the capacity to produce", which means the force necessary for production
- "the effectiveness of productive effort", which is the measurement of productive use of resources
- "the production per unit of efforts", which is the rate or the measurement of output of factors of production over a period of time.

However, the definitions made by different authors do not incorporate all three concepts included in the above definition. Economists usually define productivity as a ratio of physical output to physical input, thereby referring to the rate of production only. Wild (1995) and Rojas (2008) defined productivity as the relationship between production output and the input provided to create the output. Another definition by Forster (1981) and Allen (2003) introduced the significance of a time parameter for a production system; they defined productivity as the comparison of outputs to inputs

used in producing the output during a specific time interval. However, none of these definitions incorporates all the three concepts included in the dictionary definition.

Reid (2006) argued that when measuring output not only the quantity but also the quality should be included. Further, they stressed that when measuring input, raw materials, capital as well as invisible factors such as the contribution by management, organisation and the attitudes of workers should also be considered. The definition by Sheffrin (2003): "the ratio between the value of unit of output and the cost of all the inputs" seems a better alternative to that of Reid (2006).

However Davis's (1955) definition

> *"the degree to which the power to make or provide goods or services having exchange value is utilised as measured by the output from the resources utilised"*

seems to incorporate all three main characteristics of the productivity concept.

2.3 The Significance of Productivity in Construction

The Emerson Report, 1992 is just one of the official reports which have looked at the many problems in the construction industry. Improving construction productivity is a complex subject. There are many factors (e.g. labour motivation, site layouts) that impact productivity in the field (Adrian, 2002). Abdul-Kadira (1995), Adrian (2004)

and Thoma (2007) have suggested that one of the numerous difficulties is the alarmingly rapid decline in the growth of productivity. .

There is worrying evidence that productivity in construction has declined compared with other industries in the last 40 years (Teicholz, 2004) especially since the industry impacts on a country's GDP. Williams (1991) believes that when considering the means of improving construction productivity, a clear analysis of both on-site and off-site activities – such as design, planning procurement and delivery – must be undertaken.

The output of the construction industry in most countries is in decline or has diminishing growth due to low construction productivity (Yiu *et al,* 2004; Teicholz , 2004). Across the Euro area as a whole, construction output fell by 2.2% from December 2009 to January 2010 and by 12.5% from January 2009 to January 2010 (Skinner, 2010). For example, Construction output in the UK fell 0.7 per cent in the first quarter 2010, compared with a decrease of 0.9 per cent in the previous quarter. This is due to a decline in residential tender price inflation, rapid falls in volume of investment in commercial, tourist and agricultural buildings (DKM, 2010). A significant proportion of this service industry is forecast in the preliminary estimate (UK Publication Hub, 2010).

Thus, considering the influence the construction industry has on gross capital and the gross domestic product of the country and the numerous difficulties associated with it, it is obvious that the construction industry should give the necessary rate of return for

the investments made for it. An effective way of achieving this is by increasing the productivity level of the industry.

2.4 Measuring Productivity

Performance efficiency is widely used as a measure of productivity (Oglesby, 1988, Guzmán and Morrow, 2007). However, it should be noted that productivity is not the same as efficiency, although in the literature the terms productivity and efficiency appear often to be interchanged (Halligan *et al,* 1994; Emrouznejad, 2005). Measuring productivity in terms of efficiency, i.e. Efficiency = output / input, may appear straightforward, but difficulties arise when trying to quantify some invisible inputs such as contribution by management, organisation, workers' attitudes etc. This is also termed the economic model of measuring productivity or in other words total factor productivity (TFP) (Oglesby, 1988; Comin, 2006). This measurement is normally used to evaluate the state of the economy in a country and also to make policy.

The project specific model measures productivity as the ratio between output expressed in physical units (for example square metre) and the inputs expressed in monetary terms. This is called total productivity (TP) (Arditi and Mochtar, 2000; Oguchi, 2004). The inputs include management, labour, materials and equipment. This model seems to give more accurate results than the TFP and could be used in both governmental agencies and the private sector.

The third model, which defines productivity as labour productivity, measures the ratio between outputs expressed in specific physical units as in the TP model but inputs

expressed in man hours (Oglesby, 1988; Oguchi, 2004; Comin, 2006). The inputs include labour only. This model is more meaningful to the construction setting with the emphasis being on labour and is useful for project managers / contractors in calculating the project cost, monitoring the field activity and in job sequencing on construction sites (Olomolaiye, 1988; Olomolaiy *et al,* 1988; Sears *et al,* 2008). However, this partial measurement assumes that other variables are constant, which, in fact, they are not, thus making partial productivity measures dubious expressions of true productivity. Furthermore, construction productivity is influenced not only by labour but also by other factors such as materials, equipment, methods of construction and management (Sugiharto, 2003; Ruwanpura, 2004).

However, there is still controversy surrounding the definitions and measurements of productivity. Furthermore, most productivity input factors can be controlled or influenced by using effective and efficient site layout (Olomolaiye,. 1990; Jayawardane, 1992; James and Lagro, 2001; Hesham *et al,* 2003; Haytham *et al,* 2008). Therefore this research is concentrated on the effective and efficient site layout on productivity.

2.5 Construction site layout

> *"A good site layout is vital to ensure the safety of the working environment and effective and efficient operations. Site layout planning has significant impacts on productivity, costs, and duration of construction. Construction site layout planning involves identifying, sizing, and positioning temporary and permanent facilities within the boundary of the construction site. Site layout planning can be viewed as a complex optimization problem. Although construction site layout planning is a critical process, systematical analysis of this problem is always difficult because of the existence of a vast number of trades and interrelated planning constraints"* (Sanad *et al,* 2008).

There are two main types of factors impacting on site layout: permanent and temporary (Yeh, 1995; Sanad *et al,* 2008).

The permanent factors would usually be the proposed buildings and roads, and existing building and roads which are to be retained or refurbished. Other examples of permanent structures might be rivers etc. In addition to the permanent structures, there could be a wide range of temporary factors e.g. tower crane, site offices, amenities for workers' welfare, waste management system etc. Although it is obvious that both temporary and permanent structures will be involved in any project (Sanad *et al,* 2008), if these factors are considered more carefully during the construction site layout planning stage, an optimum solution can be achieved to enhance productivity (Hesham *et al,* 2003). Failure to see in advance the implications for the overall process of the location of each temporary structure could lead to unplanned changes

in site layout, leading to delays and inconvenience. Some changes in site layout, however, are unavoidable; but even then the impact can be minimised with careful planning.

2.6 Factors Influencing Construction Site Layout

This section mainly discusses the site factors, most of which are linked to the site productivity. The most appropriate construction site factors are:

- Materials
- Equipment
- Waste management systems
- Stores
- Site offices
- Rest rooms and sanitary facilities
- Security systems
- Health and safety systems / regulations

(Jayawardane, 1992 and 1994; Demit, 1996; Laitinen and Ruohomaki, 1996; Olomolaiye *et al,* 1998; Hesham *et al*, 2003; Wong and Yip, 2004; Haytham *et al*, 2008; Riaz *et al*, 2011).

James and Lagro (2001) stated that the following factors also affected construction site layout and productivity:

- Road layout and accessibility of sites
- Existing construction works / structures.
- Utility, drainage and sewage lines layout.
- Temporary works

Furthermore, the following factors also affected construction site layout and productivity:

- Site specific, health and safety, and government rules and regulations
- Neighbourhood conditions (e.g. school, public road or place, river)
- Geographical conditions (e.g. soil condition, water table, existing structures, weather condition)
- High risk activities (e.g. steel erection, excavation, asbestos removal, lifting operation).

(Makulsawatudom *et al*, 2004; CPA. 2008; CDM, 2003, CDM, 2007; Damm and Schultz-Nielsen, 2008; Yeol *et al*, 2008;)

All, site factors are interrelated and can affect the progress of the construction operation. Therefore, in most cases, site layouts need to be updated at various construction stages (e.g. ground work stages, superstructure stages, finishing stages) (Elbeltagi *et al*, 2004; Ma *et al*, 2004).

However, there are some cases where site layout does not need to be changed so often (e.g. when the site requires only a short duration of work, or when there is already plenty of space on the site).

Elbeltagi *et al*, (2004) commented, after an extensive study of dynamic layout of temporary construction facilities considering safety:

> *"The layout of a construction site plays a major role in the safety and productivity of operations, particularly when site space is restricted. As construction evolves, however, the site layout may need to be dynamically reorganized at various schedule intervals to accommodate operational needs."*

The following figure describes the inputs and outputs of the construction project. It shows the internal factors which are internally controllable (e.g.waste management, safety management) and external factors which are internally uncontrollable (e.g. government politics, health and safety regulations, weather conditions) significantly affect site layout and productivity.

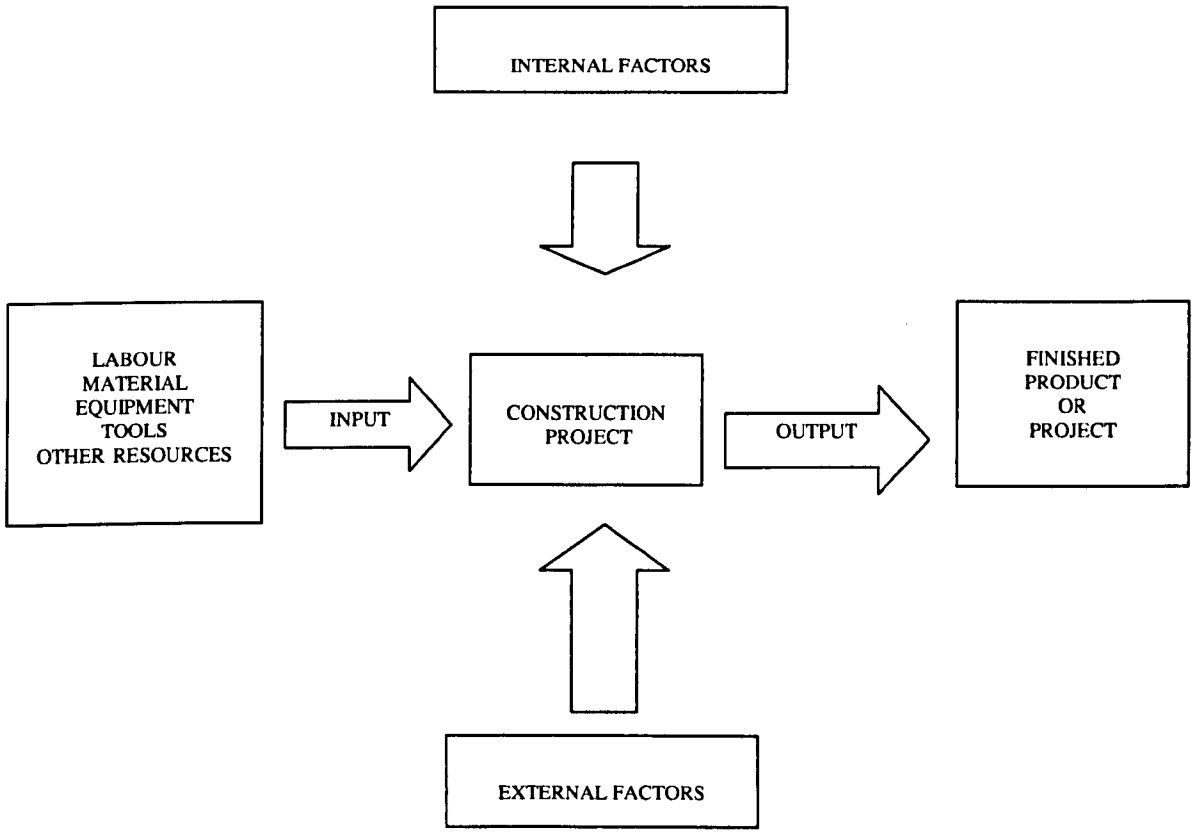


Figure 1: Input-Output Relationship in Construction
(Source: Rehabilitation of the Central Bank Building Project, 1995).

The subsequent sections discuss the above factors and their effect on site layout and productivity. Although individual factors will be discussed separately, it is important to bear in mind that most factors are interrelated.

2.6.1 Site layout factor: Construction materials

Lack of materials is the most significant factor affecting construction productivity (Makulsawatudom and Emsly, 2001; Kaming *et al,* 1997). A questionnaire survey, carried out by Mukulsawatudom and Emsley (2001) among 128 respondents within

five construction sites in Thailand, identified following causes of material unavailability:

- Funds shortage
- Waste due to sabotage / negligence
- Inadequate planning
- On-site transportation difficulties
- Improper material storage and handling
- Improper material usage to specifications
- Improper material delivery to site
- Fluctuation in availability
- Excessive paperwork for request

Also poor quality materials were one of the major factors causing low productivity (Koskela, 2000). Therefore material management is an importance element in construction planning and management and also directly linked to site layout planning. Furthermore, Alwi (2002) highlighted that lack of material is the number one (rank 1) productivity problem in Indonesia, Nigeria, UK and USA (adapted from Kaming *et al*, 1997).

2.6.2 Site layout factor: Construction equipment

The selection of the appropriate size and the type of construction equipment often affects the construction productivity and the site layout plan. Therefore construction site layout planners' familiarity with the characteristics of the construction equipment

are very crucial (Assakkaf, 2003). Functions of the machinery, health and safety issues and the availability of them are influencing the productivity (Kaming *et al*, 1998; Park, 2002; Rojag and Aramvareekul, 2003; Abdul Kadir *et al*, 2005; Riaz *et al*, 2011).

Makulsawatudom and Emsly (2001), state regarding the inadequate or improper equipment:

> *"A lack of proper tools and equipment could have a crucial effect on productivity, since, without efficient application of tools and equipment, work cannot be progressive or is done to an inadequate quality. Lack of proper tools and equipment arise from management ignorance of maintenance programmes which leads to inefficient use of tools and equipment, the use of old and obsolete equipment, shortage of spare parts or a project manager overestimating the capacity of a machine that results in insufficient numbers of the machine being employed."*

In order to increase construction productivity, it is beneficial to select equipment with proper characteristic (e.g. size, efficiency, work condition) appropriate to the site layout.

2.6.3 Site layout factor: Waste management systems

All material removed from construction sites to be land filled, burned, recycled or reused. Pallets, containers, packing and packing materials in which construction

products are delivered to the site are considered as waste materials (Houston, 1994). Web (2001) stated that using good waste management practice on site will help construction projects to comply with environmental regulations, reduce costs, reduce obstruction for other tasks, minimize the hazards and create a positive image of the project.

Consideration must be given to the quantities and types of waste (possibly including food waste) that might be generated and arrangements made for its lawful disposal.

If asbestos waste will be generated, specialist contractors must be engaged to remove and transport it. Otherwise, depending upon the nature of the waste generated, a selection of skips should enable waste to be segregated (e.g. metal and timber) (Amalendu; 2004).

2.6.4 Site layout factor: storages and stores

Provision must be made for the safe storage of materials and equipment. Consideration should be given to:

- ensuring that site roads and any access road to the site are kept clear of obstructions
- where possible avoiding 'double handling' by arranging for items (particularly heavy items that may have to be moved by hand) to be stored close to where they will be needed

- the provision of proper storage facilities for flammable substances such as bottled gases and fuels
- ensuring that materials delivered on pallets are stored in stable stacks with a safe limit on the height of each
- ensuring that there is no danger of stored materials toppling and breaching the site boundary
- the possible need for access by lifting equipment such as telehandlers, mobile and tower cranes (Elbeltagi *et al*, 2004; Pardasani *et al*, 2009).

2.6.5 Site layout factor: The site offices

Most site offices consist of office furniture, meeting area, IT / telephones, refreshment area and more importantly first aid area in case of accidents (Guy, 2010). It is acknowledged that, depending upon the size of the site and the nature of the project, the term 'site office' can cover office accommodation ranging from a single portable cabin to an office complex comprising multiple-cabins on more than one level when non-construction workers, such as administrative staff, are employed. Where such complexes are required, temporary planning permission must be sought (Elbeltagi *et al*, 2004, Mawdesley *et al*, 2002).

2.6.6 Site layout factor: The rest rooms and sanitary facilities

The provision of suitable rest rooms is a key factor in the layout of a construction site. It is essential that workers have hygienic areas for basic needs including changing areas, clothing stores, canteen or food preparation facilities and shelter from bad weather. If both male and female staff are employed then the appropriate provision must be made in relation to:

- toilets
- washing (and if necessary shower) facilities
- changing rooms
- rest facilities

(HSE, 2007).

2.6.7 Site layout factor: The security systems

The boundary of site should be secured immediately on possession, with appropriate fencing or hoarding and lockable gates to prevent unauthorised access by the general public, mainly children, and to prevent the unauthorised tipping of waste. If it is not possible to secure the whole site, steps must be taken to secure potential locations of high risk operations (Arata, 2005).

Gates and hoardings should be designed and able to withstand wind loadings. Particular attention should be given to swing gates to ensure they can be operated by one person and stops should be in place to prevent gates swinging into pedestrian/public areas. In many cases it will be necessary to make separate provisions for the security of individual items of equipment and plant (City of Sydney, 1998).

2.6.8 Site layout factor: Health and safety systems/ regulations

Regulation 22(1)(a) of The Construction (Design and Management) Regulations 2007 places a legal duty on the principal contractor to plan, manage and monitor the construction phase (which includes setting up a site) to ensure that, so far as is reasonably practicable, it can be carried out without risks to health and safety.

Regulation 22(1)(l) of The Construction (Design and Management) Regulations 2007 places a duty on the principal contractor to take reasonable steps to prevent unauthorised access to the site.

Section 33 of the Environmental Protection Act 1990 places a duty on the owner or occupier to prevent the unauthorised deposit of waste on the site.

The following requirements of The Construction (Design and Management) Regulations 2007 apply to traffic and pedestrian routes:

- Regulation 36(1) requires that, so far as is reasonably practicable, traffic routes are organised so that pedestrians and vehicles can move safely.

- Regulation 36(2) states that traffic routes will be suitable for the pedestrians and vehicles using them providing they are sufficient in number, in suitable positions and of sufficient size.

- Regulation 40 requires that, where necessary in the interests of health and safety, a sufficient number of suitable emergency routes and exits must be provided, which must: Be kept clear of obstruction, Lead to an identifiable safe area, for example an assembly point, Be provided with emergency lighting where necessary and Be identified by appropriate signs.

The Construction (Design and Management) Regulations 2007 are clear that non-smokers must be in an environment protected from tobacco smoke. Appropriate facilities must be provided including: access to clean toilets; washing facilities with hot and cold or warm water, soap and towels and with washing basins large enough to enable washing faces, hands and forearms. Where appropriate showers should be provided.

During the setting up of a site, provision must be made for dealing with emergency situations which may involve evacuation of the site. It is likely that this will be simpler for a new green-field site than, say, for the refurbishment of a multi-floor structure.

Liaison with the local fire officer may be useful in identifying a fire-fighting strategy within the plan and locations of fire-fighting cores and dry riser locations. Emergency escape routes must be determined, identified by appropriate signs and communicated to all on site. On larger, more complex sites it may be necessary to:

- compile a fire safety/emergency evacuation plan, which may or may not, as appropriate, be a part of the construction health and safety plan;
- appoint evacuation wardens who have responsibility for ensuring and confirming that a particular area of the site has been totally evacuated.

The location of a suitable assembly point, which can accommodate the maximum number of people expected on site and is a safe distance from the potential hazard, must be determined. On larger sites it may be considered appropriate to designate more than one fire assembly point (Site Emergency Planning Work Book, 2000).

There are more regulations relating to the site layout factors (e.g. The Health and Safety at Work etc. Act 1974; The Work at Height Regulations 2005). Therefore, during the site layout planning process, consideration of the productivity as well as the above regulation is crucial

2.6.9 Site layout factor: The road layout and accessibility of sites

Construction Site Solution (2010) and Wustemann (2007) recommended the following to protect works from vehicles:

- Create vehicle routes which have adequate signage, marked correctly.
- Where ever possible, use one way routes
- Keep pedestrian and vehicle routes separate from each other, especially when vehicles are loaded, unloaded or reversing.
- Allocate and mark pedestrian routes
- Always allow emergency vehicle access
- Make sure that turns and entry points are to a sufficient width in order to allow access for any large fire instruments to be used.
- Move overhead electrical lines which could cause obstruction to vehicle access (in particular, emergency vehicles).
- Separate pedestrian routes with vehicle routes when ever possible.
- Forbid pedestrians to pass through any and all exclusion zones.
- Create storage areas which allow the handling of materials to be minimized; also providing safe storage, handling and transportation of materials.
- Materials should be delivered to a suitable location where they will be used most effectively without need for further transport. A safe path between storage and use point should also be established.
- Minimize material movement for storage through the duration of the job.
- Make certain that materials of a flammable nature are stored correctly - abiding by 1926.151
- Storage areas should not be located in such close proximity to electrical hazards that the health and safety of workers is compromised.

Similar recommendations can also be found in HSE (1998 and 2005).

2.6.10 Site layout factor: The existing construction works / structures

Consider the current and past uses of the site. This could involve issues such as:

- the existence of contaminated ground and the possible need for extensive site transport movements, both within and off site
- ground water levels and/or underground water sources and the prevention of their contamination
- the previous storage of dangerous goods or hazardous substances in buildings, cellars or tanks
- the location of underground services and whether they have been, or need to be isolated or protected from surcharging, for example stockpiling heavy materials over shallow services
- the location of overhead cables and whether they need to be isolated or repositioned
- the need for equipment to create barriers and goalposts where overhead cables cross or border the site and remain live
- if working on an existing structure, whether the electrical distribution system is still live and whether or not it should be
- the condition of existing buildings – strength/condition of roofs, floors, stairs, hand-rails, walls and structural members
- the possible presence of asbestos (where existing surveys exist these should be included)

- the possible presence of other hazardous substances, viruses and organisms such as lead, leptospirosis and anthrax
- possible presence of protected plants and animals and invasive species such as Japanese knotweed
- the possible need for demolition
- the possible need for site lighting
- the existence of a health and safety file for work on existing structures.

(Staveren, 2006; BS 8460, 2005; OSHA 3096, 2002).

2.6.11 Site layout factor: The utility, drainage and sewage lines layout

Utility services include all underground pipes and cables for electricity, gas, water, sewage and telecommunications. Pipelines which carry petrochemicals and other fluids are also included in the definition. It is crucial, therefore, that prevention of damage, which could be fatal, is taken into account by clients, designers, contractors and operators of underground services, among others, (HSG47, 2005).

Early consideration must be given to the need for the installation of utility services to support the running of the welfare facilities and other site accommodations (James and Lagro; 2001). This could include:

- a 230 volt supply (or a 415 volt, 3-phase supply where there will be heavy electrical loads such as a tower crane)

- a supply of fresh water. This should be tested to ensure it is suitable quality for drinking and, if a new connection, should be made only by the local water company

- the drainage of surfaces and foul water. New connections should be made only with the knowledge of the local authority. Particular attention should be given if hydrocarbons are to be used extensively near watercourses. Petrol interceptors may be required, as are discharge consents if discharging into rivers

- the provision of gas or oil for heating

- appropriate telecommunication links

- the provision of a stand-by generator and the appropriate fuel.

2.6.12 Site layout factor: The Temporary works

At the end of a construction project, only the main structure will remain and most of the temporary works will be removed. However, temporary works require as much care and attention as the main structure. When commencing site set-up, failure to invest care and effort into the planning, design and installation of temporary works often leads to accidents and low productivity (Burrows *et al*, 2005; Mckenna, 2005; Pallett, 2006, BS 5975, 2008; BS 8454, 2006; Construction Industry Research and Information Association, 2006).

Temporary works include, but are not confined to:

- Foundation assessment for new portacabin installation and in particular multi-storey complexes.

- Excavation support assessment to be carried out for below-ground service connections.

- Services may require protection to prevent damage during site set up. Also material storage areas should be sited away from shallow services that may be susceptible to damage.

- Site hoardings and gates to be designed to withstand wind loadings. Particular attention should be given to swing gates, ensuring that these can be managed by an individual under high wind conditions.

- Any supporting structures on a cabin set-up must be designed, e.g. cabins elevated to provide parking below on congested city sites.

- Generally there will always be a need for craneage on site, so ground bearing capacities require checking for outrigger loadings on and around the site.

- Any temporary access roads on site should be assessed to ensure they are suitable to withstand loadings that may occur during site works.

- Site establishments that are at risk of objects falling from above should be protected with the use of designed crash decks or fans.

- Where site establishments are close to the public highway or temporary haul roads where heavy plant is to be used, there must be suitable barriers in place to protect the office from collision damage.

- When crane lifts are required from a neighbouring street then the temporary works engineer must be aware of any below-ground services, including basements and subways and so on, and their proximity to the crane.

- Working at height and scaffolding.

Thus, having discussed various factors pertaining to construction site layout, the next section provides different approaches to plan the construction site layout.

2.7 Different approaches to planning the construction site layout

Construction management staff members (e.g. site planners, project managers) usually plan the site layout based on their experience and knowledge. This approach could result in site layouts that significantly vary from one staff member to another (Hasham *et al,* 2003). Individual staff can also bring their own bias to a situation as well as knowledge and experience. These could be conflicts between alternative proposed site layouts. Therefore, the following research studies have introduced different approaches to planning the construction site layouts:

In 1995, Yeh studied the site layout by using an annealed neural network system. Love (1998) and Cheung *et al,* (2002) studied site layout arrangement through genetic algorithm and also Tam *et al,* (2001) carried out a similar study. In 2003 Osman *et al,* and in 2004 Sadeghpour *et al,* studied the site layout planning by using a CAD-based construction site layout system. Ma *et al,* (2004) and Zhang *et al,* (2005) carried out the site layout planning by using a 4D construction management system approach.

There have been other research studies regarding site layout planning using different approaches (e.g. facility to site/location assignment, knowledge based techniques and mathematical techniques):

Site Plan model for site layout (Tommelien, 1992); Interactive dynamic layout planning (Tommelien and Zouein, 1993); Arc Site: enhanced GIS for construction site layout (Cheng and Connor 1996); Evo Site: evolution based model for site layout planning (Hegazy and Elbeltagi, 1999); Dynamic layout planning using a hybrid incremental solution method, (Zouein and Tommelien, 1999); A Dynamic VR System For Visualizing Construction Space Usage, (Heesom *et al*, 2003); Manage Space for Construction Facilities on High-rise Buildings, (Jang *et al*, 2003); Dynamic layout of construction temporary facilities considering safety, (Elbeltagi *et al*, 2004); Application of IE techniques in laying out construction sites, (Harit, 2004); and Computer-aided site layout planning, (Sadeghpour *et al*, 2006).

2.8 Critiques of different approaches to site layout studies

In order to understand the flaws and weaknesses of the different construction site layout planning approaches in the field of construction management, it may be fitting to highlight some salient facts of different approaches by which a researcher can solve his or her problems.

Hasham *et al,* (2003), in their review of the different site layout approaches, state:

> *"The method of facility to location assignment frequently neglects one important issue, that of facility size. All locations are assumed to be able to fit all facilities. This assumption is weakened by the fact that there are usually substantial differences in size among most construction site facilities. The method of facility to site assignment is considered more generic as it assumes that the planner has not yet settled on the feasible locations for facility assignment. Nonetheless, during this type of assignment, many spatial requirements must be satisfied simultaneously. This poses extra computational burden on any automated site layout planning system that adopts the later approach."*

Some studies of site layout planning use mathematical techniques to obtain optimum layouts, but they are only applicable to smaller scale problems. This situation is similar for the heuristic approach (Sanad *et al,* 2008). Ma *et al,* (2004) describe the disadvantages that are apparent in 4-D modelling software; dynamic allocation of a site plan is not yet achievable and there is, as yet, no industry standard for data exchange between software.

There is, as yet, no consensus on the optimum technique.

Furthermore, computerised or mathematical approaches to obtain optimum site layout to enhance productivity may be meaningless or impractical in the light of the factors outlined in section 2.6, and also current construction regulations and health and safety

legislation. Therefore an empirically grounded site layout approach to enhance productivity is appropriate.

2.9 Summary and Discussion

A productivity concept relevant to the construction industry was described with a detailed discussion of definitions, significance and measurement issues. Although there exist a large number of studies about construction productivity, the definition of productivity and measurements of productivity is still controversial.

This research has shown that site layout impacts both on site safety and productivity and that the overall general contractor needs to take in the large number of factors cited in sections 2.6.1 – 2.6.12 where some of their characteristics and conceptual relationship to the site productivity were reviewed. It is the general contractor who should co-ordinate site layout with all contractors on site.

These site layout factors/issues will be examined in more detail in the context of Sri Lanka in the field work. The literature review has raised some crucial problems about the awareness issues of the benefit of site layout and its relationship to construction site productivity. Furthermore, there are numerous research studies about construction productivity and also site layout planning all over the world (please see sections 2.4 and 2.5): are there any significant differences of site layout and productivity between countries? Therefore this research is focused on the effective and efficient construction site layout in public sector construction projects in Sri Lanka.

In order to understand the ongoing research, it is appropriate to review the picture in Sri Lanka. The next chapter will focus on productivity issues in the Sri Lankan construction industry.

CHAPTER THREE

THE SRI LANKAN CONSTRUCTION INDUSTRY

3.1 INTRODUCTION

The previous chapter discussed the definitions of productivity, construction site layout and their applications. This chapter gives a historical perspective of the Sri Lankan construction industry – its past, present and future and also the factors that are shaping the industry. Over time, the Sri Lankan Construction Industry (SLCI) has evolved and productivity has improved.

This chapter is divided into two parts: part one gives an historical overview; part two gives an overview of the present situation and the factors that may increase construction productivity in the future. The chapter ends with an assessment of the need to develop a better productivity framework for the Sri Lankan construction industry.

Sri Lanka is an island with an area of 65,606 square kilometres, situated 880 kilometres north of the Equator, off the southern tip of India. The island of Sri Lanka lies in the Indian Ocean, to the southwest of the Bay of Bengal. The climate of Sri Lanka can be described as tropical and warm. Its latitude between 5 and 10 degrees north endows the country with a warm climate, moderated by ocean winds and considerable moisture.

The Sri Lanka population was estimated at 20.217 million in 2008 (Registrar General's department, 2008). English is commonly used in government and is spoken competently by about 10% of people; the Literacy Rate is 92% (Savion, 2008). Other major demographic indicators of Sri Lanka are: Population Growth Rate 1.1 (Registrar General's department, 2008); Total Labour Force 8.082 million (Department of Census, 2008); Labour Force Growth rate 1.08%; Construction Sector Growth rate 9% (Department of Census, 2007); Birth Rate 15.6/1000; Infant Mortality Rate 14.3/1000; and Life Expectancy 73.2 years (Savion, 2008).

3.2 AN HISTORICAL PERSPECTIVE

In ancient times, Sri Lanka was known by a variety of names: ancient Greek geographers called it *Taprobane* (Abeydeera, 2007) and Arabs referred to it as *Serendib* (Sri Lanka, 2007). *Ceilão* was the name given to Sri Lanka by the Portuguese when they arrived in 1505 (Rajasingham, 2007), which was transliterated into English as *Ceylon* (Zubair, 2007). As a British colony, the island was known as Ceylon, and achieved independence under the name Ceylon in 1948. In 1972, the official name of the country was changed to "Free, Sovereign and Independent Republic of Sri Lanka" (*The People*, 2007).

The construction industry existed in Sri Lanka in the ancient times of the Sinhalese kings, from the last few centuries of the first millennium BC. This is recorded in chronicles such as *Mahawamsa,* as well as in inscriptions and archaeological evidence. The ancient Buddhist kings constructed huge Buddhist shrines and '*dagebas*' to protect and promote the religion, and undertook giant irrigation

schemes to develop the economic infrastructure of the country and also to create employment.

It is evident from the remains of the giant irrigation schemes, Buddhist and Hindu religious shrines, *'stuphas'*, and palaces that the construction industry during ancient times had been of a very high standard and very vibrant. Unfortunately, the methods adopted to construct those massive structures are not available for the benefit of the present generation. The obligatory labour input of every citizen to the state, which was then known as *'rajakariya'* has left its mark in a large number of impressive remains. How these workers were motivated is not known. However, it is evident that some management structure, however primitive, may have been in place to achieve such results.

3.3 EVOLUTION OF THE SRI LANKAN CONSTRUCTION INDUSTRY

The aim of the following sections is to describe the SLCI during the ancient, colonial, pre-liberalisation and post-liberalisation eras. Unfortunately data is limited: in particular, no data exist regarding the relationship between site layout and productivity practices. Research literature regarding construction productivity before 2000 is very scarce. Between 2000 and 2009, the internal war froze all forms of development activities, including all research work. Therefore no research documents are available to discuss construction productivity in Sri Lanka for this period.

Since no research literature has ever addressed the question of site layout practices and their influence on construction productivity in Sri Lanka, this chapter will discuss the evolution of the construction industry in Sri Lanka and explain general practices in operation from historical times until the present day.

3.3.1 ANCIENT WORKS: Irrigation, Stupas, Temples and Palaces

The irrigation works dating back to very early times are remarkable. The *Tissa wewa* (Tissa Tank) in Anuradhapura in the North Central province (which was the main water reservoir for agricultural work in the area) was built by King Dewanampiyatissa during the third century BC. The construction of anicuts across streams, to direct water for irrigation was taking place in the first century AD. The concept of constructing a tank in every village in the Dry Zone prevailed in the first century AD.

The earliest residential buildings were constructed using wattle and daub techniques with a thatched roof. The next phase in the building works was the construction of giant stupas, temples and palaces. Bricks, stones and clay had been extensively used in those structures (Mahawamsa, 1950). It is interesting to observe the remains of the renovated stupas, palaces and Buddhist temples some of which are up to 400 feet in height. They were constructed using basic skills. The largest of the structures, built in 200–300 AD is *Jethawana* dageba, a Buddhist shrine containing holy relics, constructed by King Mahasen (276–303 AD). It has a base diameter of 111 metres, and is 122 metres in height (Paranavithana, 1946).

It would be reasonable to assume that the projects were well managed by overseers in order to achieve these huge and impressive structures, given the resources likely to have been available at that time. There is no information in ancient literature to indicate the level of efficiency of the projects

Although such construction diminished with the decline of the ancient civilisation, during the colonial period there was an upsurge of a different type of construction work in Sri Lanka under the British (Tissera and Weerakkodi, 1990).

3.3.2 ROADS AND BRIDGES (The Colonial Era)

Significant road or bridge construction is not known to have taken place during the ancient period. During the colonial period (1505–1948), the British (1796–1948) were responsible for building Sri Lanka's main road and rail network. The Public Works Department's records indicate that the first road of comparable technological standards to the present system was built by the British from Colombo to Kandy, in the period 1820–1833.

Serendib (1998) documents that macadamised road making began in Sri Lanka early in the 19th century, under British rule. It was a priority for administration and for the burgeoning coffee plantation industry, and later for tea, rubber and coconut. The surveying, cleaning and construction of a road network was a task of staggering proportions in a country then almost totally without roads, penetrating vast, uninhabited rain forests and rugged terrain, and bridging countless rivers. However, colonial governors such as Sir Edward Barns and the officials of the calibre of

Captain W. E. Dawson of the Royal Engineers were equal to the challenge – as was the legendary Major Thomas Skinner, commissioner of roads for half a century and sometime surveyor-general, who surveyed on foot in only three years the entire kingdom of Kandy, a region of some 20,000 square kilometres with elevations reaching over 2500 metres.

The logistics of administration of the Public Works Department (which was set up in 1836 to push ahead with the road building programme) were as colourful as its techniques of highway construction. It maintained, among other things, an establishment of working elephants. In 1848 the colonial government enforced a road ordinance that compelled Sri Lankan males to work on roads for six days a year, or else pay an indemnity. This may have contributed in a big way to the speedy and successful completion of the road network. Though the obstacles were awesome and the casualties heavy (among them Captain Dawson), in the process the island quickly developed the best road network of the British colonies (Mahawamsa, 1950). Heavy casualties in that period may have been due to poor site plans and unhealthy site layout practices (further details are not available in the literature).

The above discussion confirms that the construction industry in Sri Lanka during colonialism was also of a very high standard although modern technology or plant and machinery were unknown to the Sri Lankan constructors at that time. Even though the methods employed are not available for reference, it is evident that the ancient construction industry was predominately labour intensive. However, the positive results, evident from both the early and colonial eras, indicate successful management strategies were in operation 'silently' in a different format during these early periods.

Before one can understand the productivity of the construction industry of the past, it would be fitting to appreciate the factors relevant to the construction industry in those times. The two eras saw different achievements (e.g. palaces, bridges) which influenced the construction industry. There is no detailed documentation available from that period to clarify exactly how the management systems were structured. However, according to Perera (1989), it is reasonable to assume that religion and the monarchy were dominant in the first period, whereas enforcement and punishment were enforced in the second.

After the Colonial Era (i.e. 1948) development of the Sri Lankan construction industry was significantly influenced by political changes, especially during the late seventies. The most significant of these can be seen in the liberalisation of the economy and introduction of the open market economic policy in 1977. Overall, however, important economic changes can be categorized into pre- and post-economic liberalisation periods.

3.3.3 LIBERALISATION PERIOD OF THE CONSTRUCTION INDUSTRY

In the pre-liberalisation period, the government focused investment into the building sector. Introducing several irrigation projects under the patronage of foreign aid was the priority in this era, in order to create infrastructure for the agro-based economy in Sri Lanka. From 1970–77 the Sri Lankan economy was influenced by socialist ideas. As a result, private sector investment was restricted. The Government's introduction of a fixed exchange rates policy badly affected foreign investments in and imports to Sri Lanka (Weddikkara and Devapriya, 2000).

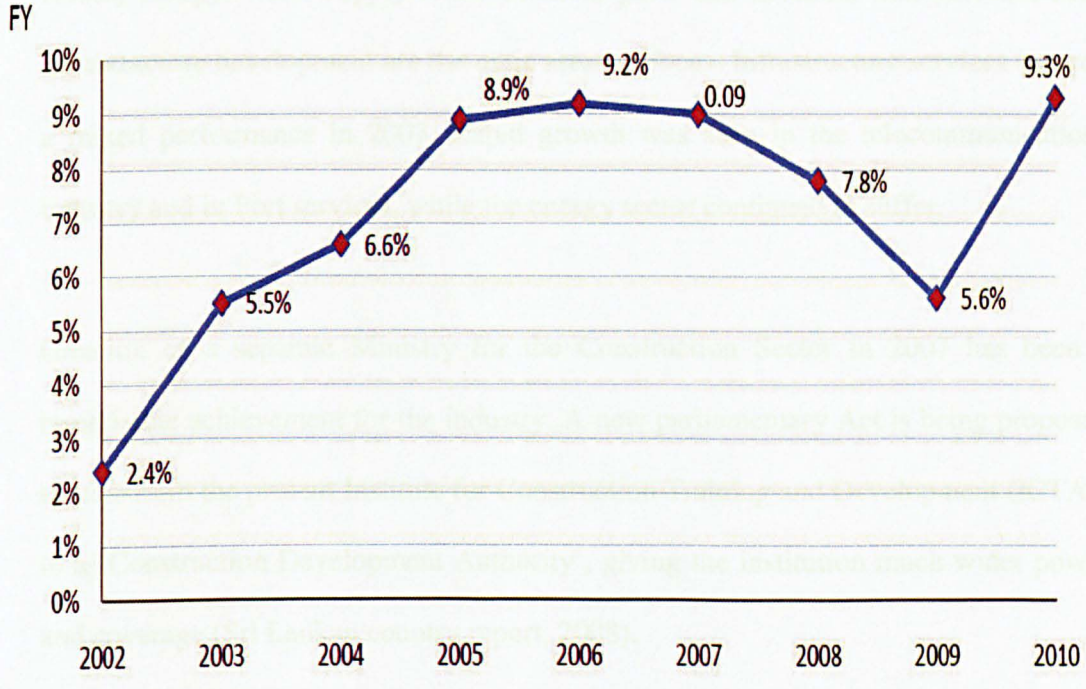
The post-liberalisation period of the economy begins in 1977: in other words Sri Lanka adopted the open market economy from 1997, but most of the capital-intensive major infrastructure was financed through the government financing mechanism. This trend changed from the early 1990s when the government began restructuring to attract private sector investment not only to the construction sector, but to all sectors. This attempt progressed slowly but improved rapidly with more concessions being offered to attract private funding. Some of these readjustments came with loans that have managerial and political conditional ties. These conditional ties – to introduce western management style in the form of effective management strategies – were not fully implemented, as they were not monitored from the funding agencies through the government. Therefore, any changes that would have helped to improve productivity in the Sri Lankan construction industry cannot be fully examined.

Vast infrastructure projects, such as the accelerated Mahaweli programme, the Greater Colombo Economic Commission and the Urban Development Programme, were authorised with a view to creating a capital base in the country. Through the provision of incentives and infrastructure support, private and foreign capital was boosted. This concept led the construction sector to grow. Between 1978 and 1981 there was a much higher rate of growth of public sector investment. Interestingly, this coincided with private sector investment in commercial and industrial buildings.

Gradual growth in the economy has since then been noticed (Central Bank of Sri Lanka, 1998b). There was a moderate growth during the five years between 1983 and 1988, followed by an economic boom in the first half of 1990. During this period a boom in construction output took place due to demand for commercial outlets and

private investment in high-rise office and apartment complexes. At its peak in 1992, the construction output growth (CGR) reached 8.1% (Weddikkara and Devapriya, 2000). There was a gradual decline in the CGR from 1992 to 1997 followed by an increase in 1998. From 1998 to 2001 CGR declined significantly by up to 1%, but again increased to 3.7% in 2003 (Country report, 2004).

Fig 2. Construction Growth Rate



(Source: ICRA Lanka, 2011)

3.3.4 THE PRESENT SITUATION

In Sri Lanka the CGR in the year 2007 has been 9% and it has experienced growth from 2002 onwards (DCandS, 2007, ICRA Lanka, 2011).

The strategy adopted by Sri Lanka for infrastructure development has been for the public sector to invest through direct budgetary allocation or foreign donor support. This is the policy in the Ten-Year Horizon Development Framework 2006–2016. These programmes have been designed with investments channelled through the consolidated Funds, private and foreign direct investments and Public Private Partnerships.

Roads, energy, water supply and sanitation, ports and aviation, transport and rural infrastructure development are the main areas in focus. Infrastructure services showed a mixed performance in 2007. Rapid growth was seen in the telecommunications industry and in Port services, while the energy sector continued to suffer.

Creation of a separate Ministry for the Construction Sector in 2007 has been a remarkable achievement for the industry. A new parliamentary Act is being proposed to transform the present Institute for Construction Training and Development (ICTAD) to a 'Construction Development Authority', giving the institution much wider power and coverage (Sri Lankan country report, 2008).

However, the 'new' self-governing nation was not well prepared to accept the responsibilities entrusted to those in power and authority. All the mechanisms (e.g. trained managers) that should aid a new nation were not in place. This was reflected in all industries in many different ways (Sri Lanka country report, 2004). The construction industry plays a major role in the socio-economic development of a country. However, it is beset by a variety of problems (e.g. disruption of cash flow,

escalation of prices). The most dominant of these are related to wastage and poor organisation (ICTAD, 2008).

There has been very limited research in Sri Lanka into construction productivity and related problems. The research is, unfortunately, very dated but nonetheless important and is discussed below.

3.4 PROBLEMS OF THE CONSTRUCTION INDUSTRY: *causes of wastage and poor organization*

A comprehensive questionnaire survey and field interviews were carried out by Jayawardane (1992a) among 67 contractors in order to identify the practitioners' views about construction manpower wastage. The questionnaire was carefully designed and piloted to include all major management areas. The results revealed that the major causes of wastage and poor organisation in construction sites were unbalanced staff deployment and misuse of manpower.

The survey revealed that 4% of contractors had excess staff (engineers), while 21% lacked staff (engineers). This understaffing was due to two main reasons:

1 they could not afford to have idle engineers due to the uncertainty of winning contracts
2 it was difficult to retain them due to financial constraints.

The survey also revealed that effective use of manpower was temporal for 16% of the contractors and rare for 8%. Misuse of manpower in this case meant the use of skilled workers for other trades, or use of unskilled workers. The contractors` view on this was that the misuse of workers was unavoidable in construction sites for the economic viability of projects. No labourer, whether skilled or unskilled, could be allowed to be idle when there was no work in his/her particular trade and he/she should be assigned to whatever work was available.

Situations where manpower was misused included urgent or unforeseen situations, when work in a particular trade was not available, when there was a lack of materials and during commencement and completion of the project.

However, it is interesting to note that 83% of the contractors said that the available manpower could be used more effectively. The suggestions made by the contractors to increase the utilisation of manpower included: education by providing short-term training programmes for workers and supervisors; motivation using incentives; effective site management; effective material supply; better communication facilities (e.g. telephones); providing job security; flexibility to transfer workers between sites; and having specialist workers. Among the above suggestions, effective site management, better communication facilities and effective material supply are directly linked with the site layout management and directly influence construction wastage and productivity.

The above study has several fundamental flaws. First, the study was limited to the building sites (reasons were given). Secondly, the target group was identified based

on the national list. It seems to be a non-random sample. The respondent rate was 25/67.

Other researchers also identify causes of wastage of manpower. One was revealed by research by Jayawardane (1994) with reference to five construction projects in Sri Lanka. In addition to a questionnaire survey (Jayawardane, 1992a), a case study was carried out. This was justifiable since similar studies have been undertaken in other countries (Skoyler and Hussey, 1974). Activity sampling field count observation was used for data collection. Field count observations at 15-minute intervals were obtained on all people working on the site under study. The following results were revealed. The average wastage of human resources was 26% (the average percentage of workers who were idle with or without work excluding official breaks). 83% of the contractors themselves identified the following major difficulties in improving the use of manpower: organisation finances; non-availability of suitable training programmes; lack of English language knowledge; non-availability of equivalent terminology in national languages; and difficulty in changing workers' attitudes.

The researcher did not mention the limitations of the activity sampling or number of responses etc., which prevents accurate general conclusions from being drawn. Furthermore, ineffective site layout also influenced wastage of manpower. For some reason the researcher completely ignored the above issue in his study.

Kodikara and Dissanayake (1993) point out that due consideration should be given to investigating whether the high wastage of human resource is, to a certain extent, due to any management shortcomings, since construction managers have direct authority

and control over many of the factors that affect productivity. Furthermore, labour-intensive-based estimates require well-defined and quantitative measures of labour productivity; hence the emphasis on measurement of labour productivity on site plays a vital role in the event of standardisation of work norms. The methodology of the above study was well-justified research design using questionnaire survey and interviews.

Most firms had taken a number of measures to improve construction productivity, but only about half of these reported that their productivity had increased recently. According to the survey results, the most crucial factors undermining construction productivity were employees` attitudes; deterioration of work ethics; lack of patience and dedication to achieve long-term productivity goals; lack of motivation; lack of flexibility in labour laws; poor public transport facilities; lack of accommodation facilities; and political interference (C.B.S.L Annual Report, 1996). However, the issues regarding the effect of site layout issues on productivity were not addressed in the above survey.

The major proposals suggested as corrective measures to improve labour productivity were linking wage increases to productivity improvements; educating the workers on the possible gains to them from high productivity; improving work ethics; redirecting training facilities; improving transport facilities; and expanding accommodation facilities (C.B.S.L. Annual Report, 1996).

Other significant findings in several construction sites in Sri Lanka can be summarised as follows:

- Lower average labour skills are available at large projects or at remote sites, where any available person, skilled or not, is hired in order to fill the vacancies (Gunawardena and Jayawardane, 1997) and (Jayawardane, 1992a).
- The lower cost of labour relative to the more rapidly rising cost of such other inputs has sometimes resulted in accelerated schedules (fast tracking) which use more labour at a lower average productivity to finish projects earlier (Jayawardane, 1992b).
- The work ethic among workers, particularly those younger and better educated, is less prevalent or absent (Jayawardane and Gunawardena, 1998).

A study carried out in nine construction sites in Sri Lanka by Kodikara and Dissanayake (1993) revealed the external and internal factors that have a significant effect on construction productivity of brickwork. Accessibility of the site, flow of materials to the site, weather, capacity of the contractor and complexity of the work are external factors. The internal factors revealed were interference; physical planning; availability of materials at location of work; use of tools and equipment; method adopted; amount of supervision; level of workplace (at floor level, on scaffolding, or on scaffolding and end wall); availability of technical information; working environment; expected quality; conflicts between activities (interference); incentive to workers; sufficiency of labour; mode of construction (piecework, sub-contract, or direct labour); repetition effect (subjected to a long period, short period or no repetition); capacity of the masons; and co-ordination among the workers.

Unfortunately, labour productivity is not seriously considered by employers in the Sri Lankan construction industry – neither in the public nor the private sector. The workforce is not considered as an asset which should be well treated and up-graded, but as an excess resource which is cheap, readily available and vulnerable to the hire and fire policy of the employers (Kodikara and Disanayake, 1993). This is more explicit in the private sector. The government is now trying to put a framework in place for Sri Lanka to become more productive, but within this framework some factors influencing productivity (e.g. effective site layout) are not included (see Chapter 2).

3.5 ON-SITE ORGANISATION PROBLEMS

In some projects, a 'people'problem has arisen in the following type of bureaucratic organisation, because of differences in backgrounds and career paths between the line managers and staff. Most individuals in the line, often including the Project Manager, are older and have reached their positions following long experience in the skilled trades. On the other hand, Chandrasena (1997) highlights that some personnel, particularly engineers or graduates in construction-related fields, are younger and college educated. Such differences have made it difficult to establish rapport and informal friendly relationships, which are crucial for the smooth management of construction projects. It is apparent that the bureaucratic organisations under which the construction projects operate today hamper whatever programmes, if any, are set up to improve productivity, and such organisational and people problems have gone unrecognised (Logonathan, 1998).

Today the majority of those who supervise on-site construction in many construction projects were originally in the crafts (CBSL, 1996) since many students who do not qualify for Advanced Level (A/L) or do not seek further education after A/L in construction-related occupations (Sri Lankan country report, 2008). Also it is usual to leave the control of on-site work largely to foremen who have had long experience and have worked up to their present positions over a period of time (Logonathan, *1998).*

Karunartna (1996) stresses that most foremen lack training in planning or management, except that which has been gained on the job. There are, of course, exceptions. Although their talents are an essential element in successful field construction management, the craft orientation – coupled with a long period of doing it the way they learned and know – have created a mental set that hampers certain basic ways of thinking needed to improve productivity. These include: a tendency to accept orders from above without question or challenge; to assume that the traditional ways of carrying out operations are the most efficient; to follow the conventional practice of leaving actual accomplishment of tasks to foremen and craftsmen from the appropriate trades without examining their approaches first; to fail to challenge themselves and others to look for creative and less costly methods for carrying out their work; and, because of an orientation towards work-face activities, to fail to recognise that matters away from the work-face situation may primarily control productivity, and therefore fail to give them critical attention (Jayawardane, 1994).

Gunasekera (1997) noted that these deficiencies, attributed to managers and foremen from the crafts but common to many others, can be corrected with management

education and practice, encouragement from higher management, and sufficient time to find and carry out the new approaches. Unfortunately, seldom are any of these corrective measures taken (Gunasekera, 1997 and Jayawardane, 1994).

Some bureaucrats (e.g. operational directors) in the construction industry in Sri Lanka have proposed that college-educated people, particularly engineers and architects, should replace construction supervisors from the crafts for all levels above foreman. It is claimed that their education permits them to overcome the weakness of supervisors from the crafts. However, Chandrasena *et al* (1995) noted that it is worthwhile considering the following implications: firstly, there are not enough graduates available within the country for this purpose. Secondly, no person familiar with both professional construction education and construction field practices sees this as a likely possibility. The new graduates lack hands-on experience in craft techniques and in getting and keeping crews at work. Although they are conditioned to accept the notions about and techniques underlying planning, scheduling and improving work, few have practised the techniques in the real world (Jayawardane and Sirikumaran, 1997). In other words, it is impossible for on-site construction managers, be they from the crafts or professionally educated, to come from backgrounds that encompass both work-face experiences in several crafts and also management education dealing with planning, scheduling, and handling people problems.

Furthermore, because of the usual craft-structured organisational plan and many other pressures, if persons with such qualifications existed, there would be neither time nor opportunity to put all their talents to work. Improving productivity therefore requires pooling the skills and knowledge of the two groups (Chandrasena *et al,* 1995).

"Planning and productivity are two key attributes for enhancement and development in the construction industry. Careful planning ranging from macro level to micro levels helps to a greater extent towards achieving productivity. The other main factors that affect productivity in Sri Lanka are quality and motivation of labour force, quality of materials, technology, quality of management and weather conditions. To improve quality of construction sector ICTAD and Sri Lanka standards institution have taken several measures and now there are many leading companies who have obtained ISO 9000 standard. All professional organisations of Sri Lanka are providing continuous professional development with respect to these issues" (Sri Lanka country report 2004–2005).

3.6 THE NATIONAL ECONOMY AND THE CONSTRUCTION INDUSTRY

The Sri Lankan government considers that there is a need for a clear policy statement to provide adequate guidance for the construction sector. The policy objectives given in the Sri Lanka country report 2004–2005 are as follows:

- In the construction sector, strive to achieve efficiency, quality and productivity.
- Aim to achieve a competitive edge to catalyse the growth of the economy, create more employment opportunities and ensure long term sustainability.
- Integrate and coordinate different economic sectors and sub-sectors and thus optimally utilise resources.

- Ensure optimum utilisation of financial and other resources by streamlining the procurement procedure. This will allow for technology transfer whilst minimising associated risks.
- Instigate effective systems for planning, regulation and monitoring of the construction sector taking into account the environment and cleaner production.
- Develop strategies to encourage recognition for the construction industry within Sri Lanka, and also recognition of the needs of construction workers for job safety and security (Sri Lanka country report, 2004–2005).

Although all the policies were adopted in order to improve the construction industry and productivity, the effects are unclear. There is a present trend of low productivity in the SLCI due to its own difficulties in improving productivity, as the product or service delivered is not standard (Sri Lanka country report, 2008). Further investigation is needed to determine the relationship between these policies and productivity within the context of the current situation.

3.7 STRATEGIES TO PROMOTE GROWTH AND DEVELOPMENT IN THE CONSTRUCTION INDUSTRY

3.7.1 ROLE OF INSTITUTION FOR CONSTRUCTION AND DEVELOPMENT (ICTAD)

ICTAD has planned to make it mandatory policy for all registered contractors; to have a quality management system functioned in their companies (ICTAD, 2008). It also conducts employee development programmes (e.g. seminars, workshops) to

develop the knowledge of employees of contracting companies. These programmes are prepared to cover the training needs from professionals to tradesmen (Pathirage, 2008).

Construction quality and productivity improvement aspects have been identified in its role by ICTAD (ICTAD, 2008). They are:

- Regulation of activities and promotion of best practices relating to the Construction Industry.
- Maintaining standards in construction work, including quality of material used and workmanship.
- Promotion and raising of professionalism in the industry.
- Monitoring and Review of the work of consultants.
- Technical Auditing of construction project work.
- Improvements in the Grading and Registration System of Contracting Companies.
- Widening of the scope relevant to specialist contractors.
- Development of skill levels of workers in the industry.
- Improvements in safety, Welfare and Health aspects of the personnel engaged in the industry.
- Promotion of sustainable and environment friendly construction.
- Prohibition of the use of hazardous material in construction.

3.7.2 CONSTRUCTION EXCELLENCE AWARD SCHEME

The annual Institute for Construction Training and Development (ICTAD) award for Construction Excellence was designed to encourage quality and professionalism in the construction industry in Sri Lanka. ICTAD`s main aim is to develop the domestic construction industry. The objective of the award scheme is to motivate contractors so that they achieve quality and efficiency in the construction industry. This is effected by encouraging innovative approaches in technology and punctual completion of projects to acceptable standards and costs (ICTAD, 2004 and ICTAD, 2008).

The construction industry plays a vital role in the national development efforts of Sri Lanka and the part played by construction contractors is very important. The ICTAD Award for Construction Excellence recognises outstanding performance in construction management and organisational skills, technical expertise and quality standards. It also recognises training of craftsmen/tradesmen as well as innovative and appropriate technology in achieving excellence in construction projects (ICTAD, 1998; Kulatilaka, 1998 and Pathirage, 2008). This is a significant step towards improving work quality and the performance of workers. However, the ruling body did not actually consult with the workers themselves in order to elicit their opinions on what could be done to improve the construction productivity.

Similar award schemes for construction projects are conducted by the national construction association of Sri Lanka and Chamber of construction industry. These schemes give encouragement and motivation for contractor members to attain quality and products, in their projects undertaken, giving emphasis to productivity.

3.7.3 FUTURE DEVELOPMENT

The government is in the process of introducing a regulatory network to the construction industry. The Construction Industry Bill drafted for this purpose has already got the approval of the Cabinet of Ministers. It is now with the legal draftsman before going to Parliament for approval. Among the range of subjects identified for coverage under the Construction Industry Bill are:

(a) the setting up of a framework for determining and reviewing national policy on construction,

(b) the staff development of engineering and architectural consultants and contractors and their registration and monitoring,

(c) standards for materials and safety,

(d) protection of construction workers,

(e) contract practices,

(f) technical bill.

A body called the Construction Industry Authority will be established to implement the Act.

All the improvements the government is introducing are positive, but what is missing is an introduction of optimum site layout strategies into the industry which could certainly help in giving direction to the way in which issues within the construction industry are addressed.

3. 8 ISSUES IN PRODUCTIVITY IMPROVEMENT

Construction operates differently from most industries. For example in Sri Lanka most construction projects are unique (one of a kind) and generally fast moving, so that organisations are not static but must be rebuilt again and again with different designs and designers, management, materials, equipment, and crews. Consequently there is little repetition and few second chances to learn from earlier mistakes.

Too often, common practice considers productivity, costs, safety, schedule and quality as separate objectives, with responsibilities for them delegated to different people in each organisation. Again owner, designer, contractor and craftsmen and their representatives have different basic objectives which affect their views of the relative importance of the factors and their effects on their individual or organisational well-being. Combining these factors – lack of repetition, accelerated scheduling, a variety of designs and viewpoints, and several parties – makes the task of setting objectives, much less carrying them out, particularly difficult in on-site construction (Sun and Nanayakkara, 1995). So, this universal concern also applies to Sri Lanka.

Karunaratna and Gunasekara (1990) highlight that the contractual structure under which projects are carried out in Sri Lanka is seldom conducive to co-operation among the parties or to joint efforts to improve productivity. Often there is no contractual relationship at all between some of the affected parties. Because of these conditions, the parties assume that there are boundaries they cannot step across; rather they tend to deal at arm's length and even become adversaries, all looking out for

their own interests when things go wrong. Karunaratna (1990) stresses that any efforts to improve job relations and productivity require that parties work together harmoniously either within or outside formal contracts to generate ideas and develop solutions.

Jayawardane and Sirikumaran (1997) noted that the traditional hierarchical management structure, developed within each organisation to get the work accomplished, hinders free discussion and exchange of ideas. Because these efforts take time and seem to delay progress, they are seldom welcome. The usual attitude of construction people, managers and workers alike, is to get on with the job. This does not provide a climate for a thoughtful, searching approach necessary to develop and carry out new or innovative ideas (Caroline, 1984). Whether these conditions can be changed to improve co-operation among parties and productivity is questionable. The perceived view in Sri Lanka is that top management and the others with influence should jointly adopt a clear set of objectives and operating plans to overcome these difficulties.

3.9. TRADITIONAL PROJECT MANAGEMENT SYSTEMS AND PRODUCTIVITY IMPROVEMENT

This section reviews the traditional views of SLCI in the field of management systems as well as the implementation of these systems with reference to productivity improvement. This will provide a useful reference point for future discussion of efficient site layout approaches in later chapters. It is generally accepted that, in the construction industry in Sri Lanka, those in charge seldom get around to establishing

and carrying out effective and continuing productivity improvement programmes (Jayawardane, 1992a). Two reasons have been given. Firstly, managers in general are unaware that proven ways of introducing and implementing productivity improvement programmes are available (Jayawardane, 1992b). The second obstacle is that managers are too occupied with the complexities involved in getting the work done to think about, much less carry out organised programmes (Jayawardane, 1992a). On the surface, the traditional project management system operating in Sri Lanka makes sense, since it maintains the status quo. The duties and objectives of the parties are defined; everyone knows what is to be done, how it is to be done and who is to do it. But it is when something goes wrong or changes are to be made, as is common in construction, that this traditional management arrangement runs into difficulty. For example, there is usually no contractual or line relationship between the designer and the contractor, because the owner has separate agreements with these parties.

Consequently, there is no established mechanism to force the designer and contractor to communicate formally to make changes or to settle differences in a manner that is agreeable to both of them and the owner as well. Agreements, if finally reached, involve the line organisations of all three parties. This procedure has proved cumbersome and time consuming, and on fast moving construction projects it has often come in to play too late (Ganesan *et al*, 1997).

Given this situation, it is easy to see why in Sri Lanka it has become difficult to introduce changes that would be mutually beneficial to the owner as well as to the other directly affected parties. There have been instances where productivity improvement schemes had to be forgone because the changes they required could not

be accomplished through the line organisation. Among these were situations where the owner or designer had to communicate directly with subcontractors and/or suppliers (Rajasiri and Dayananda, 2004).

The above examples illustrate why a top-down management style is unlikely to increase productivity. The aim of productivity improvement efforts is to find and introduce changes in the way things are being done. These changes may affect established practices such as the roles of the various parties, the concept or the design of the project, or the way operations and individual tasks are to be managed or carried out. All these can challenge the authority of line managers and threaten their egos and security. It is not unusual to observe in Sri Lanka that, on occasion, the young energetic engineers who try to promote productivity improvement efforts have been perceived as troublemakers by line management.

3.10 DISCUSSION AND CONCLUSIONS

This chapter has catalogued the way the construction industry has been influenced by different factors in the past as well as in the present. It has looked at the way the Sri Lankan construction industry has been addressed by various successive governmental and cross-governmental agencies (e.g. British government). However, the structural adjustments (e.g. open market economy) that were required in the drive towards higher productivity and introduced by successive governments after independence have major implications. This is also true of the use of western-style management in construction. The aid and loans received for these structural adjustments have political

overtones as well as managerial and organisational implications and the influence of the civil war must also be noted.

The dynamics of the '*construction organisational culture*' as it evolves are indeed a highly significant influence on worker productivity in Sri Lanka. In early Sri Lanka, the kings and the rajas were the '*organisation*' within which construction evolved. Loyalty, obedience, religious beliefs and values of the kings shaped the attitudes and culture of the workforce and the king's subjects. In the colonial era, the colonial masters were the '*organisation*' within which the Sri Lankans constructed their buildings. The organisational culture of the colonial power is reflected in the way the construction projects were managed and used for higher productivity for the Crown. However, from the construction productivity point of view, an embedded culture shaped over time may create a barrier to the effective introduction and implementation of different construction productivity techniques in the short term.

It is a very different and difficult picture when discerning the salient features of the present construction industry in Sri Lanka soon after independence. The Sri Lanka government was not well equipped to manage, function and operate effectively immediately after independence. This was due to the lack of personnel who had been adequately trained in civil services as well as other important governmental positions to assume the reins of power. The lack of trained, efficient and effective personnel was also manifested in the private and public sector industries, in particular the construction industry. The Sri Lankan government realised this and put in place measures that would address these deficiencies, in the form of loans and aid during the 'decade of productivity' (Sri Lankan country report, 2004) Such loans have

strings attached that mostly reflect some organisational and managerial adjustment for them to be continued.

In the construction sector, such loans were reflected in the influx of foreign construction firms into Sri Lanka as part of the conditions. Most of these firms still do not have mechanisms in place to train the local workforce towards higher productivity (Sri Lankan country report, 2004). Also the pay schemes offered by some of these firms do not give sustained encouragement to operatives to stay in construction. All the new incentives introduced by the government will fail if the immediate issues affecting operatives are not addressed. The finance and loans from foreign investors are not felt by the grass root workforce and labourers. This has created a dismal picture and decreases construction productivity (Weddikkara and Devapriya, 2000).

The immediate and pressing issues for workers today are their educational needs and the facilities available to the vast numbers engaged in construction activities (ICTAD, 2008). The range of skills involved is as wide as could be imagined. It extends from physical labour to intellectual expertise of the highest order. But the availability of the required skills for the future, as much as for the present, is a crucial determinant of how our construction capabilities respond to the needs of the situation and so helps shape the pattern of future development. Training needs include different skill levels, the range and quality of vocational and professional education (technical) and the scale of the facilities available at home and abroad to accomplish this.

There should be no mismatch between the needs of the construction sector and potential flow of skills due to the effective function of the construction industry. Levels of remuneration are also of strategic importance to the planning process. They are intimately linked to factors that range from the organisation of labour to opportunities for alternative employment abroad (Sri Lanka country report, 2008). All these needs and requirements are linked with construction productivity. In order to achieve higher productivity in the SLCI, the government needs to recognise all productivity-related factors as an integrated system, i.e. to see the construction industry as a whole.

Sri Lanka is a developing country whose future development is likely to involve a range of construction activities extending from small-scale housing and other medium-sized projects to vast building and infrastructure enterprises in a variety of fields, mainly conducted by subcontracted labour and direct labour employees. Access to funds on suitable terms from the general banking sector, specialised lending institutions and arrangements for medium and small-scale credits will all be major determinants of the future of the construction sector. Finding ways to increase total productivity now will bring about a whole new dimension and benefits to the construction industry in the future.

In order to foster the whole framework of Sri Lankan development initiatives – given that Sri Lanka is a developing country – Corea (1999) highlights the importance of linking the construction sector to national planning. But no less important is the need for spatial planning for several regions, cities and towns in the country. Such plans must not only be drawn up, they should be strictly adhered to as construction activity

unfolds. The agencies for town and country planning must be strengthened and endowed with authority to enforce the observance of their plans.

Sri Lanka may look to increasing progress and prosperity as the 21st century unfolds. An intensification of construction activity will be a necessary corollary of such a prospect. There will be several challenges to face, but the Sri Lankans have to be equipped to make the best choices, to select the best technologies and to follow the optimum path open to them. There also have to be highly effective strategies to improve productivity. It is believed that the strategies introduced by ICTAD in making ISO quality standards mandatory for registration of construction companies along with the newly developed employee development structure and the award scheme will increase awareness, motivate and encourage the entire SLCI to reach for higher productivity.

Chapter 2 outlined the importance of effective site layout practices on productivity. Before we introduce the site layout practices to SLCI, it is important to understand the specific factors and challenges faced by Sri Lanka (e.g. Open market economy, adapted western management strategies, ongoing management strategies, given the status of current construction productivity and related problems of the industry) and these have been outlined in this chapter. The focus of the next chapter is the methodology of the study.

CHAPTER FOUR

METHODOLOGY OF THE STUDY

4.1 INTRODUCTION

Following the literature review which established the theoretical background to the research and outlined the evolution of the construction industry in Sri Lanka, the rest of the research is divided into four phases: the development of research techniques and procedures for data collection and analysis; the data collection; the data analysis with reference to testing the research propositions and developing an empirically grounded framework; and finally the conclusions.

This chapter takes the form of a discussion of the methodology of the study (i.e. the development of research techniques and procedures for data collection and analysis). The chapter is divided into ten sections. In section two, justification of the selection of the sites, sample size and sample selection are discussed. The research paradigms are discussed in section three followed by a discussion in section four of research techniques used. Section five discusses the pilot study and section six discusses the research methods used in the study. The derivation interview guide discussed in section seven is followed by the data analysis in section eight. Finally the challenges are reflected upon before the conclusion.

4.1.1 AIMS OF THE STUDY

The research aims, to investigate how productivity could be improved in the Sri Lankan public sector construction industry by using effective and efficient site layout plans (SLP).

4.1.2 OBJECTIVES

- To review the theoretical basis of existing concepts relating to construction site productivity.
- To ascertain, to what extent employers in the construction industry (CI) in Sri Lanka are aware of the supposed advantages of effective SLP.
- To identify the perceived productivity benefits realised through the implementation of the above SLP practices
- To ascertain if there are significant differences between SLP amongst developed regions and remote regions in SLCI.
- To develop an empirically grounded framework for understanding the perceived relationship between site layout plan and site productivity of the Sri Lankan CI.

4.1.3 RESEARCH PROPOSITIONS

To obtain the above objectives the research propositions are as follows:

- The employers in Sri Lanka are aware of the supposed advantages of efficient SLP in CI
- Construction SLP in developed regions in the SLCI is different to SLP in remote regions in the SLCI.
- Effective and efficient SLP in Sri Lankan CI would contribute to improve their productivity.

4.2 RESEARCH SAMPLE

4.2.1 JUSTIFICATION OF SELECTION OF SITES

Research data was collected in Sri Lanka by means of an interview programme with five groups of actors involved in site operation (e.g. site engineers) with particular emphasis on the public sector building construction industry (CI). The public sector was chosen as the focus of this research because most of the factors affecting construction productivity can be assumed to be constant within the public sector. This emanates from the fact that, as direct labour organisations, they employ their workforce on a long-term basis and have standardised quality control procedures, training programmes, pay and work incentives and safety procedures across the country in comparison to the private sector. As such the researcher and respondents could more readily isolate the effect of SLP on productivity given that it is more

prone to variation due to topographic and project technical requirements. In addition, the public sector CI is the dominant sector of the industry in Sri Lanka, undertaking most of the major building and infrastructure construction activity. Data was collected to investigate the characteristics of site plan factors (e.g. location of site office, stores, rest rooms etc), interpret the research objectives and to test the research propositions.

4.2.2 SAMPLE SIZE

Predominantly, the Sri Lankan public sector building CI was selected as the sample for the survey. The public sector in Sri Lanka is involved in a wide range of different types of construction projects spread all over the country (Rajasiri and Dayananda, 2004). Of the construction sites commissioned by the Sri Lankan public sector construction industry, 15 construction sites representing the general construction practice in Sri Lanka employing 60 site staff members, were initially selected.

The Director General of the Ministry of Sri Lankan Building Construction was consulted and briefed about the proposed study and his permission and support requested for the survey. During this discussion, the researcher made it clear that (other than fulfilling the personal academic requirements of the researcher) the purpose of the study was to give the management of the Sri Lanka public sector building CI some valuable information which they could use for better productivity in their construction projects. At this meeting, a systematic approach of the research process was discussed with the Director General. A list of ongoing public sector construction projects and other relevant details were collected. The constituency for the research was provided by a representative cross section of personnel engaged on

public sector building construction projects in Sri Lanka. The constituency consists of a sample of 60 randomly selected (where more than one option was available) research participants.

Breakdown of the sample cross sections:

- project managers 15
- site engineers 15
- architects 13
- quantity surveyors 02 [1]
- foremen 15

Total 60

4.2.3 SAMPLE SELECTION

The 15 construction sites were selected in the following manner:

Sri Lanka is divided into nine provinces: Northern, Eastern, Southern, Western, Sabaragamuwa, Uva, Central, North Western and North Central (please see the Figure 4.2.3).

[1] Two quantity surveyors were selected as there were no architects available at two of the sites. However, in the data analysis there were no significant differences found including or excluding the quantity surveyors. (Please see chapter 5).

Fig 4.2.3: Map of Sri Lanka

Due to terrorist attacks and for security reasons, the researcher did not reach the Northern and Eastern provinces of the country. Therefore, from seven provinces, three construction sites from Western province due to the amount of ongoing construction projects are significantly higher than the other provinces (ICTAD, 2004) and two from each remaining province (i.e. 12 construction sites from the remaining six provinces) were selected utilising purposeful selection criteria based on the largest building projects in each province. Why large scale building projects? Starting with a large-scale building project aided a comparative analysis of similar cases. (Most of the factors which focus on this research – e.g. rest room and sanitary facilities – do not exist in small scale public sector building sites in Sri Lanka). Furthermore, the provinces can be categorised as developed (i.e. Western, Southern and Central

provinces) and remote (i.e. other provinces) (Rajasiri, 1999). (More information about Sri Lanka and Sri Lankan public sector construction industry will be given in chapter three). Therefore in this research, the researcher considered the following separately:

1. Overall (Considering the region as a whole without separating into developed or remote)
2. Intra region (2a) Developed
   (2b) Remote
3. Inter region: Developed vs. Remote

Tsunami-affected areas were not selected for this research because their construction projects are of a different style (involving non-governmental organisations rather than public sector organisations) and do not represent the true picture of Sri Lankan public sector construction projects. Most of these particular projects in tsunami-affected areas are very small scale maintenance projects and spread in only some coastal areas. The funding structure and the resources allocation of these projects are also independent and separate from normal Sri Lankan building construction projects. Building projects which had already started before the tsunami disaster were selected in this study. These had already-allocated resources and would not be affected by the tsunami reconstruction.

4.3 RESEARCH PARADIGM

The design of any research study begins with the selection of the research paradigm which is appropriate to the selected topic (Creswell, 1994b). The word 'paradigm' is

undeniably over-used in popular management parlance. Nevertheless, it is of fundamental importance for a researcher to be self-aware of the assumptions that lie behind the adopted theoretical position (Dash, 2005). Nevertheless, a rich understanding of the issues involved can only really be understood by referring to the broader literature on research methodology that lies beyond the domain of construction management. Any such discussion should begin with reference to the seminal work on social theory by Burrell and Morgan (1979). Whilst the debate is often characterised in terms of the merits of quantitative research *vis-à-vis* qualitative research, this fails to capture the complexity of the underlying issues of concern. Burrell and Morgan (1979) argue that the key assumptions that characterise different approaches to social theory can be analysed in terms of two dimensions. The first is the subjective-objective dimension. The second spans between the 'sociology of regulation' and 'sociology of radical change'. These two dimensions combine to create four distinct sociological paradigms, labelled functionalist, interpretive, radical humanist and radical structuralist. The four paradigms are illustrated in following figure (Fig 4.3):

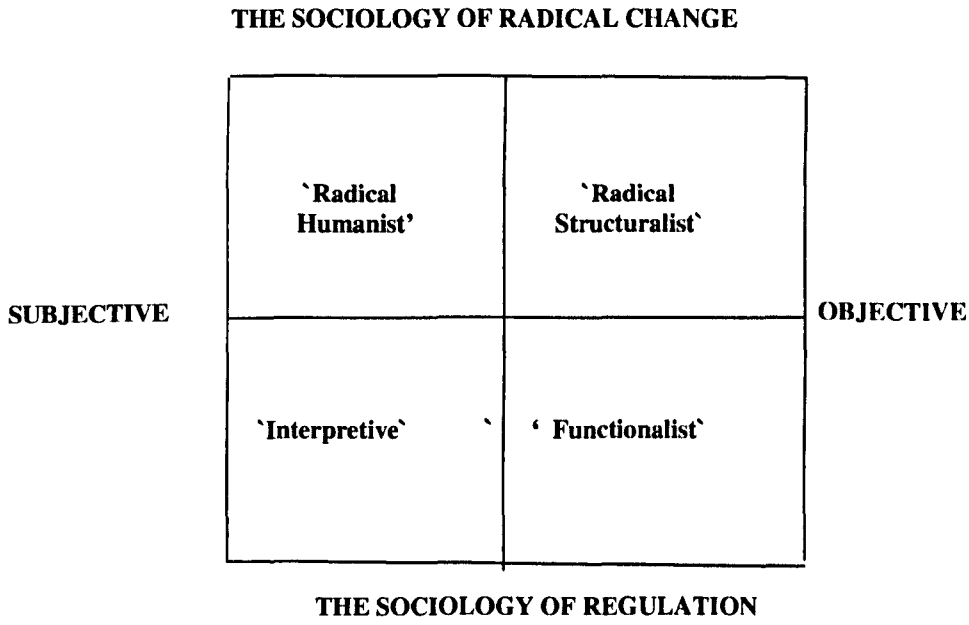


Fig 4.3: Four paradigms for the analysis of social theory

(Source: Burrell and Morgan, 1979)

4.3.1 THE FUNCTIONALIST PARADIGM

This paradigm represents a perspective which is firmly rooted in the sociology of regulation and approaches its subject matter from the objectivist point of view. Its approach to social science is rooted in the tradition of sociological positivism. This reflects the attempt *par excellence*, to apply the models and methods of the natural sciences to the study of human affairs. The functionalist approach to social science tends to assume that the social world is composed of relatively concrete empirical artefacts and relationships which can be identified, studied and measured through approaches derived from the natural sciences (Burrell and Morgan, 1979). The proposed study emphasises the importance of understanding the society from the point of view of the actors who are actually engaged in the performance of social activities, and rejects the use of mechanical analogies to study the social world.

4.3.2 THE RADICAL STRUCTURALIST PARADIGM

Theories located within this paradigm advocate a sociology of radical change from (also) an objectivist standpoint. It advocates an approach to science, which has many similarities to that of functionalist theory. While the radical humanists forge their perspective by focusing upon "*consciousness*" as the basis for radical critique of society, the radical structuralists concentrate upon structural relationships within a realist social world. They emphasise the fact that radical change is built into the very nature and structure of contemporary society, and they seek to provide explanations of the basic interrelationships within the context of total social formations. Considering the nature of the study, the researcher rejects this paradigm as suitable for the research.

4.3.3 THE INTERPRETIVE PARADIGM

As opposed to the above two paradigms, the interpretive paradigm is informed by a concern to understand the world as it is, to understand the fundamental nature of the social world at the level of subjective experience. It seeks explanation within the realm of individual consciousness and subjectivity, within the frame of reference of the participant as opposed to the observer of action. It sees the social world as an emergent social process, which is created by the individuals. Interpretive philosophers and sociologists seek to understand the very basis and source of social reality. They often enquire into the depths of human consciousness and subjectivity in their quest for the fundamental meanings, which underlie social life.

4.3.4 THE RADICAL HUMANIST PARADIGM

The concern of the radical humanist paradigm is to develop a sociology of radical change (also) from a subjectivist standpoint. Its approach to social science has much in common with that of the interpretive paradigm, and views the social world from a perspective which tends to be nominalist, anti-positivist, voluntarist and ideographic (Burrell and Morgan, 1979). Considering the nature of the study, the researcher rejects this paradigm as suitable for the research.

Much of the research methodology literature refers to the importance of 'matching' the appropriate research paradigm to the nature of the problem. This is certainly true for the most obvious cases. For example, it would be ridiculous to advocate an interpretive paradigm for research into inter-planetary motion. However, within social contexts, it must also be recognised that different research paradigms are associated with different values. The value-laden nature of research is perhaps at its most obvious with work written from the radical-humanist standpoint, which invariably provokes an angry response from those who adhere to the scientific tradition. This is often not true for those who fall unthinkingly into the functionalist paradigm due to a subconscious allegiance to 'scientism'. It is important to recognise Burrell and Morgan's (1979) contention that their four paradigms are ultimately mutually exclusive. They offer alternative views of social reality; and to understand the nature of all four is to understand four different views of society. They offer different ways of seeing. A synthesis is not possible, since in their pure forms they are contradictory, being based on at least one set of opposing meta-theoretical assumptions. They are alternatives, in the sense that one can operate in different paradigms sequentially over time, but

mutually exclusive, in the sense that one cannot operate in more than one paradigm at any given point in time, since in accepting the assumptions of one, we defy the assumptions of the others. Within the context of social theory, it is therefore impossible to say that any one paradigm is superior to any other. The key issue for the researcher is to be critically self-aware of his or her adopted theoretical position. It is also important to ensure that the adopted research methodology is internally consistent.

In terms of selecting the appropriate research paradigm for the present study and nature of the research design, the choice was quickly narrowed down to the interpretive and functionalist paradigms. Some have argued that there are two fundamental research paradigms:

- The quantitative paradigm (i.e. similar to functionalist paradigm)
- The qualitative paradigm (i.e. similar to interpretive paradigm)

They are fundamentally different and cannot be reconciled (Firestone, 1987; Guba and Lincoln, 1988; McCracken, 1988); others have hence challenged this assumption and assume that good research should use qualitative and quantitative methods as appropriate (Creswell, 2003; Grant and Fine, 1992; Mathison, 1988; Swanson, 1992). Furthermore Denzin and Lincoln (1998) argue that the word qualitative implies an emphasis on processes and meanings that are not rigorously examined or measured (if measured at all), in terms of quantity, amount, intensity, or frequency. Qualitative researchers stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, as well as its value and the situational

constraints that shape the inquiry. They seek answers to questions that stress how social experience is created and given meaning.

According to the nature of this research and the characteristics of the research techniques, it belongs to the interpretative paradigm as well as the functionalist paradigm (i.e. mixed paradigm). The idea of combining mixed approaches (i.e. qualitative and quantitative) in a single study owes much to past discussions about mixing methods, linking paradigms to methods and combining research design in whole of the study (Creswell, 1994a). Furthermore, Robson (2002) highlighted that methodological triangulation (checking the results of qualitative methods with those of quantitative methods or vice versa) as a method that influences the research validity and reliability criteria. Greene *et al.* (1989) advanced five purposes for combining methods in a single study:

- *"Triangulation in the classic sense of seeking convergence of results*
- *Complimentary, in that overlapping and different facets of a phenomenon may emerge (e.g., peeling the layers of an onion)*
- *Developmentally, wherein the first method is used sequentially to help inform the second method*
- *Initiation, wherein contradictions and fresh perspectives emerge*
- *Expansion, wherein the mixed methods add scope and breadth to a study"* (Cited in Creswell, 1994a)

4.4 THE DATA-GATHERING TECHNIQUES

The preceding paragraph provides the justification for a research design that accord with the interpretive paradigm as well as functionalist paradigm. The techniques used in this study are observations, interviews and the review of documentary evidence. Each technique is designed to get a certain type of information and does not attempt to gather other types. For example, under certain circumstances, observing behaviour is clearly a useful enquiry technique, but asking people directly about what is going on is an obvious shortcut in seeking answers to the research propositions.

According to Kane (1985) and Berg (2008), usually research techniques complement and support one another. No one technique duplicates exactly the functions of the rest. Each technique yields information that only it can obtain, but it also reinforces the other techniques. In this study as many techniques as possible were used to examine the same data through different strategies, in order to verify and strengthen the validity of the research results.

4.5 PILOT STUDIES

Before the start of fieldwork among the selected sample, the questions for the interview guide and observation schedule were pre-tested as follows, to make sure that the wording and the order gave the best possible result as a pilot study. Feedback was obtained from the pilot study, the interview guide and observation schedule were modified and restructured.

4.5.1 PILOT OBSERVATIONS IN THE UK

Three different construction sites were selected for pilot observation. They were: building construction projects in Reading, Oxford, and Aylesbury. The main purpose of these pilot observations was to test the pre-structured observation schedule and amend accordingly prior to the main observation sessions.

4.5.2 PILOT INTERVIEWS IN THE UK

Krueger (1997 and 2000) advocates that the first and easiest strategy for testing questions is for researchers to try the questions on other researchers who are familiar with the programme or activity. It is best if the questions are not just read, but asked conversationally. The researcher asked the questions and the second researcher attempted to answer. With this exercise, several aspects were tested simultaneously: the ease with which the questions could be asked and the nature of the answers.

Moreover, as the second step in the pilot interview sessions, the researcher tried the pre-structured interview guide on 12 selected construction site agents: one project manager, one site engineer, one architect and one foreman from each construction site. Those agents were selected from three different UK construction sites – the same sites where the pilot observation sessions were conducted – and their comments on the following points noted.

- Do the questions seem awkward when asked orally?
- Do the words flow smoothly?

- Does it sound conversational?
- Is the emphasis placed on certain key words in the questions correct?
- Do the responses occur relatively quickly?
- Can questions be misinterpreted?

(Fraenkel and Wallen, 1990; Robson, 2002)

Findings of this exercise were also used when modifying the final interview guide (Fraenkel and Wallen, 1990; Robson, 2002). For example, the following question in the interview guide 'How would you rate the adequacy of materials?' was modified to 'How would you rate the adequate amount of materials?' after the feedback from the pilot study. Furthermore, this pilot study helped to emphasize conceptual and logical issues in the research (e.g. the impact of some high risk activities on the site layout arrangement, such as asbestos removal processes, lifting operations etc)

4.5.3 PILOT STUDY IN SRI LANKA

The interview guide was administered during interview sessions to 60 respondents of the sample. It was done thus: first, interviews were held with 10 of the respondents, considering their attitudes and behaviour. The researcher's style and pattern of posing issues to the respondents were slightly modified when holding interviews with the rest of the participants. This pilot study was conducted in Sri Lanka to test the version of interview guide translated into Sinhala (English interview guide version was piloted in UK).

4.6 THE RESEARCH METHODS USED IN THE STUDY

4.6.1INTERVIEWS (ONE-TO-ONE)

Interview sessions were the main research instrument in the study. Sixty semi-structured interviews were conducted and most of these were fully tape recorded. This interview schedule was pilot tested prior to the main research work. Most of the interviews were conducted in Sinhala, which is the lingua franca of the Sri Lankan operatives. Interview guides are available at Appendix B.

Participant interviews were conducted using predetermined questions with flexible wording (i.e. question wording can be changed and explanations given). Questions were constructed so as to get the interviewee to discuss further something he/she mentioned in an answer. All interviews took place in private. Attempts were made to prevent other fellow employees overhearing the conversations. There were information sheets and consent forms (see Appendix A). Information sheets were read and consent forms were signed by each of the interviewees.

Each interview was preceded by the researcher stating:

"I am studying the site layout: how it is perceived to affect productivity in public sector construction projects in Sri Lanka. I would like certain information from you to further my knowledge in this regard. Our discussions will be treated as strictly confidential. This research project received clearance by the University Research Ethics Committee (UREC) at Oxford Brookes University. If you have any concerns about the conduct of this research project that you can contact the Chair of the UREC at Oxford Brookes University (email ethics@brookes.ac.uk)."

This was further clarified for participants where necessary. All interviews were kept anonymous. The sample respondents interviewed were selected randomly where more than one option was available. A cross section of sample in building construction projects commissioned by the Sri Lankan public sector construction industry was included to make it representative. The randomly selected population was stratified to check whether specific characteristics were represented in the sample and if the sample reflected the true characteristics of the population. In the interviews the researcher was anticipating negative data as well as positive data from research questions. How did the researcher know what the respondents said was true and not just what the researcher wanted to know? The researcher was cautious about this and took adequate precautionary steps to invalidate this possibility:

- Some questions were administered to a particular participant on two different occasions and the responses compared and revealed that there was no significant deviation in the responses;

- The observations were used to act as a scanner or check on the other techniques such as interviews;
- Written sources were used to check the reliability of interview results. The written sources were crosschecked against the results of interviews and observation sessions. This means the information collected through interviews was reinforced by observations and checked through documentary analysis.

To make respondents comfortable and to gain their trust, the researcher assured them of their anonymity and interviewed them in a location at a distance from fellow employees and from supervisors.

4.6.2 OBSERVATION SESSIONS

Fifteen observation sessions were conducted in 15 construction sites (which were the same sites where the interview sessions were conducted) within the public sector in Sri Lanka. A pre-structured observation schedule was used for each observation session (see Appendix C). The content of the observation in the present study includes the following aspects:

- characteristics of materials (e.g. store location of materials, material delivery methods)
- characteristics of equipment
- characteristics of waste management
- characteristics of stores
- characteristics of site office rest room and sanitary facilities

- characteristics of security systems of the site
- characteristics of health and safety systems
- general (e.g. road layout, whole site lay out).

This schedule was also pilot tested. Only one observation session was conducted from each site due to time constraints. Fifteen observation sessions were therefore conducted in total. The observation sessions were conducted in the same period as the interview sessions. They were conducted without overlap or disturbance to the interview sessions. The average time duration of one observation session was approximately four hours, including visits all over the site. The explanatory detail notes were made soon after the observation, but before embarking on a second observation session. No comments or actions from sample respondents were treated as irrelevant or trivial. The observer approached each situation with an open mind with as little bias as possible, and listened and looked. The more familiar the situation to the observer the more likely the observer is to make premature judgments. Hence more efforts had been taken to avoid them. The findings of the observations were triangulated with findings from the interview sessions (Bryman, 2003; Silverman, 2000).

4.7 DERIVATION OF INTERVIEW GUIDE

The aim and objectives of this interview guide is to investigate the research objectives. The rationale of the interview guide was derived from the literature review in chapter two and three. The interview guide was designed to cover the whole spectrum of the research. (The interview guide is available in appendix B).

Question numbers 1 to 7 are related to demographic information (e.g. age, current occupation). Other questions are related to characteristics of the site layout factors (e.g. location of the site office, accessibility to waste store locations). For each characteristic of site layout factors the following questions were addressed:

- How does it function or exist?
- Why does it not function or exist?
- In what way is it important?
- Why it is important or not?
- What are your suggestions to improve it?
- What are the difficulties in trying to improve it?

4.8 DATA ANALYSIS

This research belongs to the qualitative as well as the quantitative paradigm (please see the research paradigm section) and two types of data were collected: quantitative (i.e. demographic information of site representatives and sites) and qualitative.

Quantitative data was directly analysed using SPSS statistical data analysis software. Qualitative data was categorised using content analysis categorised techniques and analysed using SPSS statistical data analysis software.

The method of content analysis categorised techniques enables the researcher to include large amounts of textual information and identify systematically its properties, e.g. the frequencies of most used keywords by detecting the more important structures

of its communication content. Yet such amounts of textual information must be categorised according to a certain theoretical framework, which will inform the data analysis, providing at the end a meaningful reading of content under scrutiny. A number of categorising systems exist which have been developed for use in particular situations and for particular projects (Neuendorf, 2002). A few examples of such categorising systems are (1) Gameson (1992) modified the Interaction Process Analysis (IPA) system and used in his study on Interaction between Potential Building Clients and construction Professionals, (2) Budge *et al.* (2001) : Mapping Policy Preferences. Estimates for Parties, Electors and Governments 1945-1998. great example of application of content analysis methods in Political Science dealing with political parties and its impact on electoral systems

On the other hand, many computer-aided qualitative data analysis packages are available, (e.g. NUDIST , NVivo). However the researcher selected SPSS statistical data analysis software (in preference to other options) because: The interview questions were designed with SPSS analysis in mind i.e. questions are predetermined, simple, straightforward and the nature of qualitative data in the present study. Also the researcher has previous experience using qualitative analysis packages (e.g. ASCCUE project, 2005)

4.9 REFLECTION ON SOME OF THE CHALLENGES

The logic of the sample selection has already been addressed. Mid-stage construction sites only were selected; this meant avoiding early and finishing stage construction sites, since most of the site factors and characteristics (e.g. stores, site office) exist in the middle stage construction site rather than the other two stages. Because of the culture and existing gulf between employers and employees (Hofstede 1992 and 2001), respondents might lack confidence during the interviews and might not represent the true picture of the construction site. Therefore, to prevent this difficulty, the researcher had to motivate and manage the respondents by clearly explaining the significant outcomes and benefits of the study.

Concerning the reliability and validity criteria, feedback from the pilot study and other researchers were considered together with triangulating and cross checking the results with two research methods (i.e. observation and interviews). The researcher made every effort to minimise the effect of research bias and sample bias criteria. Examples:

- Development of trusting relationships between the researcher and respondents where the latter are less likely to give biased information (Wengraf, 2001)
- Data and methodological triangulation (Aldridge and Levine, 2001)
- Try to start the observations with an open mind and write up field notes into a narrative account promptly (Robson, 2002)

This chapter discussed the methodology of the study. It included discussions on sample, sample size and justification, the research paradigm, research techniques used and justification thereof. Finally the suggested procedure for data processing and coding was described followed by reflections on the challenges. The next chapter deals with the research results.

CHAPTER FIVE

RESEARCH RESULTS

5.1 INTRODUCTION

This chapter contains the analysis of the data and the interpretation of the results with respect to site layout practices in Sri Lankan public sector building construction projects. To recap, the site layout factors are materials, equipments, waste management system, stores, site office, rest room and sanitary facilities, security systems of the site, health and safety systems and other factors.

The chapter is divided into fourteen sections. Section two looks at the classification of the sites for the sample. The consideration of characteristics of materials is in Section three. Section four deals with characteristics of equipment. Waste management system, stores, site office, rest room and sanitary facilities, security systems of the site and health and safety systems are examined in sections five, six, seven, eight, nine and ten respectively. Section eleven discusses the reasons for the perceived importance of these characteristics followed by the suggestions and difficulties for improvement of site layout practices. Section thirteen is devoted to a cross-analysis of the interview results versus observation results. A summary of the chapter follows in section fourteen.

5.2 CLASSIFICATION OF THE SITES FOR THE SAMPLE

The research was conducted on 15 construction projects commissioned by the Sri Lankan public sector building construction industry. The number of employees interviewed on each site is indicated in Figure 5.2A. According to the location of the sites, these 15 sites can be categorised into seven different groups:

- Sites in Western province (sites 1, 2 and 3)
- Sites in Southern province (sites 4 and 5)
- Sites in Central province (sites 6 and 7)
- Sites in North Central province (sites 8 and 9)
- Sites in Uva province (sites 10 and 11)
- Sites in Sabaragamuwa province (sites 12 and 13)
- Sites in North Western province (sites 14 and 15)

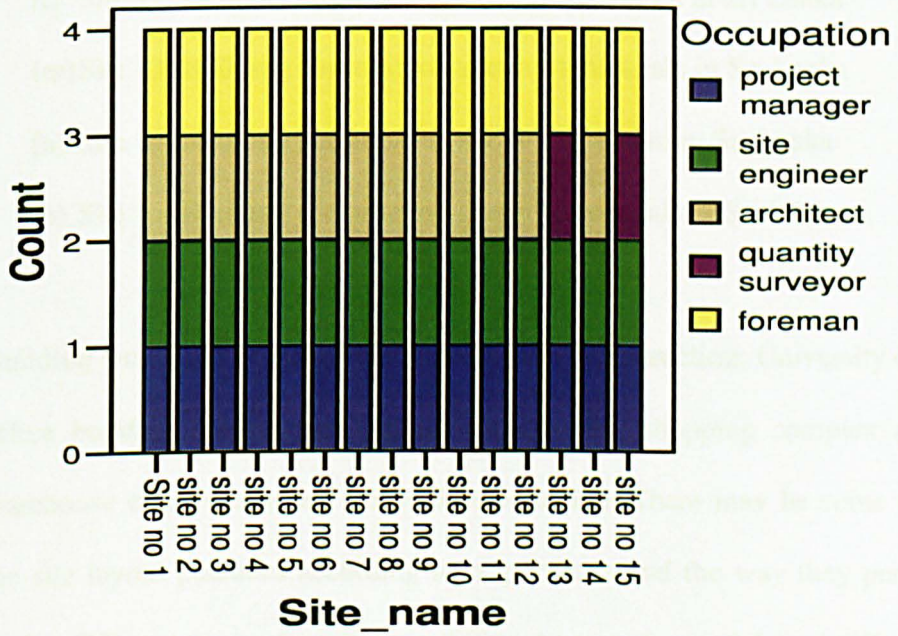


Figure 5.2A

The 15 sites are classified by their type and volume, so as to be representative of the Sri Lankan construction industry:

(a) Site 1: Building construction site in Kirulapana in Sri Lanka.

(b) Site 2: Building construction site in Jalthara in Sri Lanka.

(c) Site 3: Building construction site in Kelaniya in Sri Lanka

(d) Site 4: Building construction site in Gall in Sri Lanka

(e) Site 5: Building construction site in Ma Gall in Sri Lanka

(f) Site 6: Building construction site in Peradeniya in Sri Lanka

(g) Site 7: Building construction site in Nuwara Eliya in Sri Lanka

(h) Site 8: Building construction site in Mihinthale in Sri Lanka

(i) Site 9: Building construction site in Anuradapura in Sri Lanka

(j) Site 10: Building construction site in Badulla in Sri Lanka

(k) Site 11: Building construction site in Bandarawella in Sri Lanka

(l) Site 12: Building construction site in Rathnapura in Sri Lanka

(m) Site 13: Building construction site in Monaragala in Sri Lanka

(n) Site 14: Building construction site in Puthhalam in Sri Lanka

(o) Site 15: Building construction site in Kurunagala in Sri Lanka

Building works can be subdivided into: housing construction; University construction; office building construction; school construction; shopping complex construction; warehouse construction and hospital construction. There may be some variations in the site layout practices according to respondents and the way they perceive things during different types of works (e.g. different types of materials and different qualities of materials as well as different equipment are used for hospital construction and

warehouse construction). However, this study concentrated on significant differences focusing on *overall, intra region: developed and remote and inter region: developed vs. remote* can be found in a later section of this chapter.

Sixty construction project managers, site engineers, architects, quantity surveyors and foremen were selected as a sample total, spaced across the projects. Figure 5.2B shows the occupational distribution.

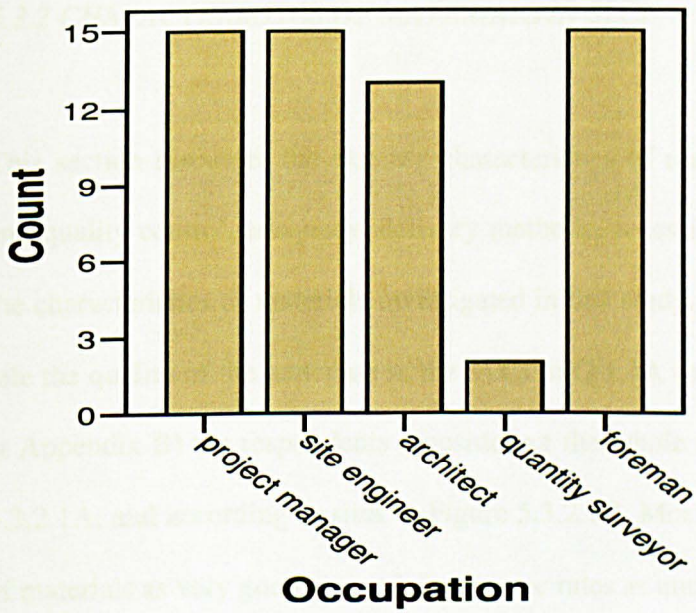


Figure 5.2B

5.3 CHARACTERISTICS OF MATERIALS

5.3.1 INTRODUCTION

This section mainly discusses characteristics of materials in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different

groups (i.e. developed and remote provinces) are also discussed. It is divided into four parts. Section 5.3.2 is concerned with the characteristics of materials in the Sri Lankan Construction Industry (SLCI) (e.g. quality of the materials in SLCI). Section 5.3.3 looks at the reasons why respondents rate the characteristics of materials. Section 5.3.4 discusses the importance of the materials characteristics to the SLCI. Finally, section 5.3.5 looks at the reasons for the perceived importance of the characteristics of materials for site layout practice.

5.3.2 CHARACTERISTICS OF MATERIALS IN SLCI

This section discusses the existing characteristics of materials in SLCI. The quality and quality control, adequacy, delivery methods, accessibility and store locations are the characteristics of materials investigated in this study. For example: when asked to rate the quality of the materials in the SLCI in Q 1.1A (please see the interview guide at Appendix B) the respondents (considering the whole sample) are shown in Figure 5.3.2.1A, and according to sites in Figure 5.3.2.1B. Most respondents rate the quality of materials as very good or good and no-one rates as unsatisfactory.

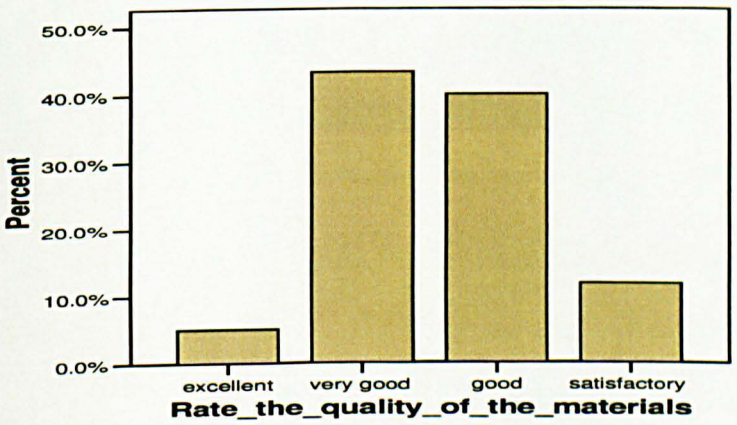


Figure 5.3.2.1A

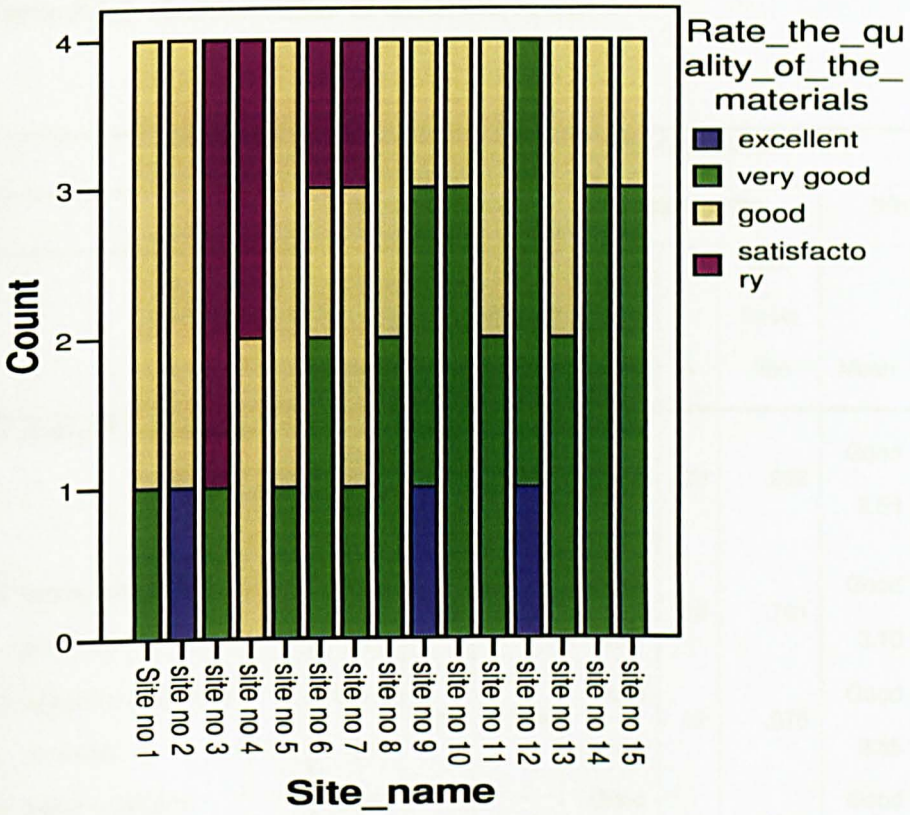


Figure 5.3.2.1B

All other existing characteristics, including the above, among developed regions, remote regions and the whole sample are indicated in following table 5.3.2.

Table 5.3.2: characteristics of materials in SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
1. quality of the materials	Good 2.96	28	.793	Very Good 2.25	32	.568	Good 2.58	60	.766
2. quality control of the materials	Good 2.68	28	1.090	Good 3.47	32	.761	Good 3.10	60	1.003
3. adequate amount of materials	Good 2.93	28	1.274	Good 2.78	32	.975	Good 2.85	60	1.117
4. material delivery methods	Good 3.46	28	1.170	Good 3.06	32	1.243	Good 3.25	60	1.216
5. accessibility to the materials	Good 2.68	28	1.090	Very Good 2.03	32	.695	Very Good 2.33	60	.951
6. store locations of materials	Good 3.14	28	1.145	Very Good 1.91	32	1.027	Very Good 2.48	60	1.242

According to above table (table 5.3.2) the characteristics of materials in sites in developed regions were rated as Good (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory). In remote sites 1st, 5th and 6th characteristics and considering the whole sample 5th and 6th characteristics rated as very good and the remaining characteristics rated as good. Differences between the existing quality of materials in developed and remote sites are due to the fact that most of the quality construction materials are produced in remote areas in Sri Lanka. Hence efficient

external material delivery systems and an increase in the quality of materials production in every source should be beneficial. We must distinguish between accessibility and locations of stores in developed and remote sites because most remote construction sites have larger ground space than in developed regions. Therefore, most construction sites in remote areas have enough space for materials storage, influencing easy access to materials and flexible locations of material stores. However, overall characteristics of materials in SLCI are above the satisfactory level. The next section discusses the reasons for the above ratings.

5.3.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF MATERIALS

This section highlights the justification of rating the existing characteristics of materials in the previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 1B, the respondents cited the following reasons shown in Table 5.3.3.

Table 5.3.3: Reasons for ratings of the characteristics of materials

Reasons	Developed Provinces % concurred	Remote Provinces % concurred	Whole Sample % concurred
1. In comparison to material use in other public sector construction sites in Sri Lanka	78.6	68.8	73.3
2. compare to private sector construction sites in Sri Lanka	53.6	75	65
3. compare to overseas construction projects in Sri Lanka	64.3	81.3	73.3
4. compare to overseas projects in other countries	78.6	71.9	75
5. according to the respondents' overall understandings	71.4	100	86.7
6. according to the productivity of the project	67.9	56.3	61.7
7. according to the knowledge obtained from the workshops or seminar or conference or training programmes	85.7	65.6	75

According to Table 5.3.3 more than 60% of respondents agreed with all the above reasons in the whole sample. There was more than a 60% respond rate except for the 2nd reason (i.e. compare to private sector construction sites in Sri Lanka: 53.6%) in construction sites in developed provinces and the 6th reason (i.e. according to the productivity of the project: 56.3%) in construction sites in remote provinces. However, the response rates the 2nd and 6th reasons are also not too low and there are not any statistically significant differences among developed, remote or considering the whole sample. Therefore it can be argued that most of the Sri Lankan site staff are reasonably aware of the characteristics of materials and productivity. Hence it partially supports the first proposition of the study (i.e. employers in Sri Lanka are aware of the supposed advantages of efficient SP in the construction industry). However, interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendations).

5.3.4 IMPORTANCE OF THE MATERIALS CHARACTERISTICS TO SLCI.

This section discusses the importance of the characteristics of materials in SLCI. The quality and quality control, adequacy, delivery methods, accessibility and store locations are the characteristics of materials investigated in this study. For example: when asked in Q 1.1C to specify the importance of quality of the materials in the SLCI in, the respondents (considering the whole sample) are shown in Figure 5.3.4.1C, and according to sites in Figure 5.3.4.1D. Almost all of the respondents rated as very highly important and highly important the quality of the materials to the construction industry in all 15 sites.

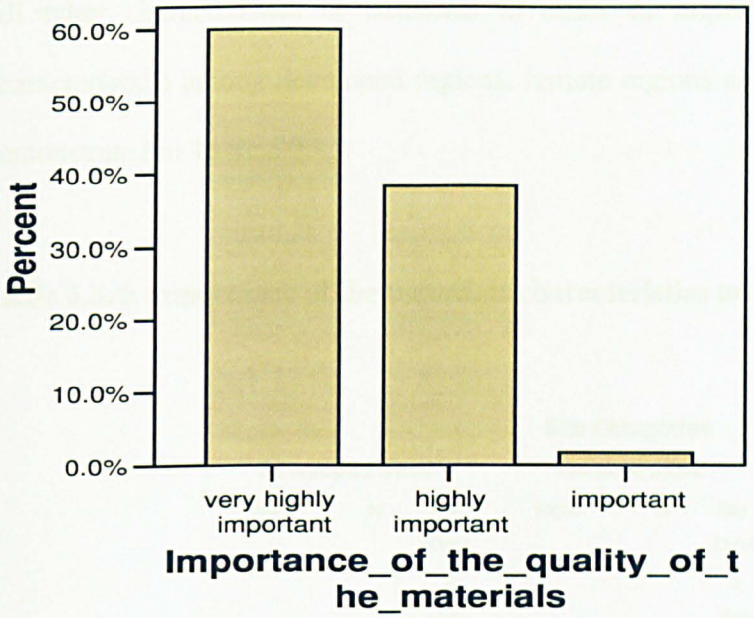


Figure 5.3.4.1C

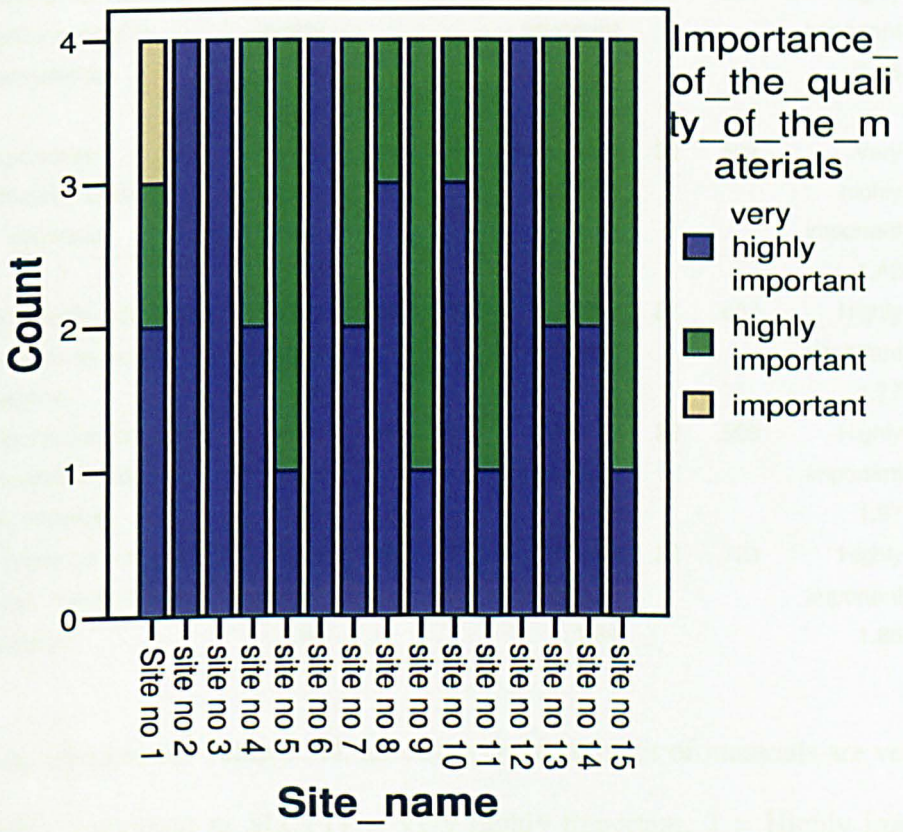


Figure 5.3.4.1D

All other characteristics of materials in terms of importance (including above characteristics) among developed regions, remote regions and the whole sample are demonstrated in Table 5.3.4.

Table 5.3.4: importance of the materials characteristics to SLCI

	Site Categories								
	Developed sites			Remote sites			whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std Deviation
Importance of quality of the materials	Very highly important 1.36	28	.559	Very highly important 1.47	32	.507	Very highly important 1.42	60	.530
Importance of the quality control of the materials	Very highly important 1.46	28	.508	Highly important 1.63	32	.554	Highly important 1.55	60	.534
Importance of adequate amount of materials	Very highly important 1.39	28	.497	Very highly important 1.44	32	.504	Very highly important 1.42	60	.497
Importance of the material delivery methods	Highly important 1.79	28	.738	Highly important 1.75	32	.622	Highly important 1.77	60	.673
Importance of the accessibility to the materials	Highly important 1.64	28	.621	Highly important 2.25	32	.508	Highly important 1.97	60	.637
Importance of the store locations of materials	Highly important 1.86	28	.756	Highly important 1.84	32	.723	Highly important 1.85	60	.732

According to the Table 5.3.4, all of the characteristics of materials are very highly or highly important to SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low importance and 5 = Very low importance) and there are not any

significant differences among developed, remote or whole sample. However, we can conclude that site staff in SLCI are well aware of the importance of materials characteristics and partially support the first proposition of the study. Therefore the management of SLCI is efficient and effective and the continuous functioning of these characteristics is beneficial.

5.3.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF MATERIALS FOR SITE LAYOUT PRACTICE

When asked to specify the reasons why the characteristics of material are important, the respondents cited the following:

Quality and quality control of construction materials directly influence the productivity and also link to the site layout practices. Respondents mentioned that low quality materials need to be handled much more carefully than high quality and durable materials during the delivery and storage process. This is time consuming and affects other construction activities (for example, delivery/loading/unloading time takes longer than average). Respondents also mentioned that most of the time these low quality materials have some defects and need to be returned to the manufacturer and new deliveries arranged. This process involved extra traffic around the site, additional pollution and directly affected the site layout.

Sufficient materials are of paramount importance for site layout management. Respondents clearly stated that excess materials unnecessarily took up site space which could be used for other critical construction activities. Insufficient materials

created low productivity and higher traffic movements around the site to deliver materials more frequently.

The material delivery methods and sequence highly affected the site layout plan. Some respondents clearly stated that material delivery with unsuitable vehicles (e.g. long and heavy vehicles utilizing small roads) sometimes damaged the road layout, some structures etc and also blocked the whole site and created unnecessary pollution. This strongly affected the site layout practices. Furthermore, most of the respondents mentioned that sometimes they had problems accessing the materials. This caused double handling of the materials, long waiting times and delays. Therefore, clearly and methodologically arranged and stored materials are crucial to achieving optimum site layout. Most of the respondents were aware that when locating materials, the existing tree protection areas, health and safety regulations, site utilities etc were very important.

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses these in detail. The next section of this chapter is about the second construction site layout factor.

5.4 CHARACTERISTICS OF EQUIPMENT

5.4.1 INTRODUCTION

This section mainly discusses characteristics of equipment in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different

groups (i.e. developed and remote provinces) are also discussed. This section is divided into four parts. Section 5.4.2 is concerned with the characteristics of equipment in SLCI (e.g. quality of the equipment). Section 5.4.3 looks at the reasons why respondents rate the characteristics of equipment. Section 5.4.4 discusses the importance of the equipment characteristics to the SLCI. Finally, section 5.4.5 looks at the reasons for the perceived importance of the characteristics of equipment for site layout practice

5.4.2 CHARACTERISTICS OF EQUIPMENT IN SLCI

This section discusses the existing characteristics of equipment in the SLCI. The quality and quality control, adequacy, locations of equipment, maintenance and update processes and delivery methods are the characteristics of equipment investigated in this research. For example: when asked to rate the quality of the equipment in the SLCI in Q 2.1A (please see Appendix B) the respondents (considering the whole sample) are shown in Figure 5.4.2.1A, and according to sites in Figure 5.4.2.1B. Therefore most respondents rated the quality of equipment as very good or good and nobody rated as unsatisfactory.

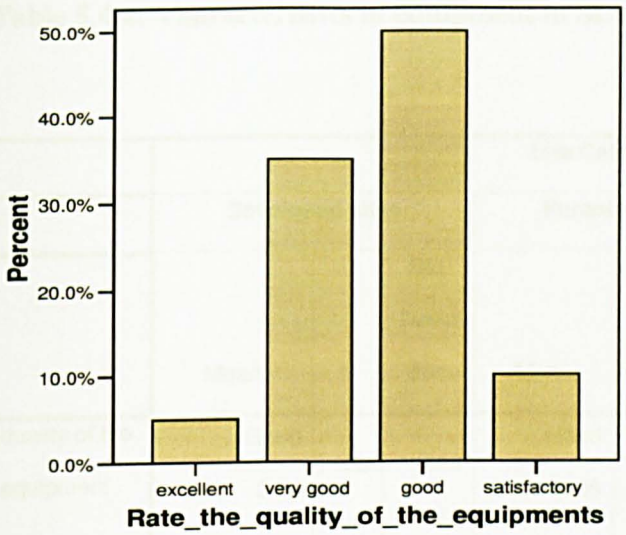


Figure 5.4.2.1A

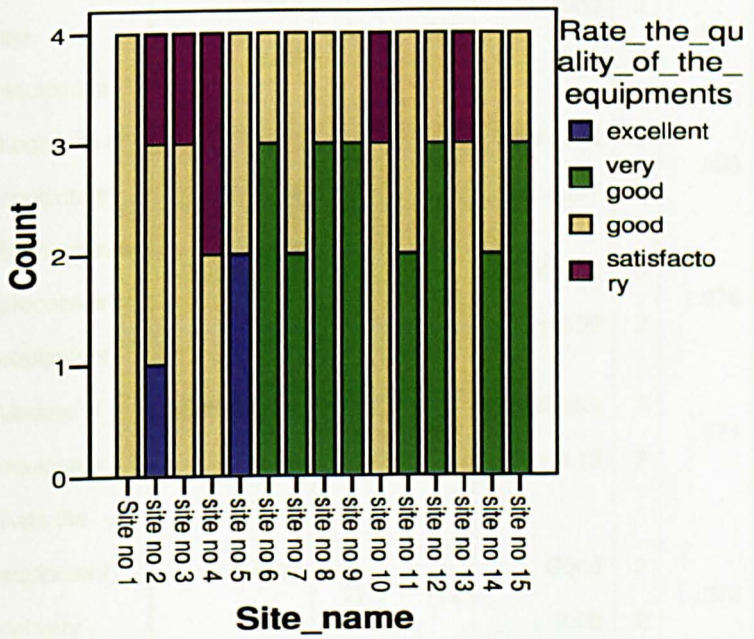


Figure 5.4.2.1B

All other existing characteristics including the above characteristic among developed regions, remote regions and whole sample are indicated in Table 5.4.2.

Table 5.4.2: characteristics of equipment in SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
quality of the equipment	Good 2.75	28	.844	Good 2.56	32	.619	Good 2.65	60	.732
quality control of the equipment	Good 3.46	28	.962	Satisfactory 3.81	32	.780	Satisfactory 3.65	60	.880
adequacy of the equipment	Good 3.43	28	.920	Good 3.28	32	.888	Good 3.35	60	.899
Locations of equipment	Good 3.04	28	.881	Very good 1.97	32	.538	Very good 2.47	60	.892
Maintenance processes of equipment	Satisfactory 3.82	28	.772	Satisfactory 3.50	32	1.078	Satisfactory 3.65	60	.954
Update of equipment	Satisfactory 4.29	28	.937	Satisfactory 4.13	32	.871	Satisfactory 4.20	60	.898
Rate the equipment delivery methods	Good 3.18	28	.772	Good 3.00	32	.672	Good 3.08	60	.720

According to above table the most of the characteristics of equipment in sites rated as Good (1 = excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory). Locations of the equipment in remote and whole sample categories rated as very good perhaps because most of the remote sites have larger ground space compared to sites

in developed regions. Therefore, remote sites have more flexible places to locate the equipment. Existing maintenance and update processes of equipment in all three sample categories (i.e. developed, remote and whole) are just satisfactory level. Therefore, these two areas have to be improved in the SLCI. Quality controls of equipment in remote sites as well as considering the whole sample are at a just satisfactory level. The developed site category has better quality controls of the equipment than remote sites since most equipment companies are situated in developed regions compared to remote areas. Government policymakers and other responsible officers have to pay more attention to these issues and spreading these facilities all over the country is an advantage to the SLCI. However, overall characteristics of equipment in SLCI should be neither excellent nor a very good level. Hence management of the SLCI and other policymakers have to focus more on this situation and take positive actions to ensure the positive function of the SLCI. The next section discusses the reasons for the above ratings.

5.4.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF EQUIPMENT

This section highlights the justification of rating the existing characteristics of equipment in previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 2B, the respondents cited the following reasons in Table 5.4.3.

Table 5.4.3: Reasons for ratings of the characteristics of equipment

Reasons	Developed Provinces % concurred	Remote Provinces % concurred	Whole Sample %concurred
1. In comparison to equipment use in other public sector construction sites in Sri Lanka	57.1	81.3	70
2. compare to private sector construction sites in Sri Lanka	96.4	78.1	86.7
3. compare to overseas construction projects in Sri Lanka	85.7	71.9	78.3
4. compare to overseas projects in other countries	64.3	71.9	68.3
5. according to the respondents' overall understandings	82.1	84.4	83.3
6. according to the productivity of the project	82.1	87.5	85
7. according to the knowledge obtained from the workshops or seminar or conference or training programmes	57.1	50	53.3

According to Table 5.4.3 more than 60% of respondents agreed with all the above reasons in all three categories of the sample except for the 1st reason for the developed category and the 7th reason for all three categories. However, the response rates for the 7th reason (i.e. knowledge obtained from the workshops or seminar or conference or training programmes) were also not too low. Furthermore, there are not any significant differences among developed, remote or considering the whole sample. This issue (i.e. the 7th reason) can be easily improved by highly appropriate use of employer–employee development programmes (e.g. short-term training and seminars

focusing on characteristics of construction industry equipment). Considering the relatively low response rate for the 1st reason in the developed category, respondents in developed regions have more chance of obtaining and comparing information regarding characteristics of equipment than other two sample categories than comparison to public sector construction sites,. Therefore, we can argue that most of the Sri Lankan site staff are reasonably aware of the characteristics of equipment and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are aware of the supposed advantages of efficient site layout in construction industry). However, interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendation).

5.4.4 IMPORTANCE OF THE EQUIPMENT CHARACTERISTICS TO SLCI.

This section discusses the importance of the characteristics of equipment in SLCI. The quality and quality control, adequacy, locations, maintenance and update processes and delivery methods are the characteristics of equipment investigated in this research. For example: when asked to specify the importance of quality of the equipment in the SLCI in Q 2.1C, the respondents (considering the whole sample) are shown in Figure 5.4.4.1C, and according to sites are shown in Figure 5.4.4.1D. Approximately all of the respondents rated as very highly important and highly important the quality of the equipment to construction industry in all sites.

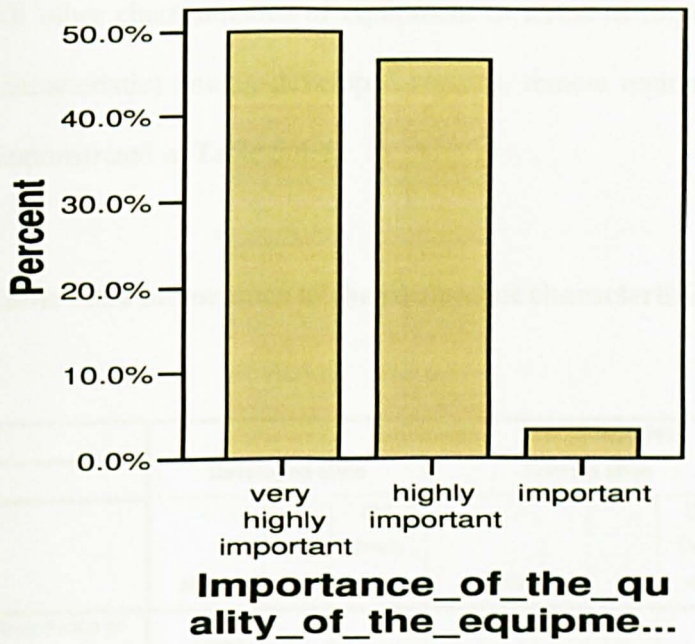


Figure 5.4.4.1C

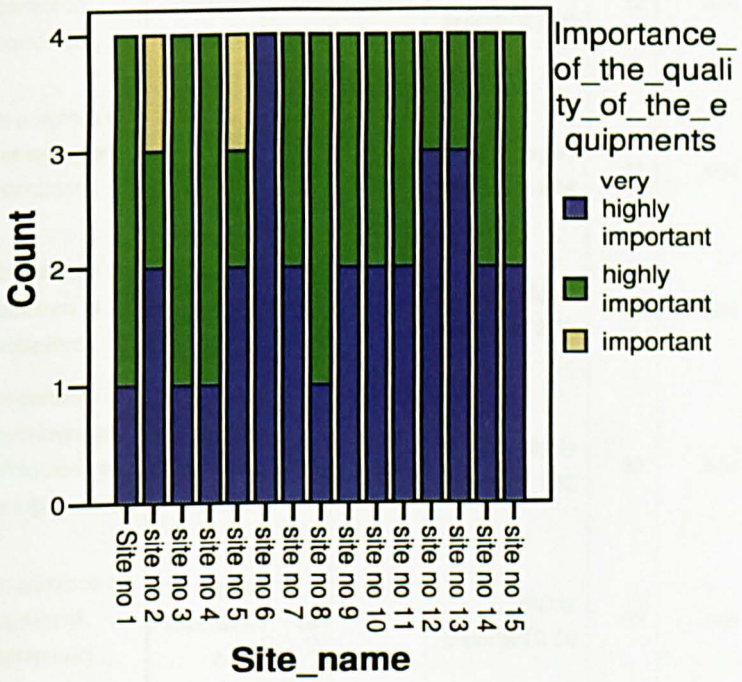


Figure 5.4.4.1D

All other characteristics of equipment in terms of importance (including the above characteristic) among developed regions, remote regions and the whole sample are demonstrated in Table 5.4.4.

Table 5.4.4 importance of the equipment characteristics to SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Importance of quality of equipment	Highly important 1.61	28	.629	Very highly important 1.47	32	.507	Highly important 1.53	60	.566
Importance of quality control of equipment	Highly important 1.96	28	.693	Highly important 2.28	32	.634	Highly important 2.13	60	.676
Importance of adequacy of equipment	Highly important 1.61	28	.737	Very highly important 1.44	32	.504	Highly important 1.52	60	.624
Importance of locations of equipment	Highly important 2.04	28	.744	Highly important 2.28	32	.581	Highly important 2.17	60	.668
Importance of maintenance Processes o_ equipment	Highly important 1.64	28	.731	Highly important 1.62	32	.554	Highly important 1.63	60	.637
Importance of update of equipment	Highly important 2.00	28	.770	Highly important 2.59	32	.665	Highly important 2.32	60	.770
Importance of equipment delivery methods	Highly important 2.14	28	.705	Highly important 2.16	32	.628	Highly important 2.15	60	.659

According to Table 5.4.4, all of the characteristics of equipment are very highly or highly important to SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low importance and 5 = Very low importance) and there are not any significant differences among developed, remote or the whole sample. Consequently we can conclude that site staffs in SLCI are well aware of the importance of equipment characteristics and this also partially supports the first proposition of the study. Hence management of SLCI is efficient and effective the continuous functioning of these characteristics is beneficial.

5.4.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF EQUIPMENT FOR SITE LAYOUT PRACTICE

When asked to specify the reasons why the characteristics of equipment are important, the respondents cited the following:

Quality and quality control of the equipment are paramount to the construction productivity, just as quality of materials in section 5.3.5. Most of the respondents have experience of poor quality equipment. They stated that poor equipment was inefficient, unreliable, generated accidents, created high pollution and also utilized more space for the frequent repair and servicing. Equipment like tower cranes, people/material hoists etc are categorized as temporary structures. Most of the respondents were aware that locations, accessibility, limitation, coverage (e.g. tower crane catchment radius) of the temporary structures are very important to plan the site layout. Almost every respondent had a good understanding of the factors such as initial installation, dismantling and maintenance process of the temporary structures

against the other structures, ongoing construction activities and other site layout factors (e.g. storage). They clearly mentioned that the above activities should be transparent throughout the site layout planning process. (E.g. the installation and dismantling process of the tower crane utilized a huge amount more of the space than the normal operation.)

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses these in detail. The next section is about the waste management system in the SLCI.

5.5 CHARACTERISTICS OF WASTE MANAGEMENT SYSTEM

5.5.1 INTRODUCTION

This section mainly discusses characteristics of the waste management system in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different groups (i.e. developed and remote provinces) are also discussed. This section is divided into four parts. Section 5.5.2 is concerned with the characteristics of the waste management system in the SLCI. Section 5.5.3 looks at the reasons why respondents rate the characteristics of the waste management system. Section 5.5.4 discusses the importance of the waste management system characteristics to the SLCI. Finally, section 5.5.5 looks at the reasons for the perceived importance of the characteristics of waste management system for site layout practice

5.5.2 CHARACTERISTICS OF THE WASTE MANAGEMENT SYSTEM IN THE SLCI

This section discusses the existing characteristics of the waste management system of the SLCI. Waste clearance systems, re-use, recycling, waste storage locations, accessibility and their capacity, waste delivery methods and prevention methods for waste pollution are the characteristics of waste management investigated in this research. For example: when asked to rate the waste clearance systems in the SLCI in Q 3.1A (please see the Appendix B) the respondents (considering the whole sample) are shown in Figure 5.5.2.1A, and according to sites are shown in Figure 5.5.2.1B. Therefore, most of the respondents rate the waste clearance systems as very good or good or at least satisfactory level and few respondents rate as unsatisfactory.

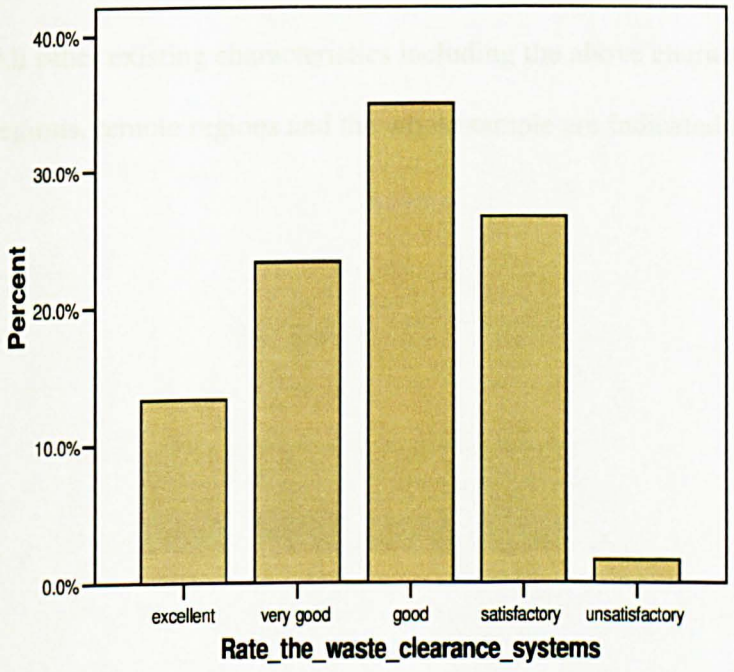


Figure 5.5.2.1A

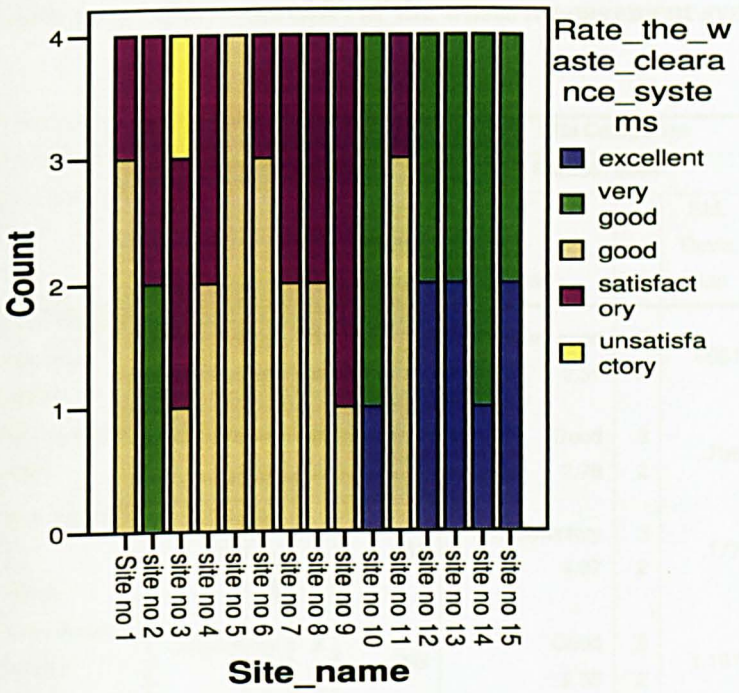


Figure 5.5.2.1B

All other existing characteristics including the above characteristics among developed regions, remote regions and the whole sample are indicated in Table 5.5.2.

Table 5.5.2: characteristics of the waste management system in the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Devia -tion	Mean	N	Std. Devia -tion	Mean	N	Std. Devia -tion
Rate waste clearance systems	Good 3.36	28	.678	Very good 2.31	32	1.061	Good 2.80	60	1.038
Rate reuse of waste	Good 3.39	28	1.031	Good 2.78	32	.706	Good 3.07	60	.918
Rate recycling of waste	Unsatis-factory 4.93	28	.262	Unsatisfactory 4.97	32	.177	Unsatis-factory 4.95	60	.220
Rate waste storage locations	Satisfactory 3.54	28	.793	Good 2.53	32	1.107	Good 3.00	60	1.089
Rate capacity of waste storage	Good 2.71	28	1.243	Very good 1.78	32	.941	Very good 2.22	60	1.180
Rate waste delivery methods	Good 3.25	28	.752	Good 2.84	32	.723	Good 3.03	60	.758
Rate accessibility to waste storage locations	Good 2.93	28	1.016	Very good 2.16	32	.767	Good 2.52	60	.965
Rate the prevention methods for waste pollution	Good 3.32	28	1.219	Good 3.44	32	.840	Good 3.38	60	1.027

According to above table most of the existing characteristics of waste management in sites was rated as Good (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 =Unsatisfactory). Considering the whole sample, capacity of waste storage is rated as very good and other characteristics of waste management (except recycling of waste) are rated as good. Recycling of waste very rarely exists in the SLCI because this approach is quite new to Sri Lanka; also the initial cost of recycling could not be

affordable for the SLCI with other overhead costs. Hence all three categories of the sample (e.g. developed) rated recycling of waste as unsatisfactory. Waste clearance systems, capacity of waste storage and accessibility of the waste stores are rated better in remote sites than sites in developed regions; this may be due to space limitation in developed areas. However, optimising the utilisation of space for the waste can be beneficial for the sites in developed areas.

5.5.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF WASTE MANAGEMENT SYSTEM

This section highlights the justification of rating the existing characteristics of waste management in the previous section. Asked to specify the reasons for their ratings of the above characteristics in Q 3B, they cited the following reasons in Table 5.5.3.

Table 5.5.3 reasons why respondents rate the characteristics of waste management system

Reasons		Developed Provinces % concurred	Remote Provinces % concurred	Whole Sample % concurred
1.	In comparison to waste management system use in other public sector construction sites in Sri Lanka	85.7	87.5	86.7
2.	compare to private sector construction sites in Sri Lanka	89.3	93.8	91.7
3.	compare to overseas construction projects in Sri Lanka	75	87.5	81.7
4.	compare to overseas projects in other countries	82.1	78.1	80
5.	according to the respondents' overall understandings	85.7	84.4	85
6.	according to the productivity of the project	82.1	90.6	86.7
7.	according to the knowledge obtained from the workshops or seminar or conference or training programmes	57.1	68.8	63.3

According to Table 5.5.3 more than 60% of respondents agreed with all of the above reasons in all three categories of the sample except the 7th reason for the developed category. However, the response rates for 7th reason (i.e. knowledge obtained from the workshops or seminar or conference or training programmes) were not too low at 57.1%. Hence there are not any statistically significant differences among developed, remote or the whole sample. However, the 8th reason mentioned above can be easily improved by conducting employer–employee development programmes (e.g. short term training and seminars focusing on characteristics of waste management in the construction industry). Therefore we can argue that most of the Sri Lankan site staff are reasonably aware of the characteristics of waste management and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are

aware of the supposed advantages of efficient SP in construction industry). However interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendations).

5.5.4 IMPORTANCE OF THE WASTE MANAGEMENT SYSTEM CHARACTERISTICS FOR THE SLCI.

This section discusses the importance of the characteristics of waste management in the SLCI. Waste clearance systems, re-use, recycling, waste storage locations, accessibility and their capacity, waste delivery methods and prevention methods for waste pollution are the characteristics of waste management investigated in this research. For example: when asked to specify the importance of waste clearance systems in the SLCI in Q 3.1C, the respondents (considering the whole sample) are shown in Figure 5.5.4.1C, and according to sites are shown in Figure 5.5.4.1D. Most of the respondents rated very highly important and highly important the waste clearance systems to the construction industry in all 15 sites.

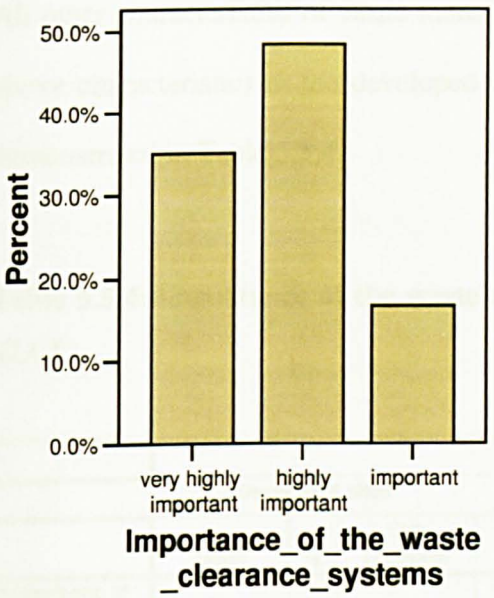


Figure 5.5.4.1C

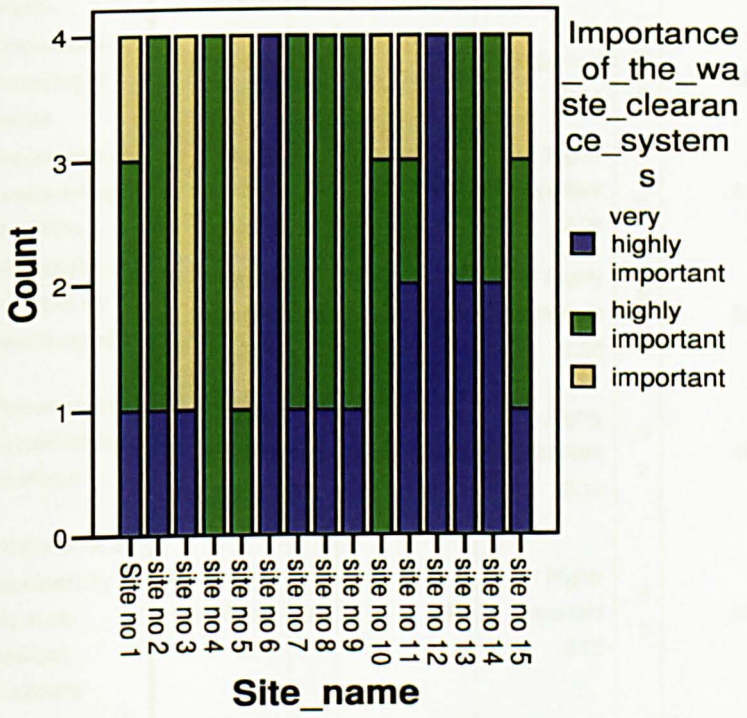


Figure 5.5.4.1D

All other characteristics of waste management in terms of importance (including the above characteristic) in the developed region, remote region and whole sample are demonstrated in Table 5.5.4.

Table 5.5.4: importance of the waste management system characteristics for the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Importance of waste clearance systems	Highly important 1.96	28	.744	Highly important 1.69	32	.644	Highly important 1.82	60	.701
Importance of reuse of waste	Highly important 2.25	28	1.041	Important 3.06	32	.759	Important 2.68	60	.983
Importance of recycling of waste	Important 3.18	28	1.056	Important 2.84	32	.920	Important 3.00	60	.991
Importance of waste storage locations	Highly important 2.14	28	.756	Highly important 2.28	32	.813	Highly important 2.22	60	.783
Importance of capacity of waste storage	Highly important 2.11	28	.685	Highly important 1.50	32	.568	Highly important 1.78	60	.691
Importance of waste delivery methods	Highly important 2.21	28	.833	Highly important 2.12	32	.660	Highly important 2.17	60	.740
Importance of accessibility to waste storage locations	Highly important 2.11	28	.786	Highly important 2.25	32	.622	Highly important 2.18	60	.701
Importance of prevention methods for waste pollution	Highly important 1.89	28	.832	Highly important 2.09	32	.530	Highly important 2.00	60	.689

According to the Table 5.5.4, most of the characteristics of waste management are very highly or highly important to the SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low important and 5 = Very low important). All three categories of sample stated that recycling of waste is not very important to the SLCI – but it is still important. It may be that respondents do not feel the worth of recycling waste, given the other essential priorities and considering the financial situation in the SLCI. Consequently we can conclude that site staffs in SLCI are well aware of the importance of waste management characteristics and this also partially support the first proposition of the study. Hence management of SLCI is efficient and effective and the continuous functioning of these characteristics is beneficial.

5.5.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF WASTE MANAGEMENT FOR SITE LAYOUT PRACTICE

When asked to specify the reasons why the characteristics of waste management are important, the respondents cited the following:

An effective waste clearance system is essential for any construction site. Some respondents stated that there are categorized skips and bins (e.g. skip for rubble waste, metal waste) in their site and some respondents stated that they do not categorize the waste. Some respondents stated that analyzing the locations/ quantity/capacity/collection and exchange frequencies of waste skips, according to the demand of the waste in a particular site, is paramount for the site layout planning. Almost every respondent agreed that inefficient management of waste influenced accidents, pollution, untidy site working areas and obstructions to access roads. These

are directly linked with the site layout planning process. Hazard waste (e.g. chemical waste, asbestos waste) needs to be handled very carefully and in specialized ways according to the health and safety regulations, otherwise the whole site may be contaminated. Some respondents cited hazardous waste and recommended analysis of the proposed waste categories before the site layout planning. Some respondents were aware of the importance of segregation of waste, easy accessibility of the waste area and recycling process.

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses these in detail. The next section is about the stores in the SLCI.

5.6 CHARACTERISTICS OF STORES

5.6.1 INTRODUCTION

This section mainly discusses characteristics of stores in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different groups (i.e. developed and remote provinces) are also discussed. This section is divided into four parts. Section 5.6.2 is concerned with the characteristics of stores in the SLCI (e.g. locations of stores in SLCI). Section 5.6.3 looks at the reasons why respondents rate the characteristics of stores, Section 5.6.4 discusses the importance of the stores' characteristics to SLCI. Finally, section 5.6.5 looks at the reasons for the perceived importance of the characteristics of stores for site layout practice

5.6.2 CHARACTERISTICS OF STORES IN THE SLCI

This section discusses the existing characteristics of stores in the SLCI. The locations, accessibility, capacity and stock level control are the characteristics of stores investigated in this study. For example: when asked to rate the locations of stores in the SLCI in Q 4.1A (please see the Appendix B) the respondents (considering the whole sample) are shown in Figure 5.6.2.1A, and according to sites are shown in Figure 5.6.2.1B. More than 70% of the respondents rate the locations of the stores as excellent, very good or good, about 20% rated them as satisfactory and only 7% as unsatisfactory.

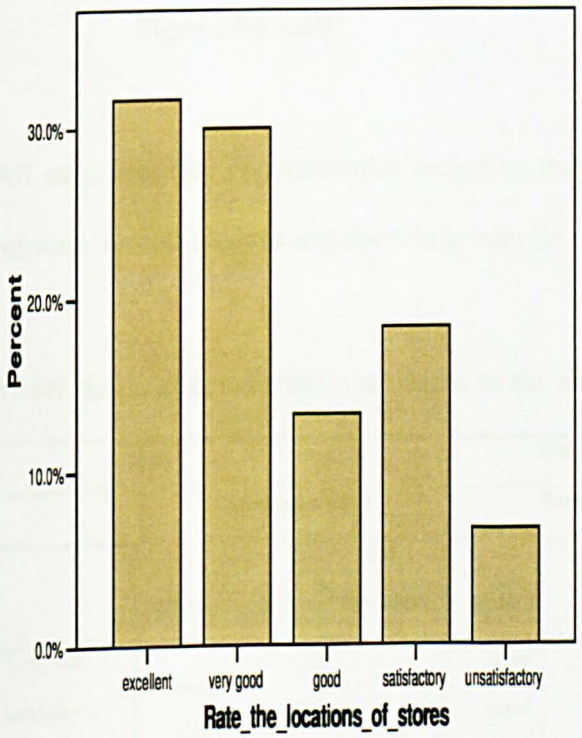


Figure 5.6.2.1A

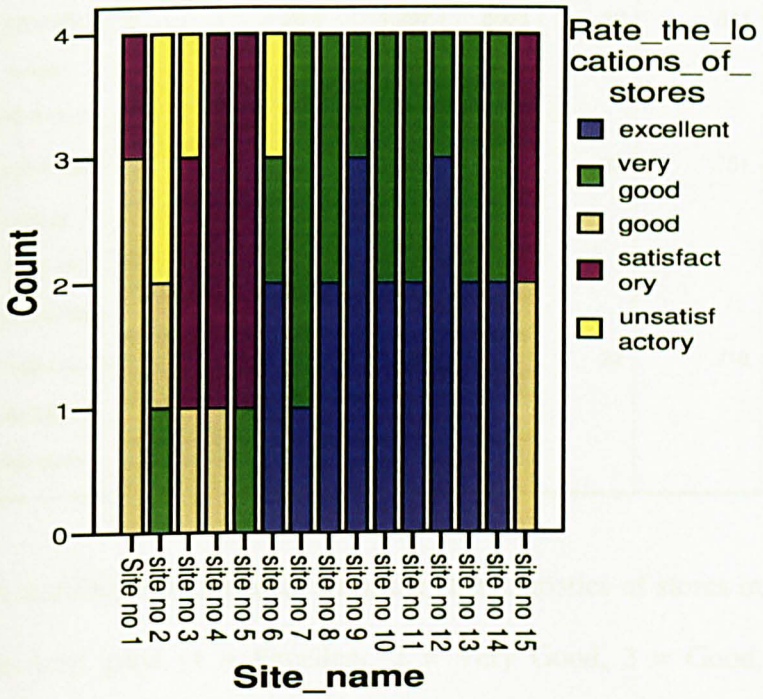


Figure 5.6.2.1B

All other existing characteristics including the above characteristic among developed regions, remote regions and the whole sample are indicated in Table 5.6.2.

Table 5.6.2: characteristics of stores in the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Rate the Locations of stores	Good 3.18	28	1.249	Very good 1.69	32	.859	Very good 2.38	60	1.290
Rate the accessibility to stores	Good 2.75	28	.844	Very good 2.06	32	.840	Very good 2.38	60	.904

Rate the capacity of stores	Good 2.79	28	1.287	Very good 2.00	32	.842	Very good 2.37	60	1.134
Rate the stock level control	Good 3.29	28	1.049	Good 2.88	32	.751	Good 3.07	60	.918
Rate the prevention methods for wastage in the store	Good 2.93	28	1.120	Good 2.50	32	.718	Good 2.70	60	.944

According to above table all of the characteristics of stores in whole sample are rated as very good (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory) except the last two (i.e. stock control level and prevention methods for wastages in the stores rated as good). Existing locations, accessibility and capacity of the stores in remote sites are better when compared to sites in developed regions since flexible ground spaces are available in most of the remote sites. However, all characteristics of stores in the SLCI are fairly above a satisfactory level. The last two characteristics of stores (i.e. stock control level and prevention methods for wastages in the stores) seem to be underdeveloped compared to others due to management deficiency, financial problems, knowledge and skills shortage and so on.

5.6.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF STORES

This section highlights the justification of rating the existing characteristics of stores in the previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 4B, they cited the following reasons in Table 5.6.3.

Table 5.6.3 Reasons for ratings of the characteristics of stores

Reasons	Developed Provinces % concurred	Remote Provinces %concurred	Whole Sample % concurred
1. In comparison to stores used in other public sector construction sites in Sri Lanka	85.7	75	80
2. compare to private sector construction sites in Sri Lanka	71.4	65.6	68.3
3. compare to overseas construction projects in Sri Lanka	82.1	84.4	83.3
4. compare to overseas projects in other countries	82.1	84.4	83.3
5. according to the respondents' overall understandings	75	78.1	76.7
6. according to the productivity of the project	96.4	87.5	91.7
7. according to the knowledge obtained from the workshops or seminar or conference or training programmes	60.7	65.6	63.3

According to Table 5.6.3 more than 60% of respondents agreed with all the above reasons in all three categories (e.g. developed provinces) of the sample. There are not any statistically significant differences among developed, remote or the whole sample. Therefore we can argue that most of the Sri Lankan site staff are reasonably aware of the characteristics of stores and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are aware of the supposed advantages of

efficient SP in construction industry). However, interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendations).

5.6.4 IMPORTANCE OF THE STORES CHARACTERISTICS TO THE SLCI.

This section discusses the importance of the characteristics of stores in the SLCI. The locations, accessibility, capacity and stock level control are the characteristics of stores investigated in this study. For example: when asked to specify the importance of the locations of stores in the SLCI in Q 4.1C, the respondents (considering the whole sample) are shown in Figure 5.6.4.1C, and according to sites are shown in Figure 5.6.4.1D. About 90% of the respondents rated as very highly important and highly important the locations of the stores and the remainder stated as important to the construction industry in all 15 sites.

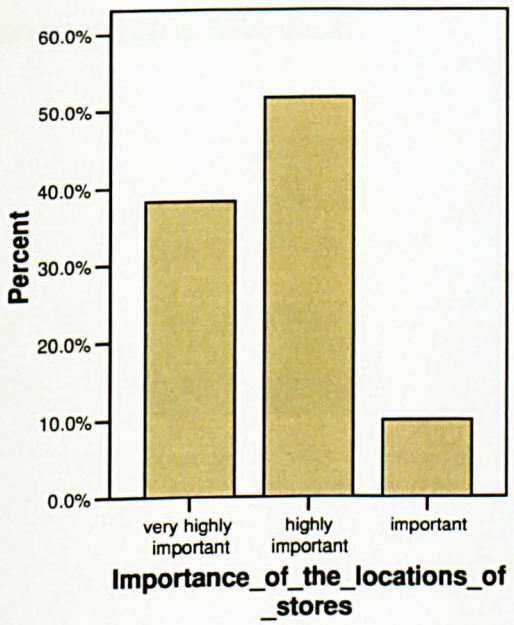


Figure 5.6.4.1C

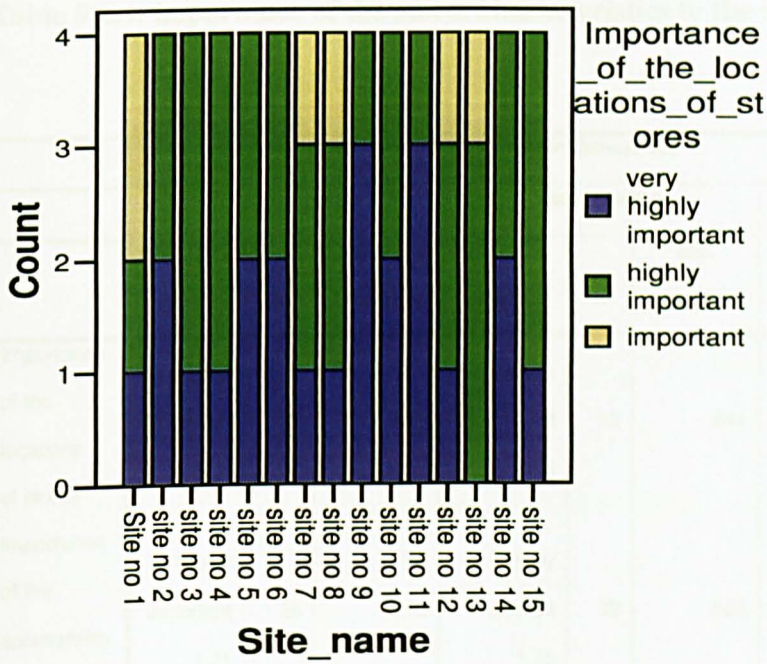


Figure 5.6.4.1D

All other characteristics of stores in terms of importance (including the above characteristic) among developed regions, remote regions and the whole sample are demonstrated in Table 5.6.4.

Table 5.6.4: importance of the stores characteristics to the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Importance of the locations of stores	Highly important 1.75	28	.645	Highly important 1.69	32	.644	Highly important 1.72	60	.640
Importance of the accessibility to stores	Highly important 1.71	28	.713	Highly important 1.75	32	.508	Highly Important 1.73	60	.607
Importance of the capacity of stores	Highly important 1.68	28	.670	Highly important 1.72	32	.523	Highly Important 1.70	60	.591
Importance of the stock level control	Highly important 1.82	28	.612	Highly important 1.59	32	.499	Highly Important 1.70	60	.561
Importance of the prevention methods for wastage in the store	Highly important 1.54	28	.576	Very highly important 1.44	32	.504	Very highly important 1.48	60	.537

According to the Table 5.6.4, all of the characteristics of stores are very highly or highly important to the SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low importance and 5 = Very low importance) and there are not any significant differences among developed, remote or the whole sample. However, we can conclude that site staff in the SLCI are well aware of the importance of stores

characteristics and partially support the first proposition of the study. Therefore management of SLCI is efficient and effective and the continuous functioning of these characteristics is beneficial.

5.6.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF STORES FOR SITE LAYOUT PRACTICE

When asked to specify the reasons why the characteristics of stores are important, the respondents cited the following:

Most of the respondents agreed that some materials and equipment need to be stored very carefully due to the value or store specifications or fragile nature or that they are easily damaged by water, heat etc. They clearly mentioned that the location, capacities and quantities of storage needed to be decided according to the requirements and also the decision needed to be coordinated with the all other factors.

Some respondents stated that they had very efficient and modern (e.g. computerised) storage, and some respondents stated that they have a full-time storekeeper in their site. Unfortunately, a few respondents mentioned that storage areas in their site are very small, not clear, making it very difficult to find the stored material and some of which was already damaged. Failure to manage the storage effectively directly influenced low construction productivity and this process was mainly linked with site layout planning.

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses these in detail.

5.7 CHARACTERISTICS OF THE SITE OFFICE

5.7.1 INTRODUCTION

This section mainly discusses characteristics of the site office in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different groups (i.e. developed and remote provinces) are also discussed.

This section is divided into four parts. Section 5.7.2 is concerned with the characteristics of the site office in SLCI (e.g. location of the site office). Section 5.7.3 looks at the reasons why respondents rate the characteristics of site office. Section 5.7.4 discusses the importance of the site office characteristics to the SLCI. Finally, section 5.7.5 looks at the reasons for the perceived importance of the characteristics of site office for site layout practice

5.7.2 CHARACTERISTICS OF THE SITE OFFICE IN SLCI

This section discusses the existing characteristics of the site office of the SLCI. The location, accessibility, available facilities and health and safety systems are the characteristics of the site office investigated in this research. For example: when asked to rate the location of the site office in the SLCI in Q 5.1A (please see the Appendix B) the respondents (considering the whole sample) are shown in Figure

5.7.2.1A, and according to sites in Figure 5.7.2.1B. Therefore, most of the respondents rate the location of the site office as excellent, very good or good, about 10% stated it was just satisfactory and 12% rated as unsatisfactory.

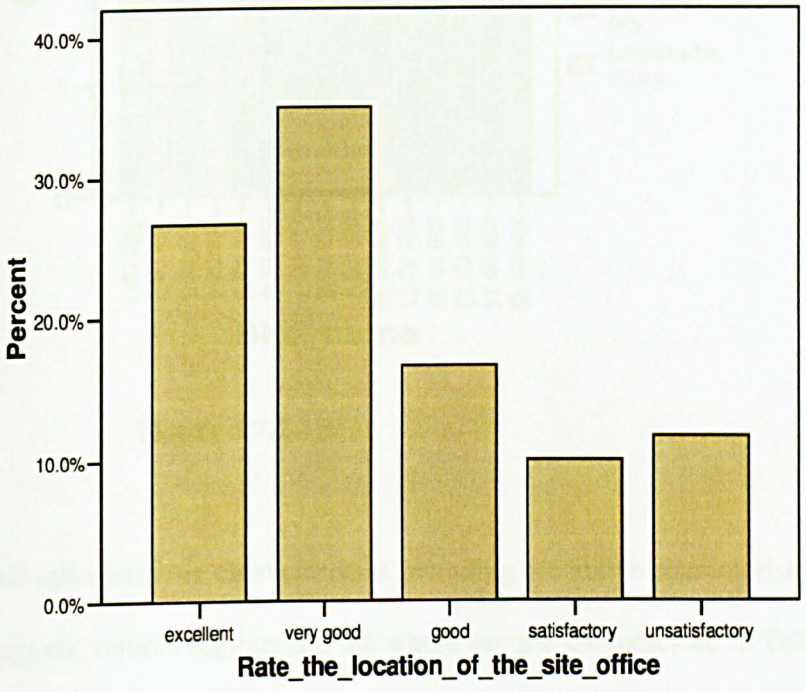


Figure 5.7.2.1A

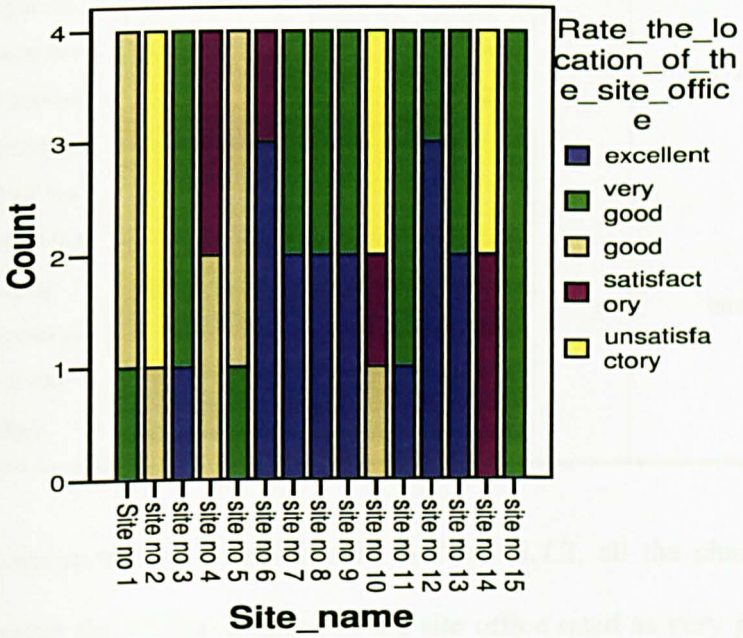


Figure 5.7.2.1B

All other existing characteristics including the above characteristics among developed regions, remote regions and the whole sample are indicated in Table 5.7.2.

Table 5.7.2: characteristics of the site office in SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Rate the location of the site office	Good 2.64	28	1.254	Very good 2.28	32	1.350	Very good 2.45	60	1.307
Rate the accessibility to site office	Good 2.89	28	1.197	Very good 2.25	32	1.244	Good 2.55	60	1.254

Rate the available facilities of site office	Good 3.46	28	.962	Good 2.72	32	.772	Good 3.07	60	.936
Rate the health and safety systems in the site office	Good 3.32	28	.983	Good 3.00	32	.803	Good 3.15	60	.899

Considering the whole sample in Table 5.7.2, all the characteristics of site office except the 1st (i.e. location of the site office rated as very good) rated as good (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory). Considering the remote sites, the location and accessibility to the site office are rated as very good, remaining characteristics of site office in remote and developed regions are rated as good. The reason that the existing locations and accessibility to sites office in remote sites is better than the developed site may also be that more site space is available in most of the remote sites than in developed sites. However, overall characteristics of site offices in SLCI are neither excellent nor a very good level and management of the SLCI has to focus more on this situation and positive actions are required to enable the SLCI to function positively.

5.7.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF SITE OFFICE

This section highlights the justification of rating the existing characteristics of site office in the previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 5B, they cited the following reasons in Table 5.7.3.

Table 5.7.3 Reasons for ratings of the characteristics of site office

Reasons	Developed Provinces % concurred	Remote Provinces %concurred	Whole Sample % concurred
1. In comparison to site office use in other public sector construction sites in Sri Lanka	78.6	81.3	80
2. compare to private sector construction sites in Sri Lanka	82.1	84.4	83.3
3. compare to overseas construction projects in Sri Lanka	82.1	84.4	83.3
4. compare to overseas projects in other countries	75	71.9	73.3
5. according to the respondents' overall understandings	82.1	78.1	80
6. according to the productivity of the project	75	87.5	81.7
7. according to the knowledge obtained from the workshops or seminar or conference or training programmes	78.6	87.5	83.3

According to Table 5.7.3 more than 70% of respondents agreed with all the above reasons in the all three categories of the sample. However, there are not any

statistically significant differences among developed, remote or the whole sample. Therefore we can argue that most of the Sri Lankan site staff are reasonably aware of the characteristics of site office and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are aware of the supposed advantages of efficient SLP in the construction industry). However interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendations).

5.7.4 IMPORTANCE OF THE SITE OFFICE CHARACTERISTICS TO THE SLCI.

This section discusses the importance of the characteristics of the site office in the SLCI. The location, accessibility, available facilities and health and safety systems, are the characteristics of site office investigated in this research. For example: when asked to specify the importance of location of the site office in the SLCI in Q 5.1C, the respondents (considering the whole sample) are shown in Figure 5.7.4.1C, and according to sites are shown in Figure 5.7.4.1D. Most of the respondents rated as very highly important or highly important and about 10% stated as important the locations of the site offices to the construction industry in all 15 sites.

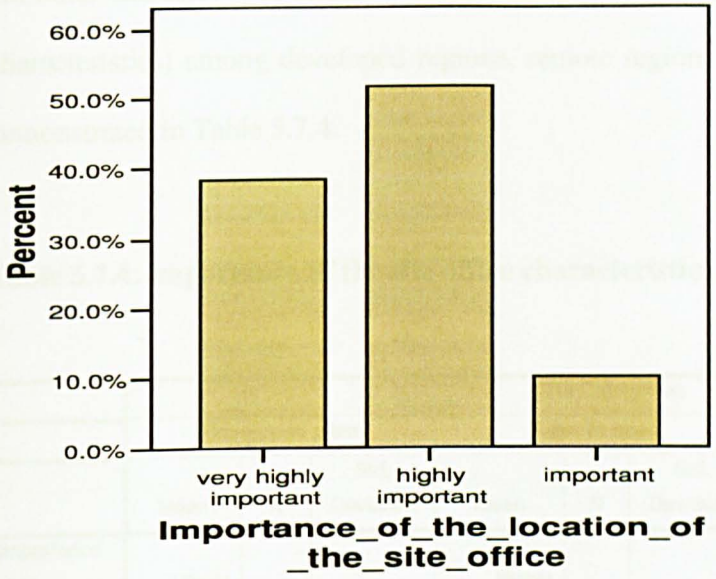


Figure 5.7.4.1C

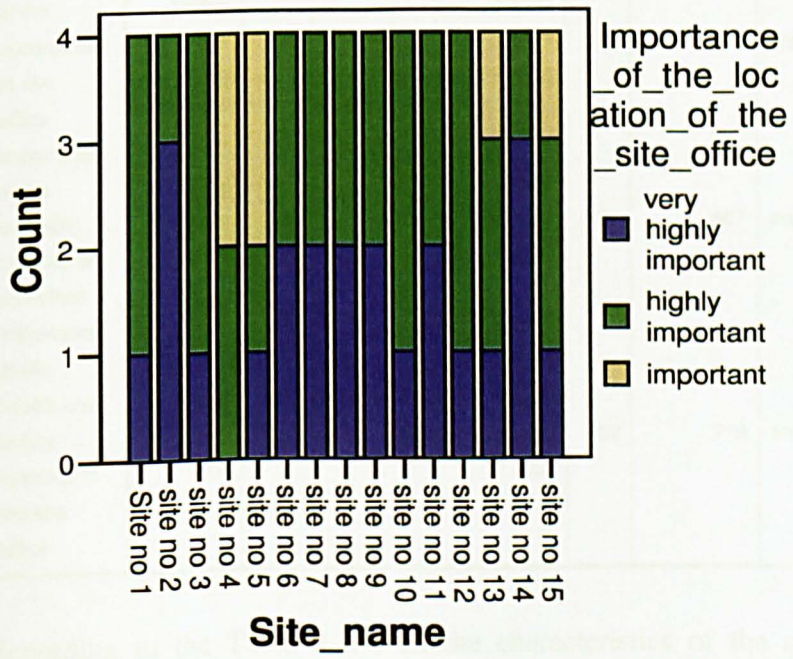


Figure 5.7.4.1D

All other characteristics of the site office in terms of importance (including the above characteristics) among developed regions, remote regions and the whole sample are demonstrated in Table 5.7.4.

Table 5.7.4: importance of the site office characteristics to the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Importance of the location of the site office	Highly important 1.79	28	.686	Highly important 1.66	32	.602	Highly important 1.72	60	.640
Importance of the accessibility to site office	Highly important 1.93	28	.858	Highly important 1.53	32	.507	Highly important 1.72	60	.715
Importance of the available facilities of site office	Highly important 2.04	28	.793	Highly important 2.47	32	.507	Highly important 2.27	60	.686
Importance of the health and safety systems in the site office	Highly important 2.04	28	.693	Highly important 2.00	32	.718	Highly important 2.02	60	.701

According to the Table 5.7.4, all the characteristics of the site office are highly important to the SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low importance and 5 = Very low importance) and there are not any significant differences among developed, remote or whole sample. Consequently, we can conclude that site staffs in SLCI are well aware of the importance of site office characteristics and this also partially supports the first proposition of the study. Hence

management of SLCI is efficient and effective and the continuous functioning of these characteristics is beneficial.

5.7.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF THE SITE OFFICE FOR SITE LAYOUT PRACTICE

When asked to specify the reasons for why the characteristics of site office are important, the respondents cited the following:

One respondent stated that:

> *"The home of the people who manage the construction project during the working time is their site office. They should be able to easily access all construction areas, therefore location accessibility to and from site office is highly important."*

Almost all respondents had a similar idea. According to the responses and the observation:

Some sites have more than one site office: they are at different locations for access to different work areas. Some have a few site offices but they are in same location. Most of the sites have only one site office.

Some respondents stated that the site office location was not changed from the beginning of the project. Some mentioned that they had already changed the locations

of the site office throughout the different stages of the construction process. Most of respondents understood the importance of the change in location of the site office or for it remaining in the same location according the requirements of each individual site. The above statement is completely related the site layout planning.

A few respondents stated that some time site layout the planners decided the site office location only by considering the temporary power supply or telephone supply etc. However, considering only a few factors and making the decision cannot be recommended. Decision makers or site layout planners should analyze and coordinate all relevant factors and make the optimum solution.

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses theses in detail.

5.8 CHARACTERISTICS OF REST ROOMS AND SANITARY FACILITIES

5.8.1 INTRODUCTION

This section mainly discusses characteristics of rest rooms and sanitary facilities in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different groups (i.e. developed and remote provinces) are also discussed. This section is divided into four parts. Section 5.8.2 is concerned with the characteristics of rest rooms and sanitary facilities in the SLCI (e.g. locations of rest rooms in SLCI). Section 5.8.3 looks at the reasons why respondents rate the characteristics of rest rooms and sanitary facilities. Section 5.8.4 discusses the

importance of the characteristics of rest rooms and sanitary facilities to the SLCI. Finally, section 5.8.5 looks at the reasons for the perceived importance of the characteristics of rest rooms and sanitary facilities for site layout practice

5.8.2 CHARACTERISTICS OF REST ROOMS AND SANITARY FACILITIES IN SLCI

This section discusses the existing characteristics of rest rooms and sanitary facilities of SLCI. The locations, adequacy, accessibility, available facilities, quality and health and safety systems, are the characteristics of rest rooms and sanitary facilities investigated in this study. For example: when asked to rate the locations of rest rooms in the SLCI in Q 6.1A (please see Appendix B) the respondents (considering the whole sample) are shown in Figure 5.8.2.1A, and according to sites are shown in Figure 5.8.2.1B. More than 65% of the respondents rate the locations of the rest rooms and sanitary facilities as excellent, very good or good, 10% of them rated as satisfactory and 25% as unsatisfactory.

Figure 5.8.2.1B

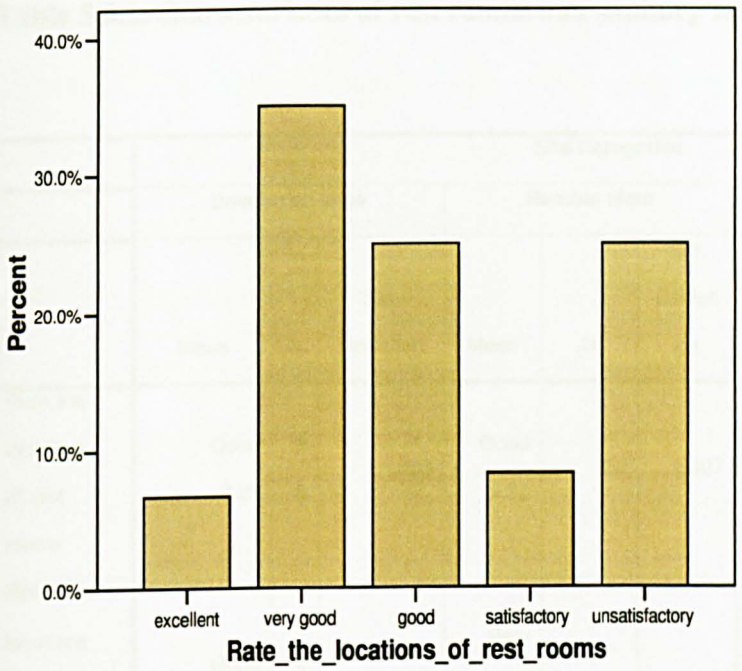


Figure 5.8.2.1A

All other existing characteristics including the above characteristic among developed regions, remote regions and the whole sample are indicated in Table 5.8.2.

Table 5.8.2: characteristics of rest rooms and sanitary facilities in SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Rate the locations of rest rooms	Good 3.25	28	1.323	Good 2.97	32	1.307	Good 3.10	60	1.311
Rate the locations of toilets and washrooms	Good 3.21	28	.957	Very good 2.41	32	1.043	Good 2.78	60	1.075
Rate the _ adequacy	Satisfactory 3.54	28	.999	Good 2.84	32	1.221	Good 3.17	60	1.167
Rate the accessibility	Good 3.14	28	.803	Very good 2.47	32	.950	Good 2.78	60	.940
Rate the available facilities of them	Good 3.36	28	.870	Good 2.75	32	.622	Good 3.03	60	.802
Rate the quality of them	Satisfactory 3.82	28	.772	Satis-factory 3.69	32	.535	Satisfactory 3.75	60	.654
Rate the health and safety systems	Satisfactory 3.75	28	.887	Good 3.38	32	1.040	Satisfactory 3.55	60	.982

In the above table considering the whole sample, all of the characteristics except last two (i.e. quality and health and safety systems in rest rooms and sanitary facilities are

rated as satisfactory) are rated as good (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 =Unsatisfactory). Their quality (e.g. rest rooms) is rated as just satisfactory level for all three sample categories. Quality is a very important characteristic; if it is not good level it will negatively affect the motivation of the workforce and contribute to low productivity in the SLCI. However, all of the existing characteristics of rest rooms and sanitary facilities are satisfactory level or above in the SLCI. Location of toilets and washrooms and accessibility to them are better in remote sites than developed sites, maybe due to the availability of larger site spaces in remote sites than in developed sites. However locations of rest rooms are not significantly different among remote and developed areas.

Adequacy is just satisfactory in the developed category and good level in remote sites. The reasons for the difference may be that a higher number of workers are employed in most of the construction sites in developed regions than in remote sites, and respondents in developed sites felt that the number of rest rooms and sanitary facilities are insufficient. Health and safety systems are rated as better in remote sites than in the developed category. This statement is exceptional since health and safety controls are more available in developed regions than in remote. Therefore the difference may be because developed respondents are more aware of health and safety aspects than on remote sites and they felt they have fewer health and safety systems in their rest rooms and sanitary facilities. Overall characteristics of rest rooms and sanitary facilities in SLCI are fairly above satisfactory level. Furthermore improvement of those characteristics in SLCI would be beneficial towards higher productivity.

5.8.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF REST ROOMS AND SANITARY FACILITIES

This section highlights the justification of rating the existing characteristics of rest rooms and sanitary facilities in the previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 6B, they cited the following reasons in Table 5.8.3.

Table 5.8.3: Reasons for ratings of the characteristics of rest rooms and sanitary facilities

Reasons	Developed Provinces % concurred	Remote Provinces %concurred	Whole Sample % concurred
1. In comparison to sanitary facilities use in other public sector construction sites in SL	82.1	84.4	83.3
2. compare to private sector construction sites in SL	92.9	90.6	91.7
3. compare to overseas construction projects in SL	89.3	90.6	90
4. compare to overseas projects in other countries	64.3	71.9	68.3
5. according to the respondents' overall understandings	92.9	90.6	91.7
6. according to the productivity of the project	82.1	81.3	81.7
7. according to the knowledge obtained from the workshops or seminar or conference or training programmes	71.4	75	73.3

According to Table 5.8.3 more than 60% of respondents agreed all the above reasons in the all three categories of the sample. There are not any statistically significant differences among developed, remote or the whole sample. Therefore we can argue that most of the Sri Lankan site staff are reasonably aware of the characteristics of rest rooms and sanitary facilities and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are aware of the supposed advantages of efficient SP in construction industry). However interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendation).

5.8.4 IMPORTANCE OF THE REST ROOMS AND SANITARY FACILITIES CHARACTERISTICS TO THE SLCI.

This section discusses the importance of the characteristics of rest rooms and sanitary facilities in the SLCI. The locations, adequacy, accessibility, available facilities, quality and health and safety systems, are the characteristics of rest rooms and sanitary facilities investigated in this study. For example: when asked to specify the importance of the locations of rest rooms in the SLCI in Q 6.1C, the respondents (considering the whole sample) are shown in Figure 5.8.4.1C, and according to sites are shown in Figure 5.8.4.1D. About 90% of the respondents stated as very highly important, highly important or important and less than 10% of respondents stated as low important to the construction industry in all 15 sites of the locations of the rest rooms and sanitary facilities.

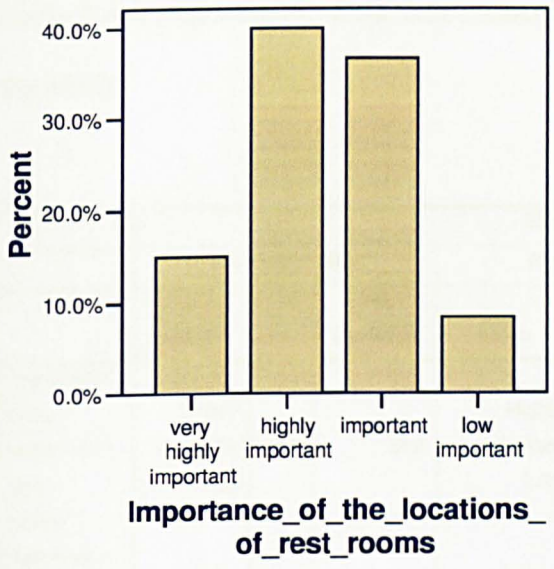


Figure 5.8.4.1C

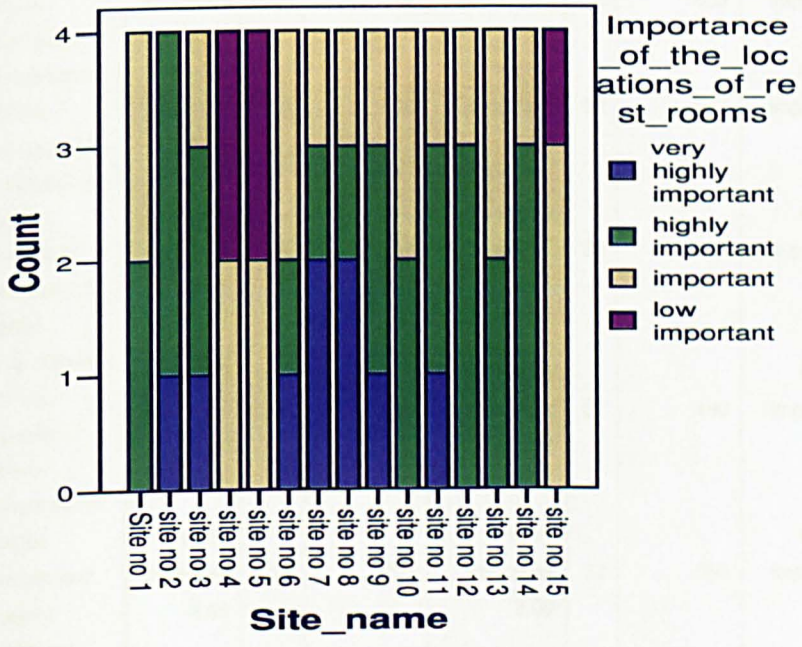


Figure 5.8.4.1D

All other characteristics of rest rooms and sanitary facilities in terms of importance (including above characteristic) among developed regions, remote regions and whole sample are demonstrated in Table 5.8.4.

Table 5.8.4: importance of the rest rooms and sanitary facilities characteristics to the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Importance of the locations of rest_ rooms	Highly important 2.46	28	.962	Highly important 2.31	32	.738	Highly important 2.38	60	.846
Importance of the locations of toilets and washrooms	Highly important 2.04	28	.637	Highly important 1.88	32	.707	Highly important 1.95	60	.675
Importance of the adequacy	Highly important 2.07	28	.716	Highly important 1.87	32	.609	Highly important 1.97	60	.663
Importance of the accessibility	Highly important 2.04	28	.693	Highly important 1.97	32	.647	Highly important 2.00	60	.664
Importance of the available facilities of them	Highly important 2.11	28	.737	Highly important 2.41	32	.499	Highly important 2.27	60	.634
Importance of the quality of them	Highly important 2.07	28	.813	Highly important 1.59	32	.499	Highly important 1.82	60	.701
Importance of the health and safety systems	Highly important 2.04	28	.793	Highly important 2.09	32	.588	Highly important 2.07	60	.686

According to Table 5.8.4, all the characteristics of rest rooms and sanitary facilities are highly important to the SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low importance and 5 = Very low importance) and there are not any

significant differences among developed, remote or whole sample. However, we can conclude that site staff in the SLCI are well aware of the importance of rest rooms and sanitary facilities' characteristics and partially support for the first proposition of the study. Therefore management of the SLCI is efficient and effective and continuous functioning of these characteristics is beneficial.

5.8.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF WELFARE FACILITIES FOR SITE LAYOUT PRACTICE

When asked to specify the reasons for why the characteristics of welfare facilities are important, the respondents cited the following:

Required quantity and capacity of welfare facilities needed to be decided according to the requirement of the particular site. Some respondents mentioned that the quantity of the toilets and the capacity of the canteen had increased compared to the beginning. Respondents from one site clearly mentioned that one of the major problems they had was the location of toilets. They had enough toilets but they were located a long distance from the construction area. One of them stated that:

> *"Our operatives take each time more than 30 minutes to walk up and down to the toilets. Average each individual used toilet 3 to 4 times during a day and lost approximately two hours only for walking to and from the toilets. This does not include the time they utilize in the toilet."*

According to above there is a significant time loss and precautions need to be taken by site layout planners.

Most of the respondents were very pleased with their welfare facilities. Few mentioned that the toilets and canteens were not clean enough and not properly maintained. Some mentioned that their rest rooms were very clean because most operatives were not using them. It was highlighted that many people did not utilize rest room facilities due to lack of ventilation and cooling. The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses these in detail.

5.9 CHARACTERISTICS OF SECURITY SYSTEMS OF THE SITE

5.9.1 INTRODUCTION

This section mainly discusses characteristics of security systems of the site in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different groups (i.e. developed and remote provinces) are also discussed. This section is divided into four parts. Section 5.9.2 is concerned with the characteristics of security systems in the SLCI (e.g. locations of security office in SLCI). Section 5.9.3 looks at the reasons why respondents rate the characteristics of security systems. Section 5.9.4 discusses the importance of the characteristics of security systems to the SLCI. Finally, section 5.9.5 looks at the reasons for the perceived importance of the characteristics of security systems for site layout practice

5.9.2 CHARACTERISTICS OF SECURITY SYSTEMS IN THE SLCI

This section discusses the existing characteristics of security systems of the SLCI. The locations of security offices and security systems against external and internal thefts are the characteristics of security systems investigated in this research. For example: when asked to rate the locations of security offices in the SLCI in Q 7.1A (please see Appendix B) the respondents (considering the whole sample) are shown in Figure 5.9.2.1A, and according to sites are shown in Figure 5.9.2.1B. Therefore most of the respondents rate the existing security systems in SLCI above the satisfactory level and less than 10% rate as unsatisfactory.

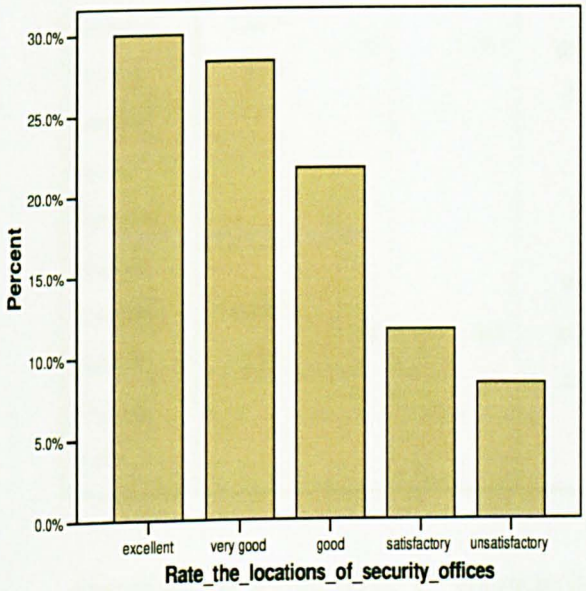


Figure 5.9.2.1A

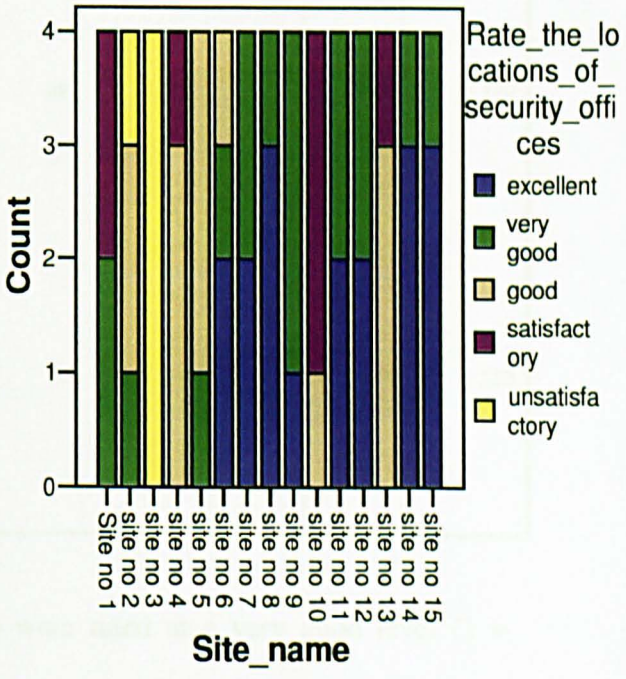


Figure 5.9.2.1B

All other existing characteristics including the above characteristic among developed regions, remote regions and the whole sample are indicated in Table 5.9.2.

Table 5.9.2: characteristics of security systems in the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Rate the Locations of security offices	Good 2.93	28	1.303	Very good 1.94	32	1.045	Very good 2.40	60	1.265
Rate the security systems against external thefts	Good 3.29	28	1.049	Very good 2.47	32	1.077	Good 2.85	60	1.132
Rate the security systems against internal thefts	Good 3.36	28	1.062	Very good 2.34	32	.745	Good 2.82	60	1.033

According to above table 1st characteristics were rated at a very good level (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory) and other two characteristics rated as good in the whole sample. In the developed sample only, all characteristics of security systems are rated as good; in remote sites they are rated as very good. The difference in locations of security systems in developed and remote areas may also be due to greater flexibility of ground space in remote sites compared

with developed. The rate of corruption rate is much higher in developed regions than in remote regions and this could be why external and internal thefts are higher in developed sites than in remote. The other reason may be that the value and the amount of the construction material and equipment are much higher in developed regions.

5.9.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF SECURITY SYSTEMS

This section highlights the justification of rating the existing characteristics of security systems in the previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 7B, they cited the following reasons in Table 5.9.3.

Table 5.9.3: Reasons for ratings of the characteristics of security systems

Reasons	**Developed Provinces % concurred**	**Remote Provinces %concurred**	**Whole Sample % concurred**
1. In comparison to security systems use in other public sector construction sites in Sri Lanka (SL)	75	81.3	78.3
2. compare to private sector construction sites in SL	78.6	87.5	83.3
3. compare to overseas construction projects in SL	85.7	87.5	86.7

4.	compare to overseas projects in other countries	82.1	75	78.3
5.	according to the respondents' overall understandings	89.3	84.4	86.7
6.	according to the productivity of the project	92.9	93.8	93.3
7.	according to the knowledge obtained from the workshops or seminar or conference or training programmes	85.7	81.3	83.3

According to Table 5.9.3 more than 75% of respondents agreed with all the above reasons in the all three categories of the sample. There are not any statistically significant differences among developed regions, remote or the whole sample. Therefore we can argue that most of the Sri Lankan site staff are reasonably aware of the characteristics of security systems and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are aware of the supposed advantages of efficient SP in the construction industry). However, interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendation).

5.9.4 IMPORTANCE OF THE SECURITY SYSTEMS CHARACTERISTICS TO THE SLCI.

This section discusses the importance of the characteristics of security systems in SLCI. The locations of security offices and security systems against external and

internal thefts are the characteristics of security systems investigated in this research. For example: when asked to specify the importance of the locations of security offices in the SLCI in Q 7.1C, the respondents (considering the whole sample) are shown in Figure 5.9.4.1C, and according to sites are shown in Figure 5.9.4.1D. Approximately all of the respondents stated as very highly important and highly important the locations of security offices to the construction industry in all 15 sites.

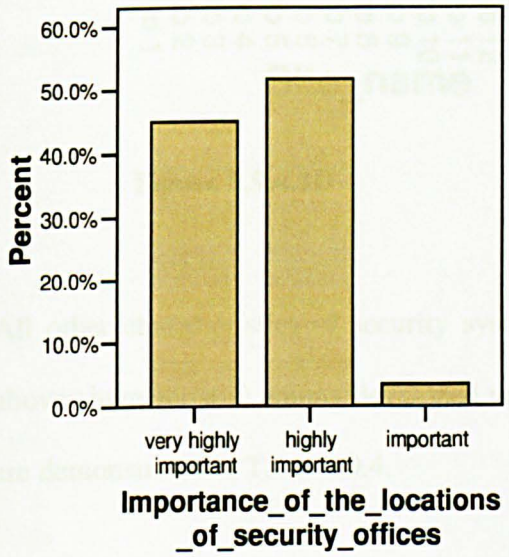


Figure 5.9.4.1C

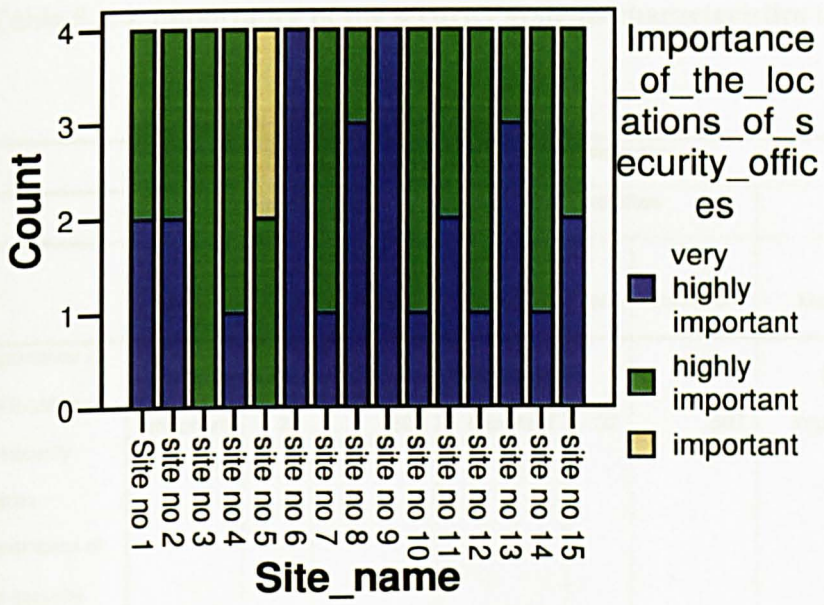


Figure 5.9.4.1D

All other characteristics of security systems in terms of importance (including the above characteristic) among developed regions, remote regions and the whole sample are demonstrated in Table 5.9.4.

Table 5.9.4: importance of the security systems characteristics to the SLCI

	Site Categories								
	Developed sites			Remote sites			Whole sample		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Importance of the locations of security offices	Highly important 1.71	28	.600	Very highly important 1.47	32	.507	Highly important 1.58	60	.561
Importance of the security systems against external thefts	Highly important 1.68	28	.476	Highly important 1.56	32	.504	Highly important 1.62	60	.490
Importance of the security systems against internal thefts	Highly important 1.64	28	.488	Highly important 1.63	32	.554	Highly important 1.63	60	.520

According to the Table 5.9.4, all of the characteristics of security systems are very highly or highly important to the SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low importance and 5 = Very low importance) and there are not any significant differences among developed regions, remote or whole sample. Consequently we can conclude that site staffs in the SLCI are well aware of the importance of security systems characteristics and this also partially supports the first proposition of the study. Hence management of SLCI is efficient and effective and continuous functioning of these characteristics is beneficial.

5.9.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF SECURITY SYSTEMS FOR SITE LAYOUT PRACTICE

When asked to specify the reasons why the characteristics of security systems are important, the respondents cited the following:

Security system and coverage is paramount to any construction industry. Most respondents mentioned that they had enough day and night security coverage. Furthermore, they mentioned that the perimeter fencing and hoarding and all gates were secured well in their site. Some sites even had a 24 hour security camera system covering the critical areas. However, a few respondents replied about theft: they stated that their tools disappeared even during the daytime. Thefts – either internally or externally – were one of the critical issues and directly influenced productivity.

All most every respondent had an understanding of the key factors in the process of site layout planning, such as site boundaries, location and number of gates, locations of security huts, security camera positions etc. One of the respondents stated a very important point; during the site layout planning process planners need to investigate the history in terms of crimes in that particular area and also should analyze the weak points and gaps around the site.

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses theses in detail.

5.10 CHARACTERISTICS OF HEALTH AND SAFETY SYSTEMS

5.10.1 INTRODUCTION

This section mainly discusses the health and safety systems in Sri Lankan construction projects for the whole sample. The statistically significant differences of the different groups (i.e. developed and remote provinces) are also discussed. This section is divided into five parts. Section 5.10.2 is concerned with the characteristics of health and safety systems in the SLCI. Section 5.10.3 looks at the reasons why respondents rate the characteristics of health and safety systems and section 5.10.4, discusses the how importance for the health and safety systems to SLCI. Section 5.10.5 looks at the reasons for the perceived importance of the characteristics of stores for site layout practice. Other site factors and characteristics in the SLCI follow in section 5.10.5.

5.10.2 CHARACTERISTICS OF HEALTH AND SAFETY SYSTEMS IN SLCI

This section discusses the existing health and safety of SLCI. When asked to rate the health and safety in the SLCI in Q 8.1A (please see the Appendix B) the respondents (considering the whole sample) are shown in Figure 5.10.2.1A, and according to sites are shown in Figure 5.10.2.1B. More than 40% of the respondents rate the existing health and safety systems as very good or good, approximately 35% rate as satisfactory and about 20% of respondent rated as unsatisfactory.

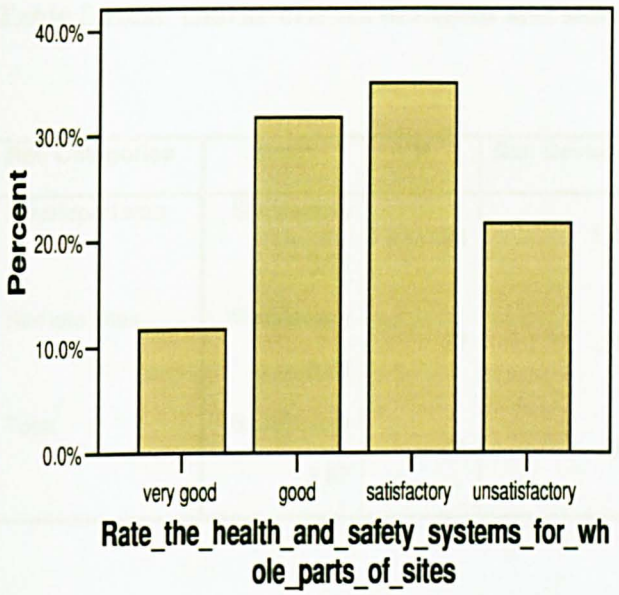


Figure 5.10.2.1A

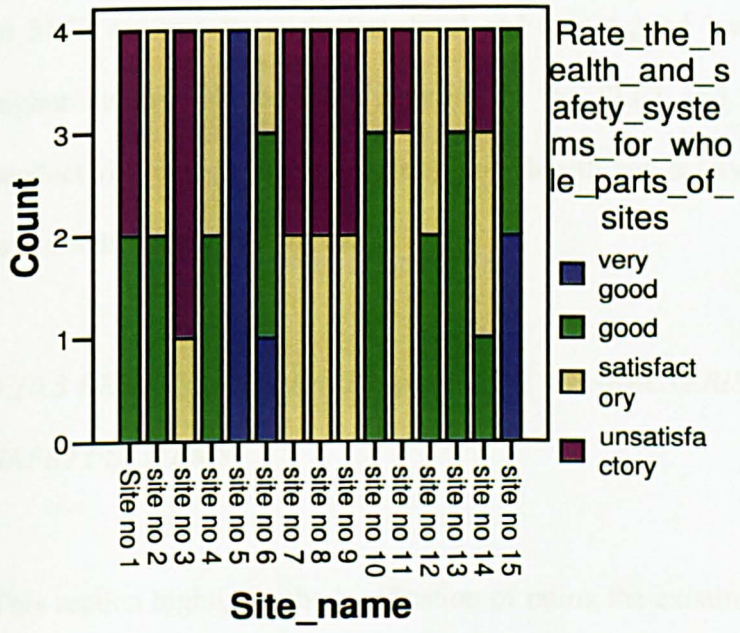


Figure 5.10.2.1B

Table 5.10.2: characteristics of health and safety systems in SLCI

Site Categories	Mean	N	Std. Deviation
Developed sites	Satisfactory 3.61	28	1.066
Remote sites	Satisfactory 3.72	32	.851
Total	Satisfactory 3.67	60	.951

According to above table 5.10.2 the characteristics of health and safety in all three sample categories rated as satisfactory (1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 =Unsatisfactory). Therefore overall characteristics of health and safety in SLCI are just at satisfactory level and not at good level. There is significantly higher number of accidents recorded in the SLCI and its direct effect on low productivity may be due to existing poor health and safety in the SLCI. Hence this area needs further improvement.

5.10.3 REASONS FOR RATINGS OF THE CHARACTERISTICS OF HEALTH AND SAFETY SYSTEMS

This section highlights the justification of rating the existing characteristics of health and safety in the previous section. When asked to specify the reasons for their ratings of the above characteristics in Q 8B, they cited the following reasons in Table 5.10.3.

Table 5.10.3: Reasons for ratings of the characteristics of health and safety systems

Reasons	Developed Provinces % concurred	Remote Provinces %concurred	Whole Sample % concurred
1. In comparison to health and safety systems use in other public sector construction sites in Sri Lanka	82.1	84.4	83.3
2. compare to private sector construction sites in SL	78.6	87.5	83.3
3. compare to overseas construction projects in Sri Lanka	78.6	81.3	80
4. compare to overseas projects in other countries	67.9	78.1	73.3
5. according to the respondents' overall understanding	85.7	87.5	86.7
6. according to the productivity of the project	92.9	93.8	93.3
7. according to the knowledge obtained from the workshops or seminar or conference or training programmes	75	75	75

According to Table 5.10.3 more than 65% of respondents agreed with all the above reasons in all three categories of the sample. There are not any statistically significant differences among developed, remote or the whole sample. Therefore we can argue that most Sri Lankan site staff are reasonably aware of the health and safety systems and productivity and partially support the first proposition of the study (i.e. the employers in Sri Lanka are aware of the supposed advantages of efficient SLP in

construction industry). However, interpretations of the propositions are discussed in detail in Chapter 7 (i.e. conclusions and recommendation).

5.10.4 IMPORTANCE FOR HEALTH AND SAFETY SYSTEMS CHARACTERISTICS TO THE SLCI.

This section discusses the importance of health and safety in the SLCI. When asked to specify the importance of health and safety systems in the SLCI in Q 8.1C, the respondents (considering the whole sample) are shown in Figure 5.10.4.1C, and according to sites are shown in Figure 5.10.4.1D. Almost 95% of the respondents stated as very highly important and highly important and the remainder as important the health and safety systems in the construction industry in all 15 sites.

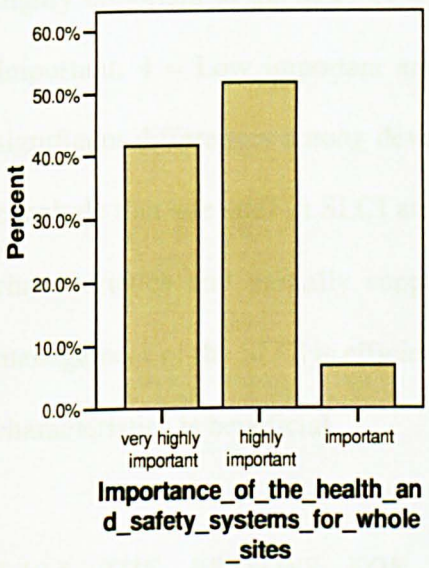


Figure 5.10.4.1C

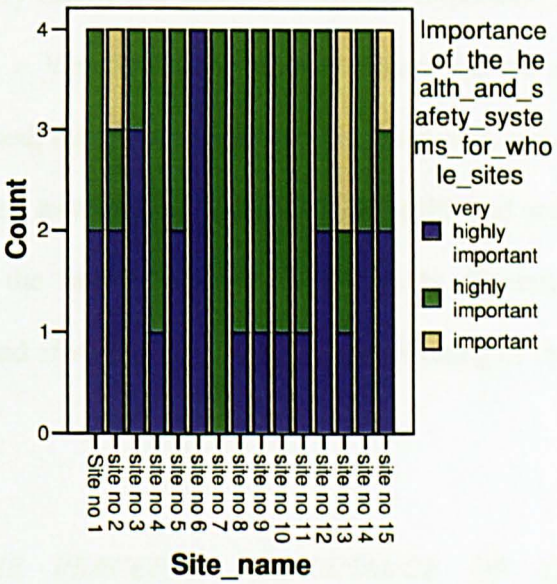


Figure 5.10.4.1D

The mean health and safety responses in terms of importance among developed regions, remote regions and whole sample are demonstrated in Table 5.10.4.

Table 5.10.4: importance for health and safety systems characteristics to the SLCI

	Site Categories		
	Developed sites	**Remote sites**	**Whole sample**
Mean	Highly important	Highly important	Highly important
	1.54	1.75	1.65
N	28	32	60
Std. Deviation	.576	.622	.606

According to the Table 5.10.4, the characteristic of mean health and safety systems is highly important to the SLCI (1 = Very highly important, 2 = Highly important, 3 = Important, 4 = Low important and 5 = Very low important) and there are not any significant differences among developed, remote or whole sample. However, we can conclude that site staff in SLCI are well aware of the importance of health and safety characteristics and partially support the first proposition of the study. Therefore, management of the SLCI is efficient and effective and continuous functioning of these characteristics is beneficial.

5.10.5 THE REASONS FOR THE PERCEIVED IMPORTANCE OF THE CHARACTERISTICS OF HEALTH AND SAFETY FOR SITE LAYOUT PRACTICE

When asked to specify the reasons why the characteristics of health and safety are important, the respondents cited the following:

Health and safety is the key area in the whole construction process. Most of the respondents mentioned that their sites were complying with health and safety regulations. Furthermore they mentioned that they have had enough safety talk, leaflets, posters and signs. A respondent stated that there were too many signs all over on his site; therefore he took no notice of them. This comment was very strong as well as critical. Therefore site management and layout planners need to carefully handle these situations otherwise it will have a negative effect. Some respondents stated that the site notice boards needed to be installed at appropriate locations. Some respondents mentioned that sometimes the fire escape routes to the fire assembly points were obstructed by other trades and some escape routes diverted or closed without updating the fire escape signs. This is a failure to comply with health and safety regulations and can occur due to the lack of a day-to-day site layout planning process.

During the research observation the researcher found the following: most of the sites comply with the safe excavation procedures (e.g. fencing or barriers around the excavations with warning signs) and most sites have clear segregations of higher risk activity (e.g. lifting operations) from other trades and the public. However, one of the sites within the sample had significant level difference areas without any separations or signs or pedestrian bridges.

The outcomes and advantages of the characteristics of all of the factors are discussed in section 5.11. The next chapter discusses these in detail.

5.10.6 OTHER SITE FACTORS AND CHARACTERISTICS IN THE SLCI

When asked to specify other site layout factors and characteristics in Q 9 (apart from the above mentioned site layout characteristics) the respondents cited the following:

- Location of existing building and relationship with on going construction works (i.e. to be demolished or renovated)
- Locations of the ongoing or proposed construction works
- Existing plants and vegetation of the construction site
- Neighbourhood conditions
- Some government laws for building regulation and construction
- Utility supply lines, cables, drainage, and sewage lines layout in the construction sites
- Geographical condition

The construction process and existing structures are the common and obvious characteristics in any construction project. They are not labelled as site layout factors in this research. However, they are the main characteristics and other main factors (e.g. material, site office, security system) are dependent on them in the site layout planning process.

However, the other site layout factors which are indicated in bullet points above had a lower response rate.

5.11 THE REASONS FOR THE PERCEIVED IMPORTANCE OF ABOVE ALL CHARACTERISTICS

When asked to specify the reasons for why the characteristics are important in Q 10, the respondents cited the following:

Table **5.11: the reasons for the perceived importance of some characteristics**

Reasons for the perceived importance of these characteristics	**Developed sites %**	**Remote sites %**	**Whole sample %**
• productivity of the organisation is increased	67.9	87.5	78.3
• there is no effect to the productivity	0	0	0
• productivity of workforce is increased	89.3	81.3	85
• motivation of workforce is increased	75	78.1	76.7
• able workers are being generated	78.6	87.5	83.3
• costs and losses are minimised	85.7	81.3	83.3
• workers work more willingly	78.6	81.3	80
• the quality of work improves	71.4	65.6	68.3
• projects are completed on time	75	87.5	81.7
• employees can be managed easily and efficiently without problem	78.6	75	76.7
• self-confidence of the employees is increased	78.6	71.9	75

• less environmental pollution	71.4	71.9	71.7
• delay is minimised	82.1	68.8	75
• goodwill of the organisation is increased	78.6	87.5	83.3
• number of accidents is decreased	92.9	90.6	91.7
• knowledge of workforce is updated	92.9	93.8	93.3

Management should take these advantages into consideration and take the necessary action to achieve the above characteristics.

5.12 SUGGESTIONS AND PERCEIVED DIFFICULTIES FOR IMPROVEMENT OF SITE LAYOUT IN SLCI

5.12.1 SUGGESTIONS FOR IMPROVEMENT

This section looks at the suggestions for improving the Sri Lankan construction industry taken from the present study's analysis and results (Q 11A), the respondents cited (%) the following.

Table 5.12.1: the suggestions for improving the SLCI

Suggestions for improvement	Developed sites %	Remote sites %	Whole sample %
• provide every facility necessary to conduct efficient work	78.6	87.5	83.3
• consider the workers' needs and requirements, so as to motivate them and satisfy them as much as possible	85.7	81.3	83.3
• there should be a co-operative relationship between employers and employees	67.9	75	71.7
• management should be much more efficient and improve their management style	64.3	65.6	65
• update the work with new technology	67.9	75	71.7
• efficient research and development centres or department need to be established	75	65.6	70
• education by short-term training programmes (e.g. workshops, seminars) for workforce	75	75	75
• clear specification of the rights and obligations of both employers and employees	67.9	53.1	60
• educate workers and management about their duties and responsibilities	53.6	68.8	61.7
• there should be enough workers	100	100	100
• workers should be well trained and experienced	71.4	62.5	66.7
• there should be no political influences on the project	71.4	71.9	71.7

• according to the site schedule, site layout should be updated	82.1	84.4	83.3
• according to the construction stage, site layout should be updated	78.6	68.8	73.3

5.12.2 DIFFICULTIES AS PERCEIVED FOR IMPROVEMENT

When asked to specify the difficulties for implementing the above suggestions, in Q 11B, the respondents cited the following:

Table 5.12.2: the difficulties for implementing the suggestions

Difficulties as perceived for improvement	**Developed sites %**	**Remote sites %**	**Whole sample %**
• financial problems within the organisation	85.7	84.4	85
• lack of facilities	82.1	87.5	85
• non availability of suitable training programmes	71.4	81.3	76.7
• public transport problems	82.1	78.1	80
• difficulty in changing workers' attitudes	75	71.9	73.3
• interference from civil problems (such as civil war)	78.6	68.8	73.3
• insufficient time due to busy schedule	71.4	84.4	78.3
• lack of employees' and employers'	78.6	71.9	75

knowledge of site layout practices			
• management deficiencies	82.1	81.3	81.7
• only trusting existing procedures and methods in the organisation	75	71.9	73.3
• increases in the overhead costs	75	87.5	81.7
• political influences	71.4	75	73.3
• other unfair influences	64.3	59.4	61.7
• communication delays	78.6	87.5	83.3
• unhealthy relationship between employers and employees	82.1	78.1	80
• lack of technology	85.7	81.3	83.3
• fewer workers	64.3	65.6	65
• changes in the crew	57.1	62.5	60
• inspection delay	71.4	78.1	75
• natural problems due to climatic conditions	82.1	71.9	76.7

5.13 CROSS ANALYSIS: INTERVIEW RESULTS VS. OBSERVATION RESULTS

In this section a cross analysis of some *interview vs. observation results* are discussed. Cross analysis is important in order to triangulate the results for validity. Chi-square goodness-of-fit test is used with 5% significant level to check whether there are any statistically significant differences. The following table (Table 5.13) shows a cross analysis of *interview vs. observation* results.

Table 5.13: The cross analysis of

Statements	Interview results mean (Rated scale as: 1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory).	Observation results mean (Rated scale as: 1 = Excellent, 2 = Very Good, 3 = Good, 4 = Satisfactory, 5 = Unsatisfactory).	'p' value	Comments: Validity confirmed or not confirmed
Materials • Quality of the materials	Good 2.58	Good 2.88	.66	Confirmed
•Quality control of the materials	Good 3.10	Good 3.44	.65	Confirmed
•Adequacy of materials	Good 2.85	Good 3.38	.48	Confirmed
• Material delivery methods	Good 3.25	Good 3.44	.66	Confirmed
• Accessibility to the materials	Very Good 2.33	Very Good 2.42	.34	Confirmed
• Store locations of materials	Very Good 2.48	Very Good 2.08	.64	Confirmed
Equipments • Quality of the equipments	Good 2.65	Good 3.42	.28	Confirmed
• Quality control of the equipments	Satisfactory 3.65	Satisfactory 4.42	.72	Confirmed
• Adequacy of the equipment	Good 3.35	Satisfactory 3.82	.18	Confirmed
• Locations of equipments	Very good 2.47	Very good 2.28	.44	Confirmed
• Maintenance processes of equipments	Satisfactory 3.65	Satisfactory 4.00	.14	Confirmed

• Update of equipments	Satisfactory 4.20	Satisfactory 4.48	.36	Confirmed
• Equipment delivery methods	Good 3.08	Good 2.58	.74	Confirmed
Waste management • Waste clearance systems	Good 2.80	Good 3.00	.66	Confirmed
•Re-use of waste	Good 3.07	Very good 2.42	.65	Confirmed
• Recycle of waste	Unsatisfactory 4.95	Unsatisfactory 5.00	.65	Confirmed
•Waste store locations	Good 3.00	Good 2.78	.76	Confirmed
•Capacity of waste storage	Very good 2.22	Very good 2.14	.62	Confirmed
•Waste delivery methods	Good 3.03	Good 3.34	.45	Confirmed
•Accessibility to waste store locations	Good 2.52	Good 2.82	.44	Confirmed
•Prevention methods for waste pollution	Good 3.38	Good 3.22	.32	Confirmed
Stores • Locations of stores	Very good 2.38	Very good 2.24	.34	Confirmed
• Accessibility to stores	Very good 2.38	Very good 2.18	.34	Confirmed
• Capacity of stores	Very good 2.37	Very good 1.88	.45	Confirmed
• Stock level control	Good 3.07	Good 3.44	.68	Confirmed
• Prevention methods for wastage in the store	Good 2.70	Very good 2..42	.12	Confirmed
Site office • Location of the site office	Very good 2.45	Very good 2.22	.44	Confirmed

• Accessibility to site office	Good 2.55	Good 3.22	.46	Confirmed
• Available facilities of site office	Good 3.07	Good 3.00	.74	Confirmed
• Health and safety systems in the site office	Good 3.15	Good 2.68	.68	Confirmed
Rest rooms and sanitary facilities • Locations of rest rooms	Good 3.10	Good 3.00	.72	Confirmed
• Locations of toilets and washrooms	Good 2.78	Good 2.88	.58	Confirmed
• Adequacy	Good 3.17	Good 3.32	.64	Confirmed
• Accessibility	Good 2.78	Good 3.00	.62	Confirmed
• Available facilities of them	Good 3.03	Satisfactory 4.22	.08	Confirmed
• Quality of them	Satisfactory 3.75	Satisfactory 4.22	.42	Confirmed
• Health and safety systems	Satisfactory 3.55	Satisfactory 3.88	.54	Confirmed
Security systems of the site • Locations of security offices	Very good 2.40	Good 2.82	.21	Confirmed
• Security systems against external thefts	Good 2.85	Good 3.24	.62	Confirmed
• Security systems against internal thefts	Good 2.82	Good 3.22	.42	Confirmed
Health and safety • Health and safety systems for whole parts of sites	Satisfactory 3.67	Satisfactory 4.22	.18	Confirmed

Note: Satisfactory is defined as 'just satisfactory to continue the work'

The interview guide and the observation schedule are available in appendices B and C in respectively. No statistically significant differences emerge. According to the above triangulation statistics (**"P" value >0.05**), it can be concluded that all characteristics confirm the validity of the interview finding and the observation findings.

5.14 SUMMARY

The chapter discussed the research results for the sample. It included the classification of the sites for the sample, a description of demographic information. From section 5.3 to 5.11 the chapter investigated the all characteristics of site layout plan factors (e.g. location of site office, accessibility to the stores etc), to interpret the research objectives and to test the research propositions. The suggested factors and difficulties in improving site layout practices in the Sri Lankan construction industry were described. Finally a cross-analysis of the interview results versus observation results to validate the results was also discussed. The next chapter is the discussion of the results.

CHAPTER SIX

DISCUSSION

6.1 INTRODUCTION

The chapter starts with a discussion of background demographic information concerning the sample. The middle part of the chapter contains the discussion of the results with respect to the site layout factors, namely materials, equipment, waste management systems, stores, site office, rest rooms and sanitary facilities, security systems, health and safety systems and other link factors of site layout (e.g. road layout and accessibility of sites, utility, drainage and sewage lines layout). Finally it looks at the interpretation of research propositions.

6.2 THE SAMPLE

A total of 60 employees were interviewed from 15 construction sites in the Sri Lankan public sector construction industry. The distribution of interviewees according to job title was: 15 project managers, 15 site engineers, 13 architects, 2 quantity surveyors and 15 foremen. Of the 15 sites, 7 sites were from developed regions. The other 8 sites were from remote regions.. Therefore, out of a total of 60 employees, 28 were from developed regions and 32 from remote regions.

6.3 DESCRIPTIONS OF DEMOGRAPHIC INFORMATION

Most of the sample respondents were between the ages of 35 – 50 years (Figure 5.3A in chapter 5). More than 75% of the workers had been in their current trade and also their present job for more than three years. Most had previous experience in construction-related work. The distribution of interviewees according to trade was as follows: 15 project managers, 15 site engineers, 13 architects, 2 quantity surveyors and 15 foremen. All the workers had on-site experience. More than 50% of the workers worked under main contractors in the selected sample and more than 30% of workers under government employees; the remaining workers worked under a subcontractor.

6.4 CHARACTERISTICS OF MATERIALS IN SLCI

Material management is a crucial part of the site layout planning process towards productivity. Poor quality materials (Koskela, 2000) and lack of materials are major factors for low construction productivity. This research shows the quality of materials and that existing quality control systems are, on average, good. However, the quality of materials found in some sites in Sri Lanka is only at a satisfactory level. It is questionable as to why the material is not of suitable standard in regards to its quality. Therefore, improving the quality control process for construction materials in SLCI is of great importance. The respondents stated that the above ratings were influenced by their comparative analysis of other similar scenarios.

The accuracy and quality of existing quality control systems for materials are paramount in order to check the actual current states of the materials. Some respondents mentioned that a quality control system is not utilized for all the time or in all cases. It applies only for randomly selected samples or particular materials. Furthermore, the quality control team should have the relevant skills and qualifications to conduct an effective quality control process. It was reported that on occasion this process can be biased due to miscellaneous reasons. These cannot be mentioned in further detail as the reasons were not clearly stated by the respondent.
A respondent from developing region stated:

> *"I do not think that we have a suitable quality control system for materials. I have heard that phrase before but I do not see it being implemented."*

Therefore, it is clear that the existing quality control systems for materials need to be improved drastically to eliminate the errors created by bias sampling. The proposed quality control process development should contain new technology, efficient testing equipment as well as the productive management of the above process.

According to the research results, adequacy of materials in SLCI is at a good level on average. However, a few respondents stated that due to the lack of communication and coordination among the site team, material shortage problems have arisen on some occasions. Furthermore, some respondents mentioned that the shortage of materials occurred due to the mismanagement of the stock control systems. This issue was previously discussed in detail in Chapter 5 section 5.6.5. All of the above issues can be minimized or prevented by using an efficient site layout planning process.

Other common on-site problems regarding the material productivity include the failure to deliver (due to the breaking down of vehicles and drastically fluctuating weather conditions). Using reliable transport systems is the optimum solution for this issue. Another issue influencing productivity is vehicle breakdowns on-site. Large immovable vehicles can obstruct deliveries of important materials and halt other construction activities which directly impact upon the site layout management process.

Accessibility to the material in SLCI is moderately good. Most of the respondents from remote sites stated that they have enough space to store material. However, the above statement is not applicable for most sites in developed regions; due to the congested nature of the site. Efficient site layout management is the key for all of the above issues. Furthermore, most of the respondents pointed out that the characteristics of the material (e.g. quality and durability) are of great importance towards construction productivity. The next section focuses on the characteristics of construction equipment.

6.5 CHARACTERISTICS OF EQUIPMENT IN SLCI

Selection of suitable and adequate amounts of equipment is paramount in planning construction site layouts, towards enhancing productivity (Park, 2002; Abdul Kadir *et al,* 2005). According to the research results, the quality of equipment is good on average. However the quality control systems of the equipment are only to a satisfactory level when considering the whole sample. The quality control processes for equipment, concerning the developed regions' sites, are better than the remote

regions'. The reason for this is that better technology and approaches are available in developed regions when compared with those of remote sites. Most of the respondents stated that the amount of existing equipment is at a good level. It can be argued that Sri Lanka is a developing country and it is more labour intensive than most developed countries which have greater capital intensity. Therefore, most of the process involves manual methods as cheap labour is readily available. However, more technology and a greater amount of equipment are always beneficial for any construction project.

A few respondents highlighted that the tower cranes and hoists on their sites are not located at proper places. It is important that before locating for the temporary structures (e.g. tower crane), site layout planners and the site management team need to analyze thoroughly the requirements, coverage, limitation, etc. regarding the site layout and find the optimum solutions.

According to the findings, upgrading equipment and maintenance processes in SLCI are only at a satisfactorily level. Therefore, the above concerns certainly need to be improved if higher productivity is to be achieved. Respondents have highlighted that some machines on their sites are inoperable and have been for the last six months. Instead of using these, different machines were hired or borrowed on a temporary basis. Operatives have been known to conduct tasks manually due to failures of machinery. Unnecessary utilization of valuable space for the additional machinery and the extra cost involved will directly influence the site layout planning and productivity. Moreover, instead of machinery, using manual methods to do the previous planned activity will increase the risk of accidents and also lower the construction productivity.

Some respondents stated that the machines and equipment which they are using are very inefficient when compared with other projects. Due to these machines and equipment being outdated and inefficient, they produce significantly higher amounts of carbon dioxide. Furthermore, these output higher sound pollution and take significantly longer to complete the required task.

A site foreman stated that:

> *"I think if we repair and maintain our available machines and equipment, we would be able to do our work much more easily."*

For these reasons, the above issues are concerns for the environment as well as obstructions to other trades and tasks. Certainly these types of issues need to be controlled in order to manage site layout productively and sustainability.

Information given by a respondent mentioned that, due to the limited space and congestion created by excessive numbers of machines on the site, traffic management (in terms of segregation of vehicles and the inclusion of pedestrian routes) has been made unnecessarily difficult. The same respondent highlighted that some of the operatives on his site were using manual methods to handle heavy tasks which were originally designed to be conducted with the aid of a machine. This has happened due to the limited availability of machinery as well as access problems with the site (other machinery and activities were blocking the path of the required machine).

It can be argued that the issues in the above section could definitely be prevented or minimized by applying an efficient site layout planning process. The next section focuses on the characteristics of waste management systems in SLCI.

6.6 CHARACTERISTICS OF WASTE MANAGEMENT SYSTEM IN SLCI

Construction waste consists of unwanted material being created directly or indirectly by the construction industry. Waste produced from the construction industry should be properly managed and disposed of in order to comply with health and safety legislations, and to minimize obstruction to other construction activities. This is a part of the site layout planning process.

From the research results, most of the characteristics of waste management systems (except recycling of waste) were at an averagely good level. The recycling of the waste is not practiced efficiently in SLCI due to the lack of knowledge and technology needed for recycling. However, in recent times recycling waste is starting to be introduced and promoted in SLCI.

A respondent mentioned that:

> *"Last month we had a workshop regarding the construction material recycling method. I think our site managers have only recently started looking into this more thoroughly."*

Hence this approach is beginning to be used on some construction sites.

Some respondents have mentioned that the waste clearance process on their site is inefficient. This is occasionally due to limited accessibility to the waste storage and waste delivery/collection shortages. Some respondents pointed out that in the planning process, the amount of waste being generated from construction activities is being underestimated or miscalculated. Hence the unpredicted amount of excess

waste slows down the clearance process and thus significantly impacts on to the productivity.

By observation and information from respondents, most of the waste was removed from the site as mixed waste rather than separate categorized waste (such as metal, timber, etc). The reported reason behind this is that storing all the waste together is much easier than categorizing them and spending additional time and effort. However, even appreciating the day-to-day busy nature of the site, the above approach is not justified as it is neither environmentally friendly nor sustainable. Therefore, these issues should be analyzed in advance and planned accordingly in the site layout planning stage.

A respondent stated that:

> *"We have to organize the required amount of material more accurate as possible and organize just in time to deliver them to reduce material losses and damages and unnecessary utilizing the storage. And also to be insured that damaged and unfinished delivery materials need to be rejected and returned as earliest as possible".*

On the other hand, efficient material ordering, delivering, returning and storing processes can be used to minimize the waste generation. The next section focuses on the characteristics of stores in SLCI.

6.7 CHARACTERISTICS OF STORES IN SLCI

Providing and having optimum levels of storage, as well as optimum locations of lay-down areas for storage of materials and equipment, are essential for any construction project to ensure a productive operation.

According to the research findings, most of the characteristics for storage in SLCI are reasonably good. Very few respondents stated that the locations of storage on their sites are at an unsatisfactory level. All these respondents were from sites in developed regions – where they have a very small amount of site space. However, this process needs to be managed productively by using efficient site layout planning techniques.

A respondent mentioned that they have enough storage facilities, but accessibility is still very difficult. Some materials are frequently damaged. He confirmed that the above situation occurred due to the lack of store management. Usually, the site management team focuses on tidying up and arranging their storage spaces. However, the site often reverts back to an untidy state after a couple of days. Therefore, continuously managing these storage spaces are paramount for any construction site to develop efficiently.

According to the observed results, it was highlighted that materials in some sites were stored for an unnecessarily long period of time. From further investigation it was found that these materials were stored on site two to three months ahead of when they were needed. This situation would be acceptable if the particular construction site has enough available space. However, in the majority of cases, the above approach is not

advised due to the possibility of damage occurring to the materials during the lengthy storage period. Furthermore, it will have a negative effect for the total cash flow of the project. Consequently, the process of ordering, delivering and the storage of materials and equipment needs to be properly coordinated with the project construction program. Some respondents stated that material lay-down areas are unnecessarily far from the construction activity areas. This has resulted in the unnecessary double handling of materials. Therefore, the site layout planning process needs to overcome the above issues in order to handle the situation more smoothly and productively. The next section focuses on the characteristics of site offices in SLCI.

6.8 CHARACTERISTICS OF SITE OFFICES IN SLCI

All construction projects, regardless of size, require site office accommodation for staff members. According to the site's requirements, the size, the facilities and the frequency of offices vary from one site to another.

In the research findings, all of the investigated site office characteristics (e.g. location of the site office) were averagely rated as good. However, some respondents mentioned that the site office locations of their sites are imperfectly located. They have recommended that having their site office at a different location would be more beneficial when considering the available accessibility from construction areas as well as the main pedestrian gates. A respondent especially mentioned that an unnecessarily long time is taken to access the site office from the construction area and vice versa.

The observation results also highlighted the same issue in this particular site. This issue directly linked with the lack of site layout practices.

During the layout planning process, considering other relevant factors, such as accessibility, together with site office locations (in order to observe construction activities from the office) is immensely beneficial for any construction site. Some respondents mentioned they frequently changed the locations of their site offices with the progress of the construction work. However, major consequences of changing the location of the site office several times is that it wastes valuable time, confuses all other trades as well as decreasing the productivity.

The lack of the facilities in the offices was also a frequently mentioned response from the research. A few respondents mentioned that they do not have telephone lines in their offices and that there is no mobile signal coverage on their site. With no means of communication with other members and supply chains, it is very difficult to manage the day-to-day construction work. Furthermore, some respondents mentioned that IT and internet facilities are not available in their offices. It was also highlighted that there are constant changes and variations to the specifications as well as the designs and drawings being updated frequently. Furthermore, new instruction orders are often issued from the client. Therefore, without internet/IT implementing the above changes (e.g. drawings, specifications) is very difficult, time consuming and inefficient in terms of productivity. The critical issues discussed above should be addressed and resolved in the initial stages of the site layout planning process.

One of the respondents stated that the site office, in terms of access to and from work is very convenient. When considering the location of the site office, the external access is risky. All visitors or outsiders need to be escorted from the gate to the site office while wearing all the necessary personal protective equipment. During the observation, some site offices were identified as highly and unnecessarily exposed to vibrations and sound pollution due to the location of the site office near an active construction area. These issues can be very easily minimized and controlled during the site layout planning process. The next section focuses on the characteristics of restrooms and sanitary facilities in SLCI.

6.9 CHARACTERISTICS OF REST ROOMS AND SANITARY FACILITIES IN SLCI

Rest rooms and sanitary facilities are the site toilets, canteens, drying rooms and other resting rooms which all are known as site welfare facilities. Within the research sample some sites have all of the above mentioned welfare facilities. Other sites have only the combinations of the above facilities, but all of the sites have at least one toilet. Quantities and the categories of above facilities depend on the size, duration, number of operatives on sites and stage of construction (finishing stage, initial ground work stage).

One respondent was concerned about his welfare.

> *"We have very large rest rooms; they are very good and are mostly clean. Occasionally, there are people who do not care about others who use the facilities and leave a mess behind."*

According to the research findings, the characteristics of all rest rooms and sanitary facilities are at a good level in the SLCI. However, most of the respondents mentioned that cleaning and maintenance process of these welfare facilities were of a poor standard. Some respondents mentioned that the number of toilets on their site is insufficient for the site operatives. There is a significant time loss as most of the time there are queues to use the toilets. Furthermore, some respondents mentioned that the canteens and rest rooms were excessively big on their site. The above statements clearly show one way that wastage of resources can be also controlled by the site layout planning process.

A few respondents stated that the accessibility of welfare facilities is not straightforward and also significantly time consuming. These issues are discussed at chapter 5 at rest room and sanitary facilities section (section 5.8.5). A respondent highlighted that the welfare facilities are very convenient and at a good level but there are significant numbers of mosquitoes around the rest rooms and toilets areas due to the polluted culvert at the neighborhood area. (Mosquitoes are insects that spread the diseases such as malaria, dengue fever, yellow fever, etc). The observation session also highlighted the above specified culvert and noted the environmental risk due to the air pollution and mosquitoes. The above type of issues (neighborhood conditions) need to be analyzed prior to the site layout planning process, which is essential to achieve smooth and optimum site layouts towards high productivity. As an example: the options for the above issue will be: welfare and site office areas need to be located at a distance from a severely polluted area or a constant scheme of implementing and monitoring the air refreshment methods and mosquito prevention methods should take place.

During the observation session, it was noted that some operatives were resting outside under the trees instead of using rest rooms, possibly due to the hot weather conditions in Sri Lanka. Increasing the ventilation by providing the more fans, or if possible air conditioning, in the rest rooms and the other relevant welfare facilities are the helpful and motivating strategy for operatives. On other hand, providing a reasonable level of welfare facilities is a mandatory policy in the construction regulations and also providing good level of welfare is one of the highly motivational factors for all construction operatives. Therefore initially spending more money on the comfortable level of welfare will prove profitable in the long-term due to the motivation of operatives resulting in an increase in construction productivity. The next section focuses on the characteristics of site security systems in SLCI.

6.10 CHARACTERISTICS OF SECURITY SYSTEMS IN SLCI

Site security systems are a very important tool for any type of construction project. Without a proper security system a construction project cannot survive, due to constant theft.

Some respondents mentioned that they have spent more money on site security systems but still have significant amounts of complaints regarding the frequent loss of tools and materials. Locations of security huts are a crucial factor for construction projects. Some respondents reported that they have not had enough security coverage on their site. The loss of material and equipment has had a significant impact on the ongoing tasks as it has a monetary effect and also takes a significant period of time to investigate the losses. Furthermore, re-ordering and re-delivering the lost materials

delays the whole programme. This unnecessarily builds up traffic and de-motivates operatives.

Some respondents stated that security huts on their site were not positioned well as the security services could not view the majority of the site and site boundaries. Therefore, the above statement may be linked to a deficiency in site layout planning. Some respondents from a particular site specifically mentioned that they have a perfectly adequate security system, along with a proper security gate and boundary fencing since the start of the project. This was done as the history/records of the area showed abnormally high theft and crime rates. The above statement positively proves the advantages of a proper site layout planning process.

A respondent mentioned that the range of their security coverage is too low and highlighted that more security officers were certainly needed. It was also mentioned that purely due to good fortune they have had no theft-related issues to date. From observation it was identified that the above site was larger than average and also had very steady-looking high leveled fencing. Therefore, it can be thought that the boundary fencing will protect the site in place of extra security officers. This advantage may have been considered initially by planners in the site layout planning process.

A few respondents from one of the developed region's sites stated that theft is a problem that they face frequently. To tackle this issue, they increased the number of security officers – which helped at that time, but the theft issue shortly resumed. Finally, they installed a security camera system with a minimum number of security

officers. This acted as a deterrent which managed to stop the theft issue completely. There have been instances where theft is generated internally rather than externally. This is a delicate issue as incorrect accusations will result in de-motivation of workers; so this type of issue needs to be cautiously analyzed initially.

It was underlined by a respondent that one of the main security flaws on their site was that the light coverage was not sufficient. This issue is a main contributor for accidents occurring on site. The above can be resolved with ease by investing in the installation of new lights; otherwise it could have a negative impact on the productivity of construction. The main focus of the next section is the characteristics of health and safety systems in SLCI.

6.11 CHARACTERISTICS OF HEALTH AND SAFETY SYSTEMS IN SLCI

The health and safety system is of great importance and is a compulsory constituent for the whole of the construction industry. According to existing legislation, maintaining health and safety is mandatory for construction activities and site layout practices. Planners or the site management team need to consider each step of the site lay out planning process by referencing to relevant health and safety laws. The research findings show that the health and safety system in SLCI is at a good standard. However, some respondents pointed out that frequent obstructions of emergency escape and access routes were the main problems at their sites. This problem has occurred due to the heightened number of construction operations and increased numbers of operatives utilizing small areas. Furthermore, the same respondents mentioned that, on occasions, no clear fire escape route is available from

their welfare or office areas. However, the above issue cannot be neglected, it needs to be managed appropriately as this is a part of the site layout planning process. If this critical issue is ignored, it will be in direct violation of current health and safety legislation.

A respondent stated that:

> *"According to my understanding the site I am working in is safe and reasonable in terms of health and safety regulations, of which I know. However, every time the safety manager visits our site, he seriously criticizes the site set up and gives us a very hard time."*

The above types of issues are very serious and there is scope to ignore the safety manager's comments or act against the health and safety laws. If there are any doubts, it is the duty of the site team to analyze, get clarification and act accordingly. All of the above sections (i.e. from 6.4 to 6.12) regarding site layout factors need to be managed by considering the relevant health and safety legislation. The next section focuses on the characteristics of other site layout factors in SLCI.

6.12 CHARACTERISTICS OF OTHER SITE LAYOUT FACTORS IN SLCI

Apart from the above factors (e.g. materials, equipment) from section 6.4 to 6.11, there are others which partially relate to the site layout and productivity of the construction industry. These factors are:

- Road layouts and accessibility of sites.
- Utility, drainage and sewage lines layouts.
- Existing construction works/structures.
- Temporary works.
- Site-specific health and safety and government rules and regulations.
- Neighbourhood conditions (e.g. school, public road or place, river).
- Geographical conditions (e.g. soil, water table, existing structures, weather).
- High risk activities (e.g. steel erection, excavation, asbestos removal, lifting operations).

This section discusses only the other significant factors which influence site layout and productivity.

From the research findings, it was clear that the managing of vehicle routes and pedestrian walkways were extremely difficult tasks. This is due to the ongoing and changing nature of the construction activities and schedules. In most instances the site management are required to divert the pedestrian and vehicle routes, as well as creating alternative routes. These processes are very critical and sensitive because the emergency escape/access routes need to be updated simultaneously. The above process requires clear communication with all site users by the usage of clear signs or similar methods. Most of the operatives mentioned that maintaining pedestrian paths and segregating vehicle traffic is an important, but difficult, task for construction projects. Some of the respondents mentioned that from the beginning of the project they addressed the segregation issue. Due to the early consideration, the issue was

able to be tackled effectively and is now functioning very smoothly and being maintained well.

Buried services are one of the most critical factors to have an effect on the site layout planning process. There are three types of buried services:

- Existing live buried services.
- Newly installed proposed services.
- Newly installed temporary services (which are only for the construction. period)

All of above services are very important and they need to be protected in order so that they are not disturbed during the construction works of the project. If there is not a feasible way to avoid them, the services should be properly diverted with advanced notice by specialist contractors. Most of the respondents mentioned that the buried services are extremely critical for the groundwork stage. There are possibilities for buried services to be damaged when heavy vehicles/plant (crane outriggers) move in close proximity to these services. Therefore, during the site layout planning process, the above activities and proposed construction programmes need to be coordinated accordingly.

All of the respondents from one site in the developed region mentioned that there are enormous amounts of existing buried services on their site; and that most of them are at a very shallow level below the existing ground level. They assumed that those services were installed a long time ago and unfortunately are not in a usable standard.

Furthermore, they mentioned that they frequently have to place steel plates or build/raise the ground to accommodate machine/plant loading in most areas on site in order to protect buried live services. The above tasks involve unavoidable additional costs and work. These types of issues are essential and need to be addressed in the site layout planning process.

Protecting existing structures and neighbourhood structures will be an important task for the site management team during the site layout planning process. Some respondents mentioned that they frequently use temporary work methods (e.g. installations of props and sheet piles) to protect the existing structures. These tasks are critical and certainly need to be managed properly; otherwise they will result in significant structural failures and accidents.

6.13 INTERPRETATION OF RESEARCH PROPOSITIONS (PROPOSITIONS: A and B)

6.13.1 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF MATERIALS

6.13.1.1 State of Awareness of the supposed advantages of an efficient site layout plan (SLP) in the Sri Lankan construction industry (SLCI) (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of materials as site factors in improving construction productivity, questions 1.1A–1.6A, 1B, 1.1C–1.6C, 11A and 11B were included in the field survey.

Existing procedures are investigated in questions 1.1A to 1.6A. 83% respondents stated that the state of quality of materials are good or very good. On average 73 % stated that they rate the characteristics of materials by comparing them with the public or private sectors or overseas projects in other countries etc (see Table 5.3.3). The difficulties which arise when implementing the SLP procedures were discussed in question 11B (see table 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 1.1C to 1.6C investigated how important these are within the industry. On average 98% believed them to be of very high or high importance and others believed them to be important.

Considering the research findings in section 5.3 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards construction materials. Furthermore, most construction firms already use most of these procedures to manage construction materials.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.1: e.g. Alwi (2002) highlighted that lack of material is the number one productivity problem in Indonesia, Nigeria, UK and USA) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.1.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between materials as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the materials characteristics in developed and remote regions are available in chapter 5 (Table 5.3.2 and Table 5.3.4). There are no significant differences in construction materials' characteristics among the developed and the remote regions. Furthermore, considering the reasons (Table 5.3.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11) there are no significant differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no difference as regards materials as SLP factors in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.2 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF EQUIPMENT

6.13.2.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of equipment as site factors in improving construction productivity, questions 2.1A-2.7A, 2B, 2.1C-2.7C 11A and 11B were included in the field survey. Existing procedures are investigated in questions 2.1A to 2.7A. 85% of respondents stated that the quality of existing equipment is good or very good. On average 75 % stated that they rate the characteristics of equipment, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.4.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 2.1C to 2.7C investigated how important these are within the industry. On average 96% believed them to be of very high or high importance and others believed them to be important.

Considering the research interpretation in section 5.4 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards construction equipment. Furthermore, most construction firms already use most of these procedures to manage construction equipment.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.2: e.g. Rojag and Aramvareekul, (2003) and Abdul Kadir *et al*, (2005) stated that functions of the machinery and the availability of them are influencing the productivity) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.2.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between equipment as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the equipment characteristics in developed and remote regions are available in chapter 5 (Table 5.4.2 and Table 5.4.4). There are no significant differences in construction equipment characteristics among the developed and the remote regions. Furthermore considering the reasons (Table 5.4.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11), there are not significant differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no significant difference as regards equipment as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.3 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF WASTE MANAGEMENT SYSTEMS

6.13.3.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of waste management systems as site factors in improving construction productivity, questions 3.1A-3.8A, 3B, 3.1C-3.8C 11A and 11B were included in the field survey. Existing procedures are investigated in questions 3.1A to 3.8A. 70% respondents stated that the states of waste clearance system are good or very good or excellent. Furthermore 27% stated as satisfactory and 3% stated as unsatisfactory. On average 82% stated that they rate the characteristics of waste management systems, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.5.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 3.1C to 3.8C investigated how important these are within the industry. On average 83% believed them to be of very high or high importance and others (17%) believed them to be important.

Considering the research findings in section 5.5 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards waste management systems. Furthermore, most construction firms already use most of these procedures to manage construction waste.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.3: e.g. Web, (2001) stated that using good waste management practice on site will help construction projects to comply with environmental regulations, reduce costs, reduce obstructions for other tasks, minimize the hazards and create a positive image of the project) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.3.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between waste management system as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the waste management system characteristics in developed and remote regions are available in chapter 5 (Table 5.5.2 and Table 5.5.4. There are no significant differences in construction waste management systems' characteristics among the developed and the remote regions.

Furthermore considering the reasons (Table 5.5.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11), there are no significant differences found. Furthermore considering the suggestions Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there are no difference as regards waste management systems as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.4 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF STORES

6.13.4.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of stores as site factors in improving construction productivity, questions 4.1A-4.5A, 4B, 4.1C-4.5C, 11A and 11B were included in the field survey. Existing procedures are investigated in questions 4.1A to 4.5A. 75% respondents stated that the locations of stores are good or very good or excellent. 20% respondents stated as satisfactory and 5% stated as unsatisfactory. On average 78 % stated that

they rate the characteristics of stores, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.6.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 4.1C to 4.5C investigated how important these are within the industry. On average 92% believed them to be of very high or high importance and others (8 %) believed them to be important.

Considering the research findings in section 5.6 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards storages and stores. Furthermore, most construction firms already use most of these procedures to manage stores.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.4: e.g. Elbeltagi *et al*, (2004); Pardasani *et al*, (2009) stated that provision must be made for the safe storage of materials and equipment) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.4.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between stores as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the stores characteristics in developed and remote regions are available in chapter 5 (Table 5.6.2 and Table 5.6.4). There are no significant differences in construction stores characteristics among the developed and the remote regions. Furthermore considering the reasons (Table 5.6.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11), there are no significant differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no difference as regards stores as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.5 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF SITE OFFICES

6.13.5.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of site offices as site factors in improving construction productivity, questions 5.1A-5.4A, 5B, 5.1C-5.4C, 11A and 11B were included in the field survey.

Existing procedures are investigated in questions 5.1A to 5.4A. 78 % respondents stated that the locations of site offices are good or very good or excellent. 10 % respondents stated as satisfactory and 12 % stated as unsatisfactory. On average 81 % stated that they rate the characteristics of site offices, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.7.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 5.1C to 5.5C investigated how important these are within the industry. On average 91% believed them to be of very high or high importance and others (9 %) believed them to be important.

Considering the research findings in section 5.7 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards site offices. Furthermore, most construction firms already use most of these procedures to manage site offices.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.5: e.g. Guy, (2010) stated that most site offices consist of office furniture, meeting area, IT / telephones, refreshment area and more importantly first aid area in case of accidents) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.5.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between site offices as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the site offices characteristics in developed and remote regions are available in chapter 5 (Table 5.7.2 and Table 5.7.4). There are no significant differences in construction site offices characteristics among the developed and the remote regions. Furthermore considering the reasons (Table 5.7.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11), there are no significant differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no difference as regards site offices as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.6 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF REST ROOMS AND SANITARY FACILITIES

6.13.6.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of rest rooms and sanitary facilities as site factors in improving construction productivity, questions 6.1A-6.7A, 6B, 6.1C-6.7C, 11A and 11B were included in the field survey. Existing procedures are investigated in questions 6.1A to 6.7A. 68% respondents stated that the locations of rest rooms and sanitary facilities are good or very good or excellent. 8% respondents stated as satisfactory and 24% stated as unsatisfactory. On average 83 % stated that why they rate the characteristics of rest rooms and sanitary facilities, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.8.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 6.1C to 6.7C investigated how important these are within the industry. On average 93% believed them to be very high or high importance or important and others (7 %) believed them to be low important.

Considering the research findings in section 5.8 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards rest rooms and sanitary facilities. . Furthermore, most

construction firms already use most of these procedures to manage rest rooms and sanitary facilities.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.6: e.g. HSE, (2007) stated that workers will need clean and hygienic portable buildings or suitable protected areas where they can change and securely store clothing, make a hot drink, heat and eat their meals, and take shelter in the event of bad weather) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.6.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between rest rooms and sanitary facilities as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the rest rooms and sanitary facilities characteristics in developed and remote regions are available in chapter 5 (Table 5.8.2 and Table 5.8.4). There are no significant differences in construction rest rooms and sanitary facilities characteristics among the developed and the remote regions. Furthermore considering the reasons (Table 5.8.3) given by respondents there are no significant differences among the developed and the remote regions. Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11), there are no significant

differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no differences regards rest rooms and sanitary facilities as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.7 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF SECURITY SYSTEMS

6.13.7.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of security systems as site factors in improving construction productivity, questions 7.1A-7.3A, 7B, 7.1C-7.3C, 11A and 11B were included in the field survey. Existing procedures are investigated in questions 7.1A to 7.3A. 80 % respondents stated that the locations of security offices are good or very good or excellent. 12 % respondents stated as satisfactory and 8 % stated as unsatisfactory. On average 84 % stated that they rate the characteristics of stores, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.9.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different

suggestions were given (Table 5.12.1). Questions 7.1C to 7.3C investigated how important these are within the industry. On average 96 % believed them to be of very high or high importance and others (4 %) believed them to be important.

Considering the research findings in section 5.9 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards security systems. Furthermore, most construction firms already use most of these procedures to manage security systems.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.7: e.g. Arata, (2005) stated that if it is not possible to secure the whole site, steps must be taken to secure potential locations of high risk operations) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.7.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the difference between security systems as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the security systems characteristics in developed and remote regions are available in chapter 5 (Table 5.9.2 and Table 5.9.4). There are no significant differences in construction security systems characteristics

among the developed and the remote regions. Furthermore considering the reasons (Table 5.9.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in chapter 5 (Table 5.11), there are no significant differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no difference as regards security systems as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.13.8 INTERPRETATION OF RESEARCH PROPOSITIONS (A and B) WITH REFERENCE TO CHARACTERISTICS OF HEALTH AND SAFETY SYSTEMS / REGULATIONS

6.13.8.1 State of Awareness of the supposed advantages of an efficient SLP in SLCI (proposition A)

In order to ascertain the extent of awareness amongst site representatives in the SLCI of characteristics of health and safety systems as site factors in improving of construction productivity, questions 8A, 8B, 8C, 11A and 11B were included in the field survey. Existing procedures are investigated in questions 8A. 43 % respondents

rated the health and safety systems are good or very good. 35 % respondents stated as satisfactory and 22 % stated as unsatisfactory. On average 82 % stated that they rate the characteristics of health and safety systems, by comparing with the public or private sectors or overseas projects in other countries etc (see Table 5.10.3). The difficulties, which arise when implementing the above procedures, were discussed in question 11B (see table no 5.12.2). Question 11A investigated the suggestions for improving the site layout characteristics. Fourteen different suggestions were given (Table 5.12.1). Questions 8C investigated how important these are within the industry. On average 92% believed them to be of very high or high importance and others (8 %) believed them to be important.

Considering the research findings in section 5.10 and the summarised paragraph above, the employers in the Sri Lankan construction industry are well aware of the supposed advantages of SLP as regards health and safety systems. Furthermore, most construction firms already use most of these procedures to manage health and safety systems.

According to the above findings it can be concluded that some important characteristics as detailed in chapter 2 literature (section 2.6.8: e.g. CDM Regulations 2007 place a legal duty on the principal contractor to plan, manage and monitor the construction phase to ensure that, so far as is reasonably practicable, it can be carried out without risks to health and safety) are already being applied and also employees are well aware of this. They are also aware of the advantages and possible obstacles.

6.13.8.2 State of comparison: construction SLP remote regions in SLCI is different to SLP in developed regions in SLCI (Proposition B)

In order to investigate the differences between health and safety systems as SLP factor in the remote and the developed regions in the SLCI, responses for all questions were analysed separately for developed and remote regions.

Response ratings and level of importance of the health and safety systems characteristics in developed and remote regions are available in chapter 5 (Table 5.10.2 and Table 5.10.4). There are no significant differences in construction health and safety systems characteristics among the developed and the remote regions. Furthermore considering the reasons (Table 5.10.3) given by respondents there are no significant differences among the developed and the remote regions.

Considering the reasons for perceived importance of the site layout characteristics among the developed and the remote regions in Chapter 5 (Table 5.11), there are no significant differences found. Furthermore considering the suggestions (Table 5.12.1) and the difficulties (Table 5.12.2) of implementation there are no significant differences between the developed and the remote regions.

Therefore, it can be concluded that there is no difference as regards the health and safety systems as SLP factors, in the developed regions in the SLCI and the remote regions in the SLCI.

6.14 INTERPRETATION OF RESEARCH PROPOSITIONS: *EFFECTIVE AND EFFICIENT SLP IN SRI LANKAN CI WOULD CONTRIBUTE TO IMPROVE THEIR PRODUCTIVITY*

6.14.1 Perceived Productivity Benefits

To identify the perceived productivity benefits realised from the implementation of the effective SLP practices, questions 1C–8C and 10 were included in the field survey. An average of 99% of respondents stated that the characteristics of effective SLP practices mentioned in questions 1C–8C are important. According to the findings it can be concluded that employees feel positive about these processes. A certain number of obstacles and suggestions for implementing are listed in table 5.12.2 and table 5.12.1. Further investigation to identify the perceived productivity benefits are in question 10 (reasons why they are important). An average of 80 % chose 15 important advantages (a breakdown of percentages is available in Chapter 5 table 5.11). Among these advantages, 82 % stated that productivity of the organizations and the workforce increase. This answer is more applicable to identify the perceived productivity benefits.

Considering the above findings the conclusion can best be described as follows: effective and efficient SLP in the SLCI would contribute to improve their productivity.

The next section focuses on the summarizing the findings of the research.

6.15 Summary

To summarise, the interpretation of research proposition with reference to all site layout factors show that the employers in Sri Lanka are aware of the supposed advantages of efficient SLP in CI. Also, construction SLP in the developed regions in the SLCI is not vastly different to SLP in remote regions of the SLCI. Finally, effective and efficient SLP in Sri Lankan CI would contribute to improvement of their productivity. In other words, Sri Lankan construction site employers realise that the SLP factors can have significant positive impacts on construction productivity. Furthermore, all respondents are aware of the productivity benefits, which can result from the implementation of the approaches. On average 80.22% of the respondents cited the following productivity benefits:

- productivity of the organisation is increased;
- productivity of the workforce is increased;
- motivation of the workforce is increased;
- knowledge of the workforce is updated;
- able workers are being generated;
- costs and losses are minimised;
- workers work more willingly;
- the quality of work improves;
- projects are completed on time;
- employees can be managed easily and efficiently without any problems;
- self-confidence of the employees is increased;
- less environmental pollution;

- delays are minimized;
- the goodwill of the organisation is increased;
- the number of accidents is reduced.

The next chapter is the conclusion of the study with recommendations and suggestions for future research.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter begins with a summary of the findings of the study together with a case which says that Sri Lankan site layout factors are influencing construction productivity. A new site layout framework in order to increase the construction productivity in the Sri Lankan construction industry is included in sections two and three. Section four is a discussion of the limitations of the study. Section five discusses the contribution of the research to construction management knowledge. Finally, a conclusion and recommendations to the industry as well as scope for future research are presented.

7.2 THE WAY FORWARD FOR A SRI LANKAN SLP FRAMEWORK

The future of the Sri Lankan construction industry is likely to involve a huge range of projects of different sizes, ranging from small-scale housing to large-scale infrastructure development and improvement.

In Sri Lanka the attitudes towards the 'organisation' must be understood in the context of the historical factors which shaped them, namely the monarchy and the colonial era. The kings and later colonial powers controlled the loyalty and obedience of those who worked for them. These factors have to some extent resulted in an

embedded culture, which may result in a partial barrier to the effective introduction and implementation of efficient construction management strategies in a short time. Sri Lanka's history left the construction industry with a "construction organisational culture". This would appear to have weakened in the years since independence.

The Sri Lankan government was not well equipped to manage, function and operate effectively immediately after independence. This was due to a lack of personnel who were adequately trained in the civil service as well as other important governmental positions to assume the reins of power. The lack of trained, efficient and effective personnel was also manifested in the private and public sector industries, in particular the construction industry.

The Sri Lankan government realised this and introduced measures that would address these deficiencies, in the forms of loans and aids from places like the World Bank and the International Monetary Fund (IMF). The aids and loans received for these structural adjustments have both political overtones as well as managerial and organisational conditionality. There was no concerted effort by the World Bank, IMF or other lending bodies to monitor the introduction of different effective management structures as part and parcel of the conditionality to the receiving government aid. This failure to monitor created a lack of accountability of the way some of the finances have been used in improving productivity and raising the productivity level of the workforce, through effective management within the public and private sectors.

The immediate and pressing issues for workers today are relevant vocational training, educational needs and facilities available to the vast number engaged in construction

activities. Increasing the availability of these required skills for the future, as much as for the present, is a crucial determinant of how our construction capabilities would respond to the needs of the situation and so help shape the pattern of future development.

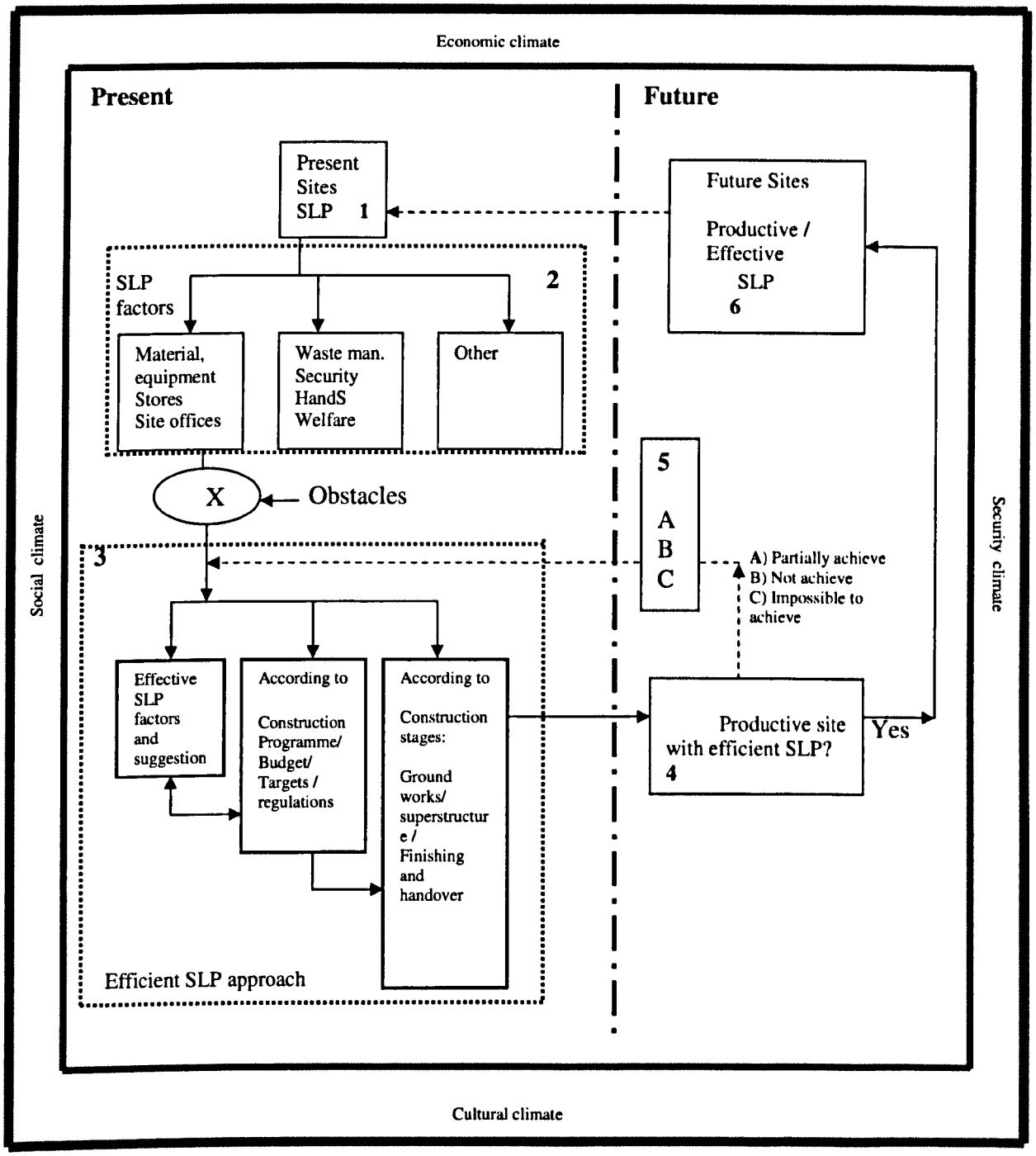
The analyses in the study have given more insight into the role of effective SLP practices in construction than the other strategies (e.g. workforce motivation) to increase construction productivity. Different geographical locations and practices would also shed a different light on how construction productivity in particular locations (i.e. Northern and Eastern parts of Sri Lanka).

The way the discourse of productivity has been introduced into Sri Lanka by various successive governmental and cross-governmental agencies and how the structural adjustments required in the implementation of higher productivity have been introduced by successive governments after independence, has major implications. Access to funds on suitable terms from the general banking sector, specialised lending institutions, and arrangements for medium and small scale credits will all be major determinants of the future of the construction sector. Increasing the construction productivity by using new proposed efficient site layout plan framework will bring about a whole new dimension and benefits to the construction industry in the future. The main reason for a greater alignment now is that Sri Lanka would be strategically placed to develop to its full potential economically. This will help in positioning themselves for the rapidly developing Asia market, where the *'centre of gravity'* in technology, commerce, construction, culture and religion is swiftly expanding. The knock-on effect of this would affect other workers, trades and industries. It would

challenge them to be productive, to be global players within the Sri Lanka context. What is required, therefore, to fully appreciate the complex nature of both human and the construction industry, is a new effective SLP framework which takes into account a holistic view of the socio-economic nature of the Sri Lankan construction industry. This is explained in the next section.

7.3 SLP FRAMEWORK FOR IMPROVING CONSTRUCTION PRODUCTIVITY

Framework for improving productivity in the Sri Lankan Construction Industry (SLCI): SLP approach



Key

A – To be modified the programme/ SLP / design; **B** – To be changed the programme/ SLP / design; **C**- To be done differently or stop the process

Figure 7.1: SLP framework for improving construction productivity

7.3.1 DESCRIPTION OF AN SLP FRAMEWORK FOR IMPROVING CONSTRUCTION PRODUCTIVITY IN THE SL

The empirical framework in Figure 7.1 shows the inclusion of SLP strategies in the Sri Lankan construction industry (SLCI). The framework moves from left to right and from top to bottom to achieve a productive construction site, except on the far right of the figure. This is explained according to the numbers in each box:

The thick dotted line running vertically downwards separates the present construction sites from the future construction sites. In effect, everything on the left of this vertical line deals with the present construction sites and where SLP are to be improved. To the right of the line is the construction site whose productivity level has been improved. Box 1 shows the present situation of SLCI. SLP factors (e.g. materials, equipment) in the present SLCI are included in dotted box 2. The research work concentrated only on the discourse of SLP strategies to the SLCI. It focuses on material, equipment, stores, site offices, waste management rest room and welfare facilities, security system, health and safety system / regulation and other factors (e.g. utilities). All other factors are available in Chapter 2 sections 2.6.9 – 2.6.12

Circle X is about the obstacles to the discourse of SLP approach to the SLCI. These obstacles were investigated in the field survey (Please see Chapter 5 table 5.12.2). Whenever there is an obstacle, the idea is usually to find a simple solution or to bypass the problem. However, in effective SLP practices only by solving (clearing) the obstacle is the solution of creating productive sites. We cannot ignore or bypass it.

Some obstacles have been identified:

- financial problems within the organisation
- lack of facilities
- non availability of suitable training programmes
- public transport problems
- difficulty in changing workers' attitudes
- interference from civil problems (such as civil war)
- insufficient time due to busy schedule
- lack of employees' and employers' knowledge of site layout practices
- management deficiencies
- only trusting existing procedures and methods in the organisation
- increases in the overhead costs
- political influences
- other unfair influences
- communication delays
- unhealthy relationship between employers and employees
- lack of technology
- fewer workers
- changes in the crew
- inspection delay
- natural problems due to climatic conditions

According to the framework these obstacles have to be cleared and monitored prior to the discourse of SLP strategies to the SLCI.

The research suggests that there are 41 characteristics about material, equipment, stores, site offices, waste management rest room and welfare facilities, security system, health and safety system / regulation to be applied to the SLCI in the present study. More than 95% stated that all of these characteristics are important to the SLCI and they are willing to accept them. The dotted box no 3 represents the effective SLP approaches in SLCI.

These strategies should be implemented with consideration of the stages of construction, liaise with, construction programme, targets, budget and regulations. Two boxes within dotted box no 3 contains these.

If this process is successful, productive construction sites can be achieved (in box 4) and there is a move towards future productive construction sites (box 6). If this process is not successful, the system will have to be checked and the previous procedures repeated until the organisation is satisfied. This process is indicated by the dotted horizontal arrow from box 4 in the framework. Furthermore, in some cases partially productive sites are achieved or in some cases productive sites are not achieved at all or in some cases productive sites are impossible to be achieved.

Therefore:

"A" in box 5 is the construction programme/ SLP / design modification process.

"B" in box 5 is the construction programme/ SLP / design changing process.

"C" in box 5 is to be done differently or stop the process

At a given point in time, the future construction site can become the present site, shown by the dotted arrow (from box 6 to box 1). If it is, the process starts again until the organisations expectation productivity level is reached.

However, the framework is influenced by the following factors:

- Cultural climate
- Economic climate
- Social climate
- Security climate.

This is indicated in-between the thick outer rectangular and inner rectangular shapes in the framework.

Cultural climate

This empirical study is limited only to Sri Lanka (i.e. within Sri Lankan culture). In a particular time period culture remains unchanged. That means during the empirical study Sri Lankan culture is constant. Therefore, there are opportunities to do similar research in many years' time in Sri Lanka and again more importantly do similar research in different cultural setting (e.g. India, Pakistan).

Security climate

In different security climates, the nature of the construction industry varies. For example Northern and Eastern parts of Sri Lanka were until very recently affected by

a civil war. Therefore construction workers' attitudes and expectations are completely different from the normal situation. Furthermore most of the other related systems (e.g. material delivery system, working hours) are also different than normal.

Economic Climate

There are some significant differences in SLP characteristics among public and private sector construction industries, mainly due to their economic structures. However, the main thrust of the economy is government oriented. As such a majority of the economic trends will have political undertones created by the government.

Social climate

There are some statistically significant differences among employees and employers, as investigated in the empirical study. The employers' higher social status is an example.

7.4 LIMITATIONS OF THE STUDY

As in any type of research, this study has faced certain limitations that are paramount to understanding the context within with the study is carried out. They are summarised as follows:

- The findings of this study relate to only 15 construction sites in Sri Lanka due to time constraints and resource availability. Due to the terrorist attacks and for security reasons, the researcher could not reach the Northern and Eastern part of the country at the time of the fieldwork. There is good deal of scope for further research in these areas;

- This research study is mainly based on the perceptions of the sample respondents. Therefore, the limitations of opinion surveys have to be recognised: the respondents' opinions might not be the same as other construction employees' beliefs and actions (Al-Souhern, 1996);

- This research study has concentrated only on public sector construction. Private sector construction works were omitted.

7.5 CONTRIBUTION TO KNOWLEDGE

Most studies to date look at construction productivity by referring to labour motivation, human resource management strategies, knowledge management etc. The

advantages of site layout planning have not yet been fully exploited empirically by scholars.

In Sri Lanka the construction industry contributes about 4–7% to the GDP and provides employment to about 10% of the country's total workforce (ICTAD, 2008). Using the above statistics, it can be concluded that government and future policy makers should start appreciating the importance of site layout planning as a one of a major methods of increasing construction productivity. However, in Sri Lanka nobody has previously conducted site layout studies influencing productivity within the construction industry.

The main contribution to knowledge is the development of an efficient site layout framework for increasing Sri Lankan construction productivity. This same framework, if successful in its implementation, could be fully or partially applied in other industries such as manufacturing and defence after it has been thoroughly tailored to fit such industries. It could also be used in other developing regions similar to Sri Lanka.

This study would open up a 'floodgate' of positive site layout on productivity studies within developing countries, which could lead to major improvement. If policy makers can understand and encourage the construction productivity in all areas (e.g. efficient site layout practice), efficient site layout planning in the construction industry would have a major impact on future development of the nation. The plea must be for a more contextually sensitive approach when understanding site layout practices in different settings.

7.6 FINALCONCLUSIONS AND RECOMMENDATIONS

7.6.1 CONCLUSIONS

(d) The employers in Sri Lanka are aware of the supposed advantages of efficient SLP in CI

(e) Construction SLP in the developed regions in the SLCI is not different to SLP in remote regions in the SLCI.

(f) Effective and efficient SLP in Sri Lankan CI would contribute to improve their productivity.

Staff on construction sites in Sri Lanka have given a positive reaction to site layout plans and an empirical survey found these SLP characteristics to be very important. However, obstacles to implementation and benefits are extremely important. Figure 7.1 shows that SLP discourse is not fully grounded in the construction industry in Sri Lanka. If the framework were implemented there would be improvements, but this would need to be led by the government sector, the industry's main employer. Other Non-government organisations and the private sector would then follow. In addition to the empirical evidence generated, this study will be of benefit to Sri Lankan policy makers in respect of facilitating a more effective and efficient CI, contractors and clients

7.6.2 FUTURE RECOMMENDATIONS

The works carried out in this research have not answered all the site layout questions on how to increase construction productivity. The following are recommended areas for future research.

1. To test the framework on one controlled site and other sites, to see whether the framework would achieve the desired results. This should be undertaken on both private and public sector projects.
2. To test the framework in Northern and Eastern province and compare with other provinces. The researcher could not access these areas due to security reasons.
3. To test the framework in few years' time to seek the differences and modify the framework accordingly; or to reject the use of the framework
4. To undertake a comparative study of another similar region (e.g. India, Pakistan, Nepal)

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APPENDIX A

OXFORD BROOKES UNIVERSITY

CONSENT FORM

Full title of the research Project: **site layout: how it is perceived to affect productivity in public sector construction projects in Sri Lanka**

Name, position and contact address of Researcher:
Leyon Nanayakkara
Researcher
Department of Real Estate and Construction
Oxford Brookes University
Oxford OX3 0BP
UK

		Please Initial Box
1.	I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	☐
2.	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.	☐
3.	I agree to take part in the above study.	☐
4.	I agree to the interview consultation being audio recorded	☐
5.	I agree to the use of anonymised quotes in publications	☐

Name of Participant	Date	Signature
Leyon Nanayakkara		
Name of Researcher	Date	Signature

Dear Participant,

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

This interview is part of a research project titled *"The perception approach adapted to site layout on productivity in public sector construction projects in Sri Lanka"*, undertaken by myself at Oxford Brookes University, England. The research project aims to investigate how productivity could be improved in the Sri Lankan public sector construction industry by using effective and efficient site plans. This study will be of benefit to Sri Lankan policy makers in facilitating a more efficient construction industry, including contractors and all others involved in the construction industry.

You were randomly selected and all together 60 site agents (i.e.15 project managers, 15 site engineers, 15 architects and 15 foremen) were randomly selected. It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

There are no right/wrong answers to the questions posed in this interview guide. No two organizations have the same way of managing their construction sites. There is a great diversity among construction projects in different parts of the Sri Lanka.

This interview is easy to response and will be taken around 90 minutes of your time. This interview guide was specially designed to obtain the following information from site agents as applicable to each category. 1. Demographic information of site agents and sites. 2. Their opinion and suggestions about site plans' characteristics towards to high productivity. The data generated in the course of the research must be kept securely in paper or electronic form for a period of five years after the completion of a research project. Some of this information will be used to write a PhD thesis and a few publications. At that time, if you need it, I am willing to give you copies of these documents.

If you have any problems in interpreting the questions you are free to ask for additional explanations from me. If you do not feel free to answer any questions you may skip them and also note that your participation is voluntary.

Replies will be treated as strictly confidential (confidentiality of information provided is subject to legal limitations). I am the only person who will deal this data. They will not be used for any purpose except that outlined above (for which only an overall summary of the results shall be used), nor will they be passed on to anyone.

This research project has received clearance by the University Research Ethics Committee (UREC) at Oxford Brookes University. If you have any concerns about the conduct of this research project that you can contact the Chair of the UREC at Oxford Brookes University (email ethics@brookes.ac.uk).

I thank you for your co-operation.

Leyon Nanayakkara
Department of Real Estate and Construction
30/06/05

APPENDIX B

INTERVIEW GUIDE

Introduction

This interview guide was designed to obtain the following information from site agents as applicable to each category. 1. Demographic information of site agents and sites. 2. Their opinion and suggestions about site plans' characteristics

THE INTERVIEW GUIDE

I am researcher in The Oxford Brookes University, UK. As a partial fulfilment of the academic requirements I am in the process of conducting a research on the topic of site layout: how it is perceived to affect productivity in public sector construction projects in Sri Lanka. This interview guide has been designed to obtain valuable information from you towards that end. Hence, I solicit your much-valued co-operation to provide your sincere and frank answers to these questions. If you have any problems in interpreting the questions you are free to ask for additional explanations from me. Your responses will be treated in absolute confidence. If you do not feel free to answer any questions you may skip them.

i). Name and location of your site:

ii). Your age:

(iiiA). what is your current occupation?
(iiiB). Your experience as a current occupation in years: .....

iv. Your previous experience in other construction related work in years: .....

v. Please indicate the types of projects which you are working?
Housing/ Public Buildings / Commercial

vi. Please specify your current employment status:
Under Subcontractor/ Under Main Contractor/ Government Employee /under project or site engineer/other

vii. How long have you been with your present employer? .....Years

APPENDIX B

Please consider the following characteristics and give your ideas accordingly?

Characteristics	**(A) How would you rate...?**	**(B) Why?**	**(C.) How it is important**	**Q. 10) Why it is important or not**	**Q. 11) Suggestions (a) for improvement (b)difficulties**
Scale	1=Excellent 2=Vary Good 3=Good 4=satisfactory 5=Unsatisfactoty		1=Very highly important 2=Highly important 3= Important 4=Low important 5= Very low important		
Q. 1) Materials • 1.1 Quality of the materials					
•1.2 Quality control of the materials					
•1.3 Adequate amount of materials					

•1.4 Material delivery methods					
•1.5 Accessibility to the materials					
•1.6 Store locations of materials					
Q. 2) Equipment • 2.1 Quality of the equipments					
•**2.2** Quality control of the equipments					
•2.3 Adequate amount of equipment					
• 2.4 Locations of equipments					
• 2.5 Maintenance processes of equipments					
•2.6 Update of equipments					
• 2.7 Equipment delivery methods					
Q.3) Waste management • Waste clearance systems					
•**3.1** Re-use of waste					

•**3.2** Recycle of waste					
•3.3 Waste store locations					
•3.4 Capacity of waste storage					
•3.5 Waste delivery methods					
•3.6 Accessibility to waste store locations					
•3.7 Prevention methods for waste pollution					
Q. 4) Stores •4.1 Locations of stores					
•4.2 Accessibility to stores					
•4.3 Capacity of stores					
•4.4 Stock level control					
•4.5 Prevention methods for wastage in the store					
Q 5) Site office •5.1 Location of the site office					

•5.2 Accessibility to site office					
•5.3 Available facilities of site office					
•5.4 Health and safety systems in the site office					
Q. 6) Rest rooms and sanitary facilities •6.1 Locations of rest rooms					
•6.2 Locations of toilets and washrooms					
•6.3 Sufficient No					
•6.4 Accessibility					
•6.5 Available facilities of them					
•6.6 Quality of them					
•6.7 Health and safety systems					
Q.7) Security systems of the site •7.1 Locations of security offices					
•7.2 Security systems against external thefts					

• Security systems against internal thefts					
Q.8) Health and safety •8.1 Health and safety systems for whole parts of sites					
Q.9) **Other**					

Q.10) Anything else you wish to say:-

Thank you very much

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APPENDIX C

Observation schedule

Characteristics	Notes
Materials • Quality of the materials	
•Quality control of the materials	
•Adequacy of materials	
• Material delivery methods	
• Accessibility to the materials	
• Store locations of materials	
Equipments • Quality of the equipments	
• Quality control of the equipments	
• Adequacy of the equipment	
• Locations of equipments	
• Maintenance processes of equipments	
• Update of equipments	
• Equipment delivery methods	
Waste management • Waste clearance systems	
•Re-use of waste	
• Recycle of waste	
•Waste store locations	
•Capacity of waste storage	
•Waste delivery methods	
•Accessibility to waste store locations	
•Prevention methods for waste pollution	
Stores • Locations of stores	
• Accessibility to stores	

• Capacity of stores	
• Stock level control	
• Prevention methods for wastage in the store	
Site office • Location of the site office	
• Accessibility to site office	
• Available facilities of site office	
• Health and safety systems in the site office	
Rest rooms and sanitary facilities • Locations of rest rooms	
• Locations of toilets and washrooms	
• Adequacy	
• Accessibility	
• Available facilities of them	
• Quality of them	
• Health and safety systems	
Security systems of the site • Locations of security offices	
• Security systems against external thefts	
• Security systems against internal thefts	
Health and safety • Health and safety systems for whole parts of sites	
• Other	

Leyon Nanayakkara

APPENDIX D

CONTENT ANALYSIS FOR INTERVIEW RESPONSES AND OBSERVATION RESULTS

i.

1 = site No. 1

2 = site No.2

3 = site No.3

4 = site No.4

5 = site No.5

6= site No.6

7 = site No.7

8 = site No.8

9 = site No.9

10 = site No.10

11 = site No.11

12= site No.12

13= site No.13

14= site No.14

15= site No.15

ii.

1 = age < or = 25

2 = 25 < age < 45

3 = age > or = 45

iiiA.

1 = Project manager

2 = Site Engineer

3= Architect

4= Quantity surveyor

5= Foreman

iiiB.

1 = duration <or = 1 year

2 =1< duration < 5 years

3 = duration > or = 5 years

iv.

1 = duration = 0

2 = duration < or = 1 year

3 =1 year < duration < 5 years

4 = duration > or = 5 years

v.

1 = Housing

2 = Public building

3 = Commercial building

vi.

1 = under subcontractor

2 = under main contractor

3 = under government employer

4 = under project manager or site engineer

5 = other

vii.

1 = duration <or = 1 year

2 =1< duration < 5 years

3 = duration > or = 5 years

1.1A – 1.6A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

2.1A – 2.7A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

3.1A- 3.8A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

4.1A – 4.5A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

5.1A – 5.4A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

6.1A – 6.7A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

7.1A – 7.3A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

8A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

9A

1 = Excellent

2 =Very Good

3 = Good

4 = Satisfactory

5 = Unsatisfactory

1B -8B

1. = compare to other public sector construction sites in Sri Lanka
2. = compare to private sector construction sites in Sri Lanka
3. = compare to overseas construction projects in Sri Lanka
4. = compare to overseas projects in other countries
5. = according to the respondents' understandings
6. = according to the productivity of the project
7. = according to the knowledge obtained from the workshops or seminar or conference or training programmes

1.1C – 1.6C

1 = Very highly important
2 = Highly important
3 = Important
4 = Low important
5 = Very low important

2.1C – 2.7C

1 = Very highly important
2 = Highly important
3 = Important
4 = Low important
5 = Very low important

3.1C- 3.8C

1 = Very highly important
2 = Highly important
3 = Important
4 = Low important
5 = Very low important

4.1C – 4.5C

1 = Very highly important

2 = Highly important

3 = Important

4 = Low important

5 = Very low important

5.1C – 5.4C

1 = Very highly important

2 = Highly important

3 = Important

4 = Low important

5 = Very low important

6.1C – 6.7C

1 = Very highly important

2 = Highly important

3 = Important

4 = Low important

5 = Very low important

7.1C – 7.3C

1 = Very highly important

2 = Highly important

3 = Important

4 = Low important

5 = Very low important

8C

1 = Very highly important

2 = Highly important

3 = Important

4 = Low important

5 = Very low important

9C

1 = Very highly important

2 = Highly important

3 = Important

4 = Low important

5 = Very low important

10

1. = productivity of the organisation is increased
2. = there is no effect on the productivity (0% from DP and 0% from RP)
3. = productivity of workforce is increased
4. = motivation of workforce is increased
5. = able workers are being generated
6. = costs and losses are minimised
7. = workers work more willingly
8. = the quality of work improves
9. = projects are completed on time
10. = employees can be managed easily and efficiently without problem
11. = self-confidence of the employees is increased
12. = less environmental pollution
13. = delay is minimised
14. = goodwill of the organisation is increased
15. = number of accidents is decreased
16. = knowledge of workforce is updated

11A.

1. = provide every facility necessary to conduct efficient work
2. = consider the workers' needs and requirements, so as to motivate them and satisfy them as much as possible
3. = there should be a co-operative relationship between employers and employees
4. = management should be much more efficient and improve their management style
5. = update the work with new technology development
6. = efficient research and development centres or department need to be established
7. = education by short-term training programmes (e.g. workshops, seminars) for workforce
8. = clear specification of the rights and obligations of both employers and employees
9. = educate workers and management about their duties and responsibilities
10. = there should be enough workers
11. = workers should be well trained and experienced
12. = there should be no political influences on the project
13. = according to the site schedule, site layout should be updated
14. = according to the construction stage, site layout should be updated

11B

1. = financial problems within the organisation
2. = lack of facilities
3. = non availability of suitable training programmes
4. = public transport problems
5. = difficulty in changing workers' attitudes
6. = interference from civil problems (such as civil war)
7. = insufficient time due to busy schedule

8. = lack of employees' and employers' knowledge of site layout practices
9. = management deficiencies
10. = only trusting existing procedures and methods in the organisation
11. = increases in the overhead costs
12. = political influences
13. = other unfair influences
14. = communication delays
15. = unhealthy relationship between employers and employees
16. = lack of technology
17. = fewer workers
18. = changes in the crew
19. = inspection delay
20. = natural problems due to climatic conditions