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**PARETO ANALYSIS OF ON-  
SITE PRODUCTIVITY  
CONSTRAINTS AND  
IMPROVEMENT  
TECHNIQUES IN NEW  
ZEALAND BUILDING  
INDUSTRY**

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2011

**PARETO ANALYSIS OF ON-SITE  
PRODUCTIVITY CONSTRAINTS AND  
IMPROVEMENT TECHNIQUES IN NEW  
ZEALAND BUILDING INDUSTRY**

A thesis presented in partial fulfillment of the requirements for  
the degree of

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of

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School of Engineering and Advanced Technology

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Massey University at Albany

New Zealand

Serdar Durdyev

2011

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## **ABSTRACT**

The steady decline in labour productivity in the New Zealand construction sector is a result of internal and external factors, which constrain the achievement of set project objectives. The main objective of this thesis is to identify the key constraints to on-site construction labour productivity based on the views of project managers, contractors and subcontractors in the New Zealand building industry. Qualitative data collected through pilot interviews formed the basis for questionnaire surveys conducted among the target populations.

Multi-attribute methods were used in the analysis of the empirical data while the Spearman's rank correlation test was used for the tests of the research propositions/hypotheses. To test the robustness of the results of the questionnaire surveys, confirmatory interviews were conducted among members of target populations, who did not participate in the earlier surveys.

Feedback from the pilot interviews revealed 56 onsite labour productivity constraint factors, which were grouped under eight broad categories: project finance, workforce, technology/process, project characteristics, project management, statutory compliance, unforeseen events, and other external forces. The first five broad categories comprise the internal constraints, while the last three were the external constraints.

Results of the analysed questionnaire surveys showed that reworks, level of skill and experience of the workforce, adequacy of method of construction, buildability issues, supervision and coordination were the most significant internal constraint factors. Among the external constraints, the Resource Management Act, ground conditions, market conditions and level of competition in the industry were found to be the most influential sub-factors affecting construction productivity in the New Zealand building industry. Project management, workforce issues and project finance were the most significant broad categories having an impact on construction productivity. Recommendations for improving onsite labour productivity in the New Zealand construction industry were made which included use of quality management systems, early involvement of specialist trades, workforce skill improvement and motivation, and effective site layout.

**Keywords:** Construction industry, On-site productivity constraints, Pareto analysis, productivity, productivity improvement.

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# STATEMENTS OF ORIGINALITY



## STATEMENT OF ORIGINALITY

### (MASTER OF CONSTRUCTION MANAGEMENT) THESIS

**TITLE: PARETO ANALYSIS OF ON-SITE PRODUCTIVITY CONSTRAINTS  
AND IMPROVEMENT TECHNIQUES IN NEW ZEALAND BUILDING  
INDUSTRY**

I declare that the above thesis is my own original work. It has not been submitted elsewhere for assessment.

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# **CHAPTER 1: INTRODUCTION**

## **1.1 Overview**

The purpose of this chapter is to provide a brief introduction to the background issues that informed the need for this study, the problems the study aims to solve, the key objectives to be achieved, the propositions postulated to guide the search for data and the method of analysis to be adopted, and the scope and limitations of the study. The chapter also highlights the importance of the research findings and the structure of the report.

## **1.2 Background**

Productivity enables an organisation to be competitive, achieve set goals, meet stakeholder value propositions and maintain strategic and financial health. At the industry level, productivity enables the sector to maintain satisfied clientele, attract investment, remain viable and contribute to the economic growth and well-being of the nation. For instance, the Department of Housing (DBH, 2008) observes that the level of activity and the productivity of the building and construction sector underpin the New Zealand's economic recovery and growth, adding that "what happens in the building and construction sector has a 'multiplier effect' on the wider economy" (p. 6). Improvement in the productivity of the New Zealand construction industry is therefore of critical importance considering its \$388 billion worth of current building stock, excluding land (CSG, 2010) and its significant contribution - of approximately 5 percent - to the GDP (DBH, 2008).

It is against this background that the Report of the Building and Construction Sector Productivity Taskforce (BCSPT) (DBH, 2009, p. 2) stating that "productivity, especially labour productivity has been disappointing and is limiting the sector's ability to respond positively to change", should be considered with seriousness. The Report re-echoes the urgent need to address this worrisome development by asserting that "the performance and productivity of the sector is critical for the overall performance of the New Zealand economy". In an earlier study, Duncan (2002, p. 1) concludes that, "an improvement in the 'efficiency' of the building and construction sector – defined as a reduction in the cost of work put in place – will have a positive effect on every other sector, and consequently on the national economy".

Sufficient evidence suggests that on-site productivity measurements should be the basis for making productivity improvement decisions (Carlos and Paul, 2010; McCullouch, 2007; Oglesby et al., 1989). This study will focus on on-site labour productivity constraints, since addressing these constraints will provide a much-needed improvement in the productivity and performance of the industry.

### **1.3 Research Problem**

A study of the factors constraining onsite labour productivity in the construction industry is not new. Several studies have been carried out on this issue both in New Zealand and overseas such as Black et al. (2003), Abdul Kadir et al. (2005), Alinaitwe et al. (2007) and Davis (2007), to mention but a few. However, the previous studies merely provided a list of constraint factors without some form of prioritization and proper segregation into controllable and uncontrollable categories. Stakeholders in the construction industry are overwhelmed by the enormity of the constraint factors presented. Given that the resources available for addressing the identified constraint factors are limited, there is therefore a crucial need for a deeper level of analysis to identify the priority factors which the stakeholders should focus on in order to optimize use of scarce resources and achieve the greatest improvement in productivity and performance. This study aims to fill this gap in the literature by not only investigating the onsite productivity constraint factors unique to the New Zealand construction industry but also analyzing their relative levels of impact with a view to identifying the key factors that are worthy of closer attention and resourcing. In doing this, the study falls back on the Pareto principle or the '80/20' rule, which assumes that 80% of the problems associated with any given phenomenon arise from 20% of the causes (Haughey, 2011; Karuppusami and Gandhinathan, 2006). The crucial question this study aims to address is therefore, "what are the 20% constraint factors responsible for 80% of the onsite labour productivity problems in the New Zealand construction industry?". The study will also address the question on the key mitigation measures for addressing the identified key constraints.

### **1.4 Objectives**

Specifically, the study aims to achieve the following objectives:

1. To establish the key constraints to on-site construction labour productivity and evaluate their relative levels of impact in the New Zealand building industry.

2. To identify the 20 percent of the constraints responsible for 80 percent of the productivity problems.
3. To explore innovative ways of improving on-site labour productivity in the industry.

### **1.5 Importance of the Research Findings**

The research findings would provide the critical onsite labour productivity constraints which project managers, contractors and other stakeholders could focus on in order to achieve the greatest improvement in onsite productivity and performance in the New Zealand building industry. This way, resources could be optimally disbursed to addressing the few causes responsible for the significant portion of the productivity issues.

### **1.6 Research Propositions**

The following propositions provided directions for the research design, data gathering and data analysis with a view to meeting the research objectives.

1. There is no difference between consultants' and contractors' ratings of the relative levels of impact in terms of broad categories of internal and external constraints.
2. Twenty percent of the causes of onsite labour productivity in New Zealand are responsible for eighty percent of the productivity problems.
3. The application of technology represents the most significant way of improving on-site productivity in the New Zealand construction industry.

### **1.7 Scope and Limitations**

The study was limited to the views expressed by project management consultants, contractors and subcontractors in the 3 major cities of New Zealand: Auckland, Wellington and Christchurch. The original intention at the quantitative survey stage was to use random stratified sampling techniques to collect representative samples from the three sampling frames comprising the membership directories of the three groupings of respondents targeted in the study namely, the Association for Consulting Engineers New Zealand Inc (ACENZ), the New Zealand Contractors' Federation (NZCF) and the New Zealand Specialist Trade Contractors Federation (NZSTCF). However, it was not possible to obtain the membership directories due to privacy concerns. The researchers

therefore resorted to the use of online search engines and the Yellow Pages to obtain a list of contacts.

The study focuses on onsite labour productivity issues, which though are known to be major indicators of overall productivity (Carlos and Paul, 2010; McCullouch, 2007; Oglesby et al., 1989), are only part of the productivity issues in the procurement process from design, through planning and construction to maintenance of the procured facility. The study is therefore limited in terms of covering all aspects of construction productivity which ought to have been taken into consideration in order to identify overall constraints to construction productivity and improvement techniques. Also, owing to constraints of time and a range of logistic issues, other key stakeholders' views such as employers, architects and engineers, were not captured in the study. These are issues for further investigations.

## **1.8 Structure of the Thesis**

The thesis report comprises five chapters as shown in Figure 1

Highlighting the background of this thesis, Chapter 1 is the Introduction, which consists of a statement of research problem, key objectives, importance of the findings, research propositions along with scope and limitations.

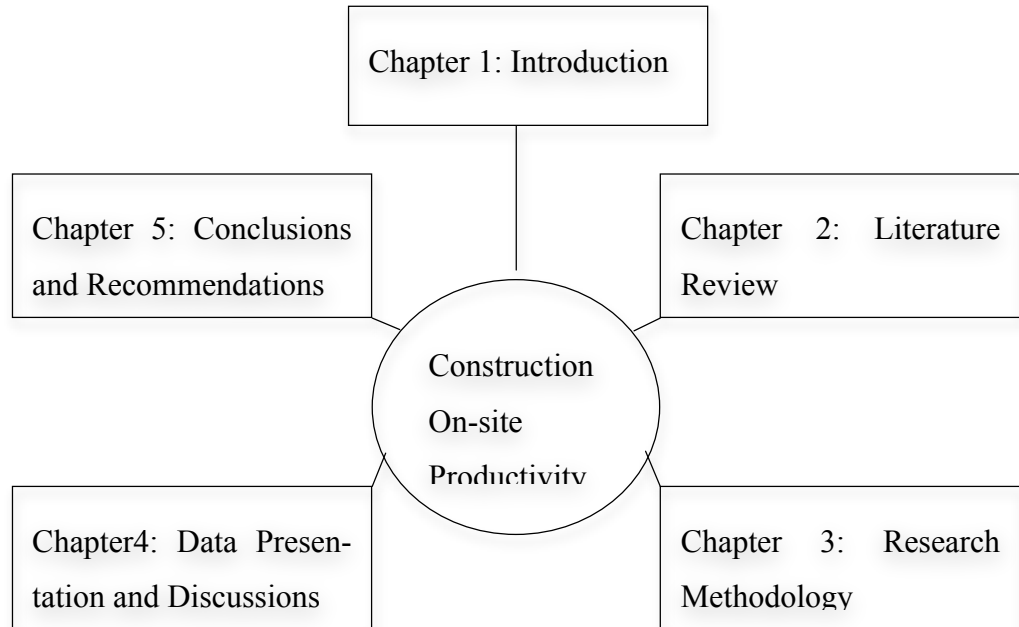
In Chapter 2, an analysis of an extensive literature review is outlined. This chapter investigates the current stand about the subject and the degree to which the objectives of this research have been addressed in part in previous studies.

Chapter 3 details the research methodology which was conducted during this study. The key elements of the methodology are the overall research strategy adopted, the data-gathering instruments used, and the methods employed in data analyses. A compliance with Massey University's Code of Research Ethics and the approval from Massey University Human Ethics Committee for undertaking this research were also included in this chapter.

Chapter 4 is for the presentation, analysis and discussions about the data obtained from the questionnaire administration. To produce the parameters to test the research propositions, preliminary analysis was conducted on the data. The results of the analyses which delineate the factors constraining construction on-site productivity, are discussed in relation to the research objectives with or divergence from related literature.

Conclusion from the findings of this research was outlined in Chapter 5 along with the recommendations about productivity improvement and about further studies.

Figure 1: Thesis layout (Self Constructed)



## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 Overview**

This chapter introduces the key concepts underpinning the study in the research context. It partly provides answers to the research objectives as gleaned from the literature. Specifically, it provides brief explanations of the key concepts embodied in the topic, such as productivity in general, productivity issues specific to the New Zealand construction industry, Pareto analysis, on-site productivity and some approaches used in the measurement of productivity. The chapter ends with a summary on the extent to which the research objectives have been accomplished in earlier studies, as well as the gaps that exist and how the study aims to contribute to filling them.

### **2.2 Introduction to Productivity**

#### **2.2.1 Productivity in Context**

The term productivity has different meanings for different people, which was formally defined by the Organisation for European Cooperation as “ the quotient obtained by dividing output by one of the factors of production. Or, in another words, “The same as efficiency, which is defined as the ratio output energy divided by input energy” (Harris and McCaffer 2006).

This study is not focused on defining productivity, but on the key productivity constraints in the New Zealand context. However, to move ahead, the research thrust is to be anchored on a contextual interpretation of productivity.

Generally, productivity is a measure of how well resources are leveraged to achieve set objectives or desired outputs. It emphasizes creativity and innovativeness, which target achieving more output with fewer resources by re-engineering the production or service delivery process and optimising the resource leverage. Productivity is a complex concept that could be interpreted in varied contexts depending on the objectives sought; the objectives in turn determine the measures to be employed in its assessment in relation to the benchmark used for its comparison. This benchmark is critical because productivity outcome in itself is meaningless unless it can be compared to a standard. The comparison could be intra-entity (i.e. comparing productivity outcomes within a given entity across a time period with a view to gaining insights into the implicit trend) it could also be inter-entities, comparing productivity outcomes across similar entities

with a view to determining the relative levels of productivity of the entities at a snapshot in time or across a time horizon.

The objectives to be achieved, the resources employed, the measures adopted and the benchmarks used for comparison give rise to different definitions of or perspectives on productivity. Whatever the definition or perspective taken, the common thread in all definitions or contextual interpretations relate to:

- Effectiveness: how effective is the leveraging of the resources to achieve the set objectives? E.g., a system can be judged productive in an effectiveness context, if the objectives are achieved through resource leverage;
- Efficiency: in achieving the set objectives, how efficient was the utilization of scarce resources in the implementation process?

Using cost as the denominator in the efficiency measure of productivity, both dimensions of effectiveness and efficiency can be combined in one coinage to represent productivity: ‘cost-effectiveness’; cost in this context refers to the optimisation of the use of scarce resources, while effectiveness refers to the achievement of the set objectives. ‘Cost-effectiveness’ as an indicator of productivity therefore targets maximising the extent of achievement of the set objectives while minimising the scarce resources employed in the process. This perspective has given rise to several buzzwords such as ‘lean production’ (which targets waste reduction as a means of optimising the use of resources), Total Quality Management (TQM which targets achieving value through a total re-engineering of the production process rather than ad-hoc quality assurance measures), and value management (which targets maximising utility output, while minimising the resources expended in the process). Overall, an operational definition of productivity that fits well with the various approaches to defining the concept - and which draws upon the output-input paradigm - is ‘the amount or quantity of output of a process per unit of resource input’. This aligns with similar definitions by Page (2010) and other authors. Equation 1 summarises the key features embodied in this definition.

$$\text{Productivity} = \frac{\text{Amount or Quantity of Output}}{\text{Resource Input}} \tag{1}$$

The nature of the resource input or combination of inputs also informs the type of productivity and the measures used to evaluate it as shown in Equation 1. Thus, labour productivity refers to the amount or quantity of work output (i.e. quantity or dollar value of products, service or revenue generated) per unit of man-hours employed. Machine productivity can also be defined in the same way, with the measure being output per machine-hour. In some instances, both labour and machine could be combined as one resource input known as ‘equipped labour’. Capital productivity is the amount or quantity of output per dollar capital input. An overall measure of productivity looks at the total output versus total input expressed in the units of the benchmark; alternatively, an indexed overall measure of productivity expresses the output and input in common units.

### 2.2.2 Measuring Productivity

Davis (2007) argues that “most measurements of productivity in New Zealand are made at the aggregate (whole economy) level. There are no official measures of industry productivity within New Zealand and only a few studies that estimate industry-level productivity” (p.11).

Ideally, the measure of overall productivity can be required at any of five levels: national, industry, organisational, project and resource levels.

#### *Measures of productivity at the national level - GDP*

At the national level, the economic perspective of productivity is used, which targets contribution towards the Gross Domestic Product (GDP) as an indicator of economic well-being, growth, development and living standards.

Sullivan and Sheffrin (1996) define the gross domestic product (GDP) or the gross domestic income (GDI) as a measure of a country's overall economic output, evaluated as the market value of all final goods and services produced within a country in a given year. The World Bank (2010) provides three approaches to determining the GDP, all of which produce the same result: they are the product (or output), income, and expenditure approaches. The product or output approach evaluates GDP by summing the national outputs in a given year. The expenditure approach sums the total amount of consumption, investment, government spending and net exports in a given year. The nominal or ordinary GDP figure is adjusted for inflation and changes in population relative to the figures for the base year to obtain the real, or constant, GDP per capita. This is used to compare the real GDP growth rate relative to the figures for a base year or to other countries' outputs.

#### *Measures of productivity at the industry level*

At the industry level, the output-input approach is used to measure productivity as the total market value of products and services produced by the industry divided by the number of workers employed within the industry. A more holistic approach looks at the total market value of products and services per unit cost of resource inputs, which includes not only labour, but also capital, machinery, materials, etc. However, the former aligns with the measure used at the national level (i.e. GDP per capita); this also helps to track the contributions of the various industries or sectors to national productivity in any given year.

#### *Measures of productivity at the organisation level*

At this level, productivity is measured according to the objectives of owners or by the management. In terms of the owners, the rate of return on investment, or capital growth, may be the measure of productivity. To the management, productivity may be a measure of how well resources have been leveraged to deliver value in one or more of three ways: 1) developing competencies and competitive advantage; 2) delivering stakeholder value; and 3) seizing opportunities for creating new value in future.

The balance score-card concept developed by Kaplan and Norton (1992) provides a tool for a holistic evaluation of productivity at the level of the organisation. An adaptation of this provides managers with information from four different perspectives which drive overall performance improvement:

- The *financial perspective* focuses on value creation for owners using financial metrics such as the return on investment (ROI).
- The *external perspective* focuses on the customer/client, the community/public, the environment, and business partners. Regarding customers, the focus is on the organisation's relationships with these valued assets including its ability to build and retain satisfied clients. For the community angle, the emphasis is on corporate social responsibility including the adoption of ethically sound and environmentally sustainable business practices. With partners (i.e. suppliers, financiers, insurers, business, etc) the emphasis is on trust, ethical conduct and responsiveness to obligations.
- The *internal perspective* focuses on employees and the operations or processes; the emphasis here is on the organisation's success at developing and keeping qualified and motivated staff. It also examines the internal operations of the organisation and seeks to achieve higher levels of efficiency and effectiveness through innovation and technology.
- The *future perspective* assesses the firm's ability to innovate and learn, and questions whether it can continue to improve and create value.

#### *Measures of productivity at the project level*

At the level of the individual projects executed by an organisation such as a construction company or consulting firm, emphasis is placed on the achievement of the three key project objectives - time, cost and quality targets. The measure of productivity at this level ought to be how well the targets set for those three objectives are achieved by the deployment of company resources (manpower, machinery, money and materials), using the process or method adopted for the project, while complying with the requirements of the statutory/regulatory environment within which the project is carried out. However, to align this with productivity measures at other levels, the project level measurement may focus on the dollar value of the project per unit cost of the resource inputs.

#### *Relationship between the measures of productivity*

This study argues that a relationship exists amongst the measures of productivity at the levels highlighted above: by consistently meeting the productivity measures at the project levels, an organisation is able to satisfy its customers or clients, achieve repeat purchase and gain market share relative to competitors. This in turn empowers the

organisation to meet the productivity measures at the organisation level; namely, satisfying the stakeholder value propositions. If several organisations within the industry are doing well at the organisation level, this will ensure more satisfied clientele; and what this does is to attract more investment into the industry thereby improving productivity at the industry level. This in turn feeds into the national productivity stream.

#### *Modified concept of productivity at the project level*

Being mindful of the relationship amongst the productivity measures highlighted above, the project level definition of productivity suited to this study is a slightly modified form of Equation 1, focussed on individual projects. The operational definition of productivity in this context is given in Equation 2 as an overall index value:

$$\text{Productivity} = \frac{\text{Total value of project(s)}}{\text{Total costs of resource}} \quad (2)$$

The productivity index value achieved using Equation 2 above for each project, or for a number of projects executed by an organisation in a year, can be aggregated to provide an organisation's productivity index value (OPI). At the industry level, all OPI values could be aggregated to provide the industry productivity index value (IPI). These could be monitored consecutively over a period to see how the productivity levels change over time relative to the figure for a base year, with adjustments for inflation and changes in the workforce population.

### **2.2.3 Key Thrust of the Research**

As highlighted before, the thrust of this study is on the key productivity constraints in the New Zealand construction industry. In order to put the study in context, operational definitions of productivity were attempted. However, the common operational definitions or interpretations of productivity given above focus on the efficiency limb of productivity and are silent on the effectiveness limb; the latter being focused on the achievement of set objectives. The objective-oriented effectiveness view provides measures which industry operators can use to measure performance and improve on productivity.

Figure 2 provides a holistic model of the concept of productivity at the individual project level. This is adopted in this study as it captures the two sides of productivity and the relationship among the productivity constraints – the key focus of the study. The

effectiveness side focuses on measuring performance as the achievement of the key project objectives: quality, schedule and cost targets. This approach provides a useful framework for industry operators to check those outputs on a project or group of projects with a view to enhancing performance. However, the efficiency side, which focuses on the optimisation of resource utilization, is equally important; since this is the approach adopted at the national level.

It should be noted that the cost performance measure of effectiveness also satisfies the investigation of efficiency, since the extent to which the cost target is achieved in a project is a measure of efficiency in the utilization of the resource input. In this context, the cost performance ought to obviate the need for the latter. However, the unit of measurement of the cost performance may not align with the unit for the national productivity evaluation (i.e. GDP per capita).

Ideally, overall performance at the level of individual project or group of projects can be operationally defined as in Equation 3.

$$\text{Performance} = \text{Schedule}_{\text{perf}} + \text{Cost}_{\text{perf}} + \text{Quality}_{\text{perf}} + \text{ConstraintMgt}_{\text{perf}} \quad (3)$$

Where:

$\text{Schedule}_{\text{perf}}$  = performance related to schedule, measured as scheduled completion time / Actual completion time;

$\text{Cost}_{\text{perf}}$  = performance related to budget, measured as cost target / Actual costs incurred;

$\text{Quality}_{\text{perf}}$  = performance related to quality target, measured as the quality level achieved relative to the quality target; this is subjectively or qualitatively determined using a rating system (involving quality rating by the client or client representative on the project).

$\text{ConstraintMgt}_{\text{perf}}$  = performance related to how well the internal and external constraints to the achievement of the project objectives are managed.

This will also be subjectively or qualitatively determined using a rating system. The constraints include relationship management with the client and other service providers involved in the project; the indicators here will include incidences of disputes, adjudications or litigations amongst parties involved in the project, etc. Other constraints include statutory compliance (e.g. compliance with Health & Safety,

environmental laws, by-laws, etc); the indicators will be records of incidences of breach of the laws, penalties and prosecutions. Additional constraints will be discovered during the empirical investigations.

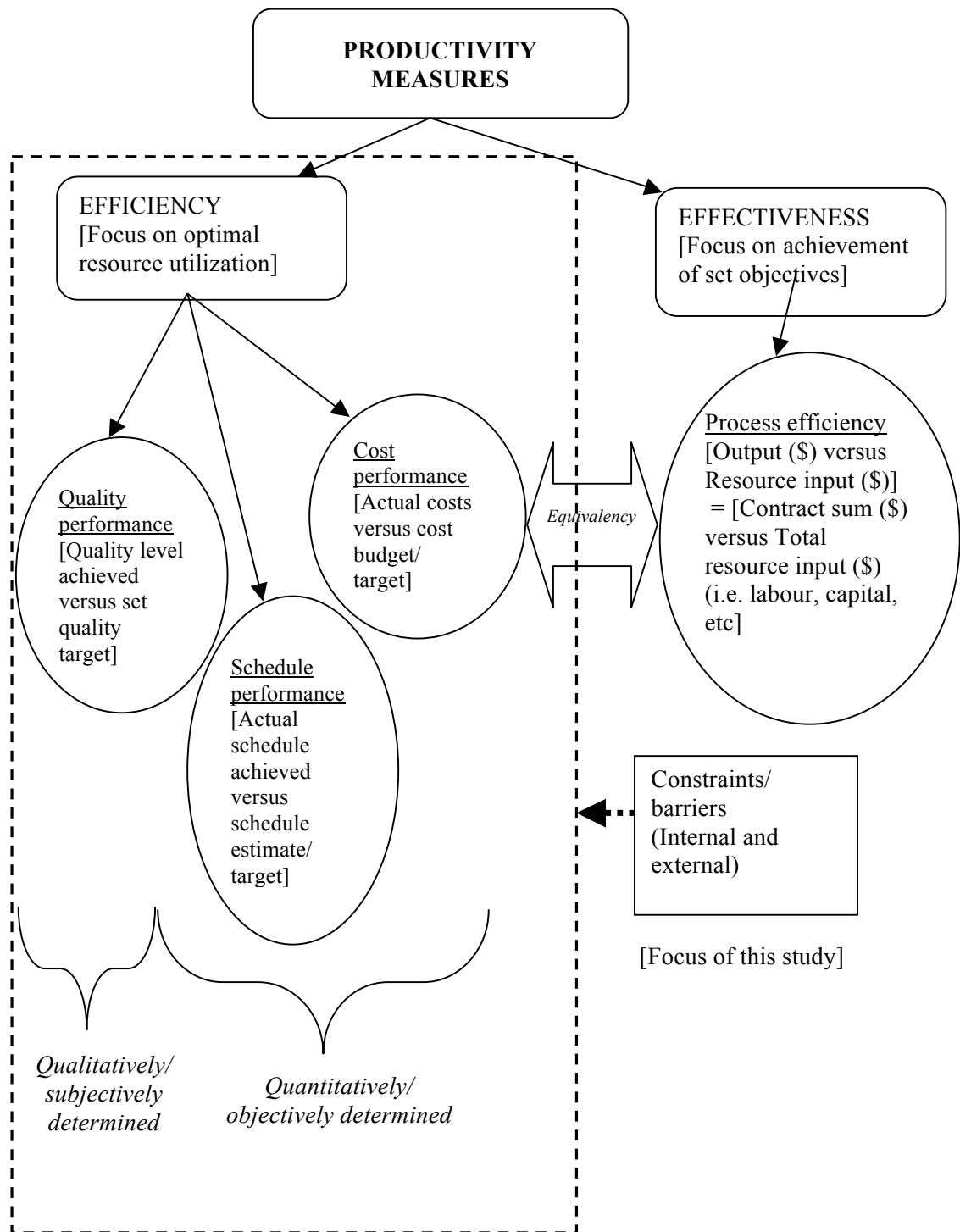


Figure 2: Model of holistic measures of productivity showing relationship with internal and external constraints focused on in this study

#### **2.2.4 Model of the Productivity Constraints**

Building on the understanding of productivity as depicted by Figure 2, Figure 3 provides a holistic model of the internal and external productivity constraints at the individual project level. In this context, a global framework for looking at the external constraints is PESTELI (the Political, Economic, Socio-cultural, TEchnology, Legal/political and Industrial constraints). The internal sources may be looked at from the perspective of the 6 Ms of the business process improvement (Prasad, 1999): Money/finance, Manpower, Management (or supervision of the workforce), Machinery, Materials and Method/process. However, this study focuses on the on-site aspects of the productivity constraints as empirically established from the feedback of consultants and contractors in the industry, drawing on their rich practical experience. Preliminary investigations involving interactions with industry operators provided leads to applicable on-site constraints in the New Zealand construction industry. These constraints are modelled in Figure 4, which graphically presents a proposition put forward in the study to guide inquiry. The model will be modified based on empirical findings.

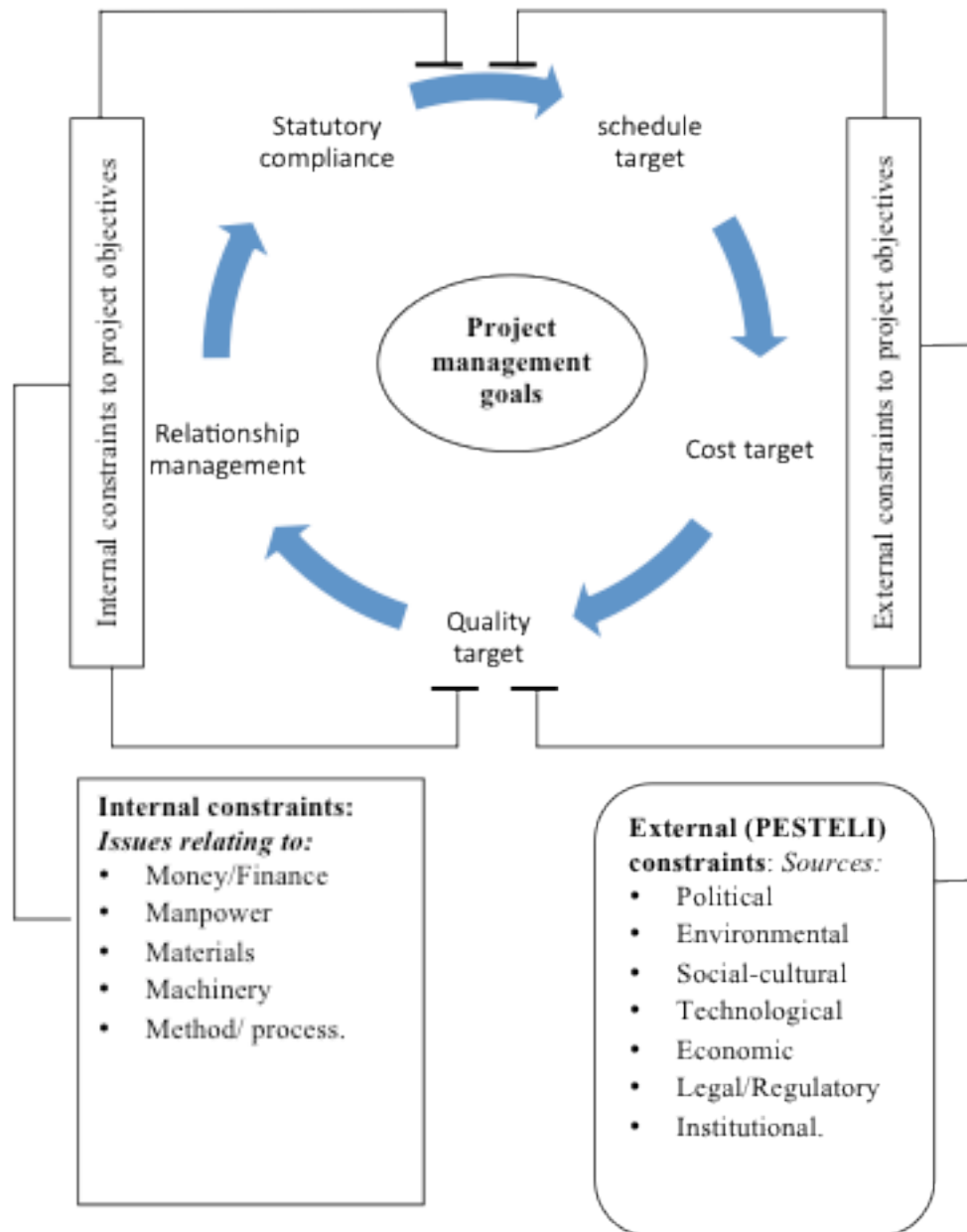


Figure 3: Holistic model of the project productivity constraints

### 2.2.5 Productivity in the New Zealand Construction Industry

A number of studies and reports have attempted to deal with the issue of labour productivity in the New Zealand building industry. Black et al. (2003) established a productivity series for national economy between 1988 and 2002. As is shown in the results of this study, demonstrated in Table 1, the multifactor productivity growth in the construction sector was worse than in other sectors. MFP of the construction industry declined by an average of 1.5% per annum from 1988 to 2002, while the average growth of MFP of the aggregate economy was calculated as 0.88% per annum. By 2002

there was a significant decline, when MFP in the construction sector was almost 20% lower than in 1988.

Table 1: Average Multifactor Productivity Growth by Industry

<b>March Year</b>	<b>Primary</b>	<b>Mining and Quarrying</b>	<b>Construction</b>	<b>Manufacturing</b>	<b>Electricity, gas and water</b>
<b>1988 to 1993</b>	-0.52%	-1.91%	-4.59%	0.29%	1.11%
<b>1993 to 2002</b>	2.45%	0.72%	0.25%	-0.16%	-0.93%
<b>1988 to 2002</b>	1.38%	-0.23%	-1.51%	0.00%	-0.21%
	<b>Transport and Communications</b>	<b>Business and property services</b>	<b>Personal and community services</b>	<b>Retail and Wholesale trade</b>	
<b>1988 to 1993</b>	6.75%	-2.54%	0.82%	-0.38%	
<b>1993 to 2002</b>	5.52%	0.74%	1.48%	1.40%	
<b>1988 to 2002</b>	5.96%	-0.44%	1.24%	0.76%	

Source: BGM (2003)

Table 2 represents the findings of Law and McLellan (2005), where they studied on the average labour productivity of entering, exiting and continuing firms from 1995 to 2003.

Table 2: Average labour productivity of entering, exiting and continuing firms by industry, 1995 – 2003

<b>Industry</b>	<b>Continuing</b>	<b>Entering</b>	<b>Exiting</b>
Mining & quarrying	207	-28	201
Manufacturing	91	62	79
Electricity, gas and water	439	320	142
Construction	61	62	61
Wholesale and Retail trade	81	35	40
Transport, shortage and Communications	200	126	113
Business services	99	93	98
Personal and community services	75	52	68
<b>Aggregate</b>	<b>100</b>	<b>64</b>	<b>68</b>

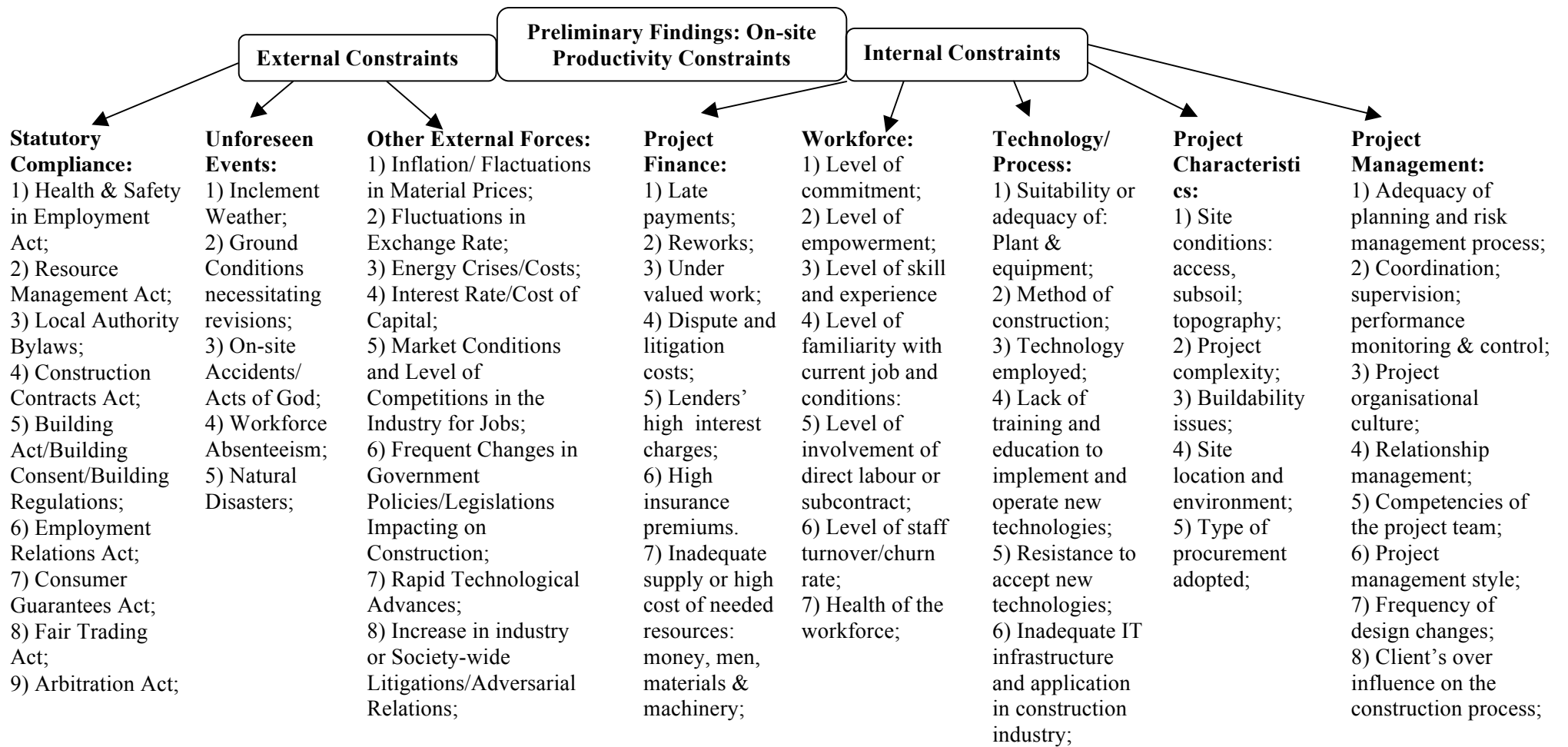
Source: L&M (2005)

There are also some estimations on construction sector productivity, such as Law et al. (2006), Mason and Osborne (2007) and the report of the Department of Building and Housing (DBH) of New Zealand. The discussion shows construction productivity in light of a hopeless picture during 1988 and 2006, when the overall view was one of poor productivity levels in the sector.

Furthermore, according to the report of the Building and Construction Sector Productivity Taskforce (DBH, 2009), productivity growth in New Zealand, particularly labour productivity, has been disappointing and is limiting sector ability to respond positively to change.

Overall, this study is motivated by the reports of the declining rate of productivity in the building and construction sector relative to the other sectors in New Zealand and the need to contribute to finding a solution to the problem by investigating the key on-site productivity constraints and their mitigation measures.

Figure 4: Proposed model of on-site project productivity constraints



### **2.2.6 Factors Influencing Construction Productivity**

It is necessary to establish whether factors affecting construction productivity act in a positive or negative way (Enshassi 2007). If all factors having an impact on productivity are identified, it will also be possible to forecast productivity (Lema 1995). Several studies have been undertaken to identify the most significant factors influencing construction productivity. For instance, Wilkinson and Scofield (2010) identify the choice of procurement system as having significant impact on the achievement of time, cost and quality targets for a project. Mbachu and Nkado (2007) identify factors relating to the acts of commission and omission of the key role-players including clients, consultants and contractors, as well as project characteristics and external factors. The BCSPT report (DBH 2009) put emphasis on the sector-wide skill shortage, approach to procurement of construction projects, and the lack of innovation in certain segments of the construction sector, (for example in building materials) and the influence of regulations, as factors of low productivity growth in the New Zealand building and construction industry between 1997 and 2008.

Enshassi (2007) classified factors affecting labour productivity into 10 groups: manpower, leadership, motivation, time, materials/tools, supervision, project, safety, quality and external factors. On the other hand Kazaz *et al.* (2008) identify sub-factors influencing construction labour productivity under 4 main headings, which are Organizational, Economic, Physical and Socio-psychological factors.

Sufficient studies exist to suggest that construction on-site productivity measurement should be the basis for decisions to improve productivity (Carlos and Paul, 2010; McCullough, 2007). With reference to those studies we can understand that on-site productivity factors have critical importance as they contribute the bulk of the sources of productivity constraints in the construction sector.

Ng *et al.* (2003) put emphasis on several predominant demotivators affecting productivity of civil engineering projects, which are rework, overcrowded work areas, crew interfacing, tool availability, inspection delays, material availability and foreman incompetence. Mojahed and Aghazadeh (2007) found major productivity factors which have an impact on labour productivity. The top five are skills and experience of the workforce, management, job planning, motivation, and material availability.

Alinaitwe *et al.* (2007) administered questionnaires to 137 contractors to identify the most important factors by ranking them according to time, cost, quality and a combined importance index. The five most significant factors were: incompetent supervisors, lack of skills among the workers, rework, lack of tools/equipment and poor construction methods.

Kaming *et al.* (1997) observed 243 craftsmen (bricklayers, carpenters, steel fixers, craftsmen) during a survey to investigate factors influencing craftsmen's productivity. The main problems were ranked as lack of materials, rework, absenteeism and interference.

Ovararin (2001) subsequently conducted a comprehensive literature review on the factors that influence labour productivity on construction sites. That study resulted in his categorizing the influencing factors into seven main areas: a) project; b) management organization; c) site and resource management; d) labour and moral values; e) acceleration; f) changes; and g) external environment. An analytical study was done on these categories, and it was discovered that 13 factors impart a strong influence towards labour productivity rates at construction sites in the United States of America. They are: i) work planning and scheduling; ii) competency of site supervisors; iii) availability of construction materials; iv) workforce availability; v) work sequence; vi) congestion; vii) repetition of similar work; viii) communication failure; ix) sub-contractor coordination; x) unpredictable weather conditions; xi) access to work sites; xii) scheduling of overtime works; and xiii) disruption to the workforce on construction sites. In short, labour productivity on work sites is influenced by various factors that are internal and external in nature (Zakeri *et al.*, 1996).

Thus, a literature review as depicted in Table 3 has been carried out as the basis for the efforts to identify the main factors that influence labour productivity.

Table 3: The factors influencing Labour Productivity

Factors Influencing Construction	Kaming et al. (1997)	Makulsawtudo m et al. (2004)	Kazaz et al. (2008)	Mojahed and Aghazadeh (2007)	Ng et al. (2003)	Alhnaive et al. (2007)	Abdul Kadir et al. (2005)	Halligan et al. (1994)	Thomas and Sakarcan (1994)	Lim and Alum (1995)	Zakeri et al. (1996)	Kaming et al. (1998)	Ovararin (2001)	Park (2002)	Rojas and Aramvareekul (2003)
On-time/Late payments;			x												
Reworks;	x	x			x	x	x		x		x	x	x	x	
Motivation;				x											
Level of skills and experience of the workforce				x		x		x							
Method of Construction;						x									
Technology;															
Site Conditions;		x				x									
Project Management				x											
Project Complexity;						x									
Buildability issues;							x								
Supervision or Supervision Delays;	x		x												
Design Changes/Change Orders;		x				x	x								
Inclement Weather;		x	x			x	x	x	x	x	x		x	x	x
Ground Conditions;															
Workforce Absenteeism;	x	x				x				x	x				
Material Availability;	x	x		x	x	x	x	x	x		x	x	x	x	x
Health of the Workforce;						x									

Accidents at Work Sites;						x	x								
Working Overtime;			x			x		x							
Interference;	x														
Incomplete Drawing;		x				x									
Poor Communication;		x				x									
Overcrowding;															
Poor Site Layout;		x	x												
Lack of Tools;	x	x			x	x			x		x	x		x	x
Lack of Coordination;							x								
Fluctuations in Exchange Rates;							x								
Interest Rates;							x								
Professionalism of Design team;											x			x	x
The level of management control;														x	x
Work planning and scheduling;								x	x				x	x	x
Incompetence of site supervisors;								x	x		x	x	x	x	x
Method and Machinery (including impairment);											x	x			x
Financial problems (payment to suppliers);															x
Sequence of work;								x	x				x	x	x
Project characteristics;									x						x
Current economic condition;															x
Congestion;								x	x			x	x	x	x

### **2.3 Pareto Analysis**

As has been mentioned, this study aims to establish key construction on-site productivity constraints based on the Pareto principle, which provides rational grounds for optimum disbursement of resources to addressing the 20 percent of the factors causing 80 percent of the productivity problems.

Haughey (2006) defines Pareto analysis as a statistical technique in decision-making that is used for the selection of a limited number of tasks that produce significant overall effect. It uses the principle that by focusing on the most crucial 20% of the causes of a problem, 80% of improvement can be achieved in the process. Karuppusami and Gandhinathan (2006) provide insights into the application of the concept by defining it as a quality control tool that rank-orders the data classifications from the highest to the lowest frequencies of occurrence or magnitude, with the ‘vital few’ items occupying a substantial amount or 80% of cumulative percentage of occurrences or impact, while the ‘useful many’ occupy only the remaining 20 percent (p.376).

As a formal technique it is useful where many possible courses of action are competing for one’s attention. It consists of estimating the benefit delivered by each action with subsequent selection of a number of the most effective actions that deliver a total benefit reasonably close to the maximal.

Operational procedure for the application of the technique involves the following steps (Wikipedia, 2011)

- 1: Form a table listing the causes along with their frequency as a percentage.
- 2: Arrange the rows in decreasing order of importance.
- 3: Add a cumulative percentage column to the table.
- 4: Plot a graph with causes on the  $x$ - and cumulative percentage on the  $y$ -axis.
- 5: Join the points to form a curve.
- 6: Draw line at 80% on the  $y$ -axis parallel to the  $x$ -axis. Then drop a line from its point of intersection with the curve, to the  $x$ -axis. This point on the  $x$ -axis separates the important causes and trivial causes.

### **2.4 Summary of Literature Review**

The reviewed literature has provided insights into the current trends and thinking in the field of construction productivity. In addition, related works of researchers in the past

have been studied with a view to identifying gaps in the literature which the current study may contribute to filling.

In relation to the research objectives, the reviews have provided part-answers as proffered by researchers in the past, as follows.

#### *Findings in relation to the objectives*

The first objective of the study is to establish the key constraints to on-site construction labour productivity in the New Zealand building industry. Preliminary findings from the literature review are categorized under eight broad categories, which are project finance, workforce, technology/process, project characteristics, project management, statutory compliance, unforeseen events and other external forces. These findings, pre-tested by selected members of the target populations for the study, established the relevance of the identified constraints to the New Zealand building industry and ensured a meaningful and clear research instrument that generates good responses.

In addition, the study evaluates the relative levels of impact of the constraints with a view to identifying the 20 percent of the constraints responsible for 80 percent of the productivity risks based on the Pareto principle.

#### *Gap in the literature*

While past studies have identified various factors affecting productivity at all levels of the construction industry, the factors are not ranked in terms of their relative levels of impact on productivity. Such prioritisation is important because it would enable the project team to leverage the limited resources at their disposal to address those factors that have higher impact on productivity. This study aims to contribute to filling this gap.

## **CHAPTER 3: RESEARCH METHODOLOGY**

### **3.1 Overview**

The objective of this chapter is to discuss the research methodology adopted in this study. A flowchart of the research is presented, which shows the steps used in carrying out the research project from conception to completion. Information about data gathering and the statistical methods used to analyze the data are also provided. The research programme shows the schedule for the tasks which provided baseline for monitoring progress. Finally, compliance with ethical requirements connected with the research is highlighted.

### **3.2 Research Design**

'Research design' refers to the plan or organization of scientific investigation. Designing a research study involves the development of a plan or strategy that will guide the collection and analyses of data (Poilt and Hungler, 1985).

As mentioned in the research proposal, the research methodology adopted in this study is the descriptive survey method comprising qualitative data gathering through pilot interviews and quantitative data gathering through questionnaire surveys. The questionnaires were structured by using the constructs sourced from the relevant literature, but with open-ended sections for further input by participants.

First, a database of 162 experienced and high-ranking project managers, directors of contracting and subcontracting firms were compiled from the Yellow Pages in the three main cities of Auckland, Wellington and Christchurch. This approach was taken after attempts to obtain the membership directories of the NZIOB, RMBF and the New Zealand Specialist Trades Confederation Inc. (NZSTCI) failed due to concerns about the Privacy Act. Nevertheless the approach adopted enabled compilation of lists of potential interviewees and respondents who were best positioned to give authoritative feedback on the subject matter on account of their experience and official designations.

#### *Qualitative surveys*

Six pilot interviews were conducted in Auckland – two interviewees each from among the project managers, contractors and subcontractors – to identify the productivity constraints in the New Zealand construction industry and to evaluate the relevance of additional insights gained from the literature to the New Zealand context. The

constructs generated during the pilot interviews were used to design a structured but open-ended questionnaire which was pre-tested with 4 interviewees – 2 project managers, 1 contractor and 1 subcontractor.

#### *Quantitative surveys*

For the quantitative surveys, emails were sent to the remaining 150 respondents in the database inviting them to participate in the online survey. The survey was hosted on the SurveyMonkey server – a web-based survey platform. Several reminders were sent at monthly intervals to the potential respondents, to improve the response rate. Given the anonymous nature of this self-administered online survey, an apology was issued in the emails to those who might have already responded while encouraging those who had not to do so before the cut-off date.

The questionnaire used in the survey contained two broad categories of constraints, which are internal and external constraints. Sub-constraints under those categories were listed in Figure 4. Respondents were asked to rate on a five point Likert scale, the level of impact and frequency of occurrence of each sub-constraint source based on their experience in New Zealand building industry.

#### *Confirmatory/ triangulation surveys*

Confirmatory interviews were planned with an additional 12 convenience samples of project managers, contractors and subcontractors who did not participate in the earlier surveys. The key thrust of the confirmatory surveys was to test whether or not the constructs generated at the pilot interviews and through the use of the open-ended questionnaire had covered the bulk of the factors constraining productivity in the local context.

Eleven confirmatory interviews were conducted comprising 6 project management consultants and 5 contractors. A sample of the interview questions which were provided to the interviewees prior to the interviews is shown, and samples of the feedback are presented in the Appendix E.

### **3.3 Flowchart of the Research**

Figure 5 presents a flowchart of the process used in carrying out the research project from conception to completion. As illustrated, the research process consists of ten phases, starting with identifying the research problem and finishing with publishing the findings and dispatching a summary of key findings to participants.

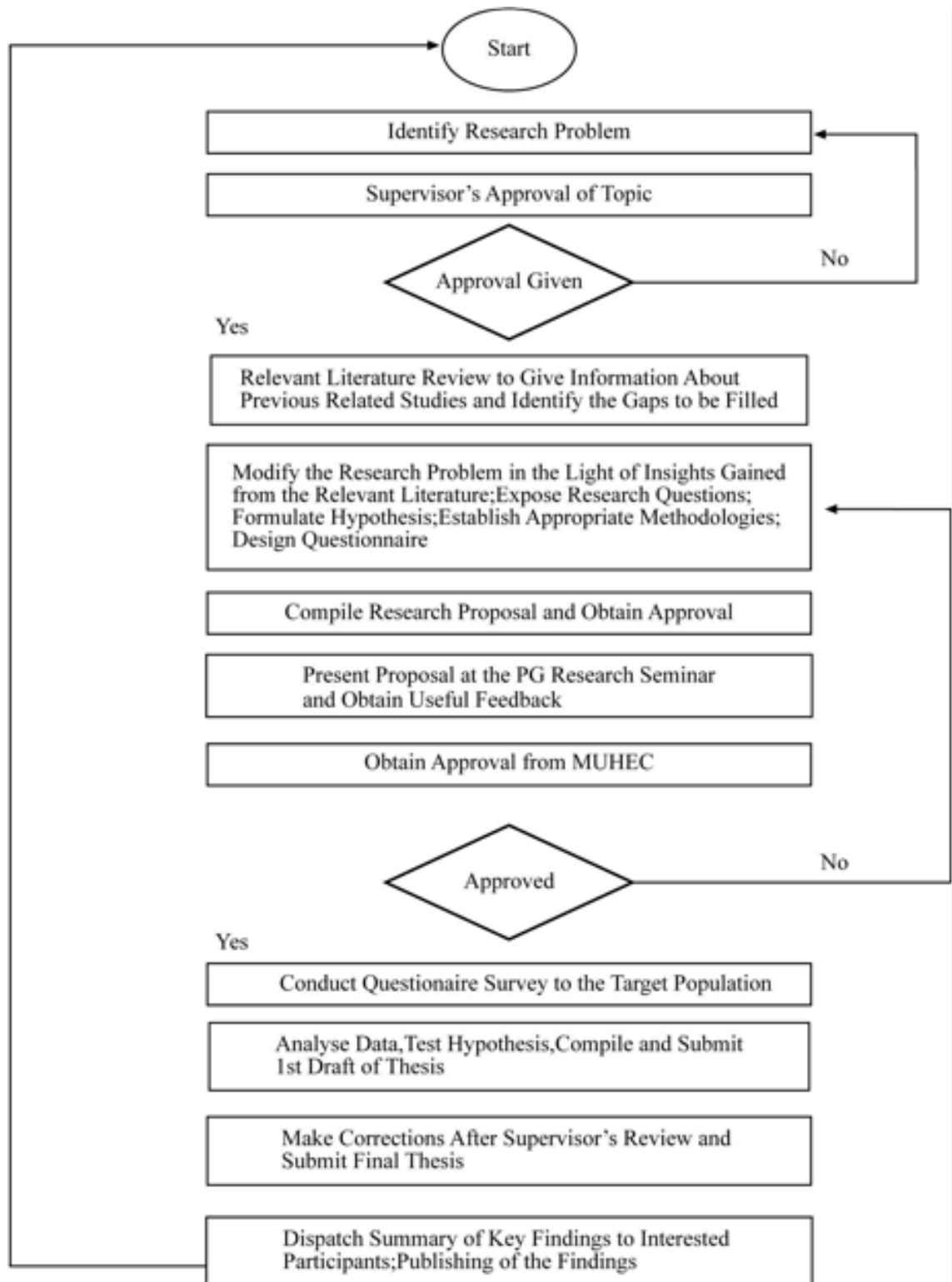


Figure 5: Flowchart of the process used in carrying out the research project from conception to completion

### 3.4 Target Population

The target populations of respondents for the study were project management consultants, contractors and subcontractors in the New Zealand building industry.

### 3.5 Data Collecting

#### *Secondary data*

The secondary data for the study was sourced from relevant literature including journals, conference proceedings, and other documents existing in the public domain. Completed theses and research reports from reputable tertiary institutions were also consulted. Information from these sources helped in putting the current research into context and providing part answers to the research objectives.

#### *Primary data*

The primary data for the study comprised the opinions of project management consultants, contractors and subcontractors in the New Zealand building industry. These were obtained through surveys involving the use of self-administered open-ended questionnaires.

### 3.6 Data Analysis

To analyze the data received from the questionnaires, the multi-attribute analytical technique was used to analyse the ratings given by the respondents and to establish a mean rating point which served as the representative rating for each group of respondents.

The multi-attribute technique used in the study was based on the recommendations of Chang and Ive (2002); it encompassed the evaluation of the Mean Rating (MR) for each sub-factor under a constraint. The MR represents the mean or average rating point ranked by the respondents as the level of significance of an attribute within a subset of attributes. In each computation, the total number of responses for each attribute was used to calculate the percentages of respondents associating a particular rating point to each attribute as shown in Equation 4.

$$MR_j = \sum_{k=1}^5 (R_{P_{jk}} \times \%R_{jk}) \quad (4)$$

where  $MR_j$  = Mean Rating for constraint factor  $j$ ;  $R_{pjk}$  = Rating Point  $k$  (ranging from 1-5); and  $R_{jk\%}$  = Percentage Response to rating point  $k$ , for constraint factor  $j$ .

*Relative Importance Index (RII):*

This index was used to compare the MR values of the variables in a given subset. It was computed as a unit of the sum of MRs in a subset of variables:

$$RII = \frac{M_i}{\sum_{i=1}^n M_i} \quad (5)$$

### 3.7 Testing of Propositions

*Rank correlation analyses*

The Spearman correlation analysis was used as the tool to measure correlation between two sets of rankings. In order to test the reliability and validity of the findings of the study, opinions of project managers and contractors were compared. Same test was used by Kometa et al. (1995) to test any agreement in ranking of the factors between various groups of respondents. The comparison involved matching the sets of rankings drawn from the responses of project managers and contractors on the attributes of the dimensions being rated.

The Spearman rank-order correlation coefficient rho ( $\rho$ ) is computed (Zar, 1972) using Equation 6.

$$r = 1 - \frac{\sum_{i=1}^n d_i^2}{n(n^2 - 1)} \quad (6)$$

where  $d_i$  is the difference between the ranks given to the  $i^{\text{th}}$  attribute by each group;  $n$  is the number of attributes being ranked.

*T-Score*

For a small sample size, with data points fewer than thirty, Zikmund (1997) recommends converting the  $\rho$  to a Student-T test statistic for a more accurate result.

This is computed using Equation 7 below:

$$T - \text{score} = \rho \sqrt{\frac{n-2}{1-\rho^2}} \quad (7)$$

where:

$n$  = number of objects ranked

$t$  = Student  $t$  test statistic, computed as a transformation of the Spearman rank correlation coefficient correlating both sets of paired ranks of the MR values computed from consultants' and contractors' ratings.

$t_c$  = Critical value of the Student  $t$  test statistic for a given degree of freedom,  $df$  (i.e.  $n-2$ ) corresponding to  $n$  number of pairs of ranked objects at 0.05 level of significance.

### *Test of significance*

In the test of significance of the computed values of Spearman rank correlation coefficients, the second proposition of the study was first translated to a hypothesis for statistical test of significance. The null hypothesis ( $H_A$ ) as translated, assumes that no significant correlation exists between the two sets of ranks of  $n$  attributes computed from the ratings of consultants and contractors. In statistical terms, this implies that the computed rho ( $\rho$ ) is less than or equal to the critical rho ( $\rho_a$ ). In this study, an alternative hypothesis ( $H_B$ ) is chosen for one tailed test, which assumes that a significant and positive correlation exists. At the 5 percent level of significance, both  $H_A$  and  $H_B$  could be stated as statistical hypotheses as follows:

$$H_A: \rho \leq \rho_a \text{ (i.e. no significant correlation exists)} \quad (8)$$

$$H_B: \rho > \rho_a \text{ (i.e. significant positive correlation exists)} \quad (9)$$

### **3.9 Research Model**

Figure 6 illustrates the fundamental process for choosing the most significant factors constraining construction on-site productivity.

The process begins by establishing the key constraints to on-site productivity in the New Zealand building industry. Each sub-factor's level of impact under each identified category is rated. In the study, in order to evaluate the levels of impact of sub-factors, the Mean Ratings and Relative Importance Indices of each sub-factor were analysed. Subsequently, 56 sub-factors were listed in decreasing order of their relative contribution to construction on-site productivity, to find the 20 percent of sub-factors responsible for 80 percent as assumed based on the Pareto principle. The outcome of the

analysis provided a basis for ascertaining whether or not the Pareto technique was applicable to the study as proposed.

Finally, improvement methods for on-site productivity in the New Zealand building industry are recommended.

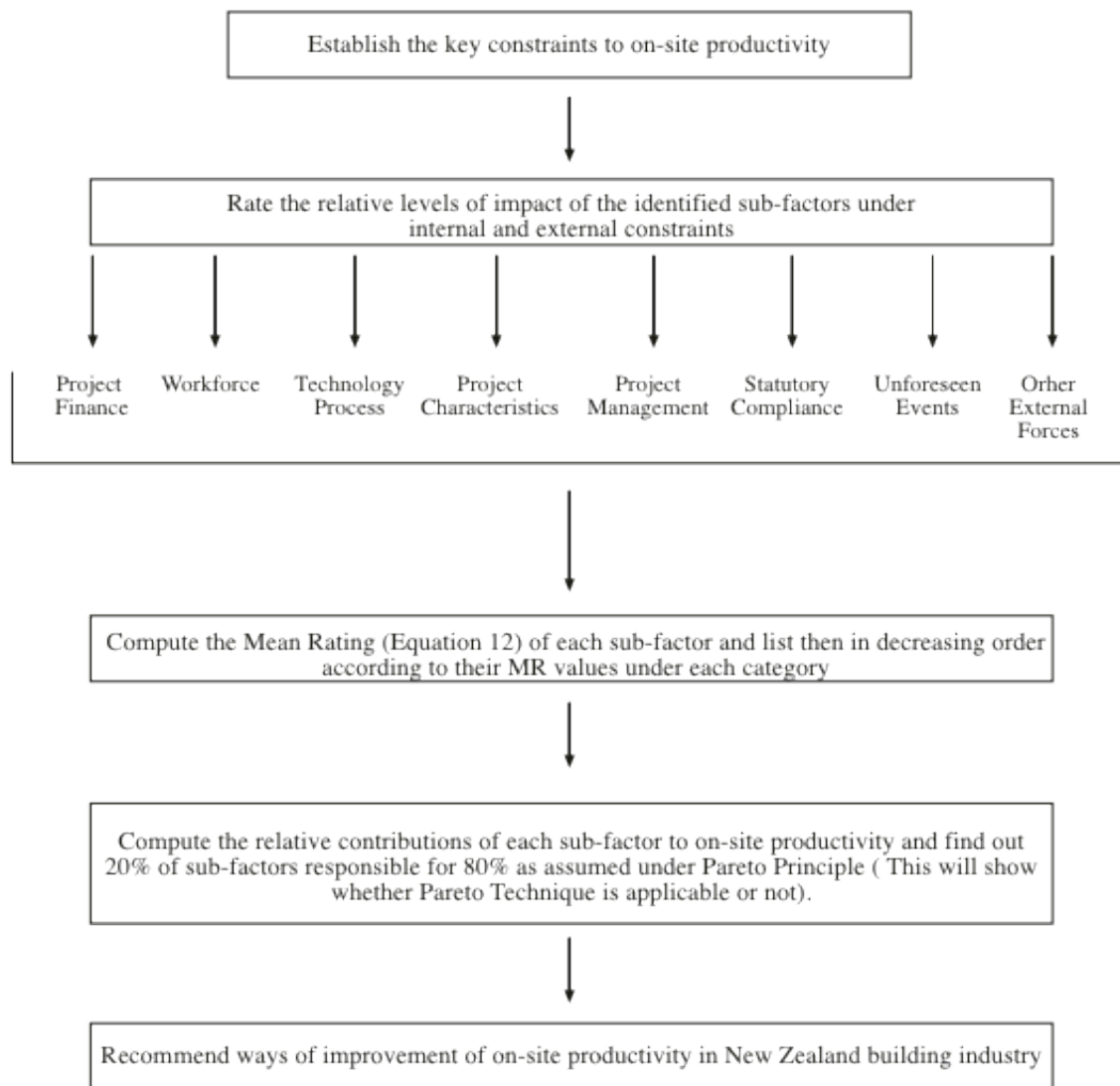


Figure 6: Flow chart of the process for choosing the most significant factors constraining on-site productivity, to meet the objectives of the study.

### 3.10 Research Programme

The timescale planned for the execution of the various stages of the research project is shown in Appendix H. As indicated, the final completion of the study was forecast to be around late June 2011, and the plan provides the basis for monitoring progress to ensure completion of the project at the stipulated time.

### **3.10 Ethical Issues in Research**

#### **3.10.1 Ethical Clearance for Research Undertaking**

Prior to obtaining the research data, Massey University's Policy about the researches involving human participants requires researchers to apply for permission to undertake the questionnaire survey to Massey University's Human Ethics Committee (MUHEC). This application was approved (see Appendix C1) on the basis of the following principals: details are provided in the MUHEC Code of Ethical Conduct (Massey Univerisity, 2011):

1. Respect for persons
2. Minimization of risk of harm
  - Risk of Harm to Participants
  - Risk of Harm to Researchers
  - Risk of Harm to Groups/Communities/Institutions
  - Risk of Harm to Massey University
3. Informed and voluntary consent
4. Respect of privacy and confidentiality
5. Avoidance of unnecessary deception
6. Avoidance of conflict of interest
7. Social and cultural sensitivity
8. Justice

## **CHAPTER 4: DATA PRESENTATION AND DISCUSSIONS**

### **4.1 Overview**

In this chapter, data obtained from the questionnaire survey is presented and analyzed. The chapter subsections include the questionnaire survey and factors which were ranked according to their levels of impact on the construction on-site labour productivity.

The demographic data serves not only to classify the responses along demographic profiles, but also to ensure that responses were from the target populations delineated for the study.

Preliminary analyses were carried out on the usable data to obtain variables for testing the research propositions.

### **4.2 Questionnaire Survey**

As mentioned earlier, the questionnaire used in the survey comprised two broad categories of internal and external constraints. Figure 4 present the sub-factors under each category.

#### **4.2.1 Survey Responses**

In total 150 email invitations were forwarded to the potential respondents who comprised the target populations for this study: 30 project management consultants, 80 contractors and 40 subcontractors in the New Zealand building industry. By the cut-off date, only 37 usable responses had been received, giving a 24 percent overall effective response rate. The discarded responses were from respondents who failed to meet the required quality and consistency checks used in the screening processes. These included those from members whose responses appeared not to have been thoughtfully made or from those who did not belong to the target populations.

#### **4.2.2 Frequent Role of the Respondents in Project Team**

The demographic profiles of the respondents relating to their principal roles as members of the project team are summarized in Figure 7:

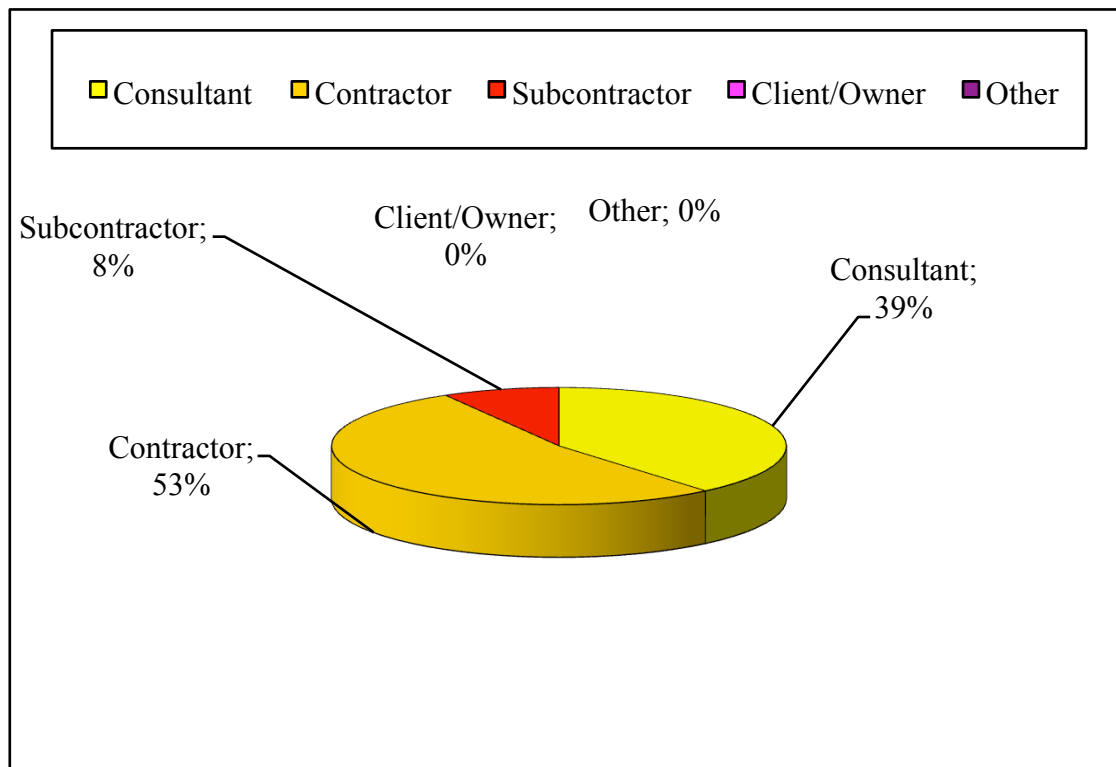


Figure 7: Frequent role of respondents in project team

Figure 7 shows that the 37 usable replies were largely from the contractors (53 percent), project management consultants (39 percent) and subcontractors (8 percent). The findings from the analysed data were therefore largely influenced by the opinions of the project managers and contractors and less by the subcontractors. This could be accepted since contractors are the key role-players in the procurement process and their performance underpins productivity and project success (Mbachu and Nkado, 2007). A key limitation here is the absence of the opinions of the clients and designers who equally influence outcomes in the procurement process. Nevertheless the scope of the study focuses only on those key role-players who are active at the coalface of the construction implementation process and who can be expected to provide more authoritative feedback on the subject matter.

### 4.2.3 Length of Experience of the Respondents in above Capacity

The lengths of experience of the respondents in their key roles as project team members are presented in Figure 8. The figure shows that 77 percent of the respondents have at least 15 years of experience in the construction industry. This profile means that the respondents' extensive experience contributes to the quality of the responses received, and to the reliability of the conclusions drawn from the research findings.

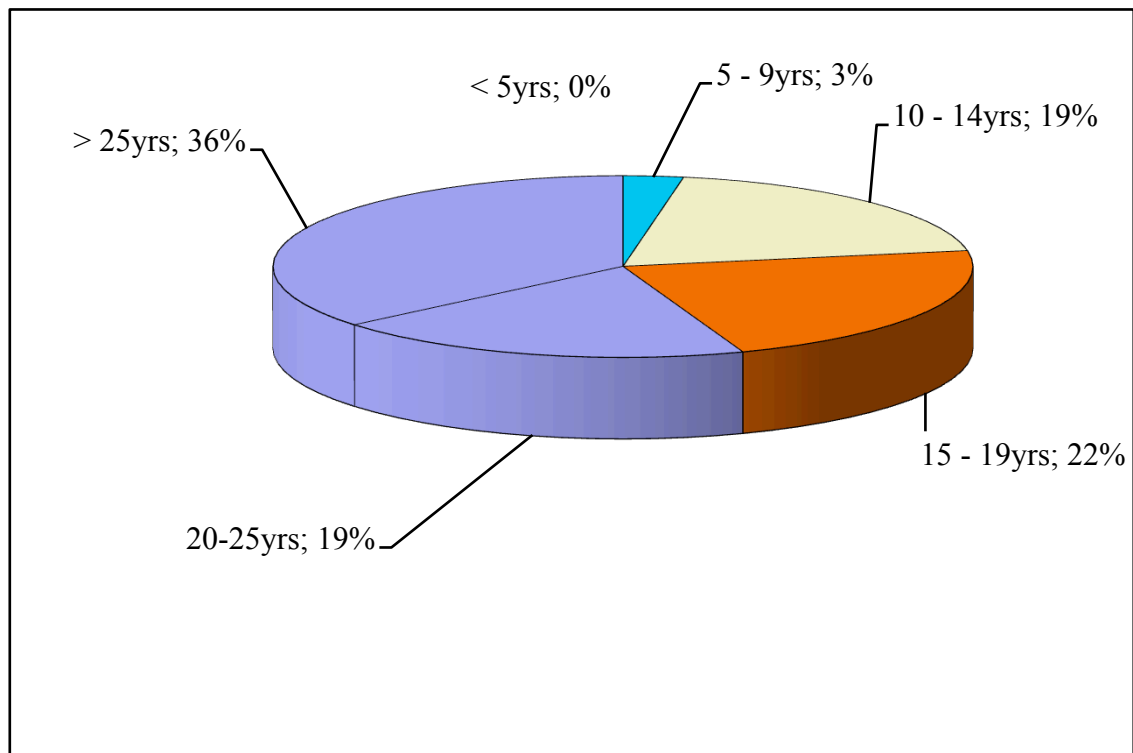


Figure 8: Respondents' length of experience as project team role players

### 4.2.4 Status of the Respondents in their Organisation

The status of the respondents in their respective organisations is summarized in Figure 9. The figure shows that most of the respondents (83 percent) were high-ranking personnel in the capacities of director/executive director and manager/associate director. This again reinforces the quality of the feedback as being from those who made decisions and controlled performance on productivity in the construction industry.

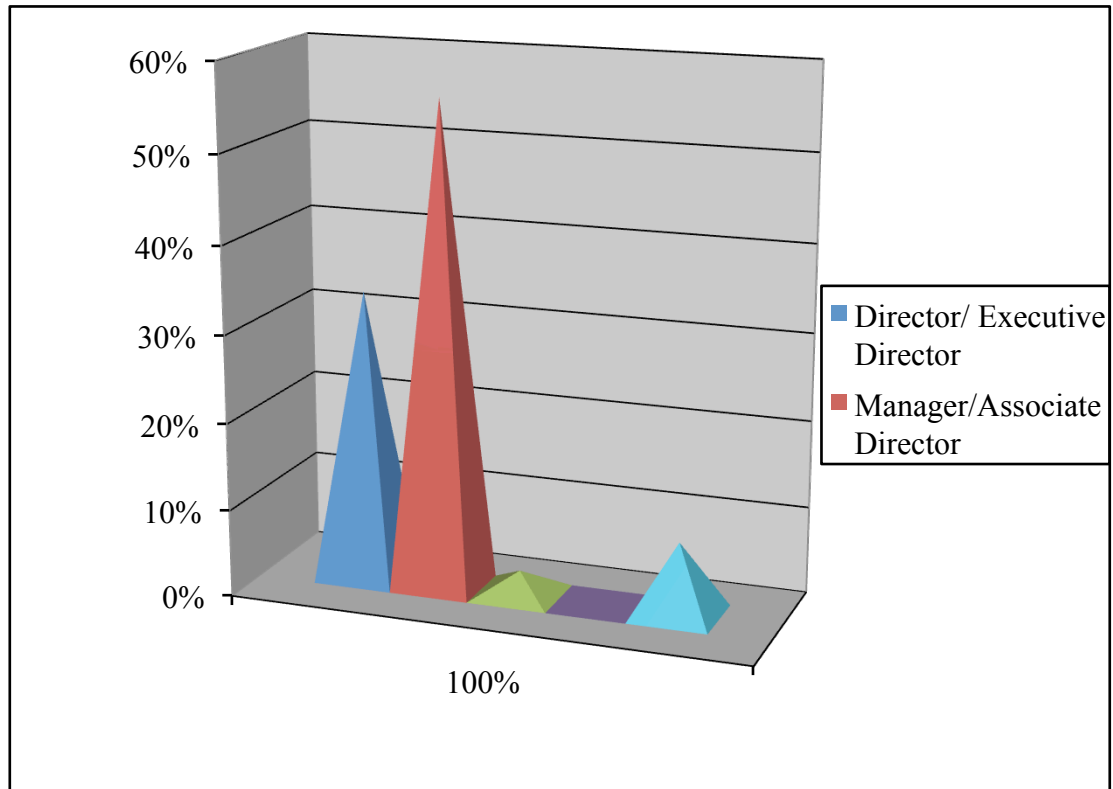


Figure 9: Respondents' status in their organisations

### 4.3 Factors Constraining On-site Productivity

In this study, 56 factors in total were identified and classified into 8 groups (project finance, workforce, technology/process, project characteristics, project management/project team characteristics, statutory compliance, unforeseen events, and other external forces) under two main constraints: internal and external.

The results in Table 4 depict the most significant factors under each group according to their levels of impact, based on the views of the respondents.

Table 4: Most significant factors under each group

<b>Groups:</b>		<b>Factors, which have most impact on on-site labour productivity under each category</b>
<b>Internal Constraints</b>	<b>A</b> Project Finance:	Rework
	<b>B</b> Workforce:	Level of skill and experience of the workforce
	<b>C</b> Technology/Process:	Adequacy of method of construction
	<b>D</b> Project Characteristics:	Buildability issues
	<b>E</b> Project Management / Project Team Characteristics:	Coordination, supervision, performance monitoring and control
<b>External Constraints</b>	<b>A</b> Statutory Compliance:	Resource Management Act
	<b>B</b> Unforeseen Events:	Ground conditions necessitating revisions
	<b>C</b> Other External Forces (Economical, Political, etc.):	Market conditions and level of competitions in the industry for jobs

#### 4.3.1 Project Finance Related Factors

The relative levels of impact of the sub-factors under the project finance broad category of on-site labour productivity constraints were analysed in Table 5. Results show that rework has the most significant impact on on-site labour productivity under this category with the highest MR value of 3.63. This result agrees with the findings of other authors (Burati *et al.* 1992; Cooper, 1993), who argued that the delays and costs associated with rework in construction have profound impact on productivity. In another study (Love *et al.* 1999, 2000), it was found that the cost of rework ranged from 2 to 12 percent of the total contract value. To minimize the problem of rework in the New Zealand construction industry, Page (2010) suggests the use of quality management systems and improvement in skills training, particularly for onsite management and the management of multi-projects at the firm level. The next most influential factor is under-valued work or poor estimation at the tender price. To guard against this, Henriod (2010) recommends the use of efficient tendering strategy involving a team approach to scrutinizing the tender documents for pitfalls and the pricing of the risks at pre-bid meetings. The involvement of the specialist trades and all key staff at these meetings helps to ensure that no important cost items are omitted and that the risks are properly priced.

Table 5: Factors ranked under Project Finance group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>A PROJECT FINANCE: <i>Cash flow problems arising from:</i></b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>				
1	14.29	31.43	25.71	14.29	14.29	35	3.17	0.15	4
2	20.00	40.00	28.57	5.71	5.71	35	3.63	0.17	1
3	14.71	32.35	35.29	11.76	5.88	34	3.38	0.16	3
4	12.90	25.81	9.68	38.71	12.90	31	2.87	0.14	5
5	0.00	13.79	24.14	51.72	10.34	29	2.41	0.11	6
6	0.00	5.56	30.56	38.89	25.00	36	2.17	0.10	7
7	22.58	22.58	38.71	12.90	3.23	31	3.48	0.16	2

- 1 Late payments;
- 2 Reworks;
- 3 Under-valued work;
- 4 Dispute and litigation costs;
- 5 Lenders' high interest charges;
- 6 High insurance premiums; bonds/ retentions;
- 7 Inadequate supply or high cost of needed resources: money, men, materials;

### **4.3.2 Workforce Related Factors**

Table 6 represents the analysis of the relative levels of impact of the sub-factors under the workforce category of on-site labour productivity constraints. Level of skill and experience of the workforce was rated as the most significant sub-factor (MR = 3.83) affecting on-site labour productivity of the New Zealand building industry. This result aligns with the earlier findings of Alinaitwe (2007) and Mojahed and Aghazadeh (2007), who similarly concluded that the skill and experience of the workforce have a remarkable influence on on-site labour productivity performance. According to Enshassi et al. (2007), experience improves both the intellectual and physical abilities of the labour force, which directly increase labour productivity. The next most influencing factor is the level of motivation or commitment of the workforce. This also concurs with Henriod (2010) conclusion that a happy team and improved work attitude can result in tremendous improvement in labour productivity. Henriod opines that high level of workforce motivation and commitment can be achieved through job security, effective reward system, culture of openness, trust and loyalty and the involvement of the people at the coalface in the decision making process.

Table 6: Factors ranked under Workforce group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH	H	M	L	VL				
<b>B WORKFORCE: <i>Productivity constraints arising from:</i></b>	5	4	3	2	1				
	%	%	%	%	%				
<b>1</b>	20.00	40.00	22.86	14.29	2.86	35	3.60	0.14	<b>2</b>
<b>2</b>	11.43	42.86	22.86	22.86	0.00	35	3.43	0.13	<b>4</b>
<b>3</b>	25.71	40.00	25.71	8.57	0.00	35	3.83	0.15	<b>1</b>
<b>4</b>	8.57	45.71	31.43	8.57	5.71	35	3.43	0.13	<b>3</b>
<b>5</b>	11.76	29.41	35.29	23.53	0.00	34	3.29	0.13	<b>5</b>
<b>6</b>	8.82	17.65	44.12	23.53	5.88	34	3.00	0.11	<b>6</b>
<b>7</b>	2.86	20.00	42.86	25.71	8.57	35	2.83	0.11	<b>7</b>
<b>8</b>	0.00	21.21	42.42	30.30	6.06	33	2.79	0.11	<b>8</b>

- 1** Level of motivation/commitment;
- 2** Level of empowerment (training and resourcing);
- 3** Level of skill and experience of the workforce;
- 4** Level of familiarity with current job and conditions;
- 5** Level of involvement of direct labour or subcontract;
- 6** Workforce absenteeism;
- 7** Level of staff turnover/ churn rate;
- 8** Health of the workforce

### **4.3.3 Technology/Process Related Factors**

Analysis of the sub-factors under the technology/process related broad category of onsite labour productivity constraints was carried out in Table 7. Majority of the respondents rated the adequacy of method of construction as having the greatest impact on onsite labour productivity. This is consistent with conclusions in previous studies (Alinaitwe et al. 2007; Sanders and Thomas, 1993) that the method adopted in the construction process has far reaching implications on productivity and performance of the construction crew. However, the method depends on the design and what the owner or the engineer is willing to approve as the appropriate method in the circumstance. Page (2010) recommends the use of modern design and construction methods such as modularisation and prefabrication and the avoidance of one-off designs. Though rated as the least significant in the set, Knutson et al. (2009) argue that the layout of the site is one of the most obvious of the impacts on productivity. Careful planning and location of the contract preliminaries could therefore ensure effective workflow and construction speed resulting in improved onsite productivity.

Table 7: Factors ranked under Technology/ Process group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>C TECHNOLOGY/PROCESS: <i>Productivity constraints arising from:</i></b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>				
1	8.57	37.14	28.57	20.00	5.71	35	3.23	0.15	2
2	19.44	33.33	33.33	13.89	0.00	36	3.58	0.16	1
3	5.71	37.14	22.86	31.43	2.86	35	3.11	0.14	4
4	2.86	25.71	48.57	22.86	0.00	35	3.09	0.14	5
5	5.88	29.41	38.24	26.47	0.00	34	3.15	0.14	3
6	0.00	37.14	34.29	25.71	2.86	35	3.06	0.14	6
7	3.03	18.18	33.33	42.42	3.03	33	2.76	0.13	7

- 1 Suitability or adequacy of the plant & Equipment employed;
- 2 Adequacy of method of construction;
- 3 Adequacy of technology employed;
- 4 Lack of training and education to implement and operate new technologies;
- 5 Resistance to accept new technologies;
- 6 Inadequate IT infrastructure and application in construction industry;
- 7 Adequacy of site layout

#### **4.3.4 Project Characteristics Related Factors**

Results in Table 8 show that buildability issues are the most significant factor in on-site labour productivity under the project characteristics group of constraints. This finding aligns with conclusions of several studies indicating that buildability has an important influence on the construction process (Jarkas, 2010; Lam and Wong, 2009; Saghatforoush et al. 2009; Lam et al. 2007).

Table 8: Factors ranked under Project Characteristics group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>PROJECT CHARACTERISTICS: <i>Productivity constraints arising</i></b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>				
<b>D from:</b>									
<b>1</b>	17.65	41.18	20.59	20.59	0.00	34	3.56	0.21	<b>3</b>
<b>2</b>	20.59	35.29	32.35	11.76	0.00	34	3.65	0.21	<b>2</b>
<b>3</b>	20.00	40.00	34.29	2.86	2.86	35	3.71	0.22	<b>1</b>
<b>4</b>	11.76	26.47	35.29	20.59	5.88	34	3.18	0.18	<b>4</b>
<b>5</b>	8.82	26.47	35.29	23.53	5.88	34	3.09	0.18	<b>5</b>

- 1 Site conditions: access, subsoil; topography;
- 2 Project complexity: scale; design;
- 3 Buildability issues;
- 4 Site location and environment
- 5 Type of procurement adopted.

#### **4.3.5 Project Management/Project Team Characteristics Related Factors**

With the highest MR of 4.43 as listed in Table 9, the coordination, supervision, performance monitoring and control set of constraints was found to be the most influential on-site labour productivity set of constraint factors under the project management/project team characteristics group. This result was supported by Thomas and Sakarcan (1994) who found supervision to be one of the most significant factors in on-site labour productivity. Abdul Kadir et al. (2005) add emphasis on subcontractor coordination, which was also ranked as one of the influential factors in the study. Furthermore Jergeas (2009) and KPMG (2009) argue that effective project integration management, comprising the activities that integrate, coordinate and bring together the various functions and multiple stakeholders, is the key to achieving onsite productivity and performance.

Table 9: Factors ranked under Project Management/ Project Team Characteristics group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints		<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
		VH 5	H 4	M 3	L 2	VL 1				
<b>E</b>	<b>PROJECT MANAGEMENT/ PROJECT TEAM CHARACTERISTICS: <i>Productivity constraints arising from:</i></b>	%	%	%	%	%				
	<b>1</b>	31.43	51.43	11.43	5.71	0.00	35	4.09	0.13	<b>4</b>
	<b>2</b>	54.29	34.29	11.43	0.00	0.00	35	4.43	0.14	<b>1</b>
	<b>3</b>	35.29	26.47	35.29	0.00	2.94	34	3.91	0.12	<b>5</b>
	<b>4</b>	37.14	45.71	11.43	2.86	2.86	35	4.11	0.13	<b>3</b>
	<b>5</b>	26.47	29.41	35.29	5.88	2.94	34	3.71	0.12	<b>7</b>
	<b>6</b>	22.86	40.00	31.43	2.86	2.86	35	3.77	0.12	<b>6</b>
	<b>7</b>	17.14	31.43	42.86	8.57	0.00	35	3.57	0.11	<b>8</b>
	<b>8</b>	41.18	50.00	5.88	2.94	0.00	34	4.29	0.13	<b>2</b>

- 1 Adequacy of planning and risk management process;
- 2 Coordination;supervision; performance monitoring and control;
- 3 Project organisational culture;
- 4 Relationship management/ degree of harmony, trust and cooperation;
- 5 Competencies of the project team;
- 6 Project management style;
- 7 Frequency of design changes/ change orders;
- 8 Cleint's overt influence on the construction process;

### **4.3.6 Statutory Compliance Related Factors**

Table 10 presents the analysis of the subcomponents of onsite productivity constraints related to statutory compliance. Compliance with the Resource Management Act (RMA) 1991 was rated as the most influential sub-factor. McShane (1996) hints that the impact of RMA on on-site labour productivity is profound especially in relation to resource content issues. The Department of Building and Housing (DBH, 2009) also notes that a number of industry leaders see regulation in its broadest sense as a critical factor constraining the industry productivity through increased compliance costs, limitation on activity, stifling of innovation and reduction of efficiency on worksites. As a mitigation measure, the Department believes that regulation should be used only sparingly and only if it is well designed. It is surprising to note that the Construction Contracts Act (CCA) 2002 – being the key legislation affecting construction contracts and operations - was rated very low by majority of the respondents. Perhaps, this could be due to the increased awareness of, and proactive response to, the Act since all parties must now abide by its provisions. Overall, having working knowledge of the provisions of the legislations and regulations affecting their daily operations and taking proactive steps to their implementations would help the industry operators to sort out the compliance issues; the risk involved should be priced in the contracts.

Table 10: Factors ranked under Statutory Compliance group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

External Constraints		<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
		VH	H	M	L	VL				
A	STATUTORY COMPLIANCE: <i>Productivity constraints arising from:</i>	5	4	3	2	1				
		%	%	%	%	%				
	<b>1</b>	2.63	23.68	44.74	10.53	18.42	38	2.82	0.13	<b>3</b>
	<b>2</b>	8.82	29.41	38.24	17.65	5.88	34	3.18	0.15	<b>1</b>
	<b>3</b>	0.00	20.59	38.24	35.29	5.88	34	2.74	0.13	<b>4</b>
	<b>4</b>	0.00	12.50	15.63	50.00	21.88	32	2.19	0.10	<b>6</b>
	<b>5</b>	9.09	27.27	27.27	33.33	3.03	33	3.06	0.14	<b>2</b>
	<b>6</b>	0.00	0.00	33.33	57.58	9.09	33	2.24	0.11	<b>5</b>
	<b>7</b>	0.00	3.33	10.00	33.33	53.33	30	1.63	0.08	<b>8</b>
	<b>8</b>	0.00	3.45	6.90	34.48	55.17	29	1.59	0.08	<b>9</b>
	<b>9</b>	3.57	0.00	10.71	39.29	46.43	28	1.75	0.08	<b>7</b>

- 1** Health & Safety in Employment Act
- 2** Resource Management Act
- 3** Local Authority Bylaws,
- 4** Construction Contracts Act
- 5** Building Act/ Building Consent/ Building Regulations
- 6** Employment Relations Act
- 7** Consumer Guarantees Act
- 8** Fair Trading Act
- 9** Arbitration Act

#### **4.3.7 Unforeseen Events Related Factors**

Table 11 shows that ground condition as a sub-factor under unforeseen events, with an MR of 3.79, has the greatest impact on on-site labour productivity in New Zealand. The same result was found by Clayton (2001) who similarly noted that ground-related problems and conditions can adversely affect the construction process and productivity in terms of costs and completion time, in a project of any scale. If the survey had been conducted during the recent earthquake in Christchurch on 22 February 2011, perhaps natural disasters would have been perceived as the most influential sub-factor given the loss of lives and the estimated \$30 billion of reconstruction work required according to Conway (2011).

Table 11: Factors ranked under Unforeseen Events group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

External Constraints		<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
		VH 5	H 4	M 3	L 2	VL 1				
<b>B</b>	<b>UNFORESEEN EVENTS: <i>Productivity impediments arising from:</i></b>	%	%	%	%	%				
	1	14.71	41.18	35.29	8.82	0.00	34	3.62	0.13	2
	2	20.59	44.12	29.41	5.88	0.00	34	3.79	0.15	1
	3	13.89	25.00	30.56	30.56	0.00	36	3.22	0.13	3
	4	32.35	14.71	8.82	17.65	26.47	34	3.09	0.08	4

- 1 Inclement weather;
- 2 Ground conditions necessitating revisions
- 3 On-site accidents/ Acts of God;
- 4 Natural disasters

#### **4.3.8 Other External Forces**

Table 12 shows that, within the wider external factor broad category, the boom-bust cycles, market conditions and the level of competitions in the industry for scarce jobs was rated by the respondents as the set of factors having the highest impact on on-site labour productivity. This result is consistent with the findings of previous studies (Tran and Tookey, 2011; DBH, 2009; Davis 2008) which equally acknowledged the damaging effect of the boom-burst cycle on the New Zealand construction industry productivity and performance. The Building and Construction Sector Task Force (DBH, 2009) notes that better management of the boom-bust cycle will help improve skill development and retention, reduce waste and give greater confidence to industry participants, adding that “how the government plans and manages its procurement with the sector can have a crucial influence on the sector’s ability to better manage the business cycle” (p. 9).

Table 12: Factors ranked under Other External Forces group

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

External Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>C OTHER EXTERNAL FORCES: Productivity Constraints Arising from Miscellaneous Sources Including:</b>	%	%	%	%	%				
1	6.06	21.21	51.52	15.15	6.06	33	3.06	0.15	2
2	0.00	0.00	38.24	52.94	8.82	34	2.29	0.11	7
3	0.00	6.06	21.21	66.67	6.06	33	2.27	0.11	8
4	0.00	6.06	30.30	57.58	6.06	33	2.36	0.11	5
5	0.00	54.84	29.03	12.90	3.23	31	3.35	0.16	1
6	0.00	12.12	27.27	54.55	6.06	33	2.45	0.12	3
7	0.00	3.03	30.30	63.64	3.03	33	2.33	0.11	6
8	3.45	6.90	24.14	62.07	3.45	29	2.45	0.12	4

- 1 Inflation / fluctuations in material prices.
- 2 Fluctuations in Exchange rate;
- 3 Energy crises/ costs
- 4 Interest rate/cost of capital;
- 5 Market conditions and level of competitions in the industry for jobs
- 6 Frequent changes in government policies/ legislations impacting on construction
- 7 Rapid technological advances
- 8 Increase in industry or society-wide litigations/ adversarial relations

#### **4.3.9 Broad Categories**

The relative levels of impact of the broad categories of onsite labour productivity constraints were analysed in Table 13. Results showed that all the eight broad categories of internal and external constraints are significant, having achieved MR values greater than the threshold value of 2.5. The internal constraint categories, comprising project finance, workforce, technology/process, project characteristics and project management contribute 67 percent of the onsite labour productivity constraints, implying that the external constraints only contribute 33 percent. This result is in agreement with the findings of Fabling and Grimes (2008); the authors examine the relative importance of internal/controllable and external/uncontrollable constraints to firms' performance and conclude that the differences in firm performance are explained in large measure by factors over which they have control rather than purely by external uncontrollable factors. The finding that the project management approach has the highest impact on onsite labour productivity concurs with the findings in previous studies (Knutson et al. 2009; Burati et al., 1992) that the way a project is managed, especially as it relates to the critical path and critical cost activities, is key to productivity and performance. However, a number of authors (Mbachu, 2008; Henriod and Lantran, 2000) believe that positive net cash flow, being the lifeblood of the industry and the source of project finance has the most profound impact on productivity and performance.

Table 13: Factors ranked under Broad Categories

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Broad Categories of Internal and External Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH	H	M	L	VL				
	5	4	3	2	1				
	%	%	%	%	%				
<b>1</b>	14.71	50.00	17.65	11.76	5.88	34	3.56	0.14	<b>2</b>
<b>2</b>	11.76	44.12	32.35	8.82	2.94	34	3.53	0.14	<b>3</b>
<b>3</b>	0.00	18.18	57.58	24.24	0.00	33	2.94	0.12	<b>6</b>
<b>4</b>	2.94	41.18	41.18	14.71	0.00	34	3.32	0.13	<b>4</b>
<b>5</b>	17.14	40.00	28.57	11.43	2.86	35	3.57	0.14	<b>1</b>
<b>6</b>	0.00	20.59	47.06	26.47	5.88	34	2.82	0.11	<b>7</b>
<b>7</b>	11.76	14.71	38.24	29.41	5.88	34	2.97	0.12	<b>5</b>
<b>8</b>	3.03	6.06	39.39	45.45	6.06	33	2.55	0.10	<b>8</b>

- 1** Project finance
- 2** Workforce
- 3** Technology/ process
- 4** Project characteristics
- 5** Project management/ project team characteristics
- 6** Statutory compliance
- 7** Unforeseen events
- 8** Other external forces (economic, political, industry, etc)

#### 4.4 Confirmatory/Triangulation Survey Results

As earlier indicated, confirmatory interviews were conducted with additional convenience sample of 11 interviewees drawn from the target population for the study, namely, project management consultants, contractors and subcontractors in the New Zealand construction industry. This set of interviewees did not participate in the earlier surveys. Feedback received from the interviewees did not provide any new constraint factors to onsite labour productivity, other than rephrasing of some of the constraints already identified. There was therefore evidence to support the assumption that the constraint factors identified in the study were robust enough. This result adds to the reliability and validity of the research findings and the conclusions drawn from them.

#### 4.5 Tests of Propositions

In this chapter, tests of the research propositions are presented and the results discussed. Figure 10 illustrates the propositions formulated from the research objectives and the testing methods used, as recommended in the literature (Naoum, 2003; Cooper and Schindler, 2006; Zikmund, 1997).

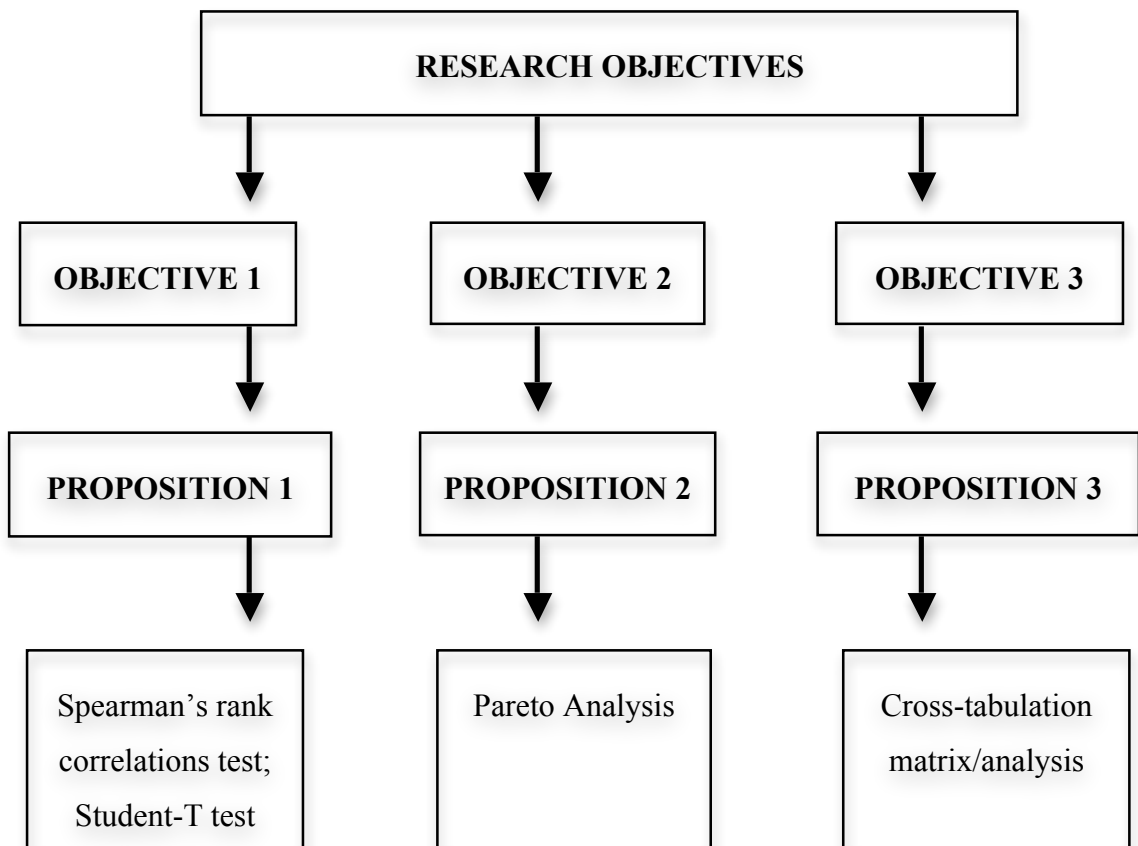


Figure 10: Snapshot of research propositions and Methods of analysis

### 4.5.1 Test of Proposition 1.0

The first objective of the study is to establish the key constraints to on-site labour productivity and to evaluate the relative levels of impact and their frequencies of occurrence, with a view to establishing the risk levels of the constraints in the New Zealand building industry. Results of the analysed questionnaire surveys showed that such constraints could be classified into 8 broad categories: project finance, workforce, technology/process, project characteristics, project management/project team characteristics, statutory compliance, unforeseen events and other external forces.

To involve some measure of triangulation of information for validity and reliability, multiple sources of evidence were sought from different stakeholder groupings. Consequently, the proposition relating to the first research objective assumed that there would be no significant differences between the consultants' and contractors' ratings of the relative levels of the broad constraint categories.

To test Proposition 1.0, a multi-attribute analytical technique was used to calculate the Mean Ratings (MR) for each broad category. The ranking of the MR values computed for the consultants were then compared to those for contractors using the Spearman rank correlation method.

#### *Spearman's rank correlation test*

This was used to establish the significance of the differences between the set of ranks of MR values for the broad constraint categories for the consultants' and contractors. The test of the research proposition using the Spearman's rank correlation test requires translating the proposition into a statistical hypothesis which is testable at 5% level of significance (Zikmund, 1997). The null hypothesis ( $H_A$ ) and the associated alternative ( $H_B$ ) are formulated as follows.

Test hypotheses:

$H_A: t \leq t_c$  (region of acceptance of  $H_A$ ) i.e, no correlation exists between both sets of paired ranks. (3)

$H_B: t > t_c$  (region of rejection of  $H_A$ ) i.e, correlation exists between both sets of paired ranks. (4)

Decision rule:

Accept  $H_A$  if  $t \leq t_c$ ; reject  $H_A$  otherwise and accept  $H_B$  (i.e. if  $t > t_c$ )

Where:

$t$  = Student t test statistic computed as a transformation of the Spearman rank correlation coefficient, correlating both sets of paired ranks of the MR values computed from consultants' and contractors' ratings.

$t_c$  = Critical value of the Student t test statistic for a given degree of freedom,  $df$  (i.e.  $n-2$ ) corresponding to  $n$  number of pairs of ranked objects at 0.05 level of significance (Kamarazaly, 2007).

Table 14 presents a typical rank correlation and the Student T tests employed in testing the translated hypotheses.

Table 14: Cross Tabulation and Spearman's rank correlation analysis for testing proposition 1.0

	Consultants			Contractors		
	<sup>c</sup> MR	<sup>d</sup> RII	Rank	<sup>c</sup> MR	<sup>d</sup> RII	Rank
<b>Broad Categories of Internal and External Constraints</b>						
<b>1</b>	3.31	0.12	<b>3</b>	3.72	0.15	<b>1</b>
<b>2</b>	3.77	0.14	<b>2</b>	3.28	0.14	<b>2</b>
<b>3</b>	3.15	0.12	<b>6</b>	2.76	0.11	<b>6</b>
<b>4</b>	3.31	0.12	<b>4</b>	3.22	0.13	<b>3</b>
<b>5</b>	4.00	0.15	<b>1</b>	3.17	0.13	<b>4</b>
<b>6</b>	3.23	0.12	<b>5</b>	2.56	0.11	<b>7</b>
<b>7</b>	3.15	0.12	<b>7</b>	3.00	0.12	<b>5</b>
<b>8</b>	2.69	0.10	<b>8</b>	2.50	0.10	<b>8</b>

Number of objects ranked, n = 8

Spearman's rank correlation coefficient, R = 0.74

t-score = 2.679659092

Degree of freedom, df = n-2 = 6

t-critical (at 5% level of significant) = 1.943

Acceptance region: =  $t \leq 1.943$

Result:  $t_{score} > t_{critical}$  (i.e. significant correlation exists between both sets of paired ranks)

Decision: Accept  $H_B$  and conclude that statistical evidence suggests that there is a correlation between the two sets of ranks

The result of the Spearman’s rank correlation test (Table 14) shows that there is a significant correlation between both sets of rank-ordered Mean Rating values computed from the consultants’ and contractors’ ratings for the broad categories. The hypothesis that there were no significant differences between the views of both respondent groupings was therefore rejected at the 5 percent level of significance. This also means that the associated Proposition 1.0 was not supported.

#### 4.5.2 Test of Proposition 2.0

The second objective of the study is to identify the 20 percent of the constraints responsible for 80 percent of the productivity risks, by using the Pareto principle.

Proposition 2.0 assumes that the Pareto principle is applicable at the levels of the individual sub-factors of internal and external constraints. The Pareto analysis technique was used in testing Proposition 2.0 as shown in Table 15; the analysis was aimed at ascertaining whether 20 percent of the constraints were responsible for 80 percent of the productivity risks. To implement the Pareto principle in Proposition 2.0, list of constraints was formed in decreasing order of their relative levels of impact. A cumulative percentage column was then added in order to show where the 80% cumulative mark lies in the list of constraints. .

Table 15: List of internal and external constraints in the decreasing order of levels of impact.

	<b>Internal and External constraints</b>	<b>MR</b>	<b>RII</b>	<b>CUM RII</b>
<b>1</b>	Coordination; supervision; performance monitoring and control;	4.43	2.55%	2.55%
<b>2</b>	Frequency of design changes/ change orders;	4.29	2.47%	5.02%
<b>3</b>	Competencies of the project team;	4.11	2.37%	7.38%
<b>4</b>	Adequacy of planning and risk management process;	4.09	2.35%	9.73%
<b>5</b>	Relationship management/ degree of harmony, trust and cooperation;	3.91	2.25%	11.98%
<b>6</b>	Level of skill and experience of the workforce;	3.83	2.20%	14.19%
<b>7</b>	Ground conditions necessitating revisions	3.79	2.18%	16.37%
<b>8</b>	Project organisational culture;	3.77	2.17%	18.54%
<b>9</b>	Buildability issues;	3.71	2.14%	20.67%
<b>10</b>	Project management style;	3.71	2.13%	22.81%
<b>11</b>	Project complexity: scale; design;	3.65	2.10%	24.90%
<b>12</b>	Reworks;	3.63	2.09%	26.99%
<b>13</b>	Inclement weather;	3.62	2.08%	29.07%
<b>14</b>	Level of motivation/commitment;	3.60	2.07%	31.14%
<b>15</b>	Adequacy of method of construction;	3.58	2.06%	33.20%
<b>16</b>	Client’s overt influence on the construction process;	3.57	2.05%	35.26%
<b>17</b>	Site conditions: access, subsoil; topography;	3.56	2.05%	37.31%

18	Inadequate supply or high cost of needed resources: money, men, materials & machinery;	3.48	2.00%	39.31%
19	Level of familiarity with current job and conditions;	3.43	1.97%	41.28%
20	Level of empowerment (training and resourcing);	3.43	1.97%	43.25%
21	Under-valued work;	3.38	1.95%	45.20%
22	Market conditions and level of competitions in the industry for jobs	3.35	1.93%	47.13%
23	Level of involvement of direct labour or subcontract;	3.29	1.89%	49.03%
24	Suitability or adequacy of the plant & Equipment employed;	3.23	1.86%	50.88%
25	On-site accidents/ Acts of God;	3.22	1.85%	52.74%
26	Site location and environment	3.18	1.83%	54.56%
27	Resource Management Act	3.18	1.83%	56.39%
28	Late payments;	3.17	1.82%	58.21%
29	Resistance to accept new technologies;	3.15	1.81%	60.02%
30	Adequacy of technology employed;	3.11	1.79%	61.82%
31	Type of procurement adopted.	3.09	1.78%	63.59%
32	Natural disasters	3.09	1.78%	65.37%
33	Lack of training and education to implement and operate new technologies;	3.09	1.78%	67.14%
34	Inflation / fluctuations in material prices.	3.06	1.76%	68.91%
35	Building Act/ Building Consent/ Building Regulations	3.06	1.76%	70.67%
36	Inadequate IT infrastructure and application in construction industry;	3.06	1.76%	72.42%
37	Workforce absenteeism;	3.00	1.73%	74.15%
38	Dispute and litigation costs;	2.87	1.65%	75.80%
39	Level of staff turnover/ churn rate;	2.83	1.63%	77.43%
40	Health & Safety in Employment Act	2.82	1.62%	79.05%
41	Health of the workforce	2.79	1.60%	80.65%
42	Adequacy of site layout	2.76	1.59%	82.24%
43	Local Authority Bylaws,	2.74	1.57%	83.81%
44	Frequent changes in government policies/ legislations impacting on construction	2.45	1.41%	85.22%
45	Increase in industry or society-wide litigations/ adversarial relations	2.45	1.41%	86.63%
46	Lenders' high interest charges;	2.41	1.39%	88.02%
47	Interest rate/cost of capital;	2.36	1.36%	89.38%
48	Rapid technological advances	2.33	1.34%	90.72%
49	Fluctuations in Exchange rate;	2.29	1.32%	92.04%
50	Energy crises/ costs	2.27	1.31%	93.35%
51	Employment Relations Act	2.24	1.29%	94.64%
52	Construction Contracts Act	2.19	1.26%	95.90%
53	High insurance premiums; bonds/ retentions.	2.17	1.25%	97.14%
54	Arbitration Act	1.75	1.01%	98.15%
55	Consumer Guarantees Act	1.63	0.94%	99.09%
56	Fair Trading Act	1.59	0.91%	100.00%

Table 15 shows the results of the implementation of the Pareto technique. The findings suggest that the highest-ranked 20 percent of the constraint factors account for only 25

percent of the problem, and not 80 percent as assumed under the Pareto principle. Proposition 2.0 was therefore rejected as not being applicable in this study.

### 4.5.3 Test of Proposition 3.0

The third objective of the study is to explore innovative ways of improving on-site labour productivity in the New Zealand construction industry. Based on an outcome of some literature survey, Proposition 3.0 was formulated to assume that the application of technology represents the most significant way of improving on-site productivity. In the questionnaire surveys, respondents were asked to suggest innovative ways of improving on-site labour productivity in the industry. Out of the 37 respondents, only 30 gave feedback on this aspect. An analysis of the frequencies of mention of the various suggestions was made in Table 16.

Table 16: Analysis of feedback on innovative ways of improving on-site labour productivity

	Suggested ways of improving onsite labour productivity	Frequency of mention	% Frequency
1	Adequate planning	15	50%
2	Application of technology	7	23%
3	Level of skills and experience of the workforce	5	17%
4	Increasing of salaries/wages	3	10%
		$\Sigma$ 30	100%

The results showed that adequate planning, with a frequency count of 15 out of 30 or 50 percent, was believed by most to be a significant way of improving onsite labour productivity. With the application of technology receiving only 23 percent frequency, the initial proposition that suggested its application, as the most significant way of improving onsite productivity was therefore not supported. However, this finding is not consistent with those of other studies (Kim et al., 2006; Shreshta et al., 2009), which suggested that technological application is the most effective way of improving on-site labour productivity in the industry. This result could be due to the reluctance of the key stakeholders in the New Zealand construction industry to approve further uptake of technology, due to the labour-intensive nature of the construction process.

#### **4.5.4 Summary of the tests of Propositions**

Based on the research objectives, propositions were formulated to direct research inquiry analyses. Results of the proposition testing were mixed – some were supportive, while some others were not. Incidentally only one out of three propositions made in this study were supported: Proposition 1.0, which assumed that in terms of the broad constraint categories there would be no significant differences between the ratings of the project management consultants and contractors, was supported. On the other hand, Proposition 2.0 which stated that the Pareto principle is applicable at the individual sub-factor levels was rejected as the findings did not align with the Pareto principle. Proposition 3.0 was also rejected, as adequate planning rather than greater use of technology was perceived as the most effective way of improving on-site productivity in the New Zealand construction industry.

# **CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS**

## **5.1 Conclusions**

Productivity is in essence the backbone that makes or breaks a company in the construction industry, as it is the key-determining factor in performance and success. Therefore one must understand the factors that raise or lower productivity.

Given the reported steady decline of labour productivity trends in the New Zealand building and construction industry, the main objectives of this study have been to identify the key constraints to on-site productivity and to rank them in accordance with their levels of impact, based on the views of project manager consultants, contractors and subcontractors. In Total, 56 factors were identified in this study, which were grouped under eight broad categories: project finance, workforce, technology/process, project characteristics, project management, statutory compliance, unforeseen events, and other external forces. The first five broad categories comprise the internal constraints, while the last three were the external constraints.

Results of a multi-attribute analysis showed that, reworks, level of skill and experience of the workforce, adequacy of method of construction, buildability issues, supervision and coordination were the most significant internal constraint factors. Among the external constraints, the Resource Management Act, ground conditions, market conditions and level of competition in the industry were found to be the most influential sub-factors affecting construction productivity of the New Zealand building industry. Project management, workforce issues and project finance were the most significant broad categories having an impact on construction productivity. In addition to addressing the key constraints found in the study, it is recommended that construction companies hold meetings with all engineers to manage the pre-construction phase, to avoid rework and also to determine an adequate method of construction during project implementation. Because of the labour-intensive nature of the construction operations, construction companies should also pay more attention to improving the level of skill and experience in the workforce. Encouraging more apprenticeships and learning new techniques of construction could also be the way to improve onsite labour productivity. Good planning and quality project management skills will improve supervision and coordination in the construction phase and play a key role in the achievement of on-site

labour productivity. Overall, a well-trained and well-led team of construction workers can achieve remarkable results and, when all the relevant factors are in balance, the productivity gains follow. It is believed that by focusing on the relative levels of impact of the identified constraints, the project team could be guided well in their efforts on addressing the constraints in a cost-effective manner.

## **5.2 Recommendations for Further Studies**

This study focused on constraints to construction on-site productivity; however, there are several aspects to construction productivity. Future studies should explore other influencing factors affecting construction productivity at all stages of the procurement process.

As demonstrated in the demographic analysis of the respondents in Section 4.2.2, the responses were largely from contractors (53 percent) and project management consultants (39 percent). The results did not include many inputs from subcontractors who provided only 8 percent of the responses). It may be necessary to aim for representative feedback from subcontractors in future studies, as they are the key players on construction sites. Also there was absence of feedback from clients and designers. Further studies should also seek to capture opinions of these stakeholders as they significantly influence on-site procurement processes and performance outcomes.

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## **APPENDICES**

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## **APPENDIX A: DOCUMENTS USED IN PLANNING AND CONDUCTING THE QUESTIONNAIRE SURVEYS**

A1: Covering letter for the questionnaire administration

A2: Sample copy of the questionnaire

A3: Form for requesting summary of the key findings of the research

# APPENDIX A1: QUESTIONNAIRE COVERING LETTER



Department of Construction  
Institute of Engineering and Advanced Technology, College of Sciences,  
Private Box 756, Wellington, Fax: 04 801 2694; Tel: 021 02399656; Email: serdarytu@gmail.com

Mr John Tymkin  
Project Manager  
Massey University at Wellington  
T20; Tel: X 62001

Date: 10<sup>th</sup> August 2010

Dear Mr Tymkin,

Research survey: **Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in New Zealand Building Industry**

Productivity represents efficient and effective utilisation of scarce resources to achieve set objectives. Increase in productivity correlates well with increased profitability, competitiveness, achievement of key stakeholder propositions as well as long term growth and sustainability of a firm, an industry and a nation. Improvement in the productivity of the New Zealand construction industry is critical considering its \$430b worth in investment outlay and significant contribution (of approximately 5 percent) to the GDP. There are identified typical constraints to productivity in the construction industry. For instance the choice of procurement system as having significant impact on the achievement of time, cost and quality targets for a project, factors relating to the acts of commission or omission of the key role players including clients, consultants and contractors, as well as project characteristics and external factors. On-site productivity issues are of critical importance as they provide the bulk – if not all - of the sources of productivity constraints in the construction industry. This study will focus on-site productivity constraints, since addressing these constraints will provide the much-needed productivity improvement in the industry. The study will seek to obtain experienced-based feedback on the key on-site productivity constraints from those at the forefront of project implementation – the contractors and consultants. These multiple sources of evidence will help to achieve triangulation of the research information for a more reliable outcome.

This is the objective of a Masters research in the Institute of Engineering and Advanced Technology, Massey University. The outcome of the study will include key constraints with their levels of impact and frequencies of occurrence and innovative ways of improving productivity of New Zealand construction industry to meet the objectives of the research; the attached questionnaire has been carefully designed and will take approximately 10 to 25 minutes to complete.

We therefore request your response to the survey, which will enhance the reliability and validity of the research findings. Your responses will be treated in strict confidence, and will be used exclusively for the purpose of the study. Kindly fax the filled questionnaire to the address indicated. If you would be interested in the key findings of this study, kindly fill the attached Summary Request Form and fax it separately should you desire anonymity.

Thank you in anticipation of your helpful response.

Yours sincerely,

*S DURDYEV*

---

Mr. Serdar DURDYEV  
(Researcher)

# APPENDIX A2: SAMPLE COPY OF QUESTIONNAIRE

S Durdyev

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MASSEY UNIVERSITY

School of Engineering & Advanced Technology

Private Bag 102 904 North Shore 0745, Auckland, New Zealand; Tel: +64 21 023 99 656; Fax: +64 9 443 9774; serdarytu@gmail.com

## Research Survey

### Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in New Zealand Building Industry

By:

Serdar DURDYEV

1 The following broad categories of internal constraints have been identified as the key restraints to the achievement of on-site productivity. Under each category, sources of the constraints are listed. Using the 5-point rating scales provided, please could you rate the levels of impact and the frequency of occurrence of each constraint source based on your experience? It will be appreciated if you could add additional constraints which have not been included in the list.

**Impact rating scale:** VH = Very high (5); H = High (4); M = Moderate (3); L = Low (2); VL = Very low (1).

**Frequency rating scale:** VF = Very frequent (5); F = Frequent (4); O = Occasional (3); R = Rare (2), VR = Very rare (1)

	Levels of impact of the constraints on productivity					Frequency of occurrence of the constraints					No idea
	VH	H	M	L	VL	VF	F	O	R	VR	
Internal constraints	5	4	3	2	1	5	4	3	2	1	

#### A PROJECT FINANCE: Cash flow problems arising from:

- 1 Late payments;
- 2 Reworks;
- 3 Under-valued work;
- 4 Dispute and litigation costs;
- 5 Lenders' high interest charges;
- 6 High insurance premiums; bonds/ retentions.
- 7 Inadequate supply or high cost of needed resources: money, men, materials & machinery;

*Other sources of cash flow problems? Please specify:*

8												
9												

#### B WORKFORCE: Productivity constraints arising from:

- 1 Level of motivation/commitment;
- 2 Level of empowerment (training and resourcing);
- 3 Level of skill and experience of the workforce;
- 4 Level of familiarity with current job and conditions;
- 5 Level of involvement of direct labour or subcontract;
- 6 Workforce absenteeism;
- 7 Level of staff turnover/ churn rate;
- 8 Health of the workforce

*Other workforce constraints? Please specify:*

8												
9												

#### C TECHNOLOGY/PROCESS: Productivity constraints arising from:

- 1 Suitability or adequacy of the plant & Equipment employed;
- 2 Adequacy of method of construction;
- 3 Adequacy of technology employed;
- 4 Lack of training and education to implement and operate new technologies;
- 5 Resistance to accept new technologies;
- 6 Inadequate IT infrastructure and application in construction industry;

*Other technology/ process constraints? Please specify:*

7												
---	--	--	--	--	--	--	--	--	--	--	--	--



# APPENDIX A2: SAMPLE COPY OF QUESTIONNAIRE

S Durdryev

Page 3 of 4

External constraints

Level of impact					Frequency					No idea
VH	H	M	L	VL	VF	F	O	R	VR	
5	4	3	2	1	5	4	3	2	1	

**C OTHER EXTERNAL FORCES: Productivity constraints arising from miscellaneous sources including:**

1 Inflation / fluctuations in material prices.											
2 Fluctuations in Exchange rate;											
3 Energy crises/ costs											
4 Interest rate/cost of capital;											
5 Market conditions and level of competitions in the industry for jobs											
6 Frequent changes in government policies/ legislations impacting on construction											
7 Rapid technological advances											
8 Increase in industry or society-wide litigations/ adversarial relations											
Other constraints from miscellaneous sources? Please specify:											
9											

3 For the broad categories of internal and external constraints mentioned before, how would you rate their relative levels of impact on the achievement of on-site productivity as well as their occurrence frequencies? Five-point rating scales have been provided as before.

Broad categories of internal and external constraints	Level of impact					Frequency					No idea	
	VH	H	M	L	VL	VF	F	O	R	VR		
	5	4	3	2	1	5	4	3	2	1		
1 Project finance												
2 Workforce												
3 Technology/ process												
4 Project characteristics												
5 Project management/ project team characteristics												
6 Statutory compliance												
7 Unforeseen events												
8 Other external forces (economic, political, industry, etc)												

4 If there is one piece of advice you can give to improve on-site productivity in the New Zealand construction industry, what would that be? (You are welcome to supply more than one piece of advice, if you choose to!):

**SECTION II: DEMOGRAPHIC BACKGROUND**

1 Kindly indicate only one of the following as your most frequent role as a member of the project team:

<input type="checkbox"/> Consultant	<input type="checkbox"/> Contractor
<input type="checkbox"/> Client/ owner	<input type="checkbox"/> Subcontractor
<input type="checkbox"/> Other (please specify): _____	

2 Kindly indicate how long you have been working in the industry in the above capacity?

<input type="checkbox"/> >25 years	<input type="checkbox"/> 10 - 14 yrs
<input type="checkbox"/> 20 - 25 yrs	<input type="checkbox"/> 5 - 9 yrs
<input type="checkbox"/> 15-19 yrs	<input type="checkbox"/> < 5 yrs

3 Kindly indicate your status in the organization.

<input type="checkbox"/> Director / Executive Director	<input type="checkbox"/> General foreman/ sectional head
<input type="checkbox"/> Manager / Associate Director	<input type="checkbox"/> Team Leader / supervisor
<input type="checkbox"/> Other (please specify): _____	

# APPENDIX A2: SAMPLE COPY OF QUESTIONNAIRE

S Durdyev

Page 4 of 4

- 5 Questionnaire design & clarity - feedback for improvement: Please could you rate the questionnaire in terms of clarity, relevance and other parameters indicated below?

	Strongly Disagree				Strongly Agree
1 The questions are meaningful or easy to understand					
2 The average response time is about 15 minutes					
3 The research outcome will be of interest to the industry					
4 All in all the questionnaire in its current form will be appealing to industry practitioners and would attract good response rate.					
5 If your ratings above show some serious flaws about any aspect of the questionnaire design that may affect its appeal and response rate from industry practitioners, please could you suggest improvement(s) in the textbox below?					

### APPRECIATION

*Thank you for your time. Kindly post the completed questionnaire using the enclosed self-addressed and stamped envelop; or fax it to: +64 9 443 9774 ; Attention: **Serdar DURDYEV**. If you have any comments in relation to the contents or any aspect of this questionnaire, or if you have any further advice that may improve the outcome of this project, you may wish to contact the researcher +64 21 023 99 656 (cell); Email: [serdarytu@gmail.com](mailto:serdarytu@gmail.com). Else, please state your overall comments below, if any:*

---

# APPENDIX A3: REQUEST FORM FOR SUMMARY OF KEY RESEARCH FINDINGS

Form for requesting summary of the key research findings

ATTENTION: MR. SERDAR DURDYEV

FAX: +64 9 443 9774

RESEARCH ON:

*Pareto Analysis of on-site Productivity Constraints and Improvement Techniques in New Zealand Building Industry*

I would like to receive a summary of the key findings of the research. My contact details are as follows.

<b>Name and address of company (optional):</b> _____ _____ _____ _____
---

<b>Fax:</b> _____
-------------------

<b>Attention:</b> _____
-------------------------

<b>E-mail:</b> _____
----------------------

## **APPENDIX B: SUMMARY OF KEY RESEARCH FINDINGS AND SUPPORTING CHARTS AND TABLES**

B1: Covering letter for the summary of key research findings and supporting charts and tables

B2: Summary of key research findings and supporting charts and tables

**APPENDIX B1: COVERING LETTER FOR THE  
SUMMARY OF KEY RESEARCH FINDINGS AND  
SUPPORTING CHARTS AND TABLES**



Department of Construction Management  
School of Engineering and Advanced Technology  
Private Bag 102 904, North Shore 0745, Auckland Fax: 09 443 9774; Tel: 021  
2399656; Email: [sdurdyev@massey.ac.nz](mailto:sdurdyev@massey.ac.nz)

Colin Moore  
New Zealand

Date: 25<sup>th</sup> December 2010

Dear Mr. Moore,

**SUMMARY OF THE KEY RESEARCH FINDINGS: “PARETO ANALYSIS OF  
ON-SITE PRODUCTIVITY CONSTRAINTS AND IMPROVEMENT  
TECHNIQUES IN NEW ZEALAND BUILDING INDUSTRY”**

Thank you very much for participating in the above research survey and for your helpful inputs that contributed to the successful completion of the project.

As promised during the survey, I am pleased to provide you with the summary of the key findings of the study (see attached documents). Your responses were treated with utmost confidence as pledged. All responses have been destroyed in line with the requirements of Massey Human Ethics Committee. The findings of the study will be presented in conferences and will be published in journals subsequently.

Once again, thank you very much!

Yours sincerely,

Serdar Durdyev  
(Research Student)

## **APPENDIX B2: SUMMARY OF KEY RESEARCH FINDINGS AND SUPPORTING CHARTS AND TABLES**

### *Research Objective 1*

**To establish the key constraints to construction on-site productivity and evaluate the relative levels of impact and their frequencies of occurrence with view to establishing risk levels in the New Zealand building industry.**

### *Findings*

This study, as part of its key aim, has identified the key on-site labour productivity constraints in the New Zealand construction industry and has prioritised the constraints based on their relative levels of impact. 56 sub-factors have been identified under 8 broad categories of internal and external constraints. The internal constraints comprising, in order of decreasing influence, project management, project finance, workforce, project characteristics and technology/ process contribute the bulk (about 67 percent) of the onsite productivity issues in the New Zealand construction industry. The key subcomponents under each of the five broad categories of the internal constraints are rework; level of skills and experience of the workforce; adequacy of method of construction; buildability issues; and issues around coordination, supervision and performance monitoring and control; respectively. Under the three external constraint broad categories, the key subcomponents are compliance with the Resource Management Act 1991; ground conditions; and the market conditions and level of competition in the industry; respectively. Table 6-14 present internal and external sub-factors rated according to their levels of impact under each category.

### *Research Objective 2:*

**To identify the 20 percent of the constraints responsible for 80 percent of the productivity risks.**

### *Findings*

The findings suggest that 20 percent of constraint factors in terms of broad category account for 28 percent of the problem and not 80 percent as assumed under Pareto principle. Table 16 shows the further Pareto analysis at the individual sub-factor levels was carried out, however at that level Pareto technique is not applicable as well.

Research Objective 3:

**To explore innovative ways of improving on-site productivity in the industry.**

*Findings*

Table 18 presents the analysis of the feedbacks on innovative ways of improving on-site productivity. The findings suggest that adequate planning is the key improvement way of on-site productivity. Technological application was suggested as the second important way to go in terms of achieving on-site labour productivity in the industry. Due to the labour-intensive nature of the industry it could be expected that the improvements in level of skills and experience of the workforce will be suggested as the significant way, however it was suggested as the third important way of improving on-site productivity in New Zealand building industry.

Table B1: Factors ranked under Project Finance category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index									
Internal Constraints	Levels of impact					TR	MR	RII	Rank
	VH	H	M	L	VL				
PROJECT FINANCE: Cash flow problems	5	4	3	2	1				
A arising from:	%	%	%	%	%				
1 Late payments;	14.29	31.43	25.71	14.29	14.29	35	3.17	0.15	4
2 Reworks;	20.00	40.00	28.57	5.71	5.71	35	3.63	0.17	1
3 Under-valued work;	14.71	32.35	35.29	11.76	5.88	34	3.38	0.16	3
4 Dispute and litigation costs;	12.90	25.81	9.68	38.71	12.90	31	2.87	0.14	5
5 Lenders' high interest charges;	0.00	13.79	24.14	51.72	10.34	29	2.41	0.11	6
6 High insurance premiums; bonds/ retentions;	0.00	5.56	30.56	38.89	25.00	36	2.17	0.10	7
7 Inadequate supply or high cost of needed resources: money, men, materials;	22.58	22.58	38.71	12.90	3.23	31	3.48	0.16	2

Table B2: Factors ranked under Workforce category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index									
Internal Constraints	Levels of impact					TR	MR	RII	Rank
	VH	H	M	L	VL				
WORKFORCE: Productivity constraints	5	4	3	2	1				
B arising from:	%	%	%	%	%				
1 Level of motivation/commitment;	20.00	40.00	22.86	14.29	2.86	35	3.60	0.14	2
2 Level of empowerment (training and resourcing);	11.43	42.86	22.86	22.86	0.00	35	3.43	0.13	4
3 Level of skill and experience of the workforce;	25.71	40.00	25.71	8.57	0.00	35	3.83	0.15	1
4 Level of familiarity with current job and conditions;	8.57	45.71	31.43	8.57	5.71	35	3.43	0.13	3
5 Level of involvement of direct labour or subcontract;	11.76	29.41	35.29	23.53	0.00	34	3.29	0.13	5
6 Workforce absenteeism;	8.82	17.65	44.12	23.53	5.88	34	3.00	0.11	6
7 Level of staff turnover/ churn rate;	2.86	20.00	42.86	25.71	8.57	35	2.83	0.11	7
8 Health of the workforce	0.00	21.21	42.42	30.30	6.06	33	2.79	0.11	8

Table B3: Factors ranked under Technology/Process category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>TECHNOLOGY/PROCESS: Productivity</b>									
<b>C constraints arising from:</b>	%	%	%	%	%				
1 Suitability or adequacy of the plant & Equipment employed;	8.57	37.14	28.57	20.00	5.71	35	3.23	0.15	2
2 Adequacy of method of construction;	19.44	33.33	33.33	13.89	0.00	36	3.58	0.16	1
3 Adequacy of technology employed;	5.71	37.14	22.86	31.43	2.86	35	3.11	0.14	4
4 Lack of training and education to implement and operate new technologies;	2.86	25.71	48.57	22.86	0.00	35	3.09	0.14	5
5 Resistance to accept new technologies;	5.88	29.41	38.24	26.47	0.00	34	3.15	0.14	3
6 Inadequate IT infrastructure and application in construction industry;	0.00	37.14	34.29	25.71	2.86	35	3.06	0.14	6
7 Adequacy of site layout	3.03	18.18	33.33	42.42	3.03	33	2.76	0.13	7

Table B4: Factors ranked under Project Characteristics category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>PROJECT CHARACTERISTICS:</b>									
<b>D Productivity constraints arising from:</b>	%	%	%	%	%				
1 Site conditions: access, subsoil; topography;	17.65	41.18	20.59	20.59	0.00	34	3.56	0.21	3
2 Project complexity: scale; design;	20.59	35.29	32.35	11.76	0.00	34	3.65	0.21	2
3 Buildability issues;	20.00	40.00	34.29	2.86	2.86	35	3.71	0.22	1
4 Site location and environment	11.76	26.47	35.29	20.59	5.88	34	3.18	0.18	4
5 Type of procurement adopted.	8.82	26.47	35.29	23.53	5.88	34	3.09	0.18	5

Table B5: Factors ranked under Project Management/Project Team Characteristics category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

Internal Constraints	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>PROJECT MANAGEMENT/ PROJECT TEAM CHARACTERISTICS: Productivity</b>									
<b>E constraints arising from:</b>	%	%	%	%	%				
1 Adequacy of planning and risk management process;	31.43	51.43	11.43	5.71	0.00	35	4.09	0.13	4
2 Coordination;supervision; performance monitoring and control;	54.29	34.29	11.43	0.00	0.00	35	4.43	0.14	1
3 Project organisational culture;	35.29	26.47	35.29	0.00	2.94	34	3.91	0.12	5
4 Relationship management/ degree of harmony, trust and cooperation;	37.14	45.71	11.43	2.86	2.86	35	4.11	0.13	3
5 Competencies of the project team;	26.47	29.41	35.29	5.88	2.94	34	3.71	0.12	7
6 Project management style;	22.86	40.00	31.43	2.86	2.86	35	3.77	0.12	6
7 Frequency of design changes/ change orders;	17.14	31.43	42.86	8.57	0.00	35	3.57	0.11	8
8 Cleint's overt influence on the construction process;	41.18	50.00	5.88	2.94	0.00	34	4.29	0.13	2

Table B6: Factors ranked under Statutory Compliance category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

External Constraints	Levels of impact					TR	MR	RII	Rank
	VH	H	M	L	VL				
	5	4	3	2	1				
<b>A STATUTORY COMPLIANCE: Productivity constraints arising from:</b>	%	%	%	%	%				
1 Health & Safety in Employment Act	2.63	23.68	44.74	10.53	18.42	38	2.82	0.13	3
2 Resource Management Act	8.82	29.41	38.24	17.65	5.88	34	3.18	0.15	1
3 Local Authority Bylaws,	0.00	20.59	38.24	35.29	5.88	34	2.74	0.13	4
4 Construction Contracts Act	0.00	12.50	15.63	50.00	21.88	32	2.19	0.10	6
5 Building Act/ Building Consent/ Building Regulations	9.09	27.27	27.27	33.33	3.03	33	3.06	0.14	2
6 Employment Relations Act	0.00	0.00	33.33	57.58	9.09	33	2.24	0.11	5
7 Consumer Guarantees Act	0.00	3.33	10.00	33.33	53.33	30	1.63	0.08	8
8 Fair Trading Act	0.00	3.45	6.90	34.48	55.17	29	1.59	0.08	9
9 Arbitration Act	3.57	0.00	10.71	39.29	46.43	28	1.75	0.08	7

Table B7: Factors ranked under Unforeseen Events category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

External Constraints	Levels of impact					TR	MR	RII	Rank
	VH	H	M	L	VL				
	5	4	3	2	1				
<b>B UNFORESEEN EVENTS: Productivity impediments arising from:</b>	%	%	%	%	%				
1 Inclement weather;	14.71	41.18	35.29	8.82	0.00	34	3.62	0.13	2
2 Ground conditions necessitating revisions	20.59	44.12	29.41	5.88	0.00	34	3.79	0.15	1
3 On-site accidents/ Acts of God;	13.89	25.00	30.56	30.56	0.00	36	3.22	0.13	3
4 Natural disasters	32.35	14.71	8.82	17.65	26.47	34	3.09	0.08	4

Table B8: Factors ranked under Other External Forces category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

External Constraints	Levels of impact					TR	MR	RII	Rank
	VH	H	M	L	VL				
	5	4	3	2	1				
<b>C OTHER EXTERNAL FORCES: Productivity Constraints Arising from Miscellaneous Sources Including:</b>	%	%	%	%	%				
1 Inflation / fluctuations in material prices.	6.06	21.21	51.52	15.15	6.06	33	3.06	0.15	2
2 Fluctuations in Exchange rate;	0.00	0.00	38.24	52.94	8.82	34	2.29	0.11	7
3 Energy crises/ costs	0.00	6.06	21.21	66.67	6.06	33	2.27	0.11	8
4 Interest rate/cost of capital;	0.00	6.06	30.30	57.58	6.06	33	2.36	0.11	5
5 Market conditions and level of competitions in the industry for jobs	0.00	54.84	29.03	12.90	3.23	31	3.35	0.16	1
6 Frequent changes in government policies/ legislations impacting on construction	0.00	12.12	27.27	54.55	6.06	33	2.45	0.12	3
7 Rapid technological advances	0.00	3.03	30.30	63.64	3.03	33	2.33	0.11	6
8 Increase in industry or society-wide litigations/ adversarial relations	3.45	6.90	24.14	62.07	3.45	29	2.45	0.12	4

Table B9: Factors ranked under Broad category

a) Levels of Impact: VH = Very high (5), H = High (4), M = Medium (3), L = Low (2), VL = Very low (1). b) TR = Total responses; c) MR = Mean responses (see Equation 03); d) RII = Relative Importance Index

	<sup>a</sup> Levels of impact					<sup>b</sup> TR	<sup>c</sup> MR	<sup>d</sup> RII	Rank
	VH 5	H 4	M 3	L 2	VL 1				
<b>Broad Categories of Internal and External Constraints</b>	%	%	%	%	%				
<b>1</b> Project finance	14.71	50.00	17.65	11.76	5.88	34	3.56	0.14	<b>2</b>
<b>2</b> Workforce	11.76	44.12	32.35	8.82	2.94	34	3.53	0.14	<b>3</b>
<b>3</b> Technology/ process	0.00	18.18	57.58	24.24	0.00	33	2.94	0.12	<b>6</b>
<b>4</b> Project characteristics	2.94	41.18	41.18	14.71	0.00	34	3.32	0.13	<b>4</b>
<b>5</b> Project management/ project team characteristics	17.14	40.00	28.57	11.43	2.86	35	3.57	0.14	<b>1</b>
<b>6</b> Statutory compliance	0.00	20.59	47.06	26.47	5.88	34	2.82	0.11	<b>7</b>
<b>7</b> Unforeseen events	11.76	14.71	38.24	29.41	5.88	34	2.97	0.12	<b>5</b>
<b>8</b> Other external forces (economic, political, industry, etc)	3.03	6.06	39.39	45.45	6.06	33	2.55	0.10	<b>8</b>

## **APPENDIX C: APPROVAL FOR MUHEC LOW RISK NOTIFICATION**

C1: Letter of Approval for MUHEC Low Risk Notification

C2: Form for Notification of Low Risk Research Involving Human Participant

C3: Screening Questionnaire to Determine the Approval Procedure

# APPENDIX C1: LETTER OF APPROVAL FOR MUHEC LOW RISK NOTIFICATION



MASSEY UNIVERSITY

FILE

27 August 2010

Serdar Durdyev  
B610, 176 Broadway  
Newmarket  
AUCKLAND 1023

Dear Serdar

**Re: Pareto Analysis of On-Site Productivity Constraints and Improvement Techniques in the New Zealand Building Industry**

Thank you for your Low Risk Notification which was received on 26 August 2010.

Your project has been recorded on the Low Risk Database which is reported in the Annual Report of the Massey University Human Ethics Committees.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

**A reminder to include the following statement on all public documents:**

*"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.*

*If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director (Research Ethics), telephone 06 350 5249, e-mail [humanethics@massey.ac.nz](mailto:humanethics@massey.ac.nz)".*

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to provide a full application to one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

John G O'Neill (Professor)  
Chair, Human Ethics Chairs' Committee and  
Director (Research Ethics)

cc Dr Jasper Mbachu  
School of Engineering and Advanced  
Technology  
Albany

Prof Don Cleland, HoS  
School of Engineering and Advanced  
Technology  
PN456

Massey University Human Ethics Committee  
Accredited by the Health Research Council

Te Kunenga  
ki Pūrehuroa

Research Ethics Office, Massey University, Private Bag 11222, Palmerston North 4442, New Zealand  
T +64 6 350 5573 +64 6 350 5575 F +64 6 350 5622  
E [humanethics@massey.ac.nz](mailto:humanethics@massey.ac.nz) [animaethics@massey.ac.nz](mailto:animaethics@massey.ac.nz) [gtc@massey.ac.nz](mailto:gtc@massey.ac.nz)  
[www.massey.ac.nz](http://www.massey.ac.nz)

# APPENDIX C2: FORM FOR NOTIFICATION OF LOW RISK RESEARCH INVOLVING HUMAN PARTICIPANTS



## NOTIFICATION OF LOW RISK RESEARCH/EVALUATION INVOLVING HUMAN PARTICIPANTS

(All notifications are to be typed)

### SECTION A:

- Project Title** PARETO ANALYSIS OF ON-SITE PRODUCTIVITY CONSTRAINTS AND IMPROVEMENT TECHNIQUES IN NEW ZEALAND BUILDING INDUSTRY  
**Projected start date for data collection** JULY 2010 **Projected end date** JUNE 2011
- Applicant Details** (Select the appropriate box and complete details)

#### ACADEMIC STAFF NOTIFICATION

**Full Name of Staff Applicant/s** .....  
**School/Department/Institute** .....  
**Region (mark one only)** Albany  Palmerston North  Wellington   
**Telephone** ..... **Email Address** .....

#### STUDENT NOTIFICATION

**Full Name of Student Applicant** SERDAR DURDYEV  
**Postal Address** B610. 176 BROADWAY RD. NEWMARKET AUCKLAND.  
**Telephone** +64 2102399656 **Email Address** serdarytu@gmail.com  
**Employer (if applicable)** .....  
**Full Name of Supervisor(s)** DR JASPER IKEOKWU MBACHU  
**School/Department/Institute** SCHOOL OF ENGINEERING AND ADVANCED TECHNOLOGY  
**Region (mark one only)** Albany  Palmerston North  Wellington   
**Telephone** X 41573 **Email Address** J.I.Mbachu@massey.ac.nz

#### GENERAL STAFF NOTIFICATION

**Full Name of Applicant** .....  
**Section** .....  
**Region (mark one only)** Albany  Palmerston North  Wellington   
**Telephone** ..... **Email Address** .....  
**Full Name of Line Manager** .....  
**Section** .....  
**Telephone** ..... **Email Address** .....

**3. Type of Project** (mark one only)

Staff Research/Evaluation:	<input type="checkbox"/>	Student Research:	<input checked="" type="checkbox"/>	If other, please specify:
Academic Staff	<input type="checkbox"/>	Qualification (MConMgmt)		
General Staff	<input type="checkbox"/>	Points Value of Research	120	

**4. Describe the peer review process used in assessing the ethical issues present in this project.**

My supervisor and I had a meeting to discuss the ethical implication of the proposed research survey in line with the provisions of the Ethical Code of Conduct. The conclusion was that the nature of the harm to participants, researcher and the University, if any, would be minimal and would be "no more than is normally encountered in daily life". The application was consequently agreed to be Low Risk Notification given that it will be a self-administered questionnaire where the respondent is assured of anonymity and his or her rights of choice whether or not to participate in the survey.

In addition, following my supervisor's direction, I have read and have been acquainted with the provisions of the Code of Ethical Conduct for Research, Teaching and Evaluations Involving Human Participants, especially as it relates to the seven major ethical principles: a) respect for persons; b) minimisation of harm to participants, researchers, institutions and groups; c) informed and voluntary consent; d) respect for privacy and confidentiality; e) the avoidance of unnecessary deception; f) avoidance of conflict of interest; g) social and cultural sensitivity to the age, gender, culture, religion, social class of the participants; and h) justice.

**5. Summary of Project**

**Please outline in no more than 200 words in lay language why you have chosen this project, what you intend to do and the methods you will use.**

*(Note: all the information provided in the notification is potentially available if a request is made under the Official Information Act. In the event that a request is made, the University, in the first instance, would endeavour to satisfy that request by providing this summary. Please ensure that the language used is comprehensible to all)*

Project topic is, "Pareto analysis of on-site productivity constraints and improvement techniques in New Zealand building industry".

Research aims to establish the key constraints of on-site productivity of New Zealand construction industry and evaluate their levels of impact and frequencies of occurrence with a view to identifying the 20% of the constraints responsible for 80% of the productivity risks. Outcome of the research will include itemised key constraints to on site productivity in New Zealand construction industry with their relative levels of impact and frequencies of occurrence. These parameters would be used to map the risk levels of the identified constraints on the Influence – Frequency Matrix for better visual appreciation and delineation.

Descriptive survey method will be used, which will involve questionnaire survey of project managers, contractors and subcontractors working on commercial and institutional projects. Participation is voluntary. Questionnaire forms will be distributed by posts with provision for response feedback using self-addressed and stamped return envelopes. Respondents will be assured of anonymity and their responses will be used solely for data analysis.

**Please submit this Low Risk Notification (with the completed Screening Questionnaire) to:**

**The Ethics Administrator  
Research Ethics Office  
Old Main Building, PN221  
Massey University  
Private Bag 11 222  
Palmerston North**

**SECTION B: DECLARATION** (Complete appropriate box)

**ACADEMIC STAFF RESEARCH**

**Declaration for Academic Staff Applicant**

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. My Head of Department/School/Institute knows that I am undertaking this research. The information contained in this notification is to the very best of my knowledge accurate and not misleading.

Staff Applicant's Signature \_\_\_\_\_ Date: \_\_\_\_\_

**STUDENT RESEARCH**

**Declaration for Student Applicant**

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and discussed the ethical analysis with my Supervisor. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. The information contained in this notification is to the very best of my knowledge accurate and not misleading.

Student Applicant's Signature SERDAR DURDUYEV Date: 11/08/2010

**Declaration for Supervisor**

I have assisted the student in the ethical analysis of this project. As supervisor of this research I will ensure that the research is carried out according to the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants.

Supervisor's Signature  Date: 11/08/2010

Print Name Dr Jasper Mbachu

**GENERAL STAFF RESEARCH/EVALUATIONS**

**Declaration for General Staff Applicant**

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and discussed the ethical analysis with my Supervisor. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. The information contained in this notification is to the very best of my knowledge accurate and not misleading.

General Staff Applicant's Signature \_\_\_\_\_ Date: \_\_\_\_\_

**Declaration for Line Manager**

I declare that to the best of my knowledge, this notification complies with the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and that I have approved its content and agreed that it can be submitted.

Line Manager's Signature \_\_\_\_\_ Date: \_\_\_\_\_

Print Name \_\_\_\_\_

# APPENDIX C3: SCREENING QUESTIONNAIRE TO DETERMINE THE APPROVAL PROCEDURE



**Massey University**

Te Kuenga ki Pūrehuroa

## SCREENING QUESTIONNAIRE TO DETERMINE THE APPROVAL PROCEDURE

*(Part A and Part B of this questionnaire must both be completed)*

**Name:** SERDAR DURDYEV

**Project Title:** PARETO ANALYSIS OF ON-SITE PRODUCTIVITY CONSTRAINTS AND IMPROVEMENT TECHNIQUES IN NEW ZEALAND BUILDING INDUSTRY

### Part A

The statements below are being used to determine the risk of your project causing physical or psychological harm to participants and whether the nature of the harm is minimal and no more than is normally encountered in daily life. The degree of risk will then be used to determine the appropriate approval procedure.

**Does your Project involve any of the following?**

*(Please answer all questions. Please circle either YES or NO for each question)*

#### Risk of Harm

1. Situations in which the researcher may be at risk of harm.	YES <input type="radio"/> NO <input checked="" type="radio"/>
2 Use of questionnaire or interview, whether or not it is anonymous which might reasonably be expected to cause discomfort, embarrassment, or psychological or spiritual harm to the participants.	YES <input type="radio"/> NO <input checked="" type="radio"/>
3. Processes that are potentially disadvantageous to a person or group, such as the collection of information which may expose the person/group to discrimination.	YES <input type="radio"/> NO <input checked="" type="radio"/>
4. Collection of information of illegal behaviour(s) gained during the research which could place the participants at risk of criminal or civil liability or be damaging to their financial standing, employability, professional or personal relationships.	YES <input type="radio"/> NO <input checked="" type="radio"/>
5. Any form of physically invasive procedure on volunteer participants, such as the collection of blood, body fluid or tissue samples, exercise regimes or physical examination.	YES <input type="radio"/> NO <input checked="" type="radio"/>
6. The administration of any form of drug, medicine (other than in the course of standard medical procedure), placebo.	YES <input type="radio"/> NO <input checked="" type="radio"/>
7. Physical pain, beyond mild discomfort.	YES <input type="radio"/> NO <input checked="" type="radio"/>
8. Any Massey University teaching which involves the participation of Massey University students for the demonstration of procedures or phenomena which have a potential for harm.	YES <input type="radio"/> NO <input checked="" type="radio"/>

**Informed and Voluntary Consent**

9. Participants whose identity is known to the researcher giving oral consent rather than written consent (if participants are anonymous you may answer No).	YES <input type="radio"/> NO <input checked="" type="radio"/>
10. Participants who are unable to give informed consent.	YES <input type="radio"/> NO <input checked="" type="radio"/>
11. Research on your own students/pupils.	YES <input type="radio"/> NO <input checked="" type="radio"/>
12. The participation of children (seven (7) years old or younger).	YES <input type="radio"/> NO <input checked="" type="radio"/>
13. The participation of children under sixteen (16) years old where parental consent is not being sought.	YES <input type="radio"/> NO <input checked="" type="radio"/>
14. Participants who are in a dependent situation, such as people with a disability, or residents of a hospital, nursing home or prison or patients highly dependent on medical care.	YES <input type="radio"/> NO <input checked="" type="radio"/>
15. Participants who are vulnerable.	YES <input type="radio"/> NO <input checked="" type="radio"/>
16. The use of previously collected information or biological samples for which there was no explicit consent for this research.	YES <input type="radio"/> NO <input checked="" type="radio"/>

**Privacy/Confidentiality Issue**

17. Any evaluation of Massey University services or organisational practices where information of a personal nature may be collected and where participants may be identified.	YES <input type="radio"/> NO <input checked="" type="radio"/>
--	---

**Deception**

18. Deception of the participants, including concealment and covert observations.	YES <input type="radio"/> NO <input checked="" type="radio"/>
---	---

**Conflict of Interest**

19. Conflict of interest situation for the researcher (e.g. is the researcher also the lecturer/teacher/treatment-provider/colleague or employer of the research participants or is there any other power relationship between the researcher and research participants?)	YES <input type="radio"/> NO <input checked="" type="radio"/>
---	---

**Compensation to Participants**

20. Payments or other financial inducements (other than reasonable reimbursement of travel expenses or time) to participants.	YES <input type="radio"/> NO <input checked="" type="radio"/>
---	---

**Procedural**

21. A requirement by an outside organisation (e.g. a funding organisation or a journal in which you wish to publish) for Massey University Human Ethics Committee approval.	YES <input type="radio"/> NO <input checked="" type="radio"/>
---	---

## Part B

The statements below are being used to determine if your project requires ethical approval by a Regional Health and Disability Ethics Committee. The statements are derived from the document “Guidelines for an Accredited Institutional Ethics Committee to refer Studies to an Accredited Health and Disability Ethics Committee” prepared by the Health Research Council Ethics Committee

(<http://www.hrc.govt.nz/assets/pdfs/policy/ReferralGuidelines.pdf>)

In situations where you are not sure whether the research needs approval by an HDEC, you should seek an opinion from the Administrator of the relevant HDEC.

(<http://www.newhealth.govt.nz/ethicscommittees/>)

Include a copy of your written response from the Administrator with your application.

### Does your Project involve any of the following?

*(It is important that you answer all questions. Please circle either YES or NO for each question)*

22. The use of staff or facilities of a health provider.	YES <input type="radio"/> NO <input type="radio"/>
23. Support, directly or indirectly, in full or in part, by public health funds.	YES <input type="radio"/> NO <input type="radio"/>
24. Participants who are patients/clients of, or health information about an identifiable individual held by, an organisation providing health services (for example, general practice, physiotherapy, occupational therapy, sports medicine), disability services, or institutionalised care.	YES <input type="radio"/> NO <input type="radio"/>
25. Requirement for ethical approval to access health or disability information about an identifiable individual held by the Ministry of Health, or held by any public or private organisation whether or not that organisation is related to health.	YES <input type="radio"/> NO <input type="radio"/>
26. A clinical trial which: requires the approval of the Standing Committee on Therapeutic Trials; requires the approval of the Gene Technology Advisory Committee; is sponsored by and/or for the benefit of the manufacturer or supplier of a drug or device.	YES <input type="radio"/> NO <input type="radio"/>
27. Research in categories 22-26 involving New Zealand agencies, researchers or funds and undertaken outside New Zealand.	YES <input type="radio"/> NO <input type="radio"/>

**Determine the type of approval procedure to be used (choose one option):**

<p>If you answer <b>YES</b> to any of the questions 1 to 21 (Part A) and <b>NO</b> to <b>all</b> questions in Part B</p>	<p>If you answer <b>YES</b> to any of the questions 22 to 27 (Part B)</p>	<p>If you answer <b>NO</b> to all of the questions *</p>
↓	↓	↓
<p><b>Following a process of peer review, prepare an application using the MUHEC Application Pack</b></p>	<p><b>Following a process of peer review, prepare an application using the Health &amp; Disability Ethics Committees Application Form</b></p>	<p>Following a process of peer review, prepare a <b>Low Risk Notification</b></p> <p><i>* Note- researchers who are new to the University, new to research with human participants or for whom Committee approval is desirable are welcome to send in a full MUHEC application, even if the Screening Questionnaire questions have all been answered "no".</i></p>
↓	↓	↓
<p>GO BACK TO APPROVAL PROCEDURES, STEP 5, AND DOWNLOAD THE INFORMATION REQUIRED.</p> <p><a href="http://humanethics.massey.ac.nz/approval_procedures.htm">http://humanethics.massey.ac.nz/approval_procedures.htm</a></p>		

## **APPENDIX D: RESEARCH AWARDS**

D1: BRANZ Building Research Postgraduate Scholarship Award

# APPENDIX D1: BRANZ BUILDING RESEARCH POSTGRADUATE SCHOLARSHIP AWARD



18 June 2010

Mr Serdar Durdyev  
1 Dunbarton Drive,  
Ranui,  
Auckland. 0612

Dear Mr Durdyev

## **Building Research Postgraduate Scholarship Award.**

We have carefully considered the material submitted to us through Dr Mbachu on 16 June, including your own letter of 15 June, regarding your proposal to carry out a masters in construction management project at Massey University on a Pareto analysis of on-site productivity constraints and improvement techniques in New Zealand building industry, and I am pleased to advise that BRANZ will make a \$20,000 (incl GST, if payable) award to you for your pursuit of completion of your studies toward your degree as defined in your proposal.

The Award will be subject to the following conditions:

- BRANZ liability for funding of this work is limited to this scholarship except as otherwise specifically stated in writing, and you are responsible for meeting any course fees, other costs related to your project, etc which may accrue.
- The award of this scholarship will not form, nor shall be represented by you to any other party to form, any employment relationship with BRANZ.
- This financial assistance is to be recognised by reference to 'assistance from the Building Research Levy' in any publications (including your thesis) or presentations on the work which arise from this date. A logo will be available for your use in Powerpoint presentations etc on request.
- You understand that this award is under the umbrella of the Construction Industry Productivity Research Programme, which places requirements on regular reports on progress to its Research Programme Board. Dr Mbachu will keep you informed of requirements for this.
- BRANZ will receive a copy of your thesis for our library, and the right to make it available to users of our library for the purposes of research.
- You will give a seminar on your work to the staff of BRANZ Group at a session at Judgeford, or to another seminar approved by BRANZ, when the project is approaching completion.
- You will prepare a 1000-word article on the completed work, suitable for publication in BRANZ's magazine BUILD, which may be edited and may or may not be printed at the Editor's sole discretion.

We would like you to also maintain liaison with BRANZ during the project, and for that purpose nominate Mr Ian Page ([ian.page@branz.co.nz](mailto:ian.page@branz.co.nz)). This liaison is not to be construed as a condition by BRANZ that he is to be a joint supervisor. Mr Page will be able to facilitate key interactions for you with BRANZ staff as required.

You outlined a project plan on page 9 of your project submission, and this is acceptable to us. We propose that we will pay your award in instalments as follows (the milestones use your numbering):

AKO

1222 MOONSHINE ROAD  
RD 1, PORIRUA 5361  
PRIVATE BAG 50 908  
PORIRUA 5240, NEW ZEALAND  
T +64 4 237 1170 F +64 4 237 1171  
WWW.BRANZ.CO.NZ

## **APPENDIX E: DOCUMENTS USED IN CONFIRMATORY INTERVIEWS**

E1: Participant Information Sheet

E2: Participant Consent Form

E3: Interview Questions

E4: Samples of Interview Feedback

# APPENDIX E1: PARTICIPANT INFORMATION SHEET



**MASSEY UNIVERSITY**  
**TE KUNENGA KI PŪREHUROA**

School of Engineering & Advanced Technology

Private Bag 102 904, North Shore City 0745

Auckland, New Zealand

Tel: +64 9 414 0800 extn 41544 Fax: +64 9 443 9774

## **Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in New Zealand Building industry**

### **PARTICIPANT INFORMATION SHEET**

*My name is Serdar Durdyev, a Master's research student of the School of Engineering and Advanced Technology, Massey University, New Zealand. My research is entitled, "Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in New Zealand Building industry". Construction industry is highly competitive, that is why the participants in the industry must improve productivity to survive. The reported poor productivity of the New Zealand building industry is as a result of identifiable factors which constrain the achievement of set project objectives. Improved On-site Productivity offers benefit to achieve the overall project objectives in the best possible time and to obtain accuracy at the most cost-effective levels with the best quality.*

*This study aims to investigate the level of impact and frequencies of occurrence of the key on-site productivity constraints as well as establishing innovative ways of improving productivity in the industry.*

*Sampling frames for this study comprise clients, consulting, contracting and subcontracting organizations in New Zealand construction industry. As an industry operative, you've been selected to participate in the research survey through a random sampling of industry members.*

*I would highly appreciate it if you could grant 20 to 25 minutes of your time for an interview with you. To give you prior knowledge of the questions to be asked, I have enclosed the interview questions, which focus on the ways for improving on-site productivity in the NZ construction industry.*

*Information collected in this project will be kept strictly confidential and used solely for research purpose. The information provided will be destroyed on completion of the research. I undertake to provide you with a summary of the key findings of the study if you could complete the attached form for requesting the summary or by contacting me directly through my contact details provided below.*

*Participation in this research is voluntary and you are under no obligation to accept this invitation. If you decide to participate, you have the right to:*

- decline to answer any particular question;*
- withdraw from the study, within 10 days of interview;*
- ask any questions about the study at any time during participation;*
- provide information on the understanding that your name will not be used unless you give permission to the researcher;*
- be given access to a summary of the project findings when it is concluded;*
- ask for the recorder to be turned off at any time during the interview, if a recorder is used.*

*Thank you very much for your time and help in making this research possible. If you have any queries, please contact me through my contact details, as under:*

*Serdar Durdyev*

*School of Engineering & advanced Technology*

*Private Bag 102 904, North Shore City 0745*

*Auckland, New Zealand*

*Cell: +64 21 -023 99656*

*Tel: +64 9 846 5436*

*Fax: +64 9 443 9774*

*sdurdyev@massey.ac.nz*

*You may wish to contact my supervisor on following contact details:*

*Dr. Jasper Mbachu*

*Senior Lecturer and coordinator, Construction Programmes*

*School of Engineering & advanced Technology*

*Private Bag 102 904, North Shore City 0745*

*Auckland, New Zealand*

*Tel: +64 9 414 0800 extn 41543*

*Fax: +64 9 443 9774*

*J.I.Mbachu@massey.ac.nz*

*Disclaimer: The project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.*

*If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director, Research Ethics, telephone 06 350 5249, email [humanethics@massey.ac.nz](mailto:humanethics@massey.ac.nz)".*

## APPENDIX E2: PARTICIPANT CONSENT FORM



**MASSEY UNIVERSITY**  
**TE KUNENGA KI PŪREHUROA**

School of Engineering & Advanced Technology  
Private Bag 102 904, North Shore City 0745  
Auckland, New Zealand

Tel: +64 9 414 0800 extn 41544 Fax: +64 9 443 9774

### **Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in New Zealand Building industry**

#### **PARTICIPANT CONSENT FORM - INDIVIDUAL**

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to the interview being sound recorded.

I wish/do not wish to have my recordings returned to me.

I agree to participate in this study under the conditions set out in the Information Sheet.

**Signature:**

**Date:**

.....

**Full Name - printed**

.....

## **APPENDIX E3: INTERVIEW QUESTIONS**

### **Pareto Analysis of On-site Productivity Constraints and Improvement Techniques in New Zealand Building Industry**

#### **Interview Questions:**

- 1- Based on your experience to date, what factors could you suggest as the key constraints to achieving on-site productivity in the New Zealand construction industry? How would you prioritize these factors in terms of their risk levels as on-site productivity constraints?
- 2- If you were to have another look at the factors at cluster levels, what further suggestions could you provide as the key constraints to on-site productivity under each of the following clusters: I.e. in what ways could issues around each of the following clusters constrain the achievement of on-site productivity?
  - a. Project finance/ cash flow;
  - b. Workforce;
  - c. Technology/process;
  - d. Project characteristics;
  - e. Project management;
  - f. Statutory compliance;
  - g. Unforeseen events;
  - h. External factors;
- 3- A) For the above 8 clusters of productivity constraints, which three would you recommend are the most risky clusters? (Please prioritise them in order of risk levels, with 1 being the most risky); B) What mitigation measures would you advise for addressing these three most risky clusters?
- 4- Generally, if there are some pieces of advice you can give to improve on-site productivity in the New Zealand construction industry, what would they be?

Thanks you very much for sparing your valuable time to participate in this research interview.

## APPENDIX E4: SAMPLES OF INTERVIEW FEEDBACK

### Colin Moors – Moors Construction

1-

- a- Lack of fully-trained personnel
- b- Lack of design for simple labour saving methods.
- c- Lack of urgency in whole on-site inspection process, Lack of knowledge by inspectors.
- d- Weather
- e- Job management: Critical to have a workable, achievable programme - Experienced trained foreman, QS backup.
- f- Site Constraints.
- g- Design Constraints.
- h- Client changes during construction.
- i- On site mistakes. - Impact on productivity is immediate and costly.

2-

- a- **Project Finance:** Reworks, Late Payments, Contract prices that are too low will always impact on quality, productivity and often completion.
  - b- **Workforce:** Trained workforce
  - c- **Technology/Process:** Improving the usage of computer controlled construction technology.
  - d- **Project Characteristics:** Design Constraints, Site Constraints,
  - e- **Project Management:** Lack of trained management, collaboration with design and construction team.
  - f- **Statutory Compliance:** N/A
  - g- **Unforeseen Events:** Weather.
  - h- **External Factors:** Strikes lockouts, natural disaster, fire imported goods unavailable.
- 3- **Project Management**

#### **Workforce**

#### **Project Characteristics**

4- **General Advice** - Based on my experience owner operator, trade thought, self thought in management, finance costing, project management etc. in hindsight Moors Construction would have grown faster and been more successful if I had created a management team rather than try to do everything myself.

The industry is now changing constantly and quickly and to be successful in the wider industry requires structured management. It is no longer enough to be a good tradesman builder. I do believe that productivity should not be the only good for a construction company. The task of consistently producing quality buildings is not a simple as having great production figures. I do acknowledge that a well trained and well lead team of construction workers can achieve remarkable results and it is my experience that when all the relevant factors are in balance the productivity gains follow.

## **John Pengelly – Mainzeal Construction**

**1-**

**a-** Poor design documentation, Lack of details and poor coordination and changes in design. Lack of Client brief leads to design not meeting Clients expectations leads to changes = rework \$ and lowers morale.

**b-** Availability of suitable skills. Lack of trained workforce and supervision.

**c-** Time constraints. Project time frame, pre-construction and contraction. Clients' commitment too late with unrealistic delivery time.

**d-** Poor understanding of planning, programming and methodology of construction.

**e-** Environmental Constraints - Weather in NZ. Location (resource availability), spatial/neighbours.

**2-**

**a- Project Finance:** Entry Price, Reworks, Late Payments,

**b- Workforce:** Lack of skills except Electrical and Plumbing, because they have suitable qualification, training and apprenticeship.

**c- Technology/Process:** NZ is behind from world technology according to building industry. Using pre-cast concrete need to increase pre-fabricated elements will increase the productivity of construction industry of NZ.

**d- Project Characteristics:** Complexity of the project. Good quality should be during construction to avoid re-work.

**e- Project Management:** Planning and programming sets the productivity targets and dependencies and sequences between trades. Absolutely key to getting productive flow to follow on trade.

**f- Statutory Compliance:** N/A

**g- Unforeseen Events:** Weather depending on location. Site accidents and natural disaster.

**h- External Factors:** N/A

## **3- Project Management and Planning**

**Skilled Workforce**

**Project Finance**

**4-** Complete design, pre-construction, adequate project time duration, having formal registration and qualification (i.e. carpentry, etc.) of workforce. Early collaboration working together. Design should be buildable and all details should be clear. It can only be achieved with the right people at the table such as designer, contractor and key supply chain people. Increase productivity goes beyond physical dimensions. Not just design, material. If you want to motivate workforce you need leaders and champions on the site and they provide motivation, set productivity targets and recognizes those who achieve and holds accountable those who do not. If one link (trade) of the chain does not perform this impacts on the performance of the next link (trade).

**APPENDIX F: NOTIFICATION OF SUBMISSION FOR  
THE PUBLICATION OF THE RESEARCH RESULTS IN A  
CONFERENCE PROCEEDING**

F1: Letter of Acceptance for Refereed Technical Paper of PAQS Conference 2011

F2: Referee Report for Technical Paper of PAQS Conference 2011

**APPENDIX F1: LETTER OF ACCEPTANCE FOR  
REFEREED TECHNICAL PAPER OF PAQS  
CONFERENCE 2011**

**15<sup>th</sup> Pacific Association of Quantity Surveyors Congress  
23<sup>rd</sup> - 26<sup>th</sup> July 2011  
Colombo, Sri Lanka**

Conference Reference Number : PAQS - S4038

Dear Serdar Durdyev, Jasper Mbachu and Robyn Phipps,

We have received reviewers' comments on your paper and we are pleased to inform that your paper is accepted subjected to addressing reviewers' comments attached herewith.

In addition, please revise the paper based on the comments on formatting attached herewith and check that the references are accurate and complete.

Please further make sure that the paper is formatted in accordance with the instructions given in the Paper Guideline on <http://www.paqs2011.lk/submission-of-papers.html>. Please use the Full Paper Template <http://www.paqs2011.lk/submission-of-papers.html> for further guidance.

Please submit your revised paper (Camera Ready Paper) on or before **15th June 2011** through [papers@paqs2011.lk](mailto:papers@paqs2011.lk) . In this revised paper, delete the title page and include Author details after the title. Also send a separate document explaining your response to reviewers' comments.

Please feel free to write to [papers@paqs2011.lk](mailto:papers@paqs2011.lk) for any other queries.

Best Regards,

Professor Chitra Weddikkara,  
Congress Chair,  
The President,  
Institute of Quantity Surveyors Sri Lanka,  
Sri Lanka.

Email : [papers@paqs2011.lk](mailto:papers@paqs2011.lk)  
Mob : [+94771227269](tel:+94771227269) (Chandanie)  
Web : [www.paqs2011.lk](http://www.paqs2011.lk)

# APPENDIX F2: REFEREE REPORT FOR TECHNICAL PAPER OF PAQS CONFERENCE 2011

15<sup>th</sup> Pacific Association of Quantity Surveyors Congress

22<sup>nd</sup> - 27<sup>th</sup> July 2011

Colombo, Sri Lanka

**Paper Review Form**

Paper Reference No.	PAQS-S4038	Paper Title	Pareto Analysis of on-site productivity constraints and improvement techniques in New Zealand construction and building industry
Comments for Author(s) (X)	Accept without changes		
	Accept subject to minor changes		X
	Accept subject to major changes		
	Reject (please provide reasons)		
<p><b><u>Reviewers' Comments</u></b></p> <p><i>Try to address reviewer's comments as much as possible.</i></p> <p>Interesting paper relate to the key theme of the conference. However few suggestions are listed below for further improvements.</p> <p>Since paper is mainly focus on on-site productivity, I would like to suggest narrowing down the introduction section giving emphasis only to on-site or at project level where you can also strict to the full paper guidelines (E.g: Refer sections 1.2 ,1.3 &amp; 1.4). Further though your paper focus on constraints &amp; improvement techniques, more emphasize has been on measures of productivity.</p> <p>Further, prior to presenting results giving a brief outline will be enhanced the readability (before section 3.1). Finally, few minor errors visible in the paper such as, syntax relates to references (refer section 1.2) and few spelling mistakes (refer section 2.1).</p>			

## **APPENDIX G: PUBLICATIONS OF RESEARCH FINDINGS**

G1: Acknowledgement of journal paper submission

# **APPENDIX G1: ACKNOWLEDGEMENT OF JOURNAL PAPER SUBMISSION**

## **AUSTRALASIAN JOURNAL OF CONSTRUCTION ECONOMICS AND BUILDING**

### **Title and Abstract**

Productivity is key to the survival and growth of any organisation, industry or nation. Some factors constrain the achievement of the set project objectives in the New Zealand building and construction industry and are responsible for the reported steady decline of productivity and performance. This study aims to identify the key constraints to on-site labour productivity and improvement measures. Using the descriptive survey method, views of some project managers, contractors and subcontractors in New Zealand were canvassed via pilot interviews and questionnaire surveys at the qualitative and quantity data gathering stages, respectively. Multi-attribute technique was used to analyse the quantitative data. Results showed that the key external constraints to on-site labour productivity comprise, in order of decreasing impact, statutory compliance, unforeseen events and wider external dynamics. The internal constraints, which contribute 67 percent of the onsite productivity issues, comprise reworks, level of skill and experience of the workforce, adequacy of method of construction, buildability issues, and inadequate supervision and coordination. . The factors underlying each broad category of external and internal constraints are reported. The relative levels of impact of the identified constraints are expected to guide the project team in addressing the constraints in a cost-effective manner.

**Keywords:** Construction management, labour productivity, New Zealand construction industry, performance improvement, productivity constraints.

Submission

Authors SERDAR DURDYEV, JASPER MBACHU

Title On-site Labour Productivity of New Zealand Construction  
Industry:  
Key Constraints and Improvement Measures

Original file [2120-8587-1-SM.DOC](#) 2011-04-27

Supp. files None [ADD A SUPPLEMENTARY FILE](#)

Submitter SERDAR DURDYEV

Date submitted April 27, 2011 - 10:32 PM

Section Articles

Editor Goran Runeson

Status

Status In Review

Initiated 2011-04-27

Last  
modified 2011-04-27


## APPENDIX H: RESEARCH PROGRAMME

(SNAPSHOT AS AT JANUARY 2011)

	DESCRIPTION	DURATION (Months)	CALENDER YEAR 2010							CALENDER YEAR 2011						
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mac	Apr	May	Jun	Jul
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Research Proposal		Completed													
2	Questionnaire design		Completed	Completed												
3	MUHEC application			Completed												
4	Questionnaire Pre-Test				Completed											
5	Questionnaire Survey					Completed	Completed	Completed								
6	Data Analysis							Completed								
7	Confirmatory interviews							Completed	Completed		Outstanding					
8	Report write up: 1st draft - supervisors										Outstanding	Outstanding				
9	Report write up: 2rd draft: Final submission										Outstanding	Outstanding	Outstanding			
10	Compile Thesis												Outstanding	Outstanding		
11	Dissemination of findings:														Outstanding	Outstanding
12	Conferences															Outstanding
13	Journal															

0

 Completed

 Outstanding