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AN EVALUATION OF THE CONTEXTUAL FACTORS THAT AFFECT LABOUR PRODUCTIVITY IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

By

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ABSTRACT

Poor labour productivity is an endemic global problem in the construction industry. In the past two decades, it has been observed over the different sectors of the construction industry that the labour productivity expended on projects has reported a decline, particularly in the building and civil sectors. This research explores the variables that affect labour productivity on construction sites and whether the estimation practices used considers the various circumstances in which buildings and infrastructure are produced.

Literature review aided in the identification of contextual factors classified in four categories that affect labour productivity on construction projects. These categories were; site environment factors, organisational factors, technical factors and social factors. These factors were used in the development and design of the questionnaire to analyse the impact of these factors on construction labour productivity. The population of the study comprised of directors, contracts managers, project and construction managers, quantity surveyors and estimators who are employees of construction firms listed in Grades 2-9 of the Construction Industry Development Board (cidb) Register of Contractors in South Africa. The study area covered nine provinces of South Africa. At the end of the survey period, 117 valid responses were received and analysed.

The findings of the study revealed that at the pre-construction phase of a construction project, social factors, complexity of the project and organisational factors are not considered in the estimation practices and techniques. Results further revealed that four core factors that affect productivity of labour are; lack of experience amongst workers, delays in the wages of labourers, change orders from designers/consultants and the relationships between labourers and their supervisors. The study established a relationship between the contextual factors and labour productivity on construction projects. Motivation and training emerged as significant changes needed to improve labour productivity on projects.

Based on these findings, the study concludes that labour productivity is impacted by contextual site factors such as lack of experience, delays in labour payment and that these are not considered by estimators at the project pre-construction phase. The study recommends that these site factors need to be considered during the pre-construction phase of a project in order to allow for their impact on labour productivity during construction. Furthermore, a benchmark and standard of what constitutes effective labour productivity needs to be developed on construction sites, especially one that is project specific and considering all the four categories of contextual factors and their probable impacts.

DECLARATION STATEMENT

I declare that the contents of this dissertation signify my own work, except for the specific and acknowledged references to the published work of others made in the text. I declare that it contains neither material previously published, nor material submitted in parts or whole for the award of any other degree or qualification.

Signed:……… Signed by candidate

Mochelo Mackson Lefoka
LFKMOC001

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DEDICATION

This study is dedicated to the industry (Construction Industry) that I love dearly and would one day love to see take care of the people that make its structures as it does the bottom-line.

PEER-REVIEWED CONFERENCE PROCEEDINGS FROM THIS RESEARCH

Lefoka, M. and Windapo. A. 2018. Causes of variation between estimated and actual labour productivity output in the construction industry. Proceedings of the 42nd AUBEA Conference 2018 – Educating Building Professionals for the Future in the Globalised World, 26-28 September 2018, Singapore. ISBN 9780987183132

Lefoka, M. and Windapo, A. 2019. An examination of contextual factors that cause variations in labour productivity. Proceedings of the 11th CIDB Conference 2019 – Positioning the Construction Industry in the Fourth Industrial Revolution, 28 – 30 July 2019, Johannesburg ISBN 9783030265274

Lefoka, M. and Windapo, A. 2019. An Evaluation of Contextual Factors That Impact Labour Productivity on Construction Sites in South Africa. Proceedings of the 35th ARCOM Conference 2019 – Productivity, Performance and Quality Conundrum, 02 – 04 September 2019, Leeds.

AWARDS FROM THIS RESEARCH

Singapore Institute of Building Limited (SIBL) Best Paper in AUBEA Conference – 2019. Causes of variation between estimated and actual labour productivity output in the construction industry.

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GLOSSARY AND ACRONYMS

ANC	African National Congress
ALP	Average Labour Productivity
BCSPT	Building and Construction Sector Productivity Taskforce
CE	Civil Engineering
CPI	Cost performance index
GB	General Building
GDP	Gross Domestic Product
RSA	Republic of South Africa
LP	Labour Productivity
TFP	Total Factor Productivity
cidb	Construction Industry Development Board
MIS	Mean Item Score
MGI	McKinsey Global Institute
USA	United States of America
UK	United Kingdom
VAT	Value Added Tax
SPI	Schedule Performance index
Stats SA	Statistics South Africa
PFA	Partial Factor Productivity
PWC	Price Waterhouse Coopers
RII	Relative Importance Index
OECD	Organisation for Economic Cooperation and Development
SPSS	Statistical Package for the Social Sciences

CHAPTER 1: INTRODUCTION

1.1 Background of the study

The purpose of this research was to evaluate contextual factors affecting labour productivity on construction projects, and whether these factors differ based on construction projects, company or location. According to a report by McKinsey Global Institute (MGI) (2017), globally, the construction industry accounts for 13% of the Gross Domestic Product (GDP) and employs 7% of the world's working population, making the construction industry one of the leading contributors to GDP (PWC, 2016; Barbosa *et al.*, 2017; StatsSA, 2017). Barbosa *et al.* (2017) said that in the past 20 years the construction industry has had a 1% annual productivity growth globally.

Durdyev and Mbachu (2011) argue that productivity outside of the contextual definition and clarity of the construction project's objectives is a complicated concept to understand. Construction and labour productivity are described as output obtained divided by input expended by Tran and Tookey (2011) and the Organisation for Economic Cooperation and Development ([OECD] 2011) respectively. While the Building and Construction Sector Productivity Taskforce (BCSPT) expand on this noting that productivity is the construction industry's ability to convert inputs into outputs (BCSPT, 2009).

Whiteside (2006) proposes that labour productivity is the output average of direct labour hours to install a unit of material. However, Allmon *et al.* (2000) argue that labour productivity can only be defined when an organisation or the project has identified the base or norm of what constitutes labour productivity. This study agrees with the proposition raised by Allmon *et al.* (2000) because logically a base or norm will be required to know whether labour is productive or not. It follows that if a construction project commences without clarity on the expectation level of productivity or a standard for efficient labour productivity, there will be no knowledge of how the project has performed.

Throughout literature, different scholars view labour productivity as one of the factors having a significant influence on construction productivity (Makulsawatudom *et al.*, 2004; Enshassi *et al.*, 2007; Jarkas and Bitar, 2012; Jarkas, 2015; Okorafor *et al.*, 2016). Lim (1995) argues that labour productivity is amongst 17 factors found to impact project productivity, while Hughes and Thorpe (2014), found labour productivity to be amongst the 15 listed factors affecting project productivity. As a result, labour factors feature frequently as a common theme within the factors impacting productivity on construction projects. According to Senthilkumar and Shafee (2013) in the same way productivity of a construction project is susceptible to a host of factors, labour productivity is also prone to a set of factors that impact it. It then becomes imperative to understand labour productivity within the context of a specific construction site and all the factors that impact its levels.

Cost and time overruns have seemingly become synonymous with the construction industry, and this principle has become more the norm in the industry than the exception (Alinaitwe *et al.*, 2007; Soekiman *et al.*, 2011). It has been argued that labour productivity has an intrinsic effect on offsetting both cost and time overruns as labour forms the core basis of bringing about construction projects (Kadir *et al.*, 2005). Ghate *et al.* (2016) expand further on this in reporting that the construction industry relies heavily on labour productivity as the industry depends on the skill of labour in carrying out the construction activities on project sites.

The delivery of construction projects and related construction processes relies on labour because labour utilisation constitutes an average 18,2% on Renovation Projects and 11,5% on New works in South Africa (Windapo *et al.*, 2016). The performance of labour on construction projects remains a global concern related to the decline in labour productivity as observed since 1993 (Dzadaza and Crafford, 2015). The productivity of labour in the construction industry remains arguably one of the factors that affect projects negatively thus causing cost and time overruns (Kadir *et al.*, 2005; Alinaitwe *et al.*, 2007; Enshassi *et al.*, 2007).

1.1.1 Labour productivity in context

The delivery of the construction projects relies primarily on labour productivity as the driving factor (Khan and Ajmal, 2015). Within the construction industry, labour productivity remains one of the factors that affect the project success. This depends on whether the projected labour productivity by construction estimators and planners, matches that which is observed on construction sites (Kadir *et al.*, 2005; Alinaitwe *et al.*, 2007; Enshassi *et al.*, 2007). The forecasted labour productivity on construction projects, in more cases than not, is always exceedingly lower than the actual productivity reported on site (Dzadaza and Crafford, 2015).

In 1994, the African National Congress (ANC) set as part of their mandate, a pledge to the Republic of South Africa (RSA) to provide free social housing and job opportunities. This mandate was a part of the socio-economic development post the apartheid regime when ANC took office in 1994 (Ofori *et al.*, 1996). Due to the emergence of new construction developments at the time, the construction sector absorbed the substantial burden of the unemployed population (cidb, 2015). However, this population lacked skills and had minimal educational background. Consequently, the efficiency of labour being employed on construction projects was not to the desired standard (Ofori *et al.*, 1996). According to Merrifield (1999), post-1994 labour started reporting a decline in productivity in the South African construction industry.

One of the major criticisms faced by the South African construction industry is the reported poor productivity of labour on construction projects (Merrifield, 1999; Abdul-Rahman *et al.*, 2006; Baloyi and Bekker, 2011). However, circumstances giving rise to this poor productivity are not fully analysed (Crawford and Vogl, 2006). A major impediment facing the South African construction industry is the complexity with which to measure the labour output on construction projects (Senthilkumar and Shafee, 2013). The productivity of labour is used as a determinant of project success and its poor performance inadvertently mean that a project has performed poorly, which is not always a true reflection of the efficiency of labour (Soekiman *et al.*, 2011). Notwithstanding using labour productivity as a measure of project success, a benchmark to measure the observed labour productivity as well as consideration of contextual factors that impact it, is critical for comparative purposes between the actual/observed and estimated labour productivity (AbouRizk *et al.*, 2001). Merrifield (1999) postulates that with the complexities around measuring labour productivity, construction organisations in South Africa subcontract construction labour services of workers so as to evade the responsibility of dealing with poor labour productivity.

Merrifield (1999) argues that main contractors rely heavily on sub-contracting labour on construction projects. This, Merrifield argues, affects labour productivity in that quality of labour becomes hard to assess. Arditi and Mochtar (1996) takes this argument further and assert that labour productivity on construction projects is substantially declining due to the lack of monitoring the quality of labour being employed on construction sites. Part of this decline is associated with main contractors not having core labour teams they use in all execution of construction work, and which are adequately skilled to do the job (Motwani *et al.*, 1995; Arditi and Mochtar, 1996; cidb, 2015; Dzadaza and Crafford, 2015) and due to contextual factors that affect labour productivity on site (Dzadaza and Crafford, 2015). These factors are seldom taken into consideration to determine the extent they affect labour, and subsequently, its productivity (Senthilkumar and Shafee, 2013; cidb, 2015).

The effect of contextual factors on labour productivity prevents construction organisations from capitalising and making a profit on projects due to eminent delays in the form of cost and time (Kadir *et al.*, 2005; Soekiman *et al.*, 2011; cidb, 2015). It is imperative to assess factors that affect labour productivity in the construction industry. This is to understand the extent these factors are accounted for in forecasting the levels of labour productivity on a construction project.

1.1.2 Factors Affecting labour productivity on construction projects

Construction labour productivity is characterised as being one of the complex input variables susceptible to influence by a variety of both internal and external factors (Radosavljevic and Horner, 2002; Senthilkumar and Shafee, 2013). The productivity of labour is influenced by internal project factors: material shortages, health and safety on site, poor communication, instruction time and absenteeism of workers which creates an uneven spread of workload amongst the remaining workers (Makulsawatudom *et al.*, 2004; Enshassi *et al.*, 2007; Jarkas and Bitar, 2012). Moreover, external project factors: government regulations, environmental factors, weather, complexity of the design and importation of materials (Lim, 1995) as well as the influence of stakeholders on the construction project (Olander and Landin, 2005) also affect labour productivity. Both external and internal project factors which will be referred to as contextual factors going forth, vary from project to project, organisation to organisation and from location to location and are thus not standard for all construction projects.

However, while Olomolaiye *et al.* (1998a) found not all factors considered critical by one researcher, are necessarily critical for other researchers, and that not all contextual factors impact negatively on labour productivity, *et al.* (1998a) and Jarkas and Bitar (2012) established that different regions, construction projects, determinants for efficient labour productivity, give varying outputs of productivity on each construction project., in analysing these contextual factors, Hughes and Thorpe (2014) noted that there seem not to be one set of centralised factors used to measure and forecast labour productivity and compare how these affect the estimated and actual productivity on construction projects. The preceding arguments emphasise the need for a compilation of centralised core factors mentioned across literature to critically test these factors against various construction projects and measure their impact.

1.1.3 Research rationale

The construction industry is plagued with many challenges that hinder project performance and atop these challenges, performance of labour is considered one of the leading challenges purely because labour force forms the backbone of the construction profession (Alinaitwe *et al.*, 2007; Soekiman *et al.*, 2011; Jarkas, 2015; Ghate *et al.*, 2016).

Great depth of research has been conducted in determining factors impacting both positively and negatively on labour productivity and to date, there has not been a hypothesised single unit of measure that can accurately identify core and common factors that affect labour productivity on construction projects, and how these vary from project to project and from location to location (Hughes and Thorpe, 2014).

There is evidence in literature that labour productivity is a key factor that affect productivity on construction projects (Lim, 1995; Hughes and Thorpe, 2014). Furthermore, literature reveals that productivity of labour in the construction industry is affected by a host of other factors (Lim, 1995; Makulsawatudom *et al.*, 2004; Olander and Landin, 2005; Enshassi *et al.*, 2007; Jarkas and Bitar, 2012). However, in determining labour productivity, Lim (1995) posits that forecasted labour productivity does not always match actual or observed labour productivity on construction projects due to contextual factors at play depending on location, project or construction company (Lim, 1995; Olander and Landin, 2005).

Different construction companies use a variety of variables to predict labour output on projects (Motwani *et al.*, 1995; Okorafor *et al.*, 2016). The variables used by construction organisations vary from location to location, project type to project type and from contractor to contractor (Alinaitwe *et al.*, 2007). An exploration of how these factors are accounted for on construction projects is not explored in great depth as evidenced by limited literature in this regard and the low levels of productivity on construction projects. Adequately identifying these factors and centralising them by location, project type and organisation, is the main objective of this study towards ensuring that all contextual factors that cause labour productivity variations are evaluated so as to establish the degree of impact they have on the levels of labour productivity and their effect on project success.

The impacts of labour productivity on project performance have been partly analysed for the Nigerian (Olomolaiye *et al.*, 1987), Indonesian (Kaming *et al.*, 1997b), Saudi Arabian (Asaaf and Al-Hejji, 2006) and the Australian construction industry (Hughes and Thorpe, 2014). The aforementioned studies did not examine how productivity is estimated at the planning stage of the construction project. Variables used by estimators in different construction organisations and their accuracy compared to actual labour productivity from project to project, organisation to organisation and from location to location were not explored. These earlier studies also did not report on how contextual factors impacting labour productivity are accounted for during the planning/development stage of the project. Within the South African construction industry, there is limited literature related to an examination of factors impacting the efficiency of labour on construction sites.

Therefore, this research focuses on the examination of contextual factors that affect labour productivity and how these give rise to variations between projected labour productivity and actual labour productivity levels yielded on construction projects.

1.2 Problem Statement

The problem statement for this research is framed as follows:

Previous studies indicate that the construction industry has poor labour productivity and performance caused by contextual project factors. There has been limited research into the contextual project factors used by estimators in the determination of measured labour productivity, and those which affect labour productivity levels during construction project execution. Also, whether the estimated labour productivity planned by estimators for construction companies in different locations and for different projects matches those obtained during the actual construction project execution is unexamined within the South African context. Therefore, this study evaluates contextual factors considered by estimators in determining labour productivity and the outputs on construction projects and whether these factors and labour productivity measured by estimators during the planning stage differs based on organisation, location and projects. This is towards proposing an accurate labour estimating framework that yields accurate labour output estimation and improve project performance, taking the contextual project factors into consideration.

1.3 Research Question

The research question addressed by this study was:

What contextual factors affect labour productivity estimation and outputs on construction projects and how do these differ between organisation, projects and locations in South Africa?

1.4 Research aim

The aim of this research was:

Investigate the contextual factors affecting levels of labour productivity on construction projects and whether there is a significant difference between the contextual factors affecting labour productivity estimates and outputs on site when differentiated by construction companies, projects and locations in South Africa.

1.5 Research objectives

The objectives of this research include:

a) *Determine the levels of labour productivity on construction projects, organisation and location.*
b) *Establish how construction organisations determine the basis and norms for labour efficiency on construction projects.*
c) *Evaluate contextual factors that impact on labour productivity on site during the execution of construction projects.*
d) *Assess the contextual factors that impact labour productivity on construction projects and compare these between project types, organisations and location.*

1.6 Research hypothesis

The research hypotheses to be tested in this study are:

Hypothesis 1:

The contextual factors such as material shortages, absenteeism, health and safety considered by estimators as affecting labour productivity estimates and outputs on site, are significantly different when differentiated by companies, projects and location in South Africa.

Hypothesis 2:

There is a significant relationship between labour productivity and project performance.

1.7 Significance of the study

The significance of this study is in the identification of contextual factors that affect labour productivity estimation at the pre-construction development/conception and pre-tendering stage of a project. Based on the identified factors, estimators can prepare cost estimates for labour productivity and propose accurate measures for mitigating the impact that these factors have on project performance.

The study has the potential to inform construction companies on the crucial considerations of labour productivity and mitigating any negating factors giving rise to time delays and cost overruns. The outcome of this study will be useful to companies listed on the Construction Industry Development Board (cidb) Register of Contractors to optimise productivity of labour, plan better for any external impacts that might disrupt labour operations and remain within the budget as far as labour costs are concerned.

This difference in contextual factors from across different companies, site and locations, will show what factors are most common and which requires priority with regards to their management on construction projects. Through understanding contextual factors and how they affect labour productivity, recommendations will be made which planners can integrate with their estimating techniques thus ensuring cost overruns and time delays are kept at a minimum or eliminated.

As part of a more extensive study, this is the beginning of a research that aims to identify all the different contextual factors that specifically affect construction industry productivity industry in different provinces of South Africa. All these factors will be analysed against the established standard of labour performance in various provinces and thereafter create a system that any contractor can pull from the database of any province they wish to tender for a job, and in their estimations, achieve a close to accurate prediction of labour performance having used the correct basis.

1.8 Structure of the research report

The research report is structured in five chapters.

Chapter 1, a brief outline of the research topic is given, followed by a succinct statement the research problem, the main research question, research objectives and the research hypotheses. The aim of the research is defined and followed by a short description of the research methodology and data collection methods. The significance of the study is also detailed in this chapter.

Chapter 2, a critical review of literature about productivity of labour in the construction industry, contextual factors and their impact on the efficiency of labour is presented. Also, a review of variables that are pertinent to estimating labour productivity both within an organisation’s estimation of output on a construction project and actual output on construction projects. This chapter mainly addresses the questions: *What has other research in this field revealed and what are the knowledge gaps?*

Chapter 3 documents the research approach and design used in data collection, data analysis and hypotheses testing.

Chapter 4 comprises the analysis and interpretation of the primary data collected together with a discussion of the results within the context of the literature.

Chapter 5 provides conclusions of the study and recommendations for construction stakeholders and future research. This is followed by a full list of **References** and appropriate **Appendices**.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The contention around the definition of what constitutes labour productivity in the construction industry is a subject of much debate and discussion through literature amongst various scholars. This has been brought about by the fact that there has been no developed measure of labour productivity that considers the scope, project type and contractor size to make it homogeneous and objective across the construction industry (Alinaitwe *et al.*, 2005; Durdyev and Mbachu, 2011). This can be expanded in that this definition does not also have parameters relating to contractors in differentiated cidb grade of registration, different projects and developments in different parts of the world (Farnad and Pouya, 2013). Furthermore, the definition of labour productivity is contrived through the utilisation of differing matrices which further adds to the complexity of refining or defining a standard that construction industry can use as the sole benchmark in measuring labour productivity (Love and Smith, 2003; Shehata and El-Gohary, 2011). However, in defining and measuring labour productivity, a disjoint practice that omits the comparative analysis between estimated labour productivity and actual labour productivity on site is observed (Proverbs *et al.*, 1999).

The lack of this benchmark further demands and elicit a sense that those that have previously measured labour productivity and claimed that it is declining, may have as well based their decisions and measures of constructs on factors that have not been validated before (Love and Smith, 2003). However, it cannot be contested that in the past two decades, there has been a reported decline in the level of labour productivity found on construction projects (Barbosa *et al.*, 2017). This decline is further evidenced in the reported cost and time overruns reported on construction projects.

The following section aims to critically assess the state of the construction industry from a global perspective and identify key issues found through literature to be pertinent to the decline of labour productivity. An identification of the estimation techniques that quantifies labour productivity on construction projects is going to be the subject of evaluation in this section. Furthermore, this section will aim to analyse how labour productivity is identified on construction projects and the matrices that are used in measuring labour productivity. This section also aims to synthesise through literature, identified factors that directly and indirectly contribute to the observed decline of productivity amongst the construction labour force. Lastly, a theoretical and conceptual framework synthesised from thorough literature review will be developed for this study.

2.2 The construction industry and the Economy

Central to a country's economic performance, lies the good performance of its constituent sectors (Abdel-Wahab and Vogl, 2011). As postulated by Barbosa *et al.* (2017) inter-alia, the construction industry accounts for 13% of the global GDP. This contribution to the global GDP is supported by Abdel-Wahab and Vogl (2011) by asserting that the significant contributor to any economy's performance, is the construction industry. A direct contribution of the construction industry in both the formal and informal sector is established to be between 6% – 8% of a country's GDP (Arditi and Mochtar, 2000). Furthermore Enshassi *et al.* (2007) submit that for both developing and developed countries, the contribution of the construction industry to the GDP subsequently drives the economic and social welfare capacity of their economy.

Notwithstanding the significant contribution of the construction industry to both global and national GDP for various countries, the level of productivity in the industry is reported to be declining and of relative concern as compared to other industries (Arditi and Mochtar, 1996; Makulsawatudom *et al.*, 2004; Barbosa *et al.*, 2017). The decline in the level of construction labour productivity demands an extensive analysis and exploration especially in the diagnosis of the core factors contributing to the decline even though the inadequacy of empirical data inhibits this pursuit (Crawford and Vogl, 2006). Furthermore, a consensus amongst scholars is that poor labour productivity or declining construction labour productivity directly impacts the growth of the industry (Barbosa *et al.*, 2017). Construction labour productivity has been identified as one of the main factors that drive productivity in the construction industry (Makulsawatudom *et al.*, 2004; Enshassi *et al.*, 2007; Okorafor *et al.*, 2016). Furthermore, it is observed to account for a third of the construction project cost (Alinaitwe *et al.*, 2007).

The construction industry as a sector is crucial to both the development and productivity of the economy. Moreover, the performance of labour in the construction industry is the bedrock of the industry production and productivity (Yi and Chan, 2014). However, definition of labour productivity is a concept that needs to be established in order to fully comprehend the extent, measures and what constitutes efficient labour performance (Durdyev and Mbachu, 2011).

2.2.1 Global performance of the construction industry

On a global scale, labour productivity in the past two decades grew by a marginal 1% across the construction industry (Barbosa *et al.*, 2017). Kazaz and Ulubeyli (2004) postulate that the construction industry contributes significantly to the strategic role of economic performance of both developing and developed countries globally.

Notwithstanding this, Barbosa *et al.* (2017) reports that close to $10 trillion projected to increase to $14 trillion, is spent each year on construction projects that span through building, infrastructure and industrial installations. Furthermore, they highlight the contribution of the construction industry and its related productivity to the global economy (Barbosa *et al.*, 2017). However, Enshassi *et al.* (2007) and Barbosa *et al.* (2017) noted the decline and the slow growth of labour productivity that impedes development and quality of the projects produced in the construction industry.

In a study conducted by Barbosa *et al.* (2017), construction labour productivity of countries from around the world are classified into four quadrants each indicating the status and position with regards to how productive the country's level of construction labour productivity relates to its growth rate in the past two decades. The first quadrant represents countries United States of America (USA), Spain, Denmark, France and Japan that have a declining level of construction labour productivity. The second quadrant represents countries such as Belgium, Israel, Netherlands, United Kingdom (UK), Germany, Australia and Canada whose level of construction labour productivity exceeds the international benchmark of rate per hour worked by labour. The third quadrant classifies countries such as Mexico, Saudi Arabia, Brazil, Malaysia and Colombia as those countries lagging behind and performing below the established international average rate per hour worked by labour. In the fourth quadrant, Barbosa *et al.* (2017) purports that countries such as China, Singapore, Greece, Chile, Indonesia, Nigeria, Egypt and South Africa are accelerators and have shown the potential to improve their construction labour productivity.

Endemic to the construction industry, is the issue of delays in the form of cost and time that impact the industry globally (Sambasivan and Soon, 2007). The quantifications of delays on projects that experience these delays, often results in disputes amongst the project team and inadvertently affect the project performance and the productivity of all the projects involved (Baloyi and Bekker, 2011). However, the two most common delays that are prevalent on the construction projects are time and cost delays (Assaf and Al-Hejji, 2006).

Cost overruns are also common and more the exception than the norm on construction projects globally (Zhu and Lin, 2004; Niazi and Painting, 2017). The phenomenon where a construction project exceeds the initial set budged defines cost overruns (Zhu and Lin, 2004; Baloyi and Bekker, 2011). One of the major criterions used to measure project success is the ability of the project to meet the intended budget as an indicator of success (Niazi and Painting, 2017) the inability of which renders a project unsuccessful (Aibinu and Jagboro, 2002). The ability of contextual project factors and their direct impact to giving rise to cost overruns also triggers further effects that may perpetually affect the project success if not addressed and these are issues with procuring sub-contractors and meeting the client's demands (Niazi and Painting, 2017). In an attempt to avoid both cost and time delays, contextual factors eminent to project environment need to have their impacts assessed to prevent their eminent impact on the project success, especially if the success of a project is measured with regards to a project adhering to cost and time (Enshassi *et al.*, 2007; Niazi and Painting, 2017).

The change experienced by a construction project that offset the original completion date to a later date is considered time delay that inadvertently give rise to time overrun on the project (Asaaf and Al-Hejji, 2006; Baloyi and Bekker, 2011). As postulated by Love *et al.* (2002) that a construction project follows a systems theory model, the disruption in the time it takes to complete one activity consequently gives rise to a knock on effect to the proceeding activities that impact the construction activities and further gives rise to time delays (Mawdesley and AL-Jibouri, 2009).

2.2.2 South African construction industry and contribution to the economy

According to the McKinsey Global Institute (MGI), a stipulated $10 trillion is related to construction-related spending every year (Barbosa *et al.*, 2017). This places the construction industry among the largest sectors of the world economy (Baloyi and Bekker, 2011). Furthermore, the MGI reports that globally the construction industry employs around 7% of the world's working population (Barbosa *et al.*, 2017). This makes the construction industry one of the largest employers in the global economy to date.

Hence, the South African economy follows the same global trend with regard to the contribution of the construction industry to the economy. The construction industry in South Africa is one of the main contributors to employment and the country's Gross Domestic Product (GDP) (Price Waterhouse Coopers (PWC), 2016). In 2015/2016 the construction industry contributed close to 9% towards the South African GDP, making it one of the sectors of the economy to steadily contribute towards GDP (Construction Industry Development Board (cidb), 2015).

Statistics South Africa (Stats SA) reported that 10,8 million people are employed in the formal sector of the economy, and that the construction industry accounts for 10% of total formal employment (cidb, 2017; StatsSA, 2017). Furthermore, the informal sector of the South African economy employed around 2.6 million people between the years 2015/2016 with the construction industry accounting for 17% of that number (cidb, 2017). Figure 2.2 gives an aggregation of the total employment figures by industry combining both formal and informal sectors of the economy. As can be deduced from the Figure 2.2, the construction industry is the fifth (5th) largest employer absorbing at least 10% of the working population.

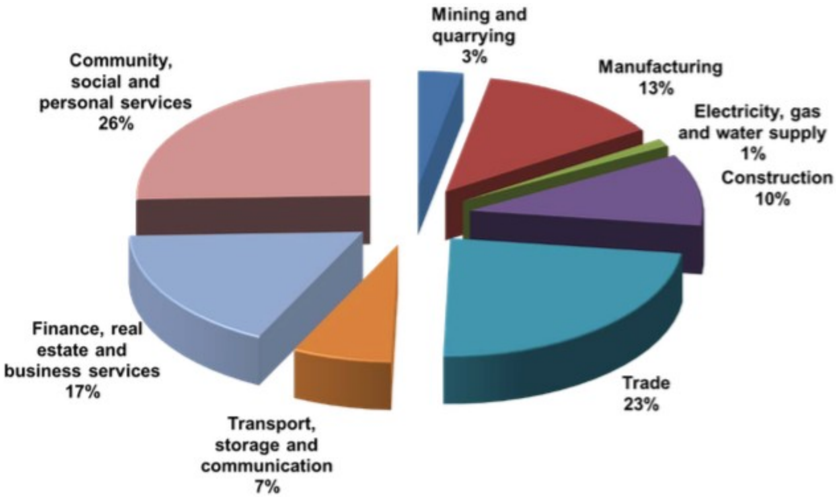


Figure 2. 1: Formal and Informal Employment by Sector (cidb, 2017)

However, the informal sector of the economy had substantial fluctuations in terms of job losses and restructuring that impacted on major sectors of the economy (cidb, 2017). Over 110 000 jobs were lost in the construction industry as reported by the cidb (2017). However, the informal sector reported a significant growth in job opportunities in the construction industry. This figure rose to 16% (as can be seen in Figure 2.3) in the third quarter of 2017 giving an indication that the industry has an impact on the economic functioning of the economy and contribution to GDP growth (Meintjes *et al.*, 2007; Barbosa *et al.*, 2017; cidb, 2017).

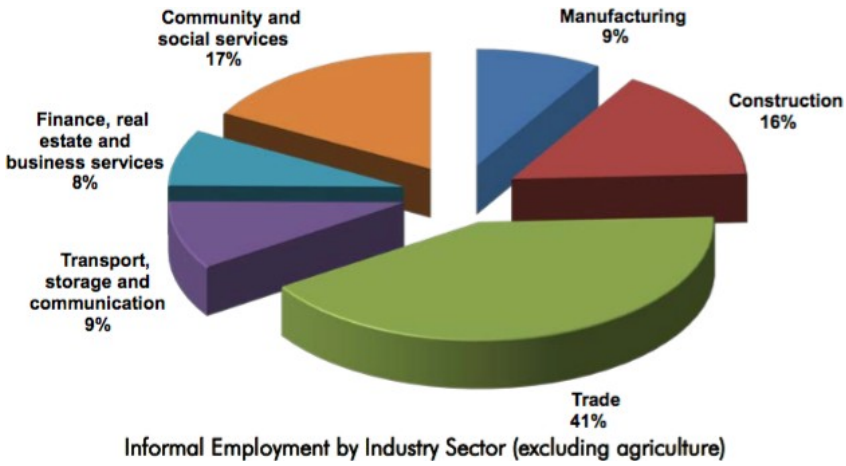


Figure 2. 2: Informal Employment (cidb, 2017)

Figures 2.2 and 2.3 show that the construction industry contributes significantly to employment in South Africa (PWC, 2016), particularly given the current national unemployment rate of 27,7% (StatsSA, 2017).

2.3 Definition of labour productivity (LP)

Amidst the amount of research that has been devoted to exploring the productivity of labour in the construction industry, two identifiable concepts still remain unclear regarding productivity. A generally accepted definition and uniform standard of measurement for labour productivity has not been established to date (Radosavljevic and Horner, 2002; Moselhi and Khan, 2012). Notwithstanding the lack of generally accepted definition and standard for labour productivity measure, different construction companies utilise their own internal standards of measure that differ from company to company (Park, 2006). Furthermore, labour productivity in the construction industry is multifaceted and complex to measure and sometimes ambiguous in its determination (Radosavljevic and Horner, 2002). Additionally, standards used to measure productivity are not standardised hence cannot be implemented in the industry (Park, 2006). Construction projects and developments are unique in nature and seldom repetitive, as a result defining the standard definition and tools of measuring productivity becomes complicated (Sweis, 2000) . In their analysis of labour productivity trends, Allmon *et al.* (2000) argues that labour productivity can only be defined when compared with the established norm or standard set by either the company.

As postulated earlier, the proposition put forward by Whiteside (2006) regarding the definition of labour productivity, is that it is the output average of an hour worked by a labourer in installing a unit of work. Park (2006) supports this assertion in stating that labour productivity is the number of actual work hours required to perform a unit of work. The measurement of labour productivity using hourly output is widely used in the construction industry in both the definition and setting the benchmark for labour productivity (Hanna *et al.*, 2008). This is an industry standard of utilising the hour worked as the input and the results as the completed product or physical quantity as the generated output (Yi and Chan, 2014). Equation 1 expresses this phenomenon as postulated by (Yi and Chan, 2014)

$$\text{Labour Productivity} = \frac{\text{Actual work hours}}{\text{installed quantity}} \qquad \textit{Equation 1}$$

The assertion to define labour productivity in the way Yi and Chan (2014) has done in equation 1 is met with contention from Moselhi and Khan (2012). The measuring of labour productivity as result of a relationship between an hour committed assumes that a single output relates to the invested hour and thus disregards other sub-activities that could be linked to the completion of the main activity performed in that hour. Furthermore, general performance cannot be postulated from this single model (Moselhi and Khan, 2012; Hiyassat, M.A., Hiyari, M.A. and Sweis, G.J. 2016).

The definition of labour productivity in the construction industry or in the production of any output can be well defined when a general basis or accepted standard of production has been established (Allmon *et al.*, 2000; Moselhi and Khan, 2012; Ulubeyli *et al.*, 2014). Moselhi and Khan (2012) further posit that the definition of labour productivity is largely dependent on the perceptions of the construction professional team involved on the project. However, another definition of labour productivity is expressed in equation 2 as output obtained over the labour input expended on the project (OECD, 2001; Alinaitwe *et al.*, 2005; Tran and Tookey, 2011; Moselhi and Khan, 2012)

$$\text{Labour productivity} = \frac{\text{Product output}}{\text{Labour input}} \qquad \textit{Equation 2}$$

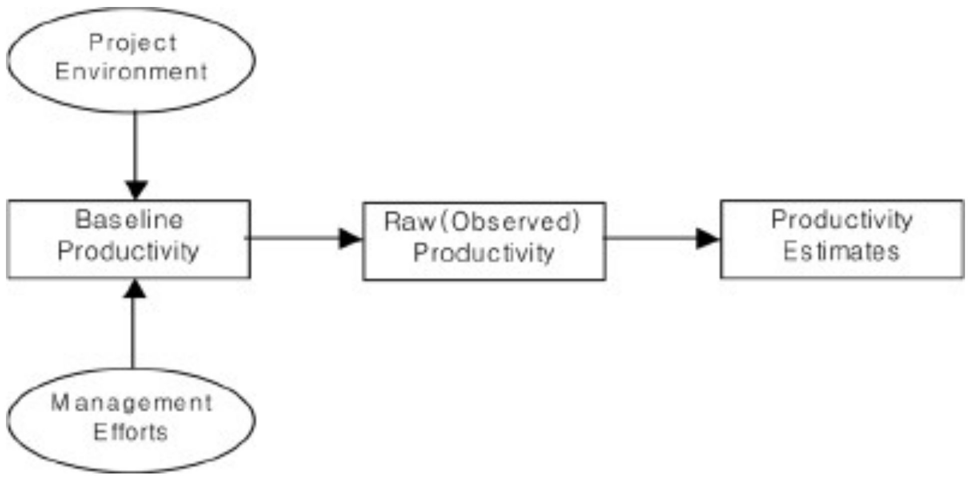
Equation 2 is the definition that this study will adopt going forward. In the determination of generally accepted definition of labour productivity, it is of paramount significance to understand the estimation practices employed by construction professionals in the determination of the labour component of the project as well as the expected productivity output.

2.4 Conceptualising Baseline productivity and labour productivity in the construction industry

Dzadaza and Crafford (2015) further postulate that an imbalance or omission in the thorough estimation practices, gives development to variances between estimated labour productivity and actual labour productivity observed on construction projects which is endemic in the construction industry (Aibinu and Jagboro, 2002). Paramount to proper planning and management ofresources, particularly labour, is the ability of the parties responsible for the estimation function to ensure accuracy of the estimate (Akintoye and Fitsgerald, 2000). Cost of labour can sometimes be difficult to obtain and even so, the rates tend to not be easily accessible as different levels of skill in the labour sought determine their rates (Abanda *et al.*, 2011). Central to this challenge is the assertion that the fragmented nature of the construction industry (Meintjes *et al.*, 2007) gives rise to this and further makes it complicated to estimate labour with absolute accuracy (Abanda *et al.*, 2011).

2.4.1 Baseline Productivity

The standard practice in the construction industry is to define and establish the estimated level of labour productivity during a project planning phase (Park, 2006). It is this estimation that set precedence for an expected baseline productivity which is defined as the optimal level of productivity that can be achieved on a construction project (Thomas and Završki, 1999; Park, 2006). In an attempt to establish expected level of project productivity, Park (2006) conceptualised a theoretical model he proposes to be a solution to the practice of estimating productivity. In Figure 2.1, Park (2006) establishes that in the determination of the baseline productivity, two aspects of the construction project must be considered. These, he purports, are the project environment as well as the management efforts expended on the project. In considering the two aspects, the conceptualisation for labour productivity can be achieved (Gulezian and Samelian, 2003; Park, 2006).



(Adapted from Park (2006)

Figure 2. 3: Determining Labour Productivity Benchmark

In an effort to further emphasise the impact the lack of a standard benchmark for labour productivity have on construction projects, Park (2006) illustrates the potential impact environmental factors and management efforts can have on the labour productivity benchmark. In his illustration, Park (2006) asserts that the success of a project largely relies on the two aspects and that the management thereof greatly impacts labour productivity. Furthermore, Park (2006) postulates that for different projects, benchmark estimation techniques are different, and this is crucial in determining the success of a project. Additionally, Park (2006) asserts that there are however challenges that affect the benchmark estimation techniques such as overtime scheduling of the work, change orders applied to the sections of the work, the management of materials, weather and human factors.

2.4.2 Estimation of labour productivity in the construction industry

The estimation of labour productivity can be understood as the approximation or projection of labour rates, labour performance, expected quality of the works to be expended by the labour force on any construction project (Proverbs *et al.*, 1999). The assumption that underpins this definition is that the project cost, time and the scope of the works are known at the pre-construction phase (Proverbs *et al.*, 1999; Alinaitwe *et al.*, 2005).

In any construction development, before any cost can be spent, material used, or labour brought onto site, an estimation of what amounts are apportioned to which activity is usually conducted. This can be done in a variety of ways but a rate per activity is established by the estimator, quantity surveyor or cost engineer (Proverbs *et al.*, 1999; Alinaitwe *et al.*, 2005). The significance underpinning this estimation technique is to ensure that a benchmark or a standard of measuring performance is established and accordingly observed as the project progresses to fully understand any deviation in the project performance from the estimated benchmark (Proverbs *et al.*, 1999; Abanda *et al.*, 2011). An argument is further raised that an estimation pre-construction of the project that is well done, allows for the efficiency of the project to be attained and ensures that construction resources are properly divided and optimised fully for the delivery of the project (Park, 2006; Abanda *et al.*, 2011; Florez and Cortissoz, 2016).

There is a variety of methodologies and methods used in the construction industry, particularly amongst different construction organisations that estimate labour productivity differently as there is no one commonly accepted method (Park, 2006). Florez and Cortissoz (2016) assert that there is complexity in the estimation of labour productivity commonly observed in the construction industry. The complexity is closely related to the multi characteristic nature of the workers, their relational engagements amongst each other and the complexity of the work being executed, particularly that which requires varying levels of experience to execute (Florez and Cortissoz, 2016). This argument is supported by Kadir *et al.* (2005), Alinaitwe *et al.* (2005) and Enshassi *et al.* (2007) who note that an accurate estimation that accounts for the environment in which the development is carried out, allows a close to accurate yield of the expected output.

An understanding of the challenges such as lack of estimation skills, lack of construction industry experience and low level of education hinders the accurate estimation of labour productivity and furthermore, gives rise in variations between estimate and actual labour productivity on construction projects (Aibinu and Jagboro, 2002; Park, 2006; Dzadaza and Crafford, 2015).

2.5 Comparison of construction industry labour productivity to other industries

There has been a notable labour productivity growth in other sectors of the economy, but the construction industry has been reporting a stagnant or declining labour productivity. According to Barbosa *et al.* (2017), over the past two decades, productivity of labour has been on the decline. Christian and Hachey (1995) report that this decline in labour productivity has been observed in the construction sector over the past 40 years. Over the past two decades, productivity in the construction industry reported a marginal growth of only 1% in and this has been of concern given that most economies rely on the construction industry for their employment generation (Kazaz and Ulubeyli, 2004; cidb, 2015; PWC, 2016; cidb, 2017). It is essential to view this assertion in relation to how other sectors of the economy are doing. Between 1995 – 2014, Barbosa *et al.* (2017) and Christian and Hachey (1995) observed that the construction industry lags behind the total economy performance (Barbosa *et al.*, 2017). It was found that labour productivity in the manufacturing industry in relation to the construction industry, in the same period of between 1995 – 2014, increased by over 300% (Christian and Hachey, 1995; Barbosa *et al.*, 2017).

It has however been established that automation and rapid implementation of technology in the manufacturing industry has been the main reason the industry has managed an exponential growth in labour productivity in relation to the construction industry (Barbosa *et al.*, 2017). Meanwhile, the adverse holds true for the construction industry as it lags behind both the economy and manufacturing productivity levels. The aversion of the industry to adapt some of its practices to a technologically geared environment is attributed to the slow growth of productivity (Barbosa *et al.*, 2017). This assertion is further raised by Naoum (2016) in reporting that lack of investment in technological tools and the industry's inability to innovate, greatly impede the growth of the construction industry. It further follows that in exploring the contextual performance on a global scale, aspects that affect the construction industry and the growth in labour productivity needs to be evaluated. As a result, it is imperative to assess factors that give rise to the decline of construction labour productivity from a general point of view.

2.6 Core causes of low construction labour productivity

Research regarding factors pertinent to labour productivity in the construction industry have been conducted and contextual factors pertinent to the decline of labour productivity been established. In a study conducted by (Barbosa *et al.*, 2017), they found that core causes of factors leading to a decline in the construction labour productivity are categorised into three categories which are, external forces, industry dynamics and firm-level operational factors respectively. External factors represent a set of factors that are outside the control and management of the construction personnel (Lim, 1995; Olander and Landin, 2005; Hughes and Thorpe, 2014). These factors were found to be the increased project and site complexity, regulations (changes in legislature) and fragmentation of the industry and lastly, the informality and the potential corruption that distorts the construction industry (Barbosa *et al.*, 2017). Naoum (2016) corroborates these factors and reports that site complexity contributes significantly to the lack of productivity in the construction industry.

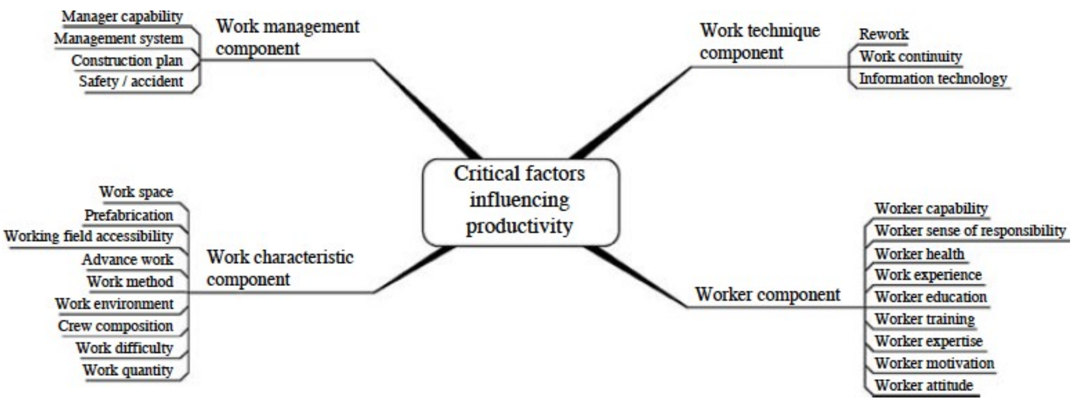
Another core factor impacting the global productivity of labour is industry dynamics (Love *et al.*, 2002; Barbosa *et al.*, 2017). The industry dynamics relate specifically to the conditions under which the construction industry operate particularly the ever-changing nature of the industry (Love *et al.*, 2002). These factors are the opaque nature of the construction industry meaning the fragmented nature of the construction industry, misalignment of contractual structures and incentive packages and suboptimal requirements by the clients in the construction industry (Barbosa *et al.*, 2017). Lastly Barbosa *et al.* (2017) postulates that firm-level operational factors also contribute significantly to the decline and marginal growth of construction labour productivity. These factors are: design processes that take time and inadequate investment in the construction sector, poor management and execution of the construction projects, lack of skill and supervisory abilities across senior management found on construction projects and lack of innovation and digitalisation in the construction industry (Alinaitwe *et al.*, 2005; Senthilkumar and Shafee, 2013; Naoum, 2016; Barbosa *et al.*, 2017).

In general terms, the complexity surrounding the identification of parameters to measure labour productivity as identified factors gives rise to this complexity, as core concern with no eminent resolution (Radosavljevic and Horner, 2002; Senthilkumar and Shafee, 2013; Barbosa *et al.*, 2017). Studies conducted by other researchers in varying countries indicate the multitude of factors that intrinsically impact negatively on labour productivity (Kaming *et al.*, 1997b; Senthilkumar and Shafee, 2013; Naoum, 2016). Some of these studies conclude with the synthesis of preventative measures to improve productivity but these solutions implemented in other contexts of the industry, do not yield any different outcomes. Notwithstanding both the identification of factors impacting productivity and preventative measures, Barbosa *et al.* (2017) postulates that the performance of labour in the construction industry is not uniform, as a result cannot be benchmarked with the same standard without consideration of contextual factors to the project (Gidado and Millar, 1992; Xia and Chan, 2012). A probe into how construction labour productivity has been analysed globally is key to understanding holistically the degree of what contextual factors affect construction labour productivity and what degree of impact these factors have on the performance of construction projects.

2.7 Factors that impact labour productivity

Endemic to the construction industry is the challenge of poor productivity intrinsically related to the performance of labour on construction projects (Soekiman *et al.*, 2011). Furthermore, the productivity of labour has been shown to be affected by a host of factors that can be classified into various groups and related to various aspects of the construction project or the organisational structure governing the execution of the project (Olomolaiye *et al.*, 1987; Olomolaiye *et al.*, 1998b; Makulsawatudom *et al.*, 2004; Soekiman *et al.*, 2011). Throughout literature, different factors are reported as being contributing factors to the decline of labour productivity in the construction industry. However, Olomolaiye *et al.* (1998a) purports that factors impacting the productivity of labour are not uniform across the construction industry. Notwithstanding the lack of uniformity in the factors impacting labour productivity, these factors also differ by country, project, organisation and in some instances, circumstances impacting the development of a project (Olomolaiye *et al.*, 1998a; Jarkas and Bitar, 2012; Hughes and Thorpe, 2014).

Following Jang *et al.* (2011), as can be seen in Figure 2.4, critical factors influencing labour productivity can be categorised into four components; work management component, work technique component, work characteristic component and worker component.



Adapted from Jang et. al (2011)

Figure 2. 4: Critical Factors that affect labour productivity

Jang *et al.* (2011) further breaks down these components into definitive factors that impact the level of labour productivity. On an overall perspective, these factors are common through various scholars and in a similar way, they are further analysed and related to their impact on the level pf labour productivity or their impact on the effect they have on the performance of the project (Enshassi *et al.*, 2007; Jang *et al.*, 2011; Jarkas, 2015). These components are elaborated on in the following sub-sections.

2.7.1 Work Management Components

Found in the work management component are; manager capability, management systems, construction plan and safety/accident. Management capabilities emphasises both the management styles and the structure in the management of the labour on construction projects (Olomolaiye *et al.*, 1987; Jarkas, 2015). The lack of proper management and inadequate experience in managing labour can introduce a problem related to the lack of project delivery on time and subsequently, give rise to delays and lack of productivity amongst labourers (Baloyi and Bekker, 2011).

Management systems are core to the success of the project and as Jang *et al.* (2011) posits them to be central to impacting productivity on construction projects, Love *et al.* (2002) corroborates this and further highlight that a systems model of operation in the construction industry is key to project success. However, some literature counters this assertion in stating that the fragmented nature of the construction industry makes it hard to standardise a system and adhere to it in both the management and delivery of the construction projects (Fulford and Standing, 2014; Nawi *et al.*, 2014). This further hinders integration between the management and the labourers on projects for any collaborative efforts to improve productivity and as a result, project performance (Nawi *et al.*, 2014).
The construction plan and the work breakdown can disrupt the efficiency and the performance of labour on construction project. Additionally, the safety of workers and the project environment's susceptibility to give rise to accidents in both the environment itself or the project can be detrimental to the performance of labour and as a result affect the productivity of labourers (Kaming *et al.*, 1998; Enshassi *et al.*, 2009; Abrey and Smallwood, 2014).

2.7.2 Work technique components

Within the work component factors, Jang *et al.* (2011) highlight rework as being core to impacting the level of labour productivity. Occurrence of faults in the construction work, either from a design fault or poor workmanship, significantly halts the construction progress and diminishes the level of productivity expended by labour (Kaming *et al.*, 1998; Love, 2002). Lack of integration or adaptation to digitalisation in the construction industry is cited as one factor that has an impact to the labour performance and Jang *et al.* (2011) reports this as information technology. Contention amongst literature further points that the lack of digitalisation is predominantly due to fragmentation which describes the construction industry (Nawi *et al.*, 2014; Barbosa *et al.*, 2017). Lastly continuity of the construction work or lack of continuity of the construction work affects labour productivity significantly. One of the major impediments of labour productivity amongst the working class is the uncertainty in the lack of job security or uncertainty in the continuity of the project thus employment (Erlinghagen, 2007).

2.7.3 Work characteristic components

This category of factors evaluates factors that are specifically directed to the environment under which the work is being carried out. Jang *et al.* (2011) reports these as; workspace, prefabrication, working field accessibility, advance work, work method, work environment, crew composition, work difficulty and work quality. Literature reports that work environment does affect the productivity of labour (Gidado and Millar, 1992; Osman and Ahmed, 2017). Nature of work environment can impede the level of output expended by labour and as a result affect the project performance. Jang *et al.* (2011) identifies prefabrication as one of the factors that impact labour productivity. Literature reports benefits of this method of construction (Blismas *et al.*, 2006). However, a great deal of skill in this method of construction is essential particularly amongst labourers on site. as a result, the lack of such skill amongst labourers introduces a decline in productivity (Osman and Ahmed, 2017).

Accessibility of construction site is pertinent to the timely and efficient level of production. The inability thereof, especially amongst labourers can create an impediment evidenced in lack of productivity of labour on site (Love *et al.*, 2002; Osman and Ahmed, 2017). Stated as one of the factors impacting on labour productivity is the work environment and crew composition. These two factors relate to the relationship between labourers and their supervisors and workers and the management structures. The inability of the labourers to have a working relationship with their supervisors inhibit both the level of information for labourers to do their work and the transparency for labourers to approach their supervisors about any suggestions pertinent to the work scope (Park, 2006; Ulubeyli *et al.*, 2014).

Additionally, Jang *et al.* (2011) highlights that work difficulty is one factor that affects the productivity of labour on a construction project. This assertion is supported by various scholars (Motwani *et al.*, 1995; Okorafor *et al.*, 2016) in that the difficulty with which each project presents, demands that labourers are equipped and proficient in the skillset necessary to execute the project (Okorafor *et al.*, 2016).

2.7.4 Worker component

Central to the construction project is the labour or worker component. This component assesses factors that directly affect the labourer and inhibit them from performing their functions in an efficient and effective manner. These are factors that are both external and external to the labourer (Love *et al.*, 2002; Alinaitwe *et al.*, 2005; Park, 2006). Worker capability is cited as one of the factors that affect the productivity of labour. This factor includes the ability, skill and knowledge of labour to be able to do their work (Jang *et al.*, 2011). Worker's sense of responsibility. The involvement and engagement of labourer in the planning and strategic phase of the project is key to their performance as a sense of active engagement elicit a sense of responsibility from their part to get the project to be a success (Park, 2006). The adverse is true.

Paramount to a labourer's ability to work, is their wellbeing and health. Keller *et al.* (2009) and Enshassi *et al.* (2007) also assert this factor and its significance to productivity of a labourer. Furthermore, a worker's experience, education and level of expertise, are factors Jang *et al.* (2011) further posits that they significantly affect the level of productivity expended by labour. The lack of construction skill and relevant knowledge places the worker at a level less than the expected level in order to execute the job efficiently (Alinaitwe *et al.*, 2005; Park, 2006). Additionally, worker motivation is found to be another key component in the productivity of labour (Kazaz *et al.*, 2008; Durdyev and Mbachu, 2011). Moreover, literature report that in the case that labourers are motivated, either in the form of work bonuses, incentivisation or promotions, they perform better as opposed to not having any form of motivation (Kazaz *et al.*, 2008).

2.8 Contextual factors impacting labour productivity on construction site

Following from Jang *et al.* (2011) categorisation of factors that impact the productivity of labour on construction projects. These factors are presented in Table 2.1. The categories are environmental, organisational/construction firm, technical and social. These factors are in accordance with previous studies that analysed both the effect and the impact they have on level of labour productivity in the construction industry, and some, the effect they have on the project performance (Olomolaiye *et al.*, 1987; Sweis, 2000; Makulsawatudom *et al.*, 2004; Enshassi *et al.*, 2007; Jarkas and Bitar, 2012; Hughes and Thorpe, 2014).

Table 2. 1: Categorisation of contextual factors impacting labour productivity

Category	Factors
Environmental Factors	Inclement weather (rain/cold/heat)
	Unexpected site ground conditions
	Site location/environment
	Lack of experience amongst workers
	Delays in delivery of material
	Poor site supervision
	Lack of tools and equipment
	Mismanagement of resources on site
	Rework due to poor quality
Organisational/Construction firm Factors	Economic changes (change in VAT, inflation and foreign exchange rates)
	Fluctuations in material/equipment prices
	Change in government legislature/policy
	Delays in payment of labour
	Non-payment of labour
	Inexperienced supervisors
	Changes in management structure
	Shortage of labour/manpower
Technical Factors	Poorly designed projects
	Incomplete Drawings
	Methods of construction (prefabrication vs onsite)
	Inspection delays from engineers
	Change orders from the designers/consultants
	Poor co-ordination/planning of activities
	Complexity of the project
	Buildability of the structure
Social Factors	Labour unrest/rioting
	Relationship between supervisors and labourers
	Lack of experience of workers
	Personal problems
	Uncertain job security
	Long commute periods to site
	Alcohol abuse
	Drug abuse

Adapted from: (Olomolaiye *et al.*, 1987; Sweis, 2000; Makulsawatudom *et al.*, 2004; Enshassi *et al.*, 2007; Jarkas and Bitar, 2012; Hughes and Thorpe, 2014).

2.8.1 Environmental Factors.

Environmental factors relate to those factors that are not within the control of the core project team but are central to the position or place under which the development is being constructed (Gidado and Millar, 1992; Park, 2006). It is also those factors that affect the progression of the development given the construction project development (Alinaitwe *et al.*, 2005). These are factors that are eminent to the environment or locale under which project is being developed. Through a thorough analysis of literature, nine factors were identified. These are: inclement weather (rain/cold/heat), unexpected site ground conditions, site location/environment, lack of experience among workers, delays in delivery of material, poor site supervision, lack of tools and equipment, mismanagement of resources on site and rework due to poor quality.

2.8.1.1 Inclement weather (rain/cold/heat)

Climatic conditions and seasonal effects on the construction development is fundamental to good planning of the construction activities (Motwani *et al.*, 1995; Park, 2006; Aziz and Abdel-Hakam, 2016). Furthermore, Park (2006) asserts that construction activities primarily takes place on the outside and as a result, weather as factor, cannot be dismissed from both the planning stages of the construction project and the management of the productivity output. Adverse weather conditions significantly impact the productivity of labour and subsequently affect the health and wellbeing of the labour productivity (Koehn and Brow, 1985). Efficient productivity is difficult to attain under adverse weather conditions (Koehn and Brow, 1985). Literature further attribute fatigue and exhaustion to extreme heat conditions that are seldom observed on construction projects, particularly given the nature of construction projects (Motwani *et al.*, 1995; Park, 2006).

2.8.1.2 Unexpected site ground conditions

Geotechnical knowledge of the ground or environment where construction is to take place is key to the assessment of the management techniques required as well as a tool to determine the expected output on the construction site (Xia and Chan, 2012). Through the development of a project, any unforeseen elements that affect the ground, can destabilise the construction project and halt the work and subsequently affecting the productivity on site (Durdyev and Mbachu, 2011; Osman and Ahmed, 2017). Furthermore, the fundamental aspect of the structure is the foundation and in the event that ground conditions are not suitable for the development, the processes necessary to make good the ground can impact the proceeding activities and as a result, rearrange the construction programme rendering the labourers idle (Durdyev and Mbachu, 2011). Certain trades are able to be carried out even out of sequence with the preceding activities (Farnad and Pouya, 2013), however no activity can be established without the foundation with which forms the substrata of a structure.

2.8.1.3 Site Location/environment

Another factor that is considered crucial with regards to the impacts it has on the level of labour productivity, is the conducive nature around which the project is being developed (Niazi and Painting, 2017). Furthermore, if the environment around the project is not safe, this leads to labourers not able to come to site feeling safe and absenteeism increases amongst workers which leads to large portions of work being distributed amongst few labourers and as a result making the project susceptible to delays and poorly produced project (Durdyev and Mbachu, 2011; Niazi and Painting, 2017).

2.8.1.4 Lack of experience among workers

Labour experience is the ability of the worker to be able to execute the job to which they are expected to with due diligence. In the construction industry, this definition does not entirely hold true as it is reported that amongst many factors that impact labour productivity, is the lack of experience (Alinaitwe *et al.*, 2005; Enshassi *et al.*, 2007; Mahamid, 2012; Murari and Joshi2019). The surge of labourers lacking adequate experience in the construction industry is intrinsically linked to labour disloyalty (Mahamid, 2012). Firms that omit the processes necessary to validate the legitimacy of the credentials of labourers applying for jobs on construction projects, and further check the experiences of the labourers, run the risk of having their projects not succeeding due to poor workmanship and poor labour performance (Durdyev and Mbachu, 2011; Mahamid, 2012; Farnad and Pouya, 2013).

2.8.1.5 Delays in delivery of material

Depending on where the development is taking place or the location of the project, delivery of material required for the execution of the work may be impacted which inadvertently affect the productivity of labour (Hughes and Thorpe, 2014). The workers on construction projects can find themselves idle in the absence of material or where the delivery of material is not actioned for the intended work scheduled (Kaming *et al.*, 1997b; Alinaitwe *et al.*, 2007; Enshassi *et al.*, 2007). Additionally the inability of construction material to be delivered on site due to the geography or any environmental impact on the project has the potential to halt the construction process and further prolong the construction period and increase the labour costs which is incurred in the form of idle labour time (Kadir *et al.*, 2005). Postulating from Love *et al.* (2002) perspective observing the construction process through system theory principles, it is evident that a halt at any part in the construction process has the potential to impact on proceeding activities and as a result, the entire construction process will be affected (Alinaitwe *et al.*, 2005; Kadir *et al.*, 2005).

2.8.1.6 Poor site supervision

The chain of command on construction projects is designed in that a supervisor (construction manager or section manager) issues directives to the labourers for the work being executed on site. Furthermore, proper supervision promotes the success of a project (Alinaitwe *et al.*, 2005). However, literature argues that poor supervision is core to the lack of productivity on construction projects (Durdyev and Mbachu, 2011; Hughes and Thorpe, 2014; Muzamil and Khurshid, 2014). Poor supervision affects the way labourers do their work and as a result, significantly affect the expected output (Jarkas, 2015; Aziz and Abdel-Hakam, 2016). Furthermore, inadequate supervision can also lead to the labour force being idle and as a result not fulfilling their expected work activities on a project. This factors carries both financial implications in that the quality of work becomes substandard in instances where supervision is absent and that potential rework become eminent (Kadir *et al.*, 2005; Jarkas, 2015).

2.8.1.7 Lack of tools and Equipment

Lack of tools and equipment refers to the absence of the adequate provision of equipment and tools essential for the labourers to carry out the specified tasks and activities with optimal efficiency (Kaming *et al.*, 1997b; Kaming *et al.*, 1998; Gündüz *et al.*, 2012). Lack of equipment and tools contribute to the difference in efficient labour productivity and give rise to idle labourers on site (Kaming et al., 1997). Kadir *et al.* (2005) attribute lack of equipment and tools to breakdowns of tools, shortage of spare parts and poor maintenance. This assertion is purported by Gündüz *et al.* (2012) in reporting that misallocation of equipment and improper allocation of resources significantly contribute to poor productivity on site equipment. Kaming *et al.* (1998) further purport that lack of tools is in most cases due to the labourers' attitudes of not taking good care of the tools and regularly maintaining them. These factors impede productivity as labourers cannot continue with the construction work, particularly those activities that require either handheld tools or the aid of plant. Furthermore, without proper tools to do the work, the productivity of labour is compromised, and often, the morale and motivation of workers decline thus impacting negatively on project performance (Kadir *et al.*, 2005; Kazaz *et al.*, 2008; Durdyev and Mbachu, 2011).

2.8.1.8 Mismanagement of resources on site

Another factor that impacts the productivity of labour, is the labour's inability to manage and effectively use the tools and equipment afforded for the execution of the project (Kadir *et al.*, 2005). As a result, the mismanagement of resources on projects can hinder the success and the progress of the project in that it is costly to replace these tools and equipment (Mahamid, 2013; Aziz and Abdel-Hakam, 2016). In their study, Aziz and Abdel-Hakam (2016) further postulate that due to improper use of the equipment, failures of equipment arise and additionally contribute to the labour's inability to carry out their function.

2.8.1.9 Rework due to poor quality

Rework of the construction work or sections of works refers to the time taken, and the resources used in repairing a section of the work not meeting the construction specifications or not built to the desired level of specified quality (Kaming et al., 1997). Pre-construction, the ideal practice is to avoid construction rework at all cost, and no one project mandates its programme with the possibility of rework. Construction rework may be measured with some level of accuracy as it is the time taken to redo the activity as well as the cost incurred in making good that part of the work (Baloyi and Bekker, 2011). This is measured by the poor quality of work expended in comparison to that which is specified in the contract data (Kaming *et al.*, 1997a). Notwithstanding this, frequent errors made by the labourers on site further necessitate rework and as a result, affect the productivity of labour (Gündüz *et al.*, 2012). A study conducted in Nigeria by Olomolaiye *et al.* (1987) found that rework directly impacts labour productivity amongst artisans. They further found that rework contributed to lack of motivation in doing the same activity more than once for the same section which further gave rise to poor labour productivity (Olomolaiye *et al.*, 1987).

2.8.2 Organisational/construction firm Factors

Organisational and management efforts have the potential to affect the level of labour productivity that can be expended on a construction project (Park, 2006; Enshassi *et al.*, 2007). These are factors that impact the organisation and as a result, the level of productivity that is expended on site. Eight factors have been identified from literature and these are: non-payment of labour, delays in payment of labour, fluctuations in material/equipment prices, changes in management structure, shortage of labour/manpower, inexperienced supervisors, change in government legislature/policy, economic changes (change in VAT, inflation and foreign exchange rate).

2.8.2.1 Non-payment of labour

Non-payment of labour is when labour is not remunerated for the services rendered. The effect that non-payment has on the level of productivity is that it tarnishes the perceived productivity of the industry at large (Ramachandra and Rotimi, 2015). Furthermore, the effects the parties involved on the construction projects as this halts the work on site due to the fact that labourers on site cannot work without prospects of remuneration (Durdyev and Mbachu, 2011; Ramachandra and Rotimi, 2015).

2.8.2.2 Delays in payment of labour

The productivity of labour if further affected by delays in payment or lack of payment for the services rendered (Enshassi *et al.*, 2007; Kaliba *et al.*, 2009). Additionally, if labour is not paid on time, they tend not to be motivated or encouraged to work and as a result, they tend to be idle and refuse to work, and this further inhibit production thus resulting in time delays to the project (Enshassi *et al.*, 2007; Jarkas and Bitar, 2012). Delays in payment is seen through literature as a factor that significantly affect the level of productivity as this affects the livelihood of the employee and their dependents (Farnad and Pouya, 2013).

Literature suggests that the productivity and efficiency of labour is related to remuneration (Van Zyl, 2010). In delaying the remuneration, the organisation affects its own labour force and stifle their productivity, and this has proven to have detrimental impacts on the success of the construction project (Durdyev and Mbachu, 2011). The level of productivity is significantly affected by labour being paid on time or receiving their remuneration and the adverse holds true (Van Zyl, 2010).

2.8.2.3 Fluctuations in material/equipment prices

The prices of material and equipment used in the construction industry is not static. This is due to changes in the economy, inflation and other factors that are pertinent to the production and manufacture of such products (Durdyev and Mbachu, 2011). The increase in material/equipment prices affects the construction productivity in the way that increases in inflation/VAT and exchange rates does. Alternative material and equipment are employed on site in order to execute the job (Mahamid, 2012; Jarkas, 2015). Alternative material or the doing away of equipment in some instances diminishes the productivity of labour as the adapting to a new system of doing things changes the level of output rate (Gündüz *et al.*, 2012).

2.8.2.4 Changes in management structure

An important factor mentioned in literature is that which relates to the organisational structures (organograms) which sometime changes due to varying reasons (Kaming *et al.*, 1998; Soekiman *et al.*, 2011). On a project site, this change in management or supervision contributes significantly to the productivity of labour (Soekiman *et al.*, 2011; Jarkas, 2015). This change in supervision also brings with it a notable disruption to the organisational dynamics, especially amongst teams on a construction project. Additionally, some of the supervisors brought onto the project display either lack of experience or generally do not have good relationship with the workers and further disruption the production output expected from the labourers (Proverbs *et al.*, 1999; Love *et al.*, 2002; Soekiman *et al.*, 2011).

2.8.2.5 Shortage of labour/manpower

Shortage of labours on construction project compromises productivity as large tasks requiring a set number of workers becomes the sole responsibility of a few labourers thus bringing to disrepute the project quality and further increasing time delay in the project (Kadir *et al.*, 2005; Alinaitwe *et al.*, 2007; Jang *et al.*, 2011). Additionally, the level of productivity on site diminishes with less labour as this means only a few tasks can be done at a time and as a result increasing the time delay in the project which also gives rise to overhead costs (Asaaf and Al-Hejji, 2006; Baloyi and Bekker, 2011). Large projects such as infrastructure projects are characterised by activities around the project happening around the clock, as a result, the shortage of labour at any given point significantly affects the productivity and additionally compromises the quality of the final product (Kaliba *et al.*, 2009; Mahamid *et al.*, 2011).

2.8.2.6 Inexperienced supervisors

Inadequate supervision a skill and abilities amongst management impacts greatly on the productivity of labour and the expended output (Alinaitwe *et al.*, 2005). Gündüz *et al.* (2012) argues that poor site supervision dissuade labour from performing at their optimal capability as the inadequacy of the manager to dispatch directives is often embroiled with errors and instructions that are not clear. This assertion is purported by Osman and Ahmed (2017) and Jarkas (2015) in postulating that knowledge of people management is core and central to good supervision. Additionally, for a team to operate efficiently and productively, a supervisor’s role is important and their knowledge of the work, paramount.

2.8.2.7 Change in government legislature/policy

Processes and systems in the construction industry, like any other industry, are governed by legislature and policies that allows the efficient operation of activities from supply chain through to production. Notwithstanding that, the industry is affected by any amendments or changes in legislature (Gündüz *et al.*, 2012; Farnad and Pouya, 2013). Changes in legislature effects a direct adjustment to the construction organisation which further impacts the level of governance over material, labour or methods of operation on a construction project. In the event that this policy is effected or amended while the project is ongoing, this then necessitate an active change which can disrupt the operations on a project and subsequently the performance of labour (Gündüz *et al.*, 2012; Farnad and Pouya, 2013).

2.8.2.8 Economic changes (change in VAT, inflation and foreign exchange rate)

Changes in the economy directly affects aspects of the construction industry and the repercussions thereof are felt on the productivity of labour on construction projects (Gündüz *et al.*, 2012). An increase in value added tax (VAT) affects the pricing of labour and the prices of material and equipment used on projects (Durdyev and Mbachu, 2011). Additionally, an increase in inflation further affects the cost of labour and the purchasing power of the organisation with regards to material and equipment they can procure. As a result, alternatives for the original specified material can be opted for and additionally this changes the productivity of labour as labour has to adapt to the utilisation of new material (Gündüz *et al.*, 2012; Mahamid, 2012; Jarkas, 2015), additionally, equipment that expedite the production are not prioritised due to the price increases and additionally, labour productivity on site is diminished (Barbosa *et al.*, 2017).

2.8.3 Technical Factors

Technical factors refer to a set of factors that are related to the project detail and specification as well as the skill and ability to deliver the project according to its eminent complexities. Different developments or construction projects exhibit a level of complexity that demands a set of technical skills necessary for the execution or the works (Mawdesley and AL-Jibouri, 2009). The following eight factors relating to the technical aspect of a project are extracted from literature. These factors are: poorly designed project, incomplete drawings, methods of construction (prefabrication vs on-site), poor co-ordination/planning activities, complexity of the project, buildability of the structure, inspection delays from engineers, change orders from the designers/consultants.

2.8.3.1 Poorly designed project

Poorly designed construction projects have a significant impact on the level of productivity of labour (Soekiman *et al.*, 2011). Furthermore, omissions or errors on the drawings also have an impact on the level of productivity (Moselhi and Khan, 2012). Additionally, in resolving the technical uncertainties on drawings, literature across different scholars points to the delays in the response time from the engineers or consultants and as a result, labourers are found to be idle and consequently, unproductive (Ofori *et al.*, 1996; Moselhi and Khan, 2012; Hughes and Thorpe, 2014).

2.8.3.2 Incomplete drawings

The contention that exists amongst the labourers in terms of their ability to execute the project lies in the information given and how they execute the work (Alinaitwe *et* *al.*, 2007). Furthermore, it is evidenced in literature that core to this contention is the construction team's inability to gather sufficient data and information that informs the design (Gündüz *et al.*, 2012). In instances where the labourer is not provided the full information regarding the section of the work, their efficiency and level of execution of the work diminishes (Moselhi and Khan, 2012).

2.8.3.3 Methods of construction (prefabrication vs on-site)

The differences in the construction method used on site affects the construction development, particularly the labour that utilises the varying methods (Durdyev and Mbachu, 2011). In the event that prefabrication elements are used on site, a marginal level of error in the assembly of elements exists and as a result, a project can be developed with ease and accuracy within time (Hughes and Thorpe, 2014). Notwithstanding this, the on-site activities that are not precast or prefabricated demands a well-structured management schedule and knowledgeable labourers to execute (Park, 2006). In the event that this is not ensured on site, lack of productivity can be observed especially when the labour is not briefed or does not have the full knowledge of what to do and how to do it. Although other scholars argue that this can be avoided purely adopting prefabricated methods of construction (Lovell and Smith, 2010) it is observed that this is hard to implement as each construction process presents different levels of complexity and the labour-intensive aspect of construction cannot be entirely disregarded (Sweis, 2000; Xia and Chan, 2012).

2.8.3.4 Poor co-ordination/planning of activities

Scheduling and planning of the construction activities and sequence is paramount to the success of the project (Sweis, 2000; Love *et al.*, 2002; Park, 2006). Furthermore, proper planning allows the construction activities to be carried out in an order that gives the labourers an understanding of what activity proceeds the other so as to ensure there is no conflict in the execution and bringing to site equipment and plant that stays idle without being utilised. Notwithstanding that, literature suggests that this is not always the practice on construction projects and as a result, this has implications on the level of labour productivity (Kadir *et al.*, 2005; Hughes and Thorpe, 2014). Additionally, in the event that the activities on a project are not planned properly one of two scenarios can occur; more labour than needed or less labour than the job demands (Hughes and Thorpe, 2014; Naoum, 2016). it further follows that no productive output can be observed in either of the scenarios and as a result labour productivity is affected (Gündüz *et al.*, 2012).

2.8.3.5 Complexity of the project

Xia and Chan (2012) refer to the complexity of the project as the interactions amongst the varying activities that comprises a construction process. Mawdesley and AL-Jibouri (2009) supports this view and further asserts that it is difficult to standardise complexity across the construction industry as each project exhibit varying levels of complexity. However, it is a common observation that the level of productivity on a project is affected by its complexity. Furthermore, when projects comprise large number of interacting parts, the level of labour productivity decreases and further affects the performance of the project (Okorafor *et al.*, 2016). As a result, quantifying and measuring labour productivity on such projects become complicated (Motwani *et al.*, 1995).

2.8.3.6 Buildability of the structure

Buildability of the structure in parts also relates to the project complexity, however it focuses on the project's ability to be constructed by the labour force employed with the skills and resources on hand. Durdyev and Mbachu (2011) asserts that as a project characteristic, the issues surrounding the buildability of a project can affect the level of labour productivity and subsequently the performance thereof. As a result, it is imperative that this element be evaluated before a project commences, especially with the level of labour employed as well as the resources provided for the job (Doloi, 2008)

2.8.3.7 Inspection delays from engineers

Engineers responsible for the inspection of the work sections can give rise to the level of low productivity amongst labourers (Alinaitwe *et al.*, 2007; Gündüz *et al.*, 2012). After the completion of a section, the relevant engineers come to site to evaluate the satisfactory nature of the work before labourers can proceed with other parts of the construction. In the event that the engineers are not available or do not make proper arrangements to carry out this section of their role, labour remains idle on the project and subsequently does not achieve the goals set at the work scheduling stage (Doloi, 2008).

2.8.3.8 Change orders from the designers/consultants

Literature postulates that one of the factors that impact on the level of labour productivity on projects is the change orders from the consultants (Kadir *et al.*, 2005; Gündüz *et al.*, 2012; Niazi and Painting, 2017; Osman and Ahmed, 2017). The inability of the consultants to produce complete drawings that can allow contractors to draw up a complete schedule of activities gives rise to labourers on a project to not be productive, particularly in instances where proceeding activities have to be carried out (Niazi and Painting, 2017). Furthermore, the project is susceptible to cost and time delays which affects the timelines of the construction project.

2.8.4 Social Factors

Social factors are factors that are related to the labourer/worker's ability to perform their duties. These are factors that include the health, psychology and habits of a worker in relation to their expected duties (Kazaz *et al.*, 2008; Jang *et al.*, 2011). An area or research that is seldom analysed when analysing the level of productivity on construction projects, is the social factors and their relation to the wellbeing of the labourers and thus their ability to execute the job (Kazaz and Ulubeyli, 2007). In a study conducted by Kazaz and Ulubeyli (2007), they analysed the drivers that impacts labour productivity and these factors were classified into two categories, economic factors and socio-psychological factors. Furthermore, through the analysis, it became evident that socio-psychological factors were significantly related to efficient productivity evidenced by labourers (Kazaz and Ulubeyli, 2007). This assertion is purported by Park (2006) in acknowledging that central to efficient labour productivity is the psychological factors that motivate labourers and the disregard thereof from the organisation, may yield an undesired level of productivity. Eight factors are extracted from literature which address the social aspect of the labourers on construction projects. These factors are: lack of experience of workers, personal problems, drug abuse, alcohol abuse, long commute periods to site, relationship between supervisors and labourers, labour unrest/rioting and uncertain job security.

2.8.4.1 Personal problems

If workers are experiencing personal problems, this may hinder their performance and as a result affect the productivity of the project (Kazaz and Ulubeyli, 2007). Personal problems have a direct relation to the worker's psychology and as a result, this affects how they engage with the work they are doing efficiently and subsequently, the expected level of productivity they expend is affected (Kazaz *et al.*, 2008). Park (2006) also suggests that psychological factors are central to the labourer's performance on construction projects and thus a key component in evaluating the productivity as this potentially affects the labourer. Additionally, fatigue due to overwork may greatly hinder the productivity of labour (Hughes and Thorpe, 2014).

2.8.4.2 Drug abuse

Drug abuse is also found through literature to be a critical factor impacting labour productivity negatively and as a result, this is to be considered with great caution during site management (Soekiman *et al.*, 2011; du Plessis *et al.*, 2013). Workers that use substances on construction sites are unproductive and their behaviour often impacts those around them as they become aggressive and sometimes violent (Osman and Ahmed, 2017).

2.8.4.3 Alcohol abuse

Similarly, alcohol abuse on construction projects is often reported in literature (Osman and Ahmed, 2017). Alcohol use affect the cognitive ability of the worker in performing their duties and this in effect impacts on the project performance. Alcohol abuse is prevalent in the construction industry and as a way to control this, measures such as the introduction of breathalysers are implemented under the health and safety portfolio of the project. However, this affects the distribution of work on the project as the workers on the project divide the scheduled activities amongst less labour present (du Plessis *et al.*, 2013).

2.8.4.4 Long commute periods to site

The commute times that labour is subjected to when going to their places of work can have an impact on their levels of productivity. Van Ommeren and Gutiérrez-i-Puigarnau (2011) suggests that labourers provide less work efforts when they have larger commutes between work and their place of residence. Additionally, this significantly contributes to the labourers' absenteeism on construction projects as they seldom arrive on site due to long commutes or are always late (Cahuc and Zylberberg, 2004; Van Ommeren and Gutiérrez-i-Puigarnau, 2011). As a result, the inability to effectively engage in the work process and absenteeism contributes to the labourer's lack of productivity and project performance is compromised as a result.

2.8.4.5 Relationship between supervisors and labourers

The relationship between managers and labourers on projects affect how well labourers perform their functions and as a result yield tangible output (Durdyev and Mbachu, 2011). Poor relationship between workers and their superiors or supervisors impacts on the level of labour productivity (Park, 2006; Enshassi *et al.*, 2007). Another factor that is found to contribute to poor productivity within the social factors' context, is the eminent cultural difference and the age differences found between the different age of labourers (Kazaz and Ulubeyli, 2007). These factors give rise to the friction that often exists between labourers and as a result offset their productivity from the expected level of output (Kazaz and Ulubeyli, 2007).

2.8.4.6 Labour unrest/rioting

Labour unrest and rioting is one of the factors that impact on the productivity of labour. Gündüz *et al.* (2012) in their study assert that under external factors, rioting/war and hostility are factors that impact on the productivity of labour, especially when it halts the construction project. This further impacts the cost and time of the project giving rise to overruns.

2.8.4.7 Uncertain job security

The reputation that clouds the construction industry is that it is an industry that in relation to its contemporaries, it is not regarded as an attractive industry to work in (Kazaz and Ulubeyli, 2007). Having said that, the industry offers a vast selection of trades that allows workers that enter the construction industry to excel within their field of specialisation (Kazaz and Ulubeyli, 2007). Additionally, individuals entering the industry with high level of skill, tend to excel in their execution of work and as a result enjoy their work thus being motivated or encouraged to work hard (Kazaz and Ulubeyli, 2007).

2.9 Techniques used to measure labour productivity on construction projects

The measurement and quantification of construction labour productivity is a complicated exercise both on construction projects and across the construction industry at large (Gündüz *et al.*, 2012; Yi and Chan, 2014; Barbosa *et al.*, 2017). This complexity in the measure of labour performance is attributed to the complexity of the construction industry and the interconnectedness of the construction activities (Love *et al.*, 2002) and the many contextual factors that impact the level of productivity at every level of the project (Durdyev and Mbachu, 2011; Yi and Chan, 2014). As a result, a few measurement techniques are identified through literature as measures of labour productivity and are discussed in the following sub-sections.

2.9.1 Total Factor Productivity (TFP)

Total factor productivity (TFP) is a measuring tool of productivity used predominantly in economics to quantify the level of productivity output (Chau and Walker, 1988; Crawford and Vogl, 2006; Park, 2006; Ghate *et al.*, 2016). This method of measuring productivity is popular in the construction industry largely based on the fact that it considers multiple factors or variables in the determination of productivity output (Jarkas, 2015). Some of the inputs embedded in the technique are labour, equipment, material and capital outputs in the determination of productivity output (Park, 2006). In a more expansive view Crawford and Vogl (2006) posits that TFP illustrate the relationship between the above variables to the level of output measured on a construction project.

However, TFP as a measuring technique of the level of productivity in the construction industry has some limitations. First of all the determination of all the inputs or variables that contribute to the bringing together of a construction project is complicated to achieve (Jarkas, 2015). Furthermore, it is arduous and impractical to monitor and analyse the impact of each input and its effect on the output of a project especially since a multi-system approach exists on projects (Love *et al.*, 2002; Jarkas, 2015). Moreover, a construction project is complicated in nature (Xia and Chan, 2012) and the interactions of the different activities that sometimes run concurrently or sequentially, makes TFP an incompatible method for use in measuring the level of labour productivity (Crawford and Vogl, 2006; Abdel-Wahab and Vogl, 2011; Jarkas, 2015). Another method used in the industry is the Average Labour Productivity (ALP).

2.9.2 Average Factor Productivity (AFP)/Partial Factor Productivity (PFP)

Average factor productivity (AFP) or Partial Factor Productivity (PFP) is a method that divide the total output by the labour input as either the number of workers involved on the project or the number of work-hours committed to an activity (Abdel-Wahab and Vogl, 2011). Jarkas and Bitar (2012) corroborate this in postulating that AFP only considers the impact of one input (labour) and its effect on the output, contrary to the TFP which is unable to consider all variables to the project, AFP only focuses on one output and as a result one can monitor its impact and control it to analyse the yield of output expected (Jarkas, 2015). According to Abdel-Wahab and Vogl (2011) another advantage of using ALP in the calculation of output on a construction project is that it measures one key variable and its impact on productivity and furthermore, the method is feasible and practical to employ on any project that requires a measure of some output or performance of one variable (labour).

2.9.3 Work Sampling

Work sampling is defined as a technique that measure the time it takes a labourer to perform a certain activity (Josephson and Björkman, 2013). The primary objective of the work sampling technique as used in the construction industry is to measure the average time it takes for an individual labourer to perform a designated activity (Josephson and Björkman, 2013; Yi and Chan, 2014). Additionally, management's rate of response to aspects of the activity where their expertise is needed is also evaluated (Josephson and Björkman, 2013). However, this is done for the manager in an observer role as opposed to a manager involved in the actual work that is a foreman (Josephson and Björkman, 2013).

According to Josephson and Björkman (2013) and Yi and Chan (2014) an advantage of work sampling method is that work sampling provides an easy and inexpensive way to analyse the non-repetitive construction work activities (Josephson and Björkman, 2013; Yi and Chan, 2014). Another advantage found that makes work sampling appealing to the construction industry is that the method aids in the determination of problem areas pertinent to giving rise to cost and time delays on projects (Josephson and Björkman, 2013). Work sampling can identify factors that are specific to a site and their potential impacts on the productivity of labour (Allmon *et al.*, 2000; Josephson and Björkman, 2013; Yi and Chan, 2014).

2.10 Theoretical Framework

The conceptual framework for this study is underpinned by systems theory and chaos theory. In the adoption of system theory, it is imperative to define what the system mean in relation to the construction industry.

A system is defined as an organised or complicated arrangement of activities comprising of parts that are interacting or sequentially following from each other and which are coordinated in a systematic order (Kundur *et al.*, 2004; Wu, 2005). Love *et al.* (2002) expands further on this definition in positing that the construction industry is perceived as a system with a dynamism evidenced by the ever-changing nature of its activities and project types, particularly when developed in different environmental contexts. Additionally, the construction industry is noted for its complexity which is described as the project's characteristic to display multiple activities or parts interacting with each other (Xia and Chan, 2012). Scholars in the field of productivity, particularly when contextualised in the construction industry, seldom consider the fact that labour component impacts the different systems (Al-Jibouri, 2003; Antunes and Gonzalez, 2015). Moreover, it is not known to what degree of impact this is observed on the different project types. However, Love *et al.* (2002) asserts that with each notable change in the construction process (system), an impact is observed that affects proceeding activities. This impact will be observed, for the purpose of this study, as a cost or time delay (Alinaitwe *et al.*, 2005; Kaliba *et al.*, 2009; Aziz and Abdel-Hakam, 2016). This study therefore examines the impact of contextual factors observed on construction projects and how they affect the established productivity when analysing the project as a whole.

The other theory that underpins this study in the development of the conceptual framework, is the chaos theory. An unpredictable behaviour that emanates from a co-ordinated system which is characterised by turbulent flow, extreme variation in the original order is defined as turbulence (Singh and Singh, 2002). The great advantage of chaos theory is its ability to offer both theoretical and methodical basis with regards to the interpretation of uncertain and complex system parts which are non-linear in nature (Lu *et al.*, 2010). Notwithstanding that, chaos theory has been developed in other fields of science to identify and diagnose the core problem areas that if quickly identified, the ripple effects thereof can be mitigated (Ayers, 1997). However, in the analysis of chaos theory, it is evident that the unpredictable or unplanned occurrence does exist but is seldom evaluated with regards to its impact on the project. Additionally, a feedback loop that is asserted by (Love *et al.*, 2002) does not exist with chaos theory. As a result, this study will aim to identify the core factors that causes turbulence/variation on construction projects and evaluate their impact and relationship to labour productivity.

2.11 Conceptual framework for the study

As postulated through literature review, environmental factors are key to the efficiency and further impacts the ability of labour to yield the required productivity output (Durdyev and Mbachu, 2011; Niazi and Painting, 2017). In addition to environmental factors, design and technical factors that are essential to the conceptualisation and delivery of the project also impacts significantly on the productivity of labour (Motwani *et al.*, 1995; Moselhi and Khan, 2012; Okorafor *et al.*, 2016). Further analysis of factors that impact on the productivity of labour on construction projects are organisation's structure and systems (Durdyev and Mbachu, 2011). in the development of factors that form organisational structure, this assertion was adopted. Additionally, the development of a construction project is achieved through labour intensive means which is employed in the form of human endeavour (Arditi and Mochtar, 1996). This further necessitate the wellbeing of labour in the evaluation of the productivity expended on construction projects. Kazaz *et al.* (2008) and Jang *et al.* (2011) corroborate this assertion in that factors affecting the personal capacity of a worker must not be evaluated in isolation to the activity the worker embarks on, especially when evaluating the level of productivity. Hence, psychological and the general wellbeing of a worker is significant to the objective evaluation of their expended level of productivity on a construction project (Park, 2006; Kazaz *et al.*, 2008; Jang *et al.*, 2011).

Figure 2.5 is developed as the conceptual framework for this study. From the onset of the project, an estimation of what the level of labour productivity on site is established and this feeds into the production process (during construction) of any construction development. From this process, the actual labour productivity expended on site can be observed. However, this follows the model of system theory and can, without any disruptions, yield the required level of productivity that is equitable to the estimate (Love *et al.*, 2002; Antunes and Gonzalez, 2015). Notwithstanding this, the labour performance of a project can be established with regards to whether having met the standard of performance or not.

However, Systems theory highlights the chaos that emanate and which has not been planned, in the context of Figure2.5, this chaos which gives rise to variation occurs during the construction process and it is through the contextual factors intrinsic to the construction process that it exists (Ayers, 1997; Singh and Singh, 2002). It is at this production process that the study aims to evaluate which of the contextual factors impact the level of labour productivity. Furthermore, to assess these contextual factors and their impacts on the level of labour productivity when differentiated by project types, organisation and location of the project. In this way, the study will utilise the relation of system to the construction project and the chaos theory to the emergence of contextual factors that impact the project in order to answer the research question which is to identify what factors affect labour productivity on construction projects in South Africa.

Factors that fall under the site environmental factors are inclement weather (rain/cold/heat), unexpected site ground conditions, site location/environment, lack of experience amongst workers, delays in delivery of material, poor site supervision, lack of tools and equipment, mismanagement of resources on site and rework due to poor quality. Factors that constitute the organisational/construction site factors which this study evaluates are: non-payment of labour, delays in payment of labour, fluctuations in material/equipment prices, changes in management structure, shortage of labour/manpower, inexperienced supervisors, change in government legislature/policy and economic changes (change in VAT, inflation and foreign exchange rates).

Found under technical factors, the study evaluates poorly designed project, incomplete drawings, methods of construction (prefabrication vs onsite), poor co-ordination/planning of activities, complexity of the project, buildability of the structure, inspection delays from engineers and change orders from the designers/consultants. Lastly, social factors evaluated by this study are: lack of experience of workers, personal problems, drug abuse, alcohol abuse, long commute periods to site, relationships between supervisors and labourers, labour unrest/rioting and uncertain job security. This paradigm given the factual, objective and deductive strengths, forms the anchor of the methods to be used in gathering data and testing the hypothesis developed from literature review for answering the research question of this study.

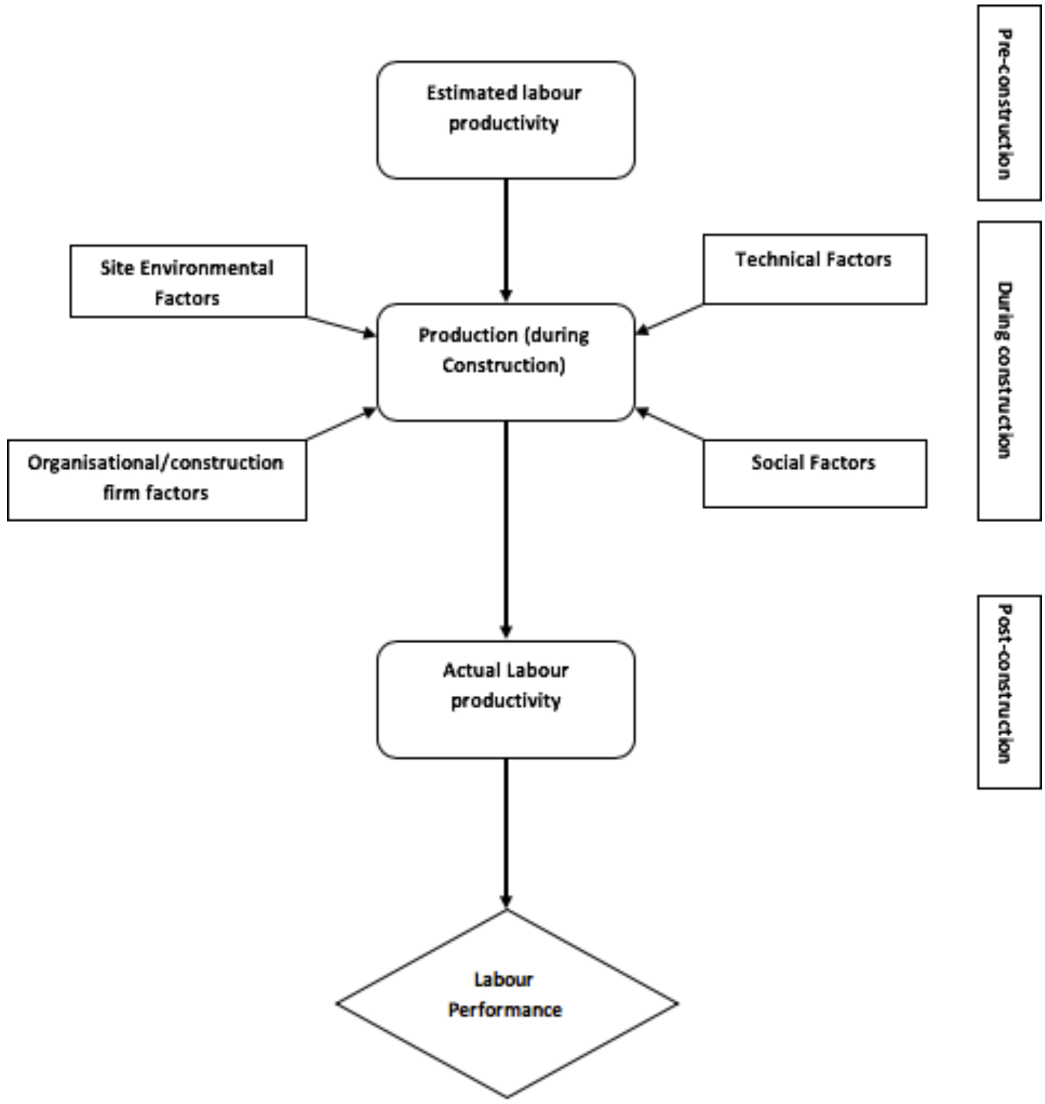


Figure 2. 5: Conceptual framework for the study

2.12 Chapter Summary

This chapter evaluated literature that is pertinent to the area of the study and established core and fundamental aspects that are intrinsic to both the construction industry and the productivity of labour. Furthermore, it was established that the definition of labour productivity is paramount to the understanding of the construction industry and the benchmarks adopted on various projects to monitor labour productivity. It emerged that a standard definition of labour productivity does not exist in the construction industry as a result, various definitions are adopted. For this study the product output over labour input is the definition of the labour productivity that is adopted. Furthermore, this chapter reported the significance of the conceptualisation of the baseline labour productivity and purport this as a crucial aspect of the construction project as it sets the standard for both labours expected on site as well as the techniques necessary to monitor and regulate the said labour productivity.

This chapter further assessed the global performance of the labour productivity on construction projects and its overall performance. It emerged from literature review that a decline in the productivity of labour is endemic to the construction industry and as a result, the construction projects are susceptible to both costs and time overruns which affects the productivity of the construction projects. Furthermore, the state of the labour productivity and its contribution to the South African context was assessed through literature. The productivity of labour yields the same for the south African construction industry and this is reported as a concern in that the construction industry is one of the main contributors to the economy with regards to job creation in both the formal and informal sectors.

It further became imperative that the construction industry be compared with its contemporaries as one cannot assess the state of an industry without evaluating the performance of others in order to objectively report on its performance. This comparison was drawn between the construction industry and the manufacturing industry and it emerged that in the past two decades, the construction industry reported a marginal growth of 1% in the productivity of labour whereas the manufacturing industry has reported an increase of over 300% in the past two decades. The causes of the low level of labour productivity growth were established through literature as being amongst other; external factors, industry dynamics as well as the firm-level operational factors. These three core factors impact the industry as a whole and a further analysis of literature reveal more factors that are more related to individual construction projects in their varying scale and function. Notwithstanding the core factors, a further synthesis of factors specific to construction firms were found to be: work management component, work technique component, work characteristic component and workers component.

These four groups of factors impacting labour productivity holistically centres the labourers in the four groups and assess what specific sub-factors have a direct impact on the labourer's level of productivity expended on a construction project. This study adopted the model of assessing factors from the literature and their relation to the labour productivity on site and contrived four groups of factors that affect the productivity of labour on site and there are: site environmental factors, organisational/construction firm factors, technical factors and social factors.

Additionally, this chapter also established the various techniques or methods used in the construction industry to measure labour productivity on construction sites. Total factor productivity (TFP), average factor productivity (AFP) or partial factor productivity (PFP) and work sampling, are some of the techniques used in measuring the level of productivity on site.

Through the analysis of literature, a couple of theories that relate to the construction industry and the level of labour productivity were adopted for, scrutinised and applied to this study as they related to the objectives and the hypothesis of the study. These theories form the theoretical framework of the study and they are systems theory and chaos theory. Additionally, from the literature review, a conceptual framework (Figure 2.5) was developed for this study which shows the impact of the contextual factors on the level of the construction labour productivity at the production stage.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This section describes the methods and the sequential processes followed in the collection and analysis of data to answer the research question. Methodology aids the researcher in conceptualising and designing the research structure in order to address the objectives of the study and answer the research question (Kivunja and Kuyini, 2017).

Research methodology details the step-by-step or the logical flow of the steps followed in answering the research question (Leedy and Ormrod, 2005; Kivunja and Kuyini, 2017). It is also a sequential process followed in the effort to acquire knowledge regarding the research problem (Kivunja and Kuyini, 2017).

An illustration of the steps followed in the design of this research are depicted in Figure 3.1. The first step in the framework of this research is the identification of the research area. A comprehensive background or literature review was conducted with the aim of identifying the knowledge gaps and subsequently, the design of the research question and hypothesis for the study. The collection of data was carried out through a questionnaire survey conducted through the web and the results thereof were analysed through a statistical software (SPSS) and further analysed and interpreted. Finally, conclusions and recommendations were drawn. This systematic structure of design for this study, follows the scientific method of research very closely which is the method of experimenting in order to observe the results as a pathway to answer the research question (Skinner, 1956).

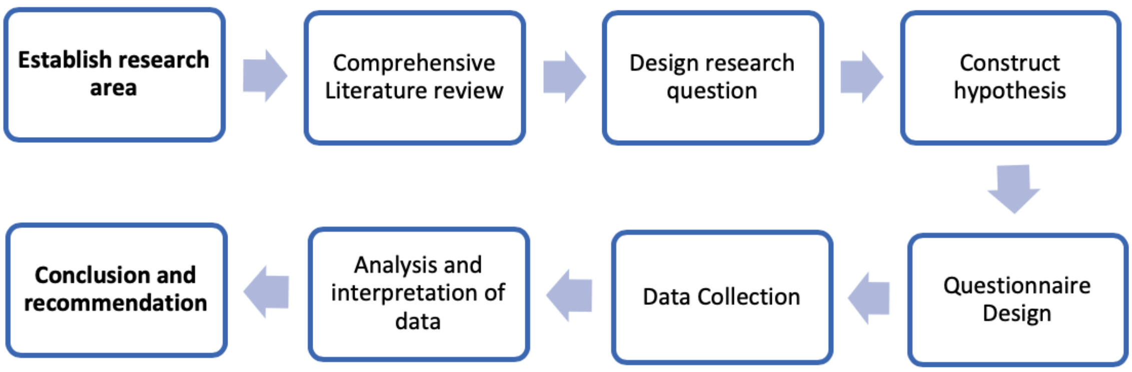


Figure 3. 1: Detailed Research Process

3.2 Research paradigm

Research paradigm is significant in that it defines the philosophical approach of the research to inevitably answering the research question (Kivunja and Kuyini, 2017). Furthermore, the manner in which a research subject is studied, can be influenced by the research paradigm as to how it should be studied and how the results of the study should be interpreted (Kivunja and Kuyini, 2017).

This research adopts the positivist research paradigm. Drawing from previous studies that utilised positivist research paradigm such as Nasirzadeh and Nojedehi (2013) and Farnad and Pouya (2013) the objective of the studies aimed to test for cause and effect which this paradigm aided in the objectives of the studies. Furthermore, other studies centred around the impacts of contextual factors on the level of labour productivity in the construction industry (Durdyev and Mbachu, 2011; Gündüz *et al.*, 2012; Naoum, 2016; Niazi and Painting, 2017; Osman and Ahmed, 2017) have also followed the positivist research approach in reaching their objectives in their studies. Similarly, to this study, the objective is to test for the impact of the contextual factors that impact the level of labour productivity on the construction projects as a result, this approach will allow the study to achieve its objectives search and testing for cause and effect. Furthermore, positivist approach allows the research observations to be interpreted on the merits of their factual and measurable variables especially since the gathered data through this paradigm can either be used to prove or disprove the conceptual framework of the study (Gephart, 2004; Nasirzadeh and Nojedehi, 2013).

The positivist research paradigm is primarily logical and deductive in nature as it allows the formulation of hypothesis as well as the testing of the hypothesis (Fadhel, 2002; Kivunja and Kuyini, 2017). As a result, mathematical formulae and computations will be utilised in the analysis of the research data and elucidate the meaning behind the findings and further draw conclusion based on the rigour of the positivism approach to research (Nasirzadeh and Nojedehi, 2013). It follows that positivist paradigm relies largely on the quantitative research approach (Kivunja and Kuyini, 2017), as a result, this study follows the same research method in the development and design of the research questionnaire to gather data. This study aims to evaluate key variables that affect the productivity of labour in the construction industry. As a result, a positivist research approach is chosen as an appropriate paradigm for this study.

3.3 Research Approach

This study is going to adopt a quantitative research approach in the collection of data and the analysis thereof. The adoption of the quantitative research approach for this study is based on the fact that this study aims to examine the variables that affect the level of labour productivity on construction projects and the qualitative approach affords the study to be able to do that because it uses statistical tools and numbers to reach that objective (Creswell and Clark, 2017). Furthermore, the study seeks to establish and explore the relationship these factors have on the level of labour productivity on projects (Creswell and Clark, 2017). The other advantage of using the quantitative research approach is that the methods seeks to test and verify the theory when utilised and this research will be testing the hypothesis in order to draw a conclusion about the impacts of factors to the level of labour productivity on construction projects. Lastly, a structured questionnaire will be used as a means to control the responses in that the responses can be aggregated and analysed with regards to the population sample used.

3.4 Research design

Research design is crucial to any study as it sets precedence for the order and direction in which the research takes (De Vaus and de Vaus, 2001; Creswell and Clark, 2017). Furthermore, research design forms the foundation from which a research is grounded, particularly in that it details the methods that the researcher employs in carrying out the research (Creswell and Clark, 2017). Kumar (2014) defines research design as the structure a researcher follows in answering the research question as validly, objectively, accurately and economically as possible. Furthermore, two fundamental functions of the research design which are the development of procedure and logical steps as well as the quality in the development of these procedures are to be taken into consideration in the design of the research (Kumar, 2014).

The study is going to adopt the cross-sectional survey research design. The main advantage of the cross-sectional survey research approach is that the different variables can be determined based on the various respondent's experiences. Furthermore, a single questionnaire is used to collect data across the various respondents that belong to different project types. The results of the respondents cannot be manipulated or altered. Additionally, the various variables can be analysed across the varying pool of respondents. Lastly, the cross-sectional survey research approach allows for the population used in the study to provide information that can be analysed through the statistical tools employed for this research.

Kumar (2014) posits that there are five distinct research designs that are found through varying researches or studies. These are; exploratory, comparative, descriptive, evaluative and explanatory in nature. Kumar (2014) further argues that the utilisation of either of these approaches is dependent on the core objectives of the study and the subsequent objectives of the study. Notwithstanding that, each research design possesses strengths that aid the researcher to answer their research question the challenge is the identification of one best suited.

This study aims to evaluate the contextual factors impacting labour productivity in the construction industry and measure the degree of variation between estimate and actual labour productivity. The research design adopted in this study is exploratory in nature. Exploratory approach to research is considered to have the ability to lead to new and useful theories (Armstrong, 1970). Juxtaposing this in a counter argument, literature cautions about the false and sometimes theories that may not add value to knowledge production (Armstrong, 1970). However, the exploratory approach consists of benefits that fits the objective of this study and align to the objectives. Quantitative findings from the study can be generalisable in context of where they are relevant and can further impact change (Creswell and Clark, 2017). Furthermore, the phenomenon being explored in this study is the contextual factors which can be quantified and measured, as a result, exploratory approach lands itself very well within this context as it is based on the premise of measuring unknown variables, particularly when the framework is not known (Creswell and Clark, 2017). Through the exploratory approach, a researcher is able to perform statistical or mathematical test to identify fundamental variables and their impact (Creswell and Clark, 2017). It further follows that with this approach as a basis for the research design, this study will address the objectives and aim to answer the research question.

3.5 Area of study

The primary focus of the study is to analyse the contextual factors that brings about variation in labour productivity, especially between the estimated labour output in comparison to expected labour output. Another major focus of the study was the selection of activities that are labour intensive in the construction industry, thus limiting the scope to controllable and easy to measure activities. For that reason, three trades were selected, namely: concrete, masonry and plastering. These activities have been found to imply intensive labour practice as opposed to other trades that demands less labour particularly with the aid of plant and equipment (Ng and Tang, 2010).

The scope of investigation of the study are among three project types: building projects, road projects and infrastructure projects. contractors that are in the construction industry but don't specialise in the above three projects will not be evaluated. Additionally, the study limits the contextual factors to only those that affect the on-site labour productivity and does not explore those that affect other aspects of the construction project such as the supply chain management, tendering for project and post-construction factors. The geographical limitation of this study is South Africa and as a result, contractors that operate outside of the South African context are not included in this study. Furthermore, only contractors that are listed on the cidb registry of contractors in the Grade 1 – 9 are evaluated in this study. Contractors that are still in the process of registering or those that are no longer operational, are not considered in this study.

3.6 Population, sampling technique and sample size

Population and sampling for this study describes the general population and the sampling technique used to select the participants for this study.

3.6.1 Population

The population drawn for this study was based on the information that needed to be collected from the respondents and the techniques intended to analyse the data. As a result, the group of construction professionals that were selected for this study are: director cadres, contracts managers, project managers, site agents, construction managers, site engineers, construction supervisors, quantity surveyors, estimators and cost engineers employed by construction companies listed in Grades 2 – 9 on the cidb register of contractors.

Additionally, cognitively, the study aims to evaluate the core variances between estimated labour output and expended labour output on a construction project, as well as the factors that give rise to this variation, input from selected respondents in construction organisations was sought. This study sought the input of top management officers in construction organisations (directors, contract managers, project managers), middle management (site agent, construction manager, site engineer and construction supervisor). Furthermore, contracts managers and directors of construction companies (CEOs) were also targeted due to the fact that their in-depth knowledge of the organisation and construction operations is core to the variables changes in the performance of the construction projects (Kaynak, 2003).Lastly, construction professionals that directly deal with the costing and estimation of the works were surveyed (quantity surveyors, cost estimators, cost engineers). Clients and client representatives, foreman, labourers were not considered in the research.

Central to the selection of these professionals, is their intrinsic engagement with both the operations on construction projects as well as their ability to plan and cost a project in terms of time and cost. Furthermore, the selected population of the study ensures that consistency in the collected information could be ascertained when conducting the analysis thus eliminating bias (Smith and Noble, 2014). The population of the contractors targeted, or this study was 8400 from the cidb data base. However, some of these contractors were out of business and this is depicted in the response rate.

3.6.2 Sampling techniques

Various sampling techniques were identified through literature and Teddlie and Yu (2007) identifies techniques as simple random sampling, stratified sampling, clustered sampling and convenience sampling. This study adopts the simple random sampling technique as the respondents have an equal chance of being selected in the study especially since they belong to the same population of contractors in the construction industry. Four types of probability sampling techniques are explained to the degree of its strength and weaknesses for the purpose that it is employed as a sampling technique (Teddlie and Yu, 2007). These sampling techniques are random sampling, stratified sampling, cluster sampling and sampling using multiple probability techniques (Teddlie and Yu, 2007). Random sampling technique is when each sampling unit in a defined population has an equal chance of being selected. However, stratified sampling occurs when the population is subdivided into different strata (or groups) based on a common factor, and the result thereof must be representative of the population. Additionally, cluster sampling is when the sampling unit is a group rather than an individual.

Lastly, sampling using multiple probability techniques is when different quantitative techniques are used in the same study (Teddlie and Yu, 2007). For the purpose of this study, the random sampling technique was employed. Part of the reason this sampling technique is employed is because each participant in the population will have an equal opportunity of being selected in the sample (Teddlie and Yu, 2007)

3.6.3 Sample size for the study

It is however imperative that the sample size is calculated. A sample size calculator was used to derive the appropriate number used in the sampling of this study. A population size of 8400 was used and a confidence interval of 95% selected and a margin of error of 5% was selected and the sample size of this study is determined to be 368 (https://www.surveymonkey.com/mp/sample-size-calculator/). However, given the low response rate in the built environment research, a response rate of 30% is adequate for the study as a result, the number of the questionnaires that must be distributed to attain the sample size is presented in equation 6 below. The sample size can be attributed to a variety of reasons for being low. Respondents tend to not complete answering the questionnaire (Manfreda *et al.*, 2008). As a result, the questionnaire were distributed to 1227 contractors registered on the cidb register of contractors which was derived by dividing the 368 by 30%. The respondents were selected on a random organisation listed in the cidb registry of contractors' database and the questionnaire was sent accordingly.

3.7 Methods of data collection/questionnaire administration

In order to collect sufficient pool of responses pertinent to this study, particularly to the answering of research question, the questionnaire was administered to a specific set of professionals in the construction industry. These were cost engineers, estimators and quantity surveyors in that they deal with estimation and projections of labour productivity and costs of the project.

The questionnaire was distributed to 1227 contractors listed on the cidb register of contractors between May – November 2018 (six months period) in the form of a web survey through a research engine called survey monkey (surveymonkey.com). At the end of the survey period, 117 completed questionnaires were collected. Representing a response rate of 9.5%. Although the selection of this method had its own benefits that were befitting to the study, the research would be remiss in not taking cognisant of the shortfalls of the method in comparison to its benefit.

The utilisation of the web to gather information from the respondents has the benefit of having a larger population coverage. The web offers access to a wider population and the potential of quick responses (Rhodes *et al.*, 2003). Respondents that are in remote areas but with access to the hardware and facilities that affords them access to the web are able to be included in the study (Rhodes *et al.*, 2003). Literature has established that the cost of administering research on the web is relatively low, making it feasible for research (Fricker and Schonlau, 2002; Rhodes *et al.*, 2003; Evans and Mathur, 2005). Further benefits of the web survey is the liberty for the respondents to conduct the survey in their own environments and as a result, comfortable to give information sufficient to the research when completing the survey (Rhodes *et al.*, 2003). Evans and Mathur (2005) elaborate more on this in that respondents are provided with the convenience to answer the questionnaire at any time that suits them thus removing the pressure of being constrained by time. Furthermore, respondents have more time to go through their responses to validate their answers. In answering the questionnaire through the web, respondents are assured of their anonymity and can thus disclose information pertinent to the study without the pressure of exposing themselves (Davis, 1999).

As a result, it is these advantages that directed this study to consider the use of the web survey particularly after weighing the benefit of the method. The core database of establishing a list of respondents is a mailing list which for the purpose of this study, was obtained through a database of contractors listed on the cidb register. However, Manfreda *et al.* (2008) contends that there is an aversion from respondents to partake in surveys. This, the aversion for participants to partake in the web surveys is due to the anxiety associated with their personal information and information they provide from potentially being used to identify them or used against them (Vehovar *et al.*, 2001; Manfreda *et al.*, 2008).

Furthermore, the response rate tends to be low for web surveys as opposed to the traditional methods of data collection (Vehovar *et al.*, 2001; Evans and Mathur, 2005). According to Manfreda *et al.* (2008) web surveys had a yield of 11% low response rate when compared to other traditional methods of conducting surveys. Notwithstanding this, there is a consensus amongst scholars (Fricker and Schonlau, 2002) that cautions against the definitive claim of the low response rate in that there is no conclusive evidence in literature that supports the claim that there is less response in web surveys than traditional methods.

Another shortfall of conducting the survey through the web is the literacy level of respondents cited to be key to the understanding and comprehension of the questionnaire (Rhodes *et al.*, 2003; Bowling, 2005). As a result, the educational level of the respondents forms the basis upon which the questionnaire is intended to yield relevant information that can be used in the analysis or not. In their analysis of further shortfall of online surveys, Evans and Mathur (2005) claim that the low response in the questionnaires conducted online can be attributed to the respondent's perception of the email as being spam and thus not being responded to.

3.8 Data collection instrument (Questionnaire)

The questionnaire for this study was designed after a through literature review. Furthermore, in lieu of answering the objectives of this study, it was important that the questionnaire be made less complicated and directly specific to the objective of the study.

There are three distinct sections in this questionnaire (see Appendix C). The first section is geared to collecting information about the respondents. The information collected was both personal and specific to the organisation that the respondent either works or worked for. These questions were: academic qualification, years of experience in the construction industry or related field, job designation or position, a list of professional bodies one is affiliated with, location in South Africa in which they conduct their business and the grade of their organisation on the cidb contractor's register. The second section of the questionnaire aimed to ask questions specific to the estimation practices employed by the construction firms in determining their estimation for labour productivity in the selected three labour intensive trades: concrete, masonry and plastering. Furthermore, the last and third section of the questionnaire asked questions relating to the contextual factors that impact the level of productivity from site environment, organisational/construction firm perspective, technological factors and lastly social factors.

3.9 Data analyses techniques

The data analyses techniques used in the study comprised of descriptive and inferential statistical techniques including the Relative Importance Index (RII), Kruskal-Wallis analysis, chi-square test and the Mean Item Score (MIS).

3.9.1 Relative Importance Index (RII)

The Relative Importance Index (RII) method of analysing data is selected for this research. This technique is selected to rank and order the different contextual factors (Fugar and Agyakwah-Baah, 2010; Jarkas and Bitar, 2012). This is especially due to the three different types of projects being investigated. For the purpose of ranking the contextual factors that affect labour productivity, RII was considered a rigorous method of ranking as opposed to calculating the mean and standard deviation of the various factors mainly due to the unreliability of these two techniques for the purpose or ranking variables (Chan and Kumaraswamy, 1997). The Relative Importance Index (RII) is evaluated using the following formula shown in equation 3 (Doloi, 2008);

$$RII = \frac{\sum_{i=1}^{n} W_i}{A \times N} \qquad \textit{Equation 3}$$

Where *W* represents the weight given to each attribute in the Likert scale assigned by the respondents from 1 to 5 (1 = very low, 2 = low, 3 = undecided, 4 = high and 5 = very high impact). *A* represents the highest weight that could be assigned to a factor on the Likert scale, in this case 5 would be the highest weight and *N* represents the total number of respondents.

Another formula used to calculate the average responses is the Mean Item Score (MIS) represented in equation 4 below;

$$MIS = \frac{5(n5)+4(n4)+3(n3)+2(n2)+n1}{5(n1+n2+n3+n4+n5)} \qquad \textit{Equation 4}$$

Similarly, to equation 3, the numerator calculates the weight of the respondents from assigned values to variables and the denominator multiplies the highest factor to the sum of the total respondents represented by *n1, n2, n3, n4, n5*. The study will adopt equation 4 in analysing and ranking the contextual factors affecting labour productivity.

3.9.2 Kruskal-Wallis test analysis

In order to evaluate the differences between the factors that affect the level of labour productivity and their impact per the different project types, organisational types and the location type, Kruskal-Wallis test is used. The Kruskal-Wallis test is used in the determination of any statistically significant difference across the groups of independent variables or factors that this study evaluates.

3.9.3 Critical ratio – Labour performance

Critical ratio is the index that is used to determine the progress of a task in relation to it being on schedule (Anbari, 2003). This study adopts the critical ratio principles and uses this to measure the labour productivity of a project using both the time and cost of the respective projects obtained from the respondents. Equation 5 represents the equating used in this study in the determination of the labour productivity. Cost performance index (CPI) is calculated as the fraction of the budgeted cost of the project to the actual cost of the project. Whereas the schedule performance index (SPI) is the ratio of the budgeted time for the project over the actual time of the project.

Critical Ratio (Labour productivity) = CPI x SPI *Equation 5*

Table 3.1 categorises the meaning of the various values and what they mean for this study.

Table 3. 1: Labour Performance

Critical ratio – labour performance	**Meaning**
< 1.00	Low labour productivity
= 1.00	On target labour productivity
> 1.00	High labour productivity

3.10 Validity and reliability of the research

Research lacking in rigour is deemed ineffective and futile (Morse *et al.*, 2002). Determinant factors which are considered to be critical to the quality of the research instrument are validity and reliability of the instrument (Morse *et al.*, 2002; Kimberlin and Winterstein, 2008; Kumar, 2014). The said quality of the research instrument ascertains and provides the credibility of the research to both the respondents and reader. Furthermore, it is known that with self-reporting of the questionnaire, an element of subjectivity emerges which inadvertently gives rise to eminent errors in the reporting process (Kimberlin and Winterstein, 2008). Notwithstanding this, a research instrument that objectively reports on the results of the research, particularly with the standardised and validated scales, is desired. Additionally, both the validity and reliability of the research rests on the research instrument's ability to measure up to the rigorous standards that gives the results of the research credibility and affords the process of designing the research instrument enough consideration to meet the standards.

3.10.1 Validity

Validity is defined as the ability of the research instrument to measure and quantify all the variables intended to be either assessed or analysed on the onset of the study (Kimberlin and Winterstein, 2008; Kumar, 2014). However, validity extends beyond the research instrument itself as it also considers the intended use of a testing method and how the results thereof are interpreted (Kimberlin and Winterstein, 2008). In ensuring the validity of this study, an internal and external validation process were adhered to. Internal validation ensures that the inputs identified in the research questionnaire are capable of yielding the expected outputs (Kumar, 2014). In designing the research instrument for this study, a thorough assessment of how researches in the same field have previously designed their research instrument, was conducted. This research has ensured that all the identified inputs in the questionnaire are both directly related to answering the research question while simultaneously addresses the objectives of the study.

The questionnaire was reviewed through a consultative process with the supervisor for structure, ambiguity and correlation to the intended measures set forth. Through this process, the questionnaire was considered valid and succinctly in line with the intention of the study. Additionally, external validation is considered to be the generalisability of the outcomes of the research beyond the research population or sample (Kumar, 2014). This refers to the ability of the research results to be extrapolated into different settings and to give emphasis to similar context evaluating the same variables. In this regard, the research results can be generalised with great emphasis on the fact that the same factors are being evaluated. Furthermore, these results may also be generalised amongst similar organisations that fall within the cidb grades examined, primarily those that involve labour intensive trades. Additionally, the results of this study prohibit their generalisability to manufacturing setting environment as the scope of operation and mechanisation of the industry may not fit the model used to assess the impacts affecting labour productivity in a closed-system environment. Moreover, construction operations that may be labour intensive and from contractors that perform the same operation but located outside South Africa, may also not fit the outcomes of these results. This is primarily due to the possibility that the environment, organisational culture, technical factors and social factors in locations that are not in South African may be different.

3.10.2 Reliability

Reliability of the research instrument is defined as the consistency of the results achieved in the research as well as the ability of the research instrument to achieve the same results if the research is carried out continuously using the same methodology and testing techniques (Morse *et al.*, 2002; Golafshani, 2003; Kimberlin and Winterstein, 2008; Kumar, 2014). Kumar (2014) expands more on this definition by postulating that reliability is the accuracy in the measurements obtained by the research instrument. The consistency, stability and the accuracy of the research instrument are the building blocks to the base of what constitutes reliability of the research instrument or the research output. Notwithstanding this, the research instrument designed for this study ensured that to ascertain reliability the wording of the questions was modified and standardised to the intended population assessed for this study. Furthermore, as the questionnaire was administered through the web, the recording of the results was done by the automated platform used to retrieve and analyse the data, hence the responses were being collected and being captured authentically without any alteration by either the software or the researcher.

3.10.3 Reliability tests

The reliability of the research instrument was tested using the Cronbach Alpha test. Bonett and Wright (2015) describes the Cronbach's alpha test as the measure of internal consistency regarding the reliability of the research instrument. Tavakol and Dennick (2011) postulates that before any test can be performed on the research data, the reliability of the data must be ascertained and a commonly utilised test to do this, is the Cronbach's test. A major advantage of the Cronbach's alpha is ease of interpretation that the alpha affords as it is not complicated to understand (Tavakol and Dennick, 2011; Yang and Green, 2011; Warrens, 2014).

Common to the social and organisational sciences, Cronbach's alpha is the widely used measure of reliability (Tavakol and Dennick, 2011; Bonett and Wright, 2015). However, the value of the alpha is prone to being affected by the length of the test being performed (Warrens, 2014). The value of the alpha is higher for a test that comprises of more than 15 items or more and the adverse is true for the test comprising of fewer items (Tavakol and Dennick, 2011; Warrens, 2014). Notwithstanding the assertions made above, the tolerable range for the alpha to deem a test is reliable is between 0.7 – 0.95 (Tavakol and Dennick, 2011). This tolerance is based on the fact that the alpha coefficient lies between 0 and 1 (Tavakol and Dennick, 2011) and the closer the coefficient to 1, the greater the internal consistency of the research instrument and the furthest it is to 1, the less consistent. Cronbach alpha test results for this study are presented in Table 3.2.

Table 3. 2: Reliability test results using Cronbach's Alpha.

	Cronbach's Alpha	No of Items
Overall Items.	0.995	33
Site Environmental factors.	0.900	9
Organisational/Construction Firm factors.	0.880	8
Technical factors.	0.926	8
Social factors.	0.893	8

As can be seen in Table 3.2, the reliability of the data obtained from the online questionnaire survey has a Cronbach's alpha of 0,995 which validates the fact that the research instrument used in this study is highly reliable and capable of producing consistent results.

3.10.4 Managing Bias

The understanding of bias in research is crucial as it has the potential to impact negatively on the validity and the reliability of the research output and consequently affect the intended use of the research output (Smith and Noble, 2014). Kumar (2014) defines research bias as a deliberate attempt to conceal true findings of the research or falsely exaggerating an outcome not to its true analysis. Smith and Noble (2014) postulate that there five types of research bias that need to be avoided when undertaking research. These are: design bias, selection/participant bias, data collection bias and measurement bias, analysis bias and publication bias.

Design bias relates to the research's inability to have clear emphasis of the study objectives and conversely, lack of relation between the study aim and research method (Smith and Noble, 2014). For this research, the aims and the objectives of the study are well defined, and both the method and the research methodology are identified. The bedrock of any good research rests on the active participation of the identified participants in the research (Smith and Noble, 2014). Hence, the participants of this study were randomly selected from a sample frame of contractors registered by the cidb in order to answer the research aim.

Another type of bias the research had to control is that evidenced through data collection and measuring scales of the research. This bias is largely inferred in the research process by the researcher's influence and personal belief (Smith and Noble, 2014). The research instrument was assessed through a consultative process between the supervisor and the researcher, scrutinised for validity and reliability. This process of assessing the language set for the intended population, any ambiguity which may distort and affect the response behaviour, ensuring uniformity across the different designations and grading of the cidb respondents are designed to eliminate leading questions that elicit an expected response as opposed to allow the respondents to give their own responses (Smith and Noble, 2014).

Analysis bias relates to an active attempt by the researcher to consider only the data that supports their hypothesis. Furthermore, analysis bias actively disregards any data the researcher find incongruent to their personal beliefs (Smith and Noble, 2014). During the analysis of the results of the research, the presented data was not distorted or presented in a manner contravening the ethical consideration of the research as obtained from the University of Cape Town. Lastly, publication bias does not form part of the research at this stage and will be further discussed in later studies.

3.11 Ethical Considerations

In conducting research, ethical considerations are to be considered paramount as the study may have consequences and implications on either the respondents and the researcher (Kivunja and Kuyini, 2017). Mill (1969) identifies four criterion of ethical conduct that guides how the ethical issues of research are to be considered. These are; teleology which is the theory of morality which entrenches the moral obligation of the researcher to treat the responses with no prejudice, Deontology which highlights the significance of the reciprocity of the participants in the research, particularly the results which will benefit the participants, researcher, the academic community at large and possibly the industry in which the study finds itself. Another criterion to consider when considering ethical issues is the morality criterion which premise its roots in the values that the researcher needs to abide by and honest and truthfully report on the findings. Lastly, is fairness. This criterion asserts that the researcher must be fair to all the participants and not contravene their rights in any form (Mill, 1969; Kumar, 2014; Kivunja and Kuyini, 2017).

In adhering to the criterion posited by Mill (1969), ethics clearance was obtained for the study from the University of Cape Town (UCT), Department of Construction Economics and Management (see Appendix A). A comprehensive cover letter (see Appendix B) draws the attention of the respondents to the objective of the study and explicitly details to the respondents what the research's objectives are. Furthermore, respondents are made aware of the fact that they may withdraw their participation in the survey at any point without any penalty or form of harm, legal or physical, subjected to their person. Additionally, the respondents are ascertained confidentiality. This means that no one respondent may be identified for their responses as the responses are to be analysed in an aggregate format.

The research solicits sensitive information which may put respondents at risk if such information is leaked, as a result, confidentiality and anonymity of their responses is further guaranteed and explained in the consent form each respondent signs before completing the survey. The research acknowledges potential harm that may emanate from the study findings as an ethical consideration, the reporting of data will not include any names of the respondents or organisations they are affiliated with, their identity numbers or personal information that may allow anyone to identify them. Lastly, work of other scholars is properly cited and indexed in accordance with the university's policy and due regard is given to them.

3.12 Limitations of the study

The research is based on the construction industry in South Africa, all the participants only operate within the construction projects that are based in the nine provinces of South Africa. Furthermore, the study only explores the factors that gives rise to the level of poor labour productivity on construction projects and all the other factors that affect different aspects of the construction project such as supply chain management and procurement departments as well as tendering, are not explored and evaluated. Additionally, subcontractors are not included in this study. Another limitation of the study is that all the examined contextual factors were not derived from South African project sites but rather extracted from literature and tested on the South African construction companies.

3.13 Summary of the chapter

This chapter presented the research paradigm that this study employs in the exploration of the intended objectives and in an attempt to answer the research question. Additionally, the research design employed is also explained. Furthermore, the research methodology that this study adopts is also explained in this chapter. Methods of data collection with the use of a questionnaire and the result evaluated using statistical analysis (SPSS) to analyse and report was outlined. Moreover, how the data collected will be used in the identification of the contextual factors was highlighted.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter reports the data obtained from the survey of contractors listed in Grades 1 - 9 of the Construction Industry Development Board (cidb) register of contractors. Responses from contractors specialising in General Building (GB) and Civil Engineering (CE) projects are analysed. In reporting the data, the first section of the report will be divided into three (3) sections that gives general information of the respondents, estimation methods followed in determining labour productivity and lastly the results of contextual factors impacting labour productivity on construction projects.

4.2 Background Profile of the respondents

This section reports the background information of the respondents to the survey.

4.2.1 Distribution of respondents per academic qualifications

An objective of the study is to understand both the definition and the determination of the labour output expected on a construction site. This inadvertently also analyses the output observed and the factors that gives rise to the variation (if any). Hence, it is imperative to understand the academic background of the respondents. The respondents displayed varying levels of academic qualifications as can be seen in Table 4.1.

Table 4. 1: Academic Qualifications of respondents

Academic Qualification	Frequency	Percentage (%)
BSc/BEng degree/Diploma	35	30
Honours/BTech degree	29	25
Matric Certificate	26	22
Craftsman Certificate (related trade)	15	13
MSc/MBA	12	10
PhD	0	0

Table 4.1 indicates that 30% of the respondents have either a Bachelors/diploma qualification, followed by 25%, 22%, 13% and 10% who have Honours or BTech degree, matric certificate, a craftsman certificate (or related trade) and lastly, a Masters/MBA degree respectively. It can be deduced from these results that the respondents have varied qualification and are knowledgeable.

4.2.2 Distribution of respondents according to their experience in the construction industry

The results in Table 4.2 shows the distribution of the respondents according to their years of work experience in the construction industry. It emerged that 71% of the respondents have more than 10 years of industry experience. This suggests that the respondents have adequate knowledge of the construction industry that will enable them to provide informed answers to the survey questions.

Table 4. 2: Number of years of experience in the construction industry

Number of Years	Frequency	Percentage (%)
Between 0 - 10	34	29%
Between 11- 20	53	45%
Between 21 - 30	16	14%
Over 30	14	12%

4.2.3 Distribution of respondents according to their work designation

The questionnaire was administered to construction personnel from senior management level to junior management level in the construction industry. This ensured that through the contractors that responded to the questionnaire, a level of management and understanding of how labour operates both from a cost perspective as well as the output generation, were given the liberty to answer according to their experiences and engagement with labour on construction sites. Table 4.3 presents the results of the designation of the participants of the study.

Table 4. 3: Designation/Job descriptions of respondents

Job Description	Frequency	Percentage (%)
Director Cadre	57	49
Project Manager	18	15
Construction Manager	16	14
Contracts Manager	15	13
Quantity Surveyor	7	6
Construction Supervisor	2	2
Site Agent	1	1
Site Engineer	1	1

Table 4.3 shows that 49% of the respondents work at the level of director cadres while 15% of the respondents work at the level of project managers, making this designation the second largest respondents. However, 14%, 13% ,6%, 2%, and 1% are designated as construction managers, contracts managers, quantity surveyors, construction supervisors and both site agent and site engineer respectively. This suggests that the

respondents are well placed to provide knowledgeable answers to the research questionnaire.

4.2.4 Professional registration and qualifications obtained

In light of credibility and legitimacy of the research, particularly assessing the rigour with which construction firms display in terms of adhering to both professional registration and qualifications in order to competitively operate in obtaining work, it is of great significance to assess the proactiveness of construction personnel with industry recognised credentials. These credentials are divided into two, professional councils to which construction personnel belong to as well as the professional qualifications obtained over the years. Table 4.4 presents the distribution of the respondents according to their professional qualifications. The study found that of the 117 respondents, 36 respondents have obtained professional qualifications (Professional Engineer (Pr.Eng), Professional Technical Engineer (Pr.TechEng), Professional Construction Manager (Pr.CM), Professional Quantity Surveyor (Pr.QS), Professional Construction Project Manager (Pr.CPM) and Professional Project Manager (Pr.PM).

Table 4. 4: Professional registrations (councils) and qualifications

Professional Qualification	Frequency	Percentage (%)
PrPM	11	31
PrQS	10	28
PrEng	6	17
PrTechEng	4	11
PrCM	3	8
PrCPM	2	6

Of the 36 professionally registered respondents, 31% are professional project managers followed by professional quantity surveyors (28%), professional engineers (17%), professional technical engineers (11%), professional construction managers (8%) and professional construction project managers (6%).

4.2.5 Distribution of respondents' companies according to location

This section of the research reports the distribution of the respondents' companies with regard to their current location. The data collected in this regard is presented in Table 4.5.

Table 4.5 shows that the majority of the respondents (23%) operate in Kwa-Zulu Natal province. The second province that presented a larger participation in the study is Gauteng province with a representation of 19% followed by the Eastern Cape Province which contributed 15%. Furthermore, Mpumalanga, Limpopo, Western Cape, Free State, North West and Western Cape had 12%, 12%, 10%, 4%, 3% and 2% representation respectively. It can be inferred from these findings that the study sample are represented across all provinces in South Africa.

Table 4. 5: Geographical location where respondents' companies operate

Province	Frequency	Percentage (%)
Kwa-Zulu Natal	27	23
Gauteng	22	19
Eastern Cape	18	15
Mpumalanga	14	12
Limpopo	14	12
Western Cape	12	10
Free State	5	4
North West	3	3
Northern Cape	2	2

4.2.6 Classification of construction firms by cidb registration

The objective of the research is to evaluate the contextual factors that affect the productivity of labour on construction sites. Furthermore, this evaluation is going to be observed from construction organisations/contractors Graded between 1 – 9 on the cidb register of contractors. In light of the fact that the questionnaire was distributed to a large population sought from the cidb register of contractors, it is of paramount importance to note that over the years, particularly the date of the retrieval of the database (2017), some of the contractors may have upgraded to a different (higher) Grade or downgraded. Table 4.6 indicates the distribution of the responding companies according to the different grade of contractors on the cidb register

Table 4. 6: CIDB Grading respondents belong

	1	2	3	4	5	6	7	8	9
General Building (GB) (%)	18	7	15	17	16	11	8	8	1
Civil Engineering (CE) (%)	14	8	14	23	15	10	9	7	1

These contractors are further divided into contractors that operate within the category General Building (GB) and those that do Civil Engineering (CE) works. However, one firm can be found to operate in both the categories as this is common amongst construction firms, especially if they are certified to do both types of developments. Table 4.6 shows that in the GB category, 18% of contractors in the study are listed in Grade 1 of the cidb register of contractors followed by 7% in Grade

2 and 15% in Grade 3. However, 17%, 16%, 11%,8%,8% and 1% represent firms Graded in Grade 4, Grade 5, Grade 6, Grade 7, Grade 8 and Grade 9 respectively.

In the CE category, Table 4.6 shows that 14% are registered Grade 1 contractors, followed by 8% in Grade 2. However, 14%, 23%, 15%, 10%, 9%, 7% and 1% represent Grade 3, Grade 4, Grade 5, Grade 6, Grade 7, Grade 8 and Grade 9 contractors on the cidb register respectively.

Figure 4.1 presents the split of both GB and CE contractors graded in Grades 1 – 9 of the cidb register of contractors. Grade 4 contractors are the largest cohort in the study as they represent 17% in GB and 23% in CE followed by Grade 5 contractors with a split of 16% GB and 15% CE. Contractors listed in Grade 3 are represented by the composition of 15% GB and 14% CE while contractors listed in Grades 7 and 8 have a composition of 8% GE and 9% CE and 8% GE and 7% CE respectively. Lastly, contractors listed in Grade 2 are represented by 7% of contractors in GB and 8% in category CE. Figure 4.1 and Table 4.6 suggest that the study presents a balanced range of contractors listed in the different grades and categories of the cidb register of contractors.

4.3 Levels of construction project performance

This section reports the methods and techniques used by construction companies in determining the basis of what constitutes labour productivity on construction projects.

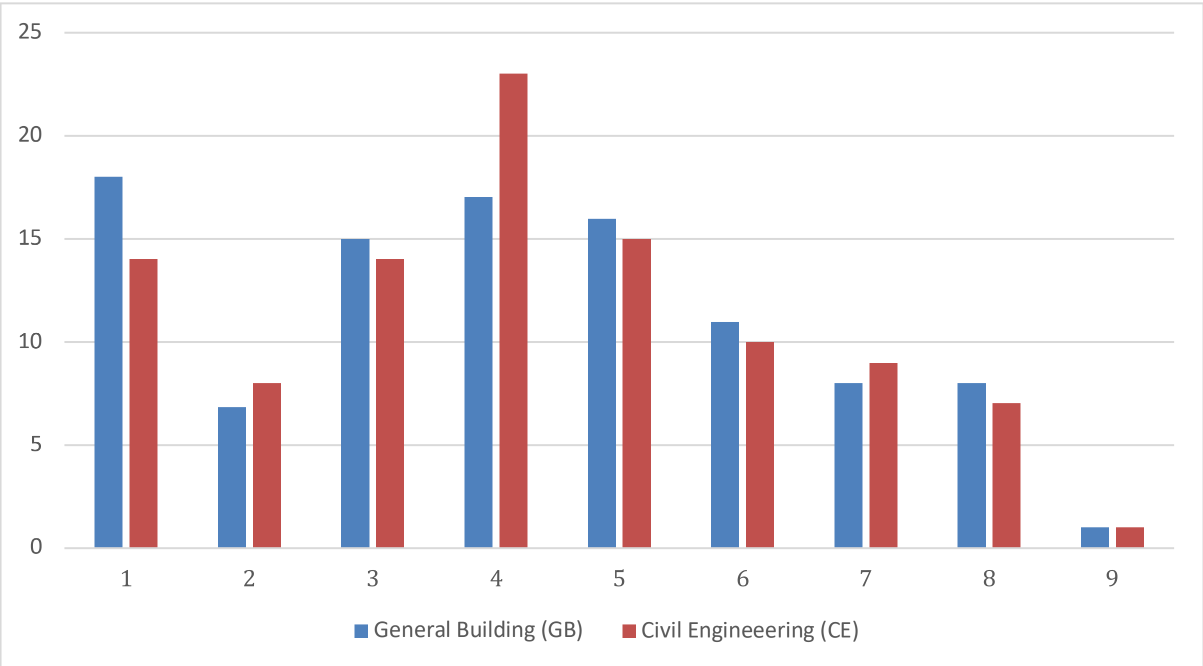


Figure 4. 1: CIDB Graded Contractors

4.3.1 Type of project

In order to estimate the level of productivity on construction projects, the study sought to know the type of projects that respondents have undertaken over the past five years (2014 to 2018) and which they are familiar with. Figure 4.2 presents the results obtained concerning this enquiry.

Figure 4.2 shows that 50% of the respondents have undertaken and are more familiar with building projects, followed by infrastructure projects (32%) and lastly roads projects which contributed 19%.

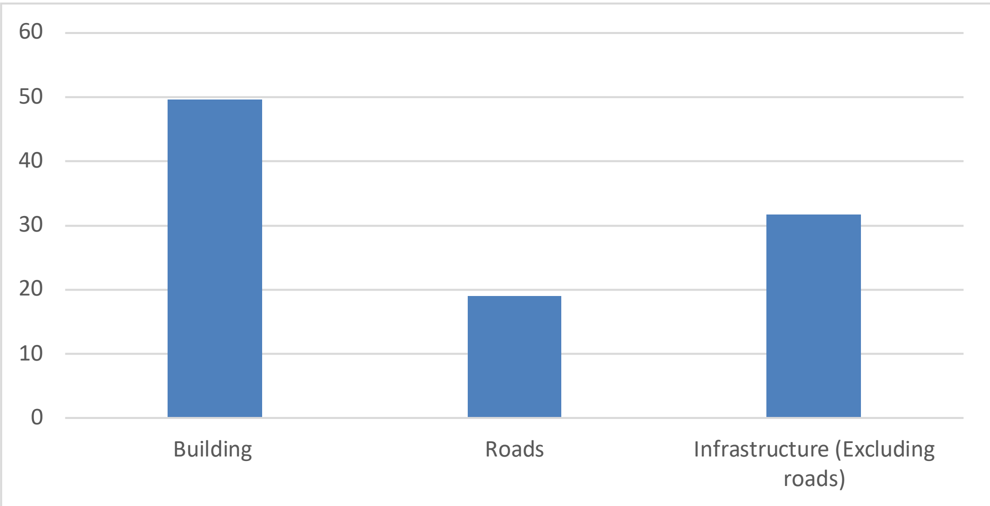


Figure 4. 2: Project Type

4.3.2 Cost performance of projects

This section presents a summary of the findings of the cost performance of the recent project the respondents have worked on based on how the cost variances between initial and final cost estimate. Table 4.7 represents the average variances between initial and final cost estimate of the building projects. As can be seen in Table 4.7, across the different project types, the level of project performances is different and all evidence an overrun on the estimated cost in comparison to the actual cost. This shows that a variation exists between estimated and actual cost which gives rise to cost overruns.

Table 4. 7: Cost Performance of projects

Type of Project	Average Actual cost	Average Estimated cost	Average cost performance variation
Building	14 501 299	13 287 116	1 214 183
Roads	14 358 369	13 705 682	652 688
Infrastructure	20 254 178	17 784 961	2 469 217
Overall	**49 113 846**	**44 777 759**	**4 336 088**

4.3.3 Time performance of projects

This section presents the average results observed between the planned completion time and the final completion time observed on the construction projects of the respondents.

Table 4.8 reports the average time performances across the various project types. It can be seen in building projects that the average time overrun experienced across the projects is three months. Furthermore, across the road projects, a one-month average overrun is reported and lastly, across the infrastructure projects, an average overrun of two months is reported. Table 4.8 shows that time overruns are endemic across the construction projects of any type.

Table 4. 8: Time Performance of projects

Type of Project	Average Actual time	Average Estimated time	Average time performance variation
Building	12	9	3
Roads	8	7	1
Infrastructure	13	11	2
Overall	**33**	**27**	**6**

4.3.4 Levels of labour productivity

This section reports the levels of labour productivity on the various types of construction projects, organisational level as well as the location types calculated using the critical index ratio which presents the level of labour productivity on construction projects.

4.3.4.1 levels of labour productivity differentiated by project types

Table 4.9 presents the crosstabulation of the types of projects and the impacts on the performance of labour. It can be observed from Table 4.9 that building projects reported a significant low level of labour performance (66,1%). In contrast to road projects, 40,9% of the projects reported a low performance of labour and 36,4% reported a high performance of labour. Infrastructure projects reported that 36,4% of the projects have a low performance of labour and 42,4% of the projects reported a high performance of labour. Overall, there is generally low level of labour performance (53%) reported across all aggregated project types.

Table 4. 9: Labour performance differentiated by project type

Project Type		Labour Performance: Low labour productivity	On target labour productivity	High labour productivity	Total
Building	Count	41	13	8	62
	% within Type	66.1%	21.0%	12.9%	100.0%
Road	Count	9	5	8	22
	% within Type	40.9%	22.7%	36.4%	100.0%
Infrastructure	Count	12	7	14	33
	% within Type	36.4%	21.2%	42.4%	100.0%
Total	Count	62	25	30	117
	% within Type	53.0%	21.4%	25.6%	100.0%
	% within Perform	100.0%	100.0%	100.0%	100.0%
	% of Total	53.0%	21.4%	25.6%	100.0%

Figure 4.3 shows graphically that building projects have the lowest level of labour performance recorded in relation to the infrastructure projects that have a marginally higher level of labour performance. A marginal difference exists between low level of labour performance and higher level of labour performance in road projects.

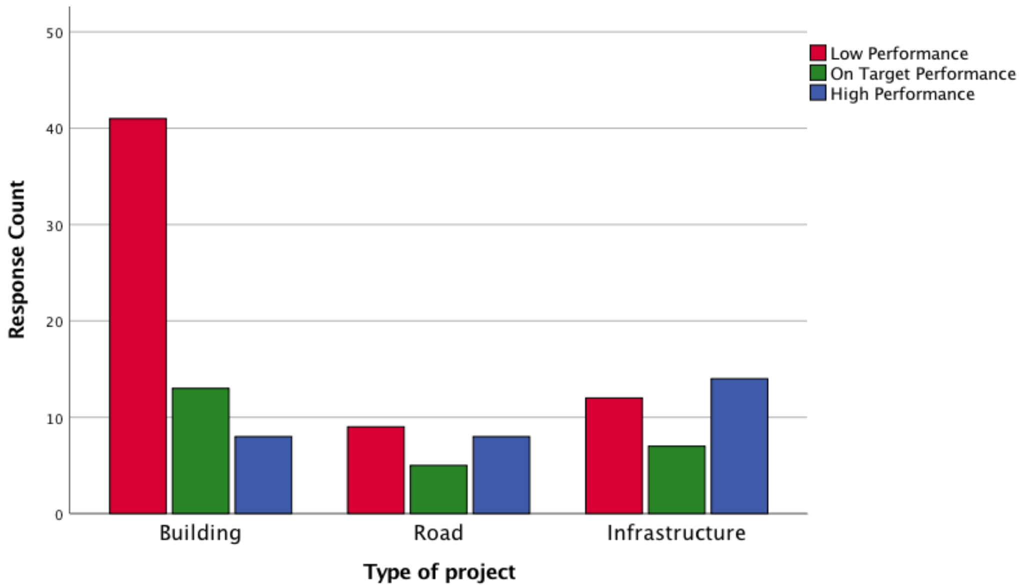


Figure 4. 3: Results of labour performance when differentiated by project type

4.3.4.2 Levels of labour productivity differentiated by organisational types (cidb grading)

Table 4.10 reports the crosstabulation of the performance of labour productivity and the type of organisation or cidb graded contractor. As can be seen from the Table 4.10, when differentiated by cidb grade, the performance levels of labour productivity of the responding companies are different. It can be deduced that cidb Grade 4 companies report a significant level of low labour performance (94.7%) and cidb Grade 2 and 8 companies display a higher performance of labour productivity (44.4%). However, on aggregated perspective, contractors displaying low performance contribute 53% of the study population, whereas 25,6% of the contractors reported a high level of labour performance, with 21.4% contractors performing on target.

Table 4. 10: Labour performance differentiated by organisational type

		Labour performance			
cidb grade		Low labour Productivity	On target labour productivity	High labour productivity	Total
1	Count % within cidb	9 42.9%	6 28.6%	6 28.6%	21 100.0%
2	Count % within cidb	2 22.2%	3 33.3%	4 44.4%	9 100.0%
3	Count % within cidb	8 47.1%	4 23.5%	5 29.4%	17 100.0%
4	Count % within cidb	18 94.7%	1 5.3%	0 0.0%	19 100.0%
5	Count % within cidb	7 36.8%	5 26.3%	7 36.8%	19 100.0%
6	Count % within cidb	9 69.2%	2 15.4%	2 15.4%	13 100.0%
7	Count % within cidb	6 66.7%	1 11.1%	2 22.2%	9 100.0%
8	Count % within cidb	3 33.3%	2 22.2%	4 44.4%	9 100.0%
9	Count % within cidb	0 0.0%	1 100.0%	0 0.0%	1 100.0%
Total	Count % within cidb % within Perform % of Total	62 53.0% 100.0% 53.0%	25 21.4% 100.0% 21.4%	30 25.6% 100.0% 25.6%	117 100.0% 100.0% 100.0%

Figure 4.4 depicts the results of the project performance in relation to the cidb grade of the organisation graphically. It can be seen from the results that the level of labour performance significantly differs according to cidb grade. As can be observed, organisations report a significantly low level of labour performance across cidb Grade 1, Grade 3, Grade 4, Grade 5, Grade 6 and Grade 7. Alternatively, organisations in cidb Grade 2 and 8 have higher level of labour performance. And organisations in cidb Grade 9 performed on target. However, it can be evidently seen that cidb Grade 4 companies have the largest portion of the study that performed with a very low level of labour performance.

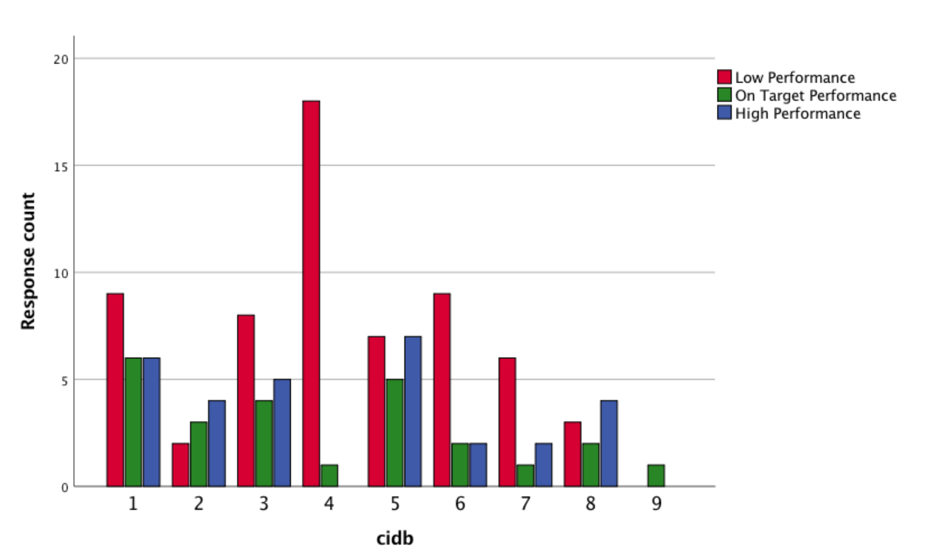


Figure 4. 4: Results of labour performance when differentiated by project type

4.3.4.3 levels of labour productivity differentiated by location

Table 4.11 presents the crosstabulation of the construction project location (province) and performance of labour. The results show that the provinces in which low levels of labour performance on construction projects are Free State (60%), followed by Western Cape (58,3%), Limpopo (57,1%), and Kwa-Zulu Natal (55,5%). While provinces that report higher percentage of performance of labour are North West (66,7%) followed by Free State (40%), Mpumalanga (28,6%), Limpopo (28,6%).

Table 4. 11. Labour performance differentiated by location

		Labour Perform			
Location		**Low labour productivity**	**On target labour productivity**	**High labour productivity**	**Total**
Mpumalanga	Count	6	4	4	14
	% within Location	42.9%	28.6%	28.6%	100.0%
Limpopo	Count	8	2	4	14
	% within Location	57.1%	14.3%	28.6%	100.0%
Gauteng	Count	10	8	4	22
	% within Location	45.5%	36.4%	18.2%	100.0%
North West	Count	1	0	2	3
	% within Location	33.3%	0.0%	66.7%	100.0%
Free State	Count	3	0	2	5
	% within Location	60.0%	0.0%	40.0%	100.0%
Kwa-Zulu Natal	Count	15	5	7	27
	% within Location	55.6%	18.5%	25.9%	100.0%
Northern Cape	Count	2	0	0	2
	% within Location	100.0%	0.0%	0.0%	100.0%
Eastern Cape	Count	10	3	5	18
	% within Location	55.6%	16.7%	27.8%	100.0%
Western Cape	Count	7	3	2	12

	% within Location	58.3%	25.0%	16.7%	100.0%
Total	Count % within Location % within Perform % of Total	62 53.0% 100.0% 53.0%	25 21.4% 100.0% 21.4%	30 25.6% 100.0% 25.6%	117 100.0% 100.0% 100.0%

Figure 4.5 shows graphically that Kwa-Zulu Natal reported a higher level of low performance of labour productivity, followed by Eastern Cape and Gauteng, Limpopo, Western Cape, Mpumalanga, Free State, Northern Cape and North West when based on response count. However, the Chi-square test presented in Table 4.40 reveal that there is no a statistically significant relationship between project location and the level of labour performance on construction projects.

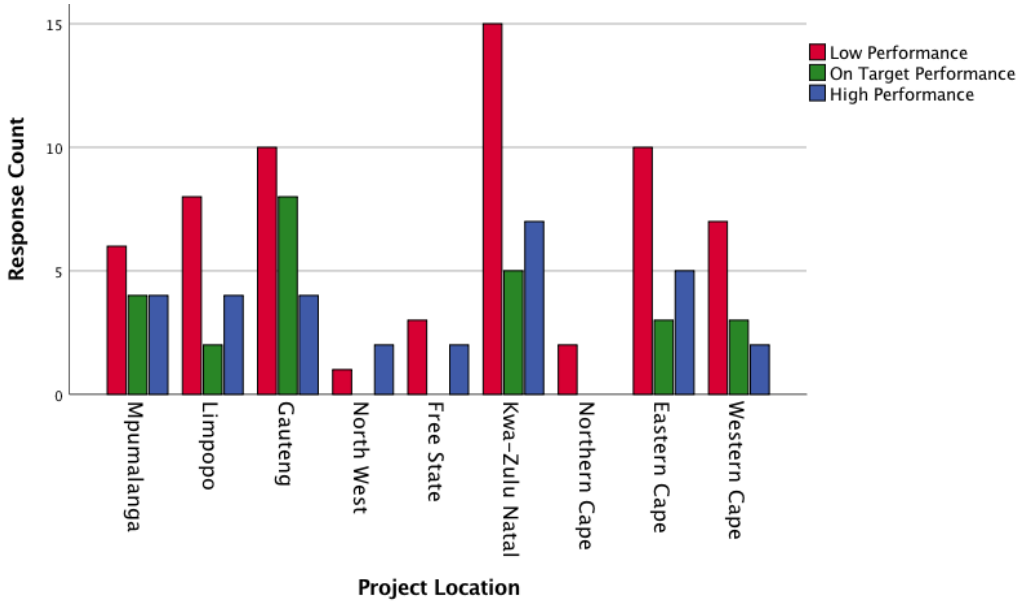


Figure 4. 5: Results of labour performance when differentiated by project type

4.3.5 Estimation of concrete, masonry and plastering labour productivity

Three labour intensive trades were identified for this study which are concrete, masonry and plastering. An objective of the study is to establish the method used by construction companies in establishing or estimating the labour productivity on construction sites. A host of methods and systems exists in industry and the questionnaire distributed to respondents synthesised five methods of estimation to establish the process followed in determining the level of expected labour productivity per the selected trades. Tables 4.12 – Table 4.14 presents the average response rate per method of estimation across the three selected trades. A scale of 1 – 5 where 1 is never and 5 is always was used. The Mean Item Score (MIS) is calculated for each estimation method and used to rank them.

4.3.5.1 Concrete estimation

Estimation methods used to determine labour productivity for concrete are presented in Table 4.12. The estimation method predominantly used to estimate productivity of labour on concrete trade is, experience from previous projects (MIS = 0,807; R = 1), labour performance (MIS = 0,701; R = 2), time study (MIS = 0,655; R = 3), activity sampling (MIS = 0,631; R = 4) and work sampling (MIS = 0,615; R = 5).

Table 4. 12: Concrete Estimation

	Never	Rarely	Sometimes	Often	Always		
Estimation Method	**1**	**2**	**3**	**4**	**5**	**MIS**	**Rank (R)**
Experience from previous projects	18	1	6	26	66	0,807	1
Labour performance	24	4	19	29	41	0,701	2
Time Study	23	8	29	28	29	0,655	3
Activity Sampling	32	9	21	19	36	0,631	4
Work Sampling	32	8	27	19	31	0,615	5

4.3.5.2 Masonry estimation

From a ranking perspective, Table 4.13 shows that experience from previous projects (MIS = 0,733; R = 1), followed by labour performance (MIS = 0,632; R = 2), time study (MIS = 0,593; R = 3), work sampling (MIS = 0,561; R = 4) and lastly, activity sampling (MIS = 0,538; R = 5) represents the order of estimation methods respondents use in determining labour productivity for the masonry trade.

Table 4. 13: Masonry Estimation

	Never	Rarely	Sometimes	Often	Always		
Estimation Method	**1**	**2**	**3**	**4**	**5**	**MIS**	**Rank (R)**
Experience from previous projects	25	3	11	25	53	0,733	1
Labour performance	37	5	14	24	37	0,632	2
Time Study	40	7	19	19	32	0,593	3
Work Sampling	41	12	17	23	24	0,561	4
Activity Sampling	45	11	21	15	25	0,538	5

4.3.5.3 Plastering estimation

It can be seen from a ranking perspective in Table 4.14 that the primary estimation method used in determining the labour productivity for plastering trade is experience from previous projects (MIS = 0,757; R = 1), followed by labour performance (MIS = 0,641; R = 2), followed by time study (MIS = 0,583; R = 3), and lastly followed by work sampling (MIS = 0,579; R = 4) and lastly activity sampling (MIS = 0,579; R = 4).

Table 4. 14: Plastering Estimation

	Never	Rarely	Sometimes	Often	Always		
Estimation Method	**1**	**2**	**3**	**4**	**5**	**MIS**	**Rank (R)**
Experience from previous projects	26	2	4	24	61	0,757	1
Labour performance	37	3	11	31	35	0,641	2
Time Study	42	9	13	23	30	0,583	3
Work Sampling	42	5	18	27	25	0,579	4
Activity Sampling	43	4	22	18	30	0,579	4

Overall, the results presented in Table 4.12 – 4.14 reveal that the key estimation methods used on projects for the concrete, masonry and plastering trade are not scientific, but based on the past judgement and labour performance which could vary on projects

4.3.6 Causes of variation between estimated and final project cost and time

This section of the research reports the respondent's perceptions of what causes cost and time variances using a rating scale of 1 – 5 where 1 is not significant and 5 is extremely significant.

4.3.6.1 Causes of cost variations on projects

Based on the ranking of factors that contribute to the variances in project costs, Table 4.15 shows that labour productivity (MIS = 0,721; R = 1) is the key factors perceived by the respondents as being responsible for the cost variation on construction projects, followed by material availability (MIS = 0,689; R = 2), inadequate information from professionals (MIS = 0,680; R = 3), project complexity (MIS = 0,656; R = 4) and lastly lack of equipment and plant (MIS = 0,597; R = 5). It can be inferred from these findings that productivity of labour is crucial to the performance of a project from a cost perspective.

Table 4. 15: Causes of cost variations

	Not Significant	Slightly Significant	Mildly Significant	Very Significant	Extremely Significant		
	1	**2**	**3**	**4**	**5**	**MIS**	**Rank (R)**
Productivity of Labour	14	10	16	45	32	0,721	1
Material availability	23	10	17	26	41	0,689	2
Inadequate information from professionals	22	11	17	32	35	0,680	3
Project complexity	16	17	25	36	23	0,656	4
Lack of equipment and tools	31	15	17	33	21	0,597	5

4.3.6.2 Causes of time variations on projects

Table 4.16 shows that from a ranking perspective using the mean score index (MIS), labour productivity (MIS = 0,691; R = 1) is the key factor responsible for time variation on construction projects, followed by material availability (MIS = 0,674; R = 2), followed by inadequate information from professionals (MIS = 0,667; R = 3), project complexity (MIS = 0,650; R = 4) and lastly lack of equipment and tools (MIS = 0,583; R = 5). Similar to causes of cost variations presented in Table 4.15, it can further be inferred from these findings in Table 4.16 that the productivity of labour is also central to the performance of a project with regard to time.

Table 4. 16: Causes of time variations

	Not Significant	Slightly Significant	Mildly Significant	Very Significant	Extremely Significant		
	1	**2**	**3**	**4**	**5**	**MIS**	**Rank (R)**
Productivity of Labour	22	10	15	33	37	0,691	1
Material availability	23	13	12	36	33	0,674	2
Inadequate information from professionals	26	9	16	32	34	0,667	3
Project complexity	23	13	20	34	27	0,650	4
Lack of equipment and tools	35	16	15	26	25	0,583	5

4.3.7 Basis and norms for labour efficiency used by construction organisations on projects

One of the main objectives of the study is to determine how construction organisations determine and establish labour productivity on construction projects. In determining labour productivity, construction organisations are able to further determine the expected level of efficiency on construction projects. In the analysis of data, three projects were identified and each analysed according to its determination of labour productivity targets. As can be seen in Figure 4.6, different projects determine labour productivity has using various criterion.

Overall, it can be observed from Figure 4.6 that 43.65% of the projects use completion within cost as a determinant for productivity of labour on a project while 34.92% of projects completed on time inadvertently mean that labour is efficient on that particular project. Also, 9.5% of construction projects report the use of average labour productivity (ALP) to determine the productivity of labour and 7.9% of projects use total factor productivity (TFP) in the determination of labour productivity. However, 3.9% of the projects surveyed use other measures to determine labour productivity. These comprise of client satisfaction, less rework on projects and minimal defects post practical completion.

However, building projects use the completion of a project within time (40%) as a determinant of labour productivity, followed by completion of a project within cost (41.67%). Following this, ALP (8.33%) and TFP (5%) are also used to determine the productivity of labour on building projects. Lastly, other factors (5%) such as client satisfaction, less rework on projects and minimal defects post practical completion are also used to determine the productivity of labour on building projects.

On road projects 45.83% of the respondents reported that their determinant factor of labour productivity is the completion of a project within cost. While 29.17% of road projects use time as a determinant of labour productivity. ALP (12.50%) and TFP (8.33%) are also used in the determination of labour productivity. Other measures (4.17%) such as client satisfaction, less rework on projects and minimal defects post practical completion, are the least used method of determining labour productivity on road projects.

Comparable to road projects, 48.15% of the respondents indicate that labour productivity on infrastructure projects is determined on the basis that a project is completed within cost, followed by completion within time (29.63%). ALP (11.11%) and TFP (7.41%) are also used in the determination of labour productivity on infrastructure projects. It was found that 3.70% of infrastructure projects use other methods such as client satisfaction, less rework on projects and minimal defects post practical completion to determine labour productivity.

Lastly other types of construction projects such as irrigation, landscaping projects, alterations and service pipe installation projects surveyed utilise cost (40.00%), time (33.33%), TFP (20%), ALP (6.67%) and other methods in determining labour productivity. Overall the results suggest that the respondents view cost as a more preferable measure for the determination of labour productivity on construction projects.

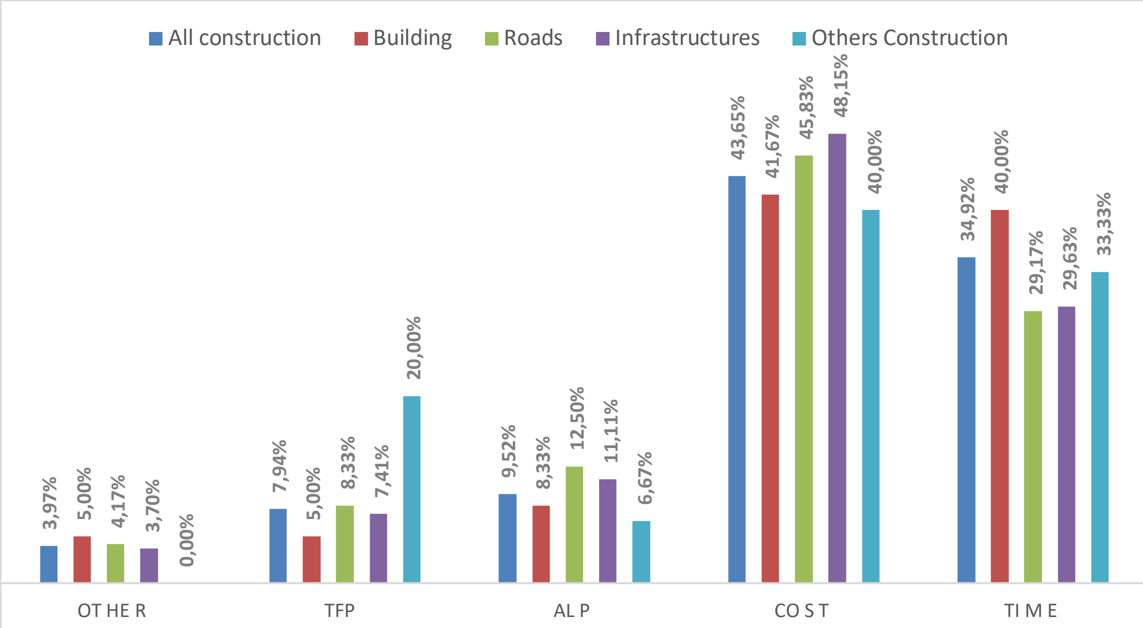


Figure 4. 6: Determination of labour productivity in the construction industry

4.3.8 Contextual Factors impacting labour productivity across different projects (building, roads and infrastructure)

In the evaluation of contextual factors that impact the productivity of labour on construction projects, relative importance index (RII) is used in order to rank the factors that impact on the productivity of labour. As stated in Chapter 2, the contextual factors are subdivided into four (4) categories and these are; site environment factors, organisational/construction firm factors, technical factors and social factors. These four categories will also be analysed relative to the three different types of projects; building projects, road projects and infrastructure projects studied. The ranking and analysis of these factors is conducted to examine the contextual factors affecting construction project labour productivity when differentiated by project, location and organisation.

4.3.8.1 Aggregate ranking of contextual factors impacting labour productivity across projects

The aim of the study is to collect respondents' perceptions of the contextual factors that affect the productivity of labour productivity on construction projects. This data is presented in Table 4.17 according to RII values and ranked.

Table 4.17 shows that from a ranking perspective, the respondents perceive inclement weather (rain/cold/heat) (RII = 0.662) as priority contextual factor impacting labour productivity on construction projects, followed by Change orders from the designers/consultants (RII = 0.656); Fluctuations in material/equipment prices (RII = 0.648), Unexpected site ground conditions (RII = 0.646) and lack of experience amongst workers (RII = 0.646), Inspection delays from engineers (RII = 0,644), Economic changes (change in VAT, inflation and foreign exchange rates) (RII = 0,641), Delays in delivery of material (RII = 0,634), Incomplete Drawings (RII = 0,631) and Poorly designed project (RII = 0,629).

Table 4. 17: Perception of respondents regarding contextual factors that impact labour productivity on overall projects

		Very low impact…Very high impact						
	Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Rank (R)**
1	Inclement weather (rain/cold/heat)	13	28	11	40	25	0,662	1
2	Change orders from the designers/consultants	21	19	17	26	34	0,656	2
3	Fluctuations in material/equipment prices	17	22	22	28	28	0,648	3
4	Unexpected site ground conditions	13	26	22	33	23	0,646	4
5	Lack of experience amongst workers	13	30	14	37	23	0,646	4
6	Inspection delays from engineers	20	23	16	27	31	0,644	6
7	Economic changes (change in VAT, inflation and foreign exchange rates)	21	25	15	21	35	0,641	7
8	Delays in delivery of material	17	32	12	26	30	0,634	8
9	Incomplete Drawings	22	25	14	25	31	0,631	9
10	Poorly designed project	21	23	18	28	27	0,629	10
11	Lack of experience of workers	21	25	12	34	25	0,629	10
12	Labour unrest/rioting	28	20	15	18	36	0,624	12
13	Site location/environment	13	33	17	37	17	0,621	13
14	Delays in payment of labour	33	17	6	28	33	0,619	14
15	Relationship between supervisors and labourers	17	30	14	38	18	0,617	15
16	Complexity of the project	21	22	24	31	19	0,609	16
17	Poor co-ordination/planning of activities	24	24	12	39	18	0,605	17
18	Non-payment of labour	38	14	8	22	35	0,603	18
19	Inexperienced supervisors	30	21	12	30	24	0,595	19
20	Uncertain job security	28	18	24	25	22	0,591	20
21	Change in government legislature/policy	26	26	16	26	23	0,590	21
22	Poor site supervision	24	34	9	26	24	0,586	22
23	Methods of construction (prefabrication vs onsite)	27	27	17	28	18	0,571	23
24	Mismanagement of resources on site	28	32	12	21	24	0,568	24
25	Rework due to poor quality	33	28	10	20	26	0,562	25
26	Personal problems	31	23	18	28	17	0,561	26
27	Shortage of labour/manpower	25	38	8	31	15	0,554	27
28	Buildability of the structure	31	24	20	29	13	0,547	28
29	Long commute periods to site	33	24	19	29	12	0,537	29
30	Lack of tools and equipment	31	37	9	19	21	0,535	30
31	Changes in management structure	30	31	21	20	15	0,530	31
32	Drug abuse	41	24	16	21	15	0,506	32
33	Alcohol abuse	38	33	10	23	13	0,497	33

4.3.8.2 Site Environment factors that affect labour productivity across projects

The study sought to investigate site environment factors that impact on labour productivity on projects. These factors are ranked according to their respective RII values presented in Table 4.18.

Table 4.18 indicates that in the site environment category, factors that affect labour productivity, from a ranking perspective are: inclement weather (rain/cold/heat) (RII = 0.662), unexpected site ground conditions (RII = 0.646), lack of experience amongst workers (RII = 0.646), delays in the delivery of material (RII = 0.634) and site location/environment (RII = 0.621) are ranked as core factors that impact the productivity of labour.

Table 4. 18: Perception of respondents regarding site environmental factors and their impact on labour productivity across different project types

	Very low impact…Very high impact						
Site Environment Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Rank (R)**
Inclement weather (rain/cold/heat)	13	28	11	40	25	0,662	1
Unexpected site ground conditions	13	26	22	33	23	0,646	2
Lack of experience amongst workers	13	30	14	37	23	0,646	2
Delays in delivery of material	17	32	12	26	30	0,634	4
Site location/environment	13	33	17	37	17	0,621	5
Poor site supervision	24	34	9	26	24	0,586	6
Mismanagement of resources on site	28	32	12	21	24	0,568	7
Rework due to poor quality	33	28	10	20	26	0,562	8
Lack of tools and equipment	31	37	9	19	21	0,535	9

4.3.8.3 Organisational/construction firm factors that impact labour productivity across project types

The ranking of the organisational/construction firm factors impacting construction labour productivity is presented in Table 4.19 and their respective RII values. Table 4.19 shows that from a ranking perspective, the respondents perceived that the primary organisational/construction firm factors that impact labour productivity are; fluctuations in material/equipment prices (RII = 0.648), economic changes (change in VAT, inflation and foreign exchange rates) (RII = 0.641), delays in payment of labour (RII = 0.619), non-payment of labour (RII = 0.603) and inexperienced supervisors (RII = 0.595).

Table 4. 19: Perception of respondents regarding organisational/construction firm factors and their impact on labour productivity across various project types

	Very low impact…Very high impact						
Organisational/Construction Firm Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Rank (R)**
Fluctuations in material/equipment prices	17	22	22	28	28	0,648	1
Economic changes (change in VAT, inflation and foreign exchange rates)	21	25	15	21	35	0,641	2
Delays in payment of labour	33	17	6	28	33	0,619	3
Non-payment of labour	38	14	8	22	35	0,603	4
Inexperienced supervisors	30	21	12	30	24	0,595	5
Change in government legislature/policy	26	26	16	26	23	0,590	6
Shortage of labour/manpower	25	38	8	31	15	0,554	7
Changes in management structure	30	31	21	20	15	0,530	8

4.3.8.4 Technical factors that impact labour productivity across project types

The study further sought to evaluate technical factors perceived to impact on the construction labour productivity and this is presented in Table 4.20.

Table 4. 20: Perception of respondents regarding technical factors that impact labour productivity across different project types

	Very low impact…Very high impact						
Technical Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Rank (R)**
Change orders from the designers/consultants	21	19	17	26	34	0,656	1
Inspection delays from engineers	20	23	16	27	31	0,644	2
Incomplete Drawings	22	25	14	25	31	0,631	3
Poorly designed project	21	23	18	28	27	0,629	4
Complexity of the project	21	22	24	31	19	0,609	5
Poor co-ordination/planning of activities	24	24	12	39	18	0,605	6
Methods of construction (prefabrication vs onsite)	27	27	17	28	18	0,571	7
Buildability of the structure	31	24	20	29	13	0,547	8

As can be seen from the data presented in Table 4.20, change orders from the designers/consultants (RII = 0.656) is ranked as the primary factor impacting labour productivity on projects followed by inspection delays from engineers (RII = 0.644), incomplete drawings (RII = 0.631), poorly designed project (RII = 0.629) and complexity of the project (RII = 0.609).

4.3.8.5 Social factors that impact labour productivity across project types

Table 4.21 reports the perceptions of the respondents and their ranking of social factors impacting construction labour productivity. The results of the enquiry into the perception of the respondents on the social factors impacting labour productivity is presented in Table 4.21.

From a ranking perspective, Table 4.21 shows that lack of experience of workers (RII = 0.629) is ranked as the primary factor impacting labour productivity on projects followed by labour unrest/rioting (RII = 0.624), relationship between supervisors and labourers (RII = 0.617) uncertain job security (RII = 0.591) and personal problems (RII = 0.561).

Table 4. 21: Perception of respondents regarding social factors and their impact on labour productivity on across various project types

	Very low impact…Very high impact						
Social Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Rank (R)**
Lack of experience of workers	21	25	12	34	25	0,629	1
Labour unrest/rioting	28	20	15	18	36	0,624	2
Relationship between supervisors and labourers	17	30	14	38	18	0,617	3
Uncertain job security	28	18	24	25	22	0,591	4
Personal problems	31	23	18	28	17	0,561	5
Long commute periods to site	33	24	19	29	12	0,537	6
Drug abuse	41	24	16	21	15	0,506	7
Alcohol abuse	38	33	10	23	13	0,497	8

4.3.9 Contextual factors impacting labour productivity differentiated by project types and split by categories

In the previous section, all the different types of projects were aggregated and the impacts and rank of the factors that impact labour productivity were analysed using RII values and later sub-divided into the categories. In this section, analysis is distributed according to project type. Table 4.22 presents the respondent's perceptions of factors that impact labour productivity in the building, roads and infrastructure projects and further ranks these according to the respective RII values obtained.

When observing core factors impacting the level of productivity in the building projects under the different categories, within the site environmental factors, Table 4.22 shows that from a ranking perspective; delays in delivery of material (RII = 0,703), followed by lack of experience amongst workers (RII = 0,669), mismanagement of resources on site (RII = 0,666), unexpected site ground conditions (RII = 0,652) and inclement weather (rain/cold/heat) (RII = 0,638) are perceived to be the leading site environmental factors that impact on the level of labour productivity on building sites.

Additionally, under the organisational/construction factors; delays in payment of labour (RII = 0,645), fluctuations in material/equipment prices (RII = 0,645), non-payment of labour (RII = 0,641), followed by inexperienced supervisors (RII = 0,614) and economic changes (change in VAT, inflation and foreign exchange rate) (RII = 0,614) are found to be key factors impacting labour productivity on building projects from a ranking perspective.

Moreover, when analysing core factors affecting the productivity of labour within technical factors, it is observed that inspection delays from engineers (RII = 0,679), followed by change orders from the designers/consultants (RII = 0,679), incomplete drawings (RII = 0,659), poorly designed project (RII = 0,648) and complexity of the project (RII = 0,634) are critical factors that impact labour productivity on building projects.

Lastly, under social factors, relationship between supervisors and labourers (RII = 0,634) followed by labour unrest/rioting (RII = 0,617), uncertain job security (RII = 0,617), lack of experience of workers (RII = 0,614) and personal problems (RII = 0,572) are leading factors that impact on the productivity of labour on building projects.

Amongst the Road projects, under group rankings, Table 4.22 shows that factors considered to be critical to the productivity of labour under site environmental factors are; inclement weather (rain/cold/heat) (RII = 0,718), unexpected site ground conditions (RII = 0,645), site location/environment (RII = 0,636), lack of experience amongst workers (RII = 0,609) followed by delays in delivery of material (RII = 0,609).

However, organisational/construction firm factors that are crucial to the productivity of labour on road projects are economic changes (change in VAT, inflation and foreign exchange rates) (RII = 0,727), fluctuations in material/equipment prices (RII = 0,682), change in government legislature/policy (RII = 0,645), delays in payment of labour (RII = 0,618) and followed by non-payment of labour (RII = 0,564).

Technical factors that impact the productivity of labour on road projects are poorly designed project (RII = 0,655), incomplete drawings (RII = 0,618), methods of construction (prefabrication vs on-site) (RII = 0,591), inspection delays from engineers (RII = 0,582) followed by change orders from the designers/consultants (RII = 0,582).

Social factors that are critical to the efficiency of labour productivity on road projects are labour unrest/rioting (RII = 0,627), relationship between supervisors and labourers (RII = 0,609), lack of experience of workers (RII = 0,591), personal problems (RII = 0,573) and followed by uncertain job security (RII = 0,564).

Table 4. 22: Contextual factors split by categories and ranked by project types

	Factors	Project Type (Ranked by RII Values) Building	Road	Infrastructure
Site Environmental Factors	Delays in delivery of material	1	4	6
	Lack of experience amongst workers	2	7	3
	Mismanagement of resources on site	3	8	8
	Unexpected site ground conditions	4	2	2
	Inclement weather (rain/cold/heat)	5	1	1
	Rework due to poor quality	6	9	7
	Site location/environment	7	3	4
	Poor site supervision	7	6	5
	Lack of tools and equipment	9	4	9
Organisational/Construction Factors	Delays in payment of labour	1	4	8
	Fluctuations in material/equipment prices	1	2	4
	Non-payment of labour	3	5	7
	Inexperienced supervisors	4	5	3
	Economic changes (change in VAT, inflation and foreign exchange rates)	4	1	5
	Shortage of labour/manpower	6	8	1
	Change in government legislature/policy	6	3	1
	Changes in management structure	8	7	6
Technical Factors	Inspection delays from engineers	1	4	4
	Change orders from the designers/consultants	1	4	3
	Incomplete Drawings	3	2	5
	Poorly designed project	4	1	6
	Complexity of the project	5	7	2
	Poor co-ordination/planning of activities	6	6	8
	Buildability of the structure	7	8	1
	Methods of construction (prefabrication vs onsite)	8	3	7
Social Factors	Relationship between supervisors and labourers	1	2	5
	Labour unrest/rioting	2	1	1
	Uncertain job security	2	5	7
	Lack of experience of workers	4	3	6
	Personal problems	5	4	7
	Long commute periods to site	6	6	3
	Drug abuse	7	8	4
	Alcohol abuse	8	7	2

And lastly, amongst infrastructure projects as shown in Table 4.22, it is revealed that under site environment factors, Inclement weather (rain/cold/heat) (RII = 0,665), followed by unexpected site ground conditions (RII = 0,638), lack of experience amongst workers (RII = 0,632), site location/environment (RII = 0,616) and poor site supervision (RII = 0,557) are crucial factors considered to affect the productivity of labour.

From a ranking perspective amongst the organisational/construction firm perspective, factors perceived to be crucial to impacting the productivity of labour on infrastructure projects are change in government legislature/policy (RII = 0,632), Shortage of labour/manpower (RII = 0,632), Inexperienced supervisors (RII = 0,584), Fluctuations in material/equipment prices (RII = 0,578) and Economic changes (change in VAT, inflation and foreign exchange rates) (RII = 0,568).

Technical factors that impact the productivity of labour on infrastructure projects are buildability of the structure (RII = 0,665), Complexity of the project (RII = 0,627), Change orders from the designers/consultants (RII = 0,605), Inspection delays from engineers (RII = 0,600) and Incomplete Drawings (RII = 0,595).

Lastly, from a ranking perspective Labour unrest/rioting (RII = 0,676) followed by Alcohol abuse (RII = 0,632), Long commute periods to site (RII = 0,595), Drug abuse (RII = 0,568) and relationship between supervisors and labourers (RII = 0,535) are perceived as the leading factors that impact labour productivity on infrastructure projects (excluding roads) under social category. (see Appendix F).

4.3.10 Contextual factors impacting labour productivity differentiated by project types

Overall ranking of the contextual factors impacting labour productivity on the building projects (Table 4.23) are found to vary from both road projects and infrastructure projects as per the perceptions of the respondents. In the building projects delays in delivery of materials (RII = 0,703), followed by Inspection delays from engineers (RII = 0.679), Change orders from the designers/consultants (RII = 0,679), lack of experience amongst workers (RII = 0,669) and Mismanagement of resources on site (RII = 0,666) are perceived as leading factors that affect the level of labour productivity on building projects (see Appendix F).

Similar to building projects, contextual factors impacting labour productivity on road projects were analysed and ranked according to their respective RII scores. Table 4.23 shows that from an overall ranking of factors, economic changes (change in VAT, inflation and foreign exchange rates) (RII = 0,727) followed by inclement weather (rain/cold/heat) (RII = 0,718), fluctuations in material/equipment prices (RII = 0.682), poorly designed project (RII = 0,655) and unexpected site ground conditions (RII = 0,645) are perceived as leading factors that impact labour productivity on road projects.

Lastly, in analysing the respondents' perceptions of contextual factors that impact labour productivity on infrastructure projects, Table 4.23 shows that from a ranking perspective, these factors are labour unrest/rioting (RII = 0,676) followed by inclement weather (rain/cold/heat) (RII = 0,665), buildability of the structure (RII = 0,665), unexpected site ground conditions (RII = 0,638), lack of experience amongst workers (RII = 0,632), change in government legislature/policy (RII = 0,632), shortage of labour/manpower (RII = 0,632) and alcohol abuse (RII = 0,632) are perceived as the leading factors that impact labour productivity on infrastructure projects.

Table 4. 23: Contextual factors split by project types

		Project Type (Ranked by RII Values)		
	Factors	**Building Projects**	**Road Projects**	**Infrastructure Projects**
1	Delays in delivery of material	1	11	22
2	Inspection delays from engineers	2	16	12
3	Change orders from the designers/consultants	2	16	11
4	Lack of experience amongst workers	4	11	5
5	Mismanagement of resources on site	5	29	32
6	Incomplete Drawings	6	9	13
7	Unexpected site ground conditions	7	5	4
8	Poorly designed project	8	4	15
9	Delays in payment of labour	9	9	31
10	Fluctuations in material/equipment prices	9	3	17
11	Non-payment of labour	11	19	25
12	Inclement weather (rain/cold/heat)	12	2	2
13	Complexity of the project	13	24	9
14	Relationship between supervisors and labourers	13	11	23
15	Rework due to poor quality	15	32	25
16	Poor co-ordination/planning of activities	15	19	30
17	Site location/environment	17	7	10
18	Poor site supervision	17	23	20
19	Labour unrest/rioting	17	8	1
20	Uncertain job security	17	19	28
21	Lack of tools and equipment	21	28	33
22	Inexperienced supervisors	21	19	15
23	Economic changes (change in VAT, inflation and foreign exchange rates)	21	1	18
24	Lack of experience of workers	21	14	25
25	Buildability of the structure	25	29	2
26	Methods of construction (prefabrication vs onsite)	26	14	24
27	Shortage of labour/manpower	27	27	5
28	Change in government legislature/policy	27	5	5
29	Personal problems	29	18	28
30	Changes in management structure	30	25	20
31	Long commute periods to site	31	25	13
32	Drug abuse	32	33	18
33	Alcohol abuse	33	29	5

The data presented in Table 4.23 suggests that there are differences in the perceptions of the respondents on factors impacting labour productivity, when their responses are differentiated by project type. The study probes this further by testing a hypothesis that there are significant differences in the perceptions of respondents regarding the factors that impact labour productivity when their responses are differentiated by project type, contractor grade and location.

4.4 Data Analysis

Hypothesis (H1) one states that contextual factors such as material shortages, absenteeism, health and safety considered by estimators as affecting labour productivity estimates and outputs on site are significantly different when differentiated by companies, project and location in South Africa. It also tests Hypothesis two (H2) that there is a relationship between labour productivity and project performance.

4.4.1 Test of Hypothesis 1.

After the analysis of the various factors and their respective rankings using the RII value, it became imperative to analyse the variations in the differences amongst these factors when separated by project type, organisational level (cidb grading) and project location. The Kruskal-Wallis H test was used for to test for this objective. The factors are evaluated on the 5% confidence level and the results are reported as follows.

4.4.1.1 Variation in contextual factors that impact labour productivity when differentiated by project type

Tables 4.24, it can be observed that when observing the differences across factors when differentiated by the project type, delays in delivery of material (P = 0,032) and mismanagement of resources on site (p = 0,003) are the two factors that have a statistically significant difference across the various project types. At a confidence level of 95% and with a margin of error of 5%, delays in the delivery of material and the mismanagement of resources have a statistically significant difference across all the project types. While there was no statistical differences between other contextual factors impacting labour productivity when the perceptions of the respondents regarding factors influencing labour productivity are differentiated by project type. See Appendix G for the outcomes of all the other factors.

Table 4. 24: Kruskal-Wallis results for site environmental factors for project types

Null Hypothesis	Test	Sig	Decision
Delays in delivery of material is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.032	Reject the null hypothesis

Mismanagement of resources on site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.003	Reject the null hypothesis

4.4.1.2 Variation in contextual factors that impact labour productivity when differentiated by organisational type (cidb grading)

However, when the respondents' perceptions are differentiated by organisational, at a confidence level of 95% and a margin of error of 5%, it can be observed (see Table 4.25) that a statistically significant difference exists between their perceptions in delays in delivery of material (p = 0,034), fluctuations in material/equipment prices(p = 0.049), rework due to poor quality (p = 0,033), delays in payment of labour (p = 0,005) and uncertain job security (p = 0,043). See Appendix G for the outcomes of all the other factors.

Table 4. 25: Kruskal-Wallis results for organisational/construction firm factors for project types

Null Hypothesis	Test	Sig	Decision
Delays in delivery of material is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.034	Reject the null hypothesis
Rework due to poor quality is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.033	Reject the null hypothesis
Fluctuations in material/equipment prices is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.049	Reject the null hypothesis
Delays in payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.005	Reject the null hypothesis
Uncertain job security is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.043	Reject the null hypothesis

4.4.1.3 Variation in contextual factors that impact labour productivity when differentiated by location

It can however be observed in Appendix G that there is no statistically significant difference in the perception of respondents on the contextual factors that impact on labour productivity when differentiated by location and as a result, location does not have an impact on the views of respondents on the contextual factors that impact the level of labour productivity on construction projects. This suggests that the view of respondents regarding contextual factors that impact labour productivity on construction projects does not change as a result of location. It can be deduced from these findings that the respondents have very strong variance in their views of the impact of delays in the delivery of materials when differentiated by organisation types.

4.4.2 Test of Hypothesis 2.

After the cross-tabulation, the study sought to find out whether there is a significant relationship between labour productivity and cost and time variances on the projects reported in this study.

4.4.2.1 Relationship between measured labour productivity and the cost variance of construction projects

Figure 4.7 represent the relationship between the level of labour productivity and the cost variance of the projects involved in this study. The strength of the correlation is signified by the relationship presented in Figure 4.7. The finding shows that labour productivity is responsible for 46.81% of changes in the cost variance on the projects involved in this study. This finding suggests that as the level of labour productivity increases, the cost variance of the project increases.

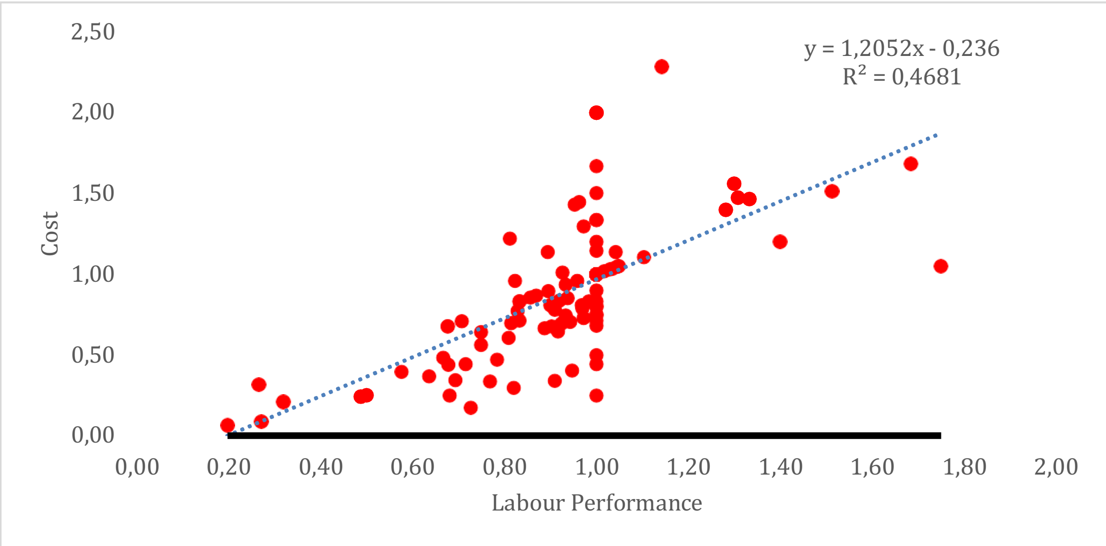


Figure 4. 7: Correlation between the labour performance and cost variance

4.4.2.2 Relationship between measured labour productivity and the time variance of construction projects

Figure 4.8 represent the relationship between the time variance and labour productivity. There is a strong linear relationship between labour productivity and the time variance suggesting that as the level of labour productivity increases, the time variance of the project also increases. Figure 4.8 shows that labour productivity accounts for 79.79% of time variance on construction projects which is significant.

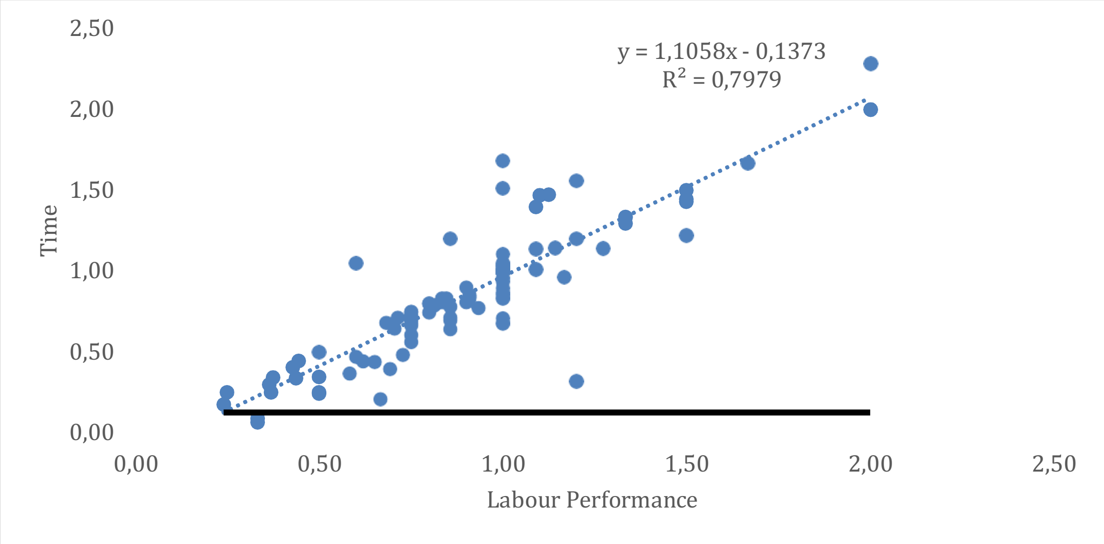


Figure 4. 8: Correlation between the labour performance and time variance

4.5 Discussion of findings

This section of the study discusses the findings of the research to answer the research question as well as the research objectives set out. Furthermore, a thorough comparison of the research study in relation to the previous studies as detailed in the literature review is conducted. This is in lieu of ascertaining that the research question and objectives have been answered from the findings.

4.5.1 Levels of labour productivity on construction projects

The study sought to establish the levels of labour productivity that is found across the various project types, organisations and the locations across which construction development takes place. The findings revealed that across project types, the building projects have the largest level of poor labour productivity. However, higher labour performance is reported across infrastructure projects in comparison to building projects, and lastly, road projects also have a marginally higher level of labour productivity when compared to the average number of projects that actually have a high level of labour productivity.

However, when evaluated across the various types of the organisations, a distinct observation through the analysis was that Grade 4 contractors have a significantly higher level of poor labour productivity across this category. This is aligned to previous findings by Barbosa *et al.* (2017) who found that there is significantly low level of labour productivity within building projects.

And lastly, when the labour performance was evaluated based on the location types, the results of the study revealed that across the provinces in South Africa, there was no difference in the level of labour productivity that was evaluated. However, Kwa-Zulu Natal showed a significant number of poor performances of labour, and this could be attributed to the fact that the number of the responses in the survey largely were from the province. However, generally, there was no significant difference in labour productivity in relation to location.

4.5.2 Basis and norms for labour productivity established by construction companies

One of the main determinants of the norms for the levels of labour productivity on construction projects is to use the project cost or completing the projects within cost as the measure of efficient labour performance and thus project success. The findings of the study revealed that the various types of construction projects utilise this standard. Furthermore, when evaluated on an aggregated perspective across the projects, it still remained evident that completing project within cost is largely a benchmark for labour performance. Following this, the study further established that the completion of project within time is also another factor that the construction industry uses to determine the level of labour performance on projects. This finding is consistent with literature as Alinaitwe *et al.* (2007) found that the completion of a project within cost is also one of the determinants of project performance. Additionally, this finding suggests that construction projects completed within time or on schedule automatically have labour that can be assumed to be efficient in their operations.

It did emerge however that Total Factor Productivity (TFP) and Average Labour Productivity (ALP) are the two least measures used by construction projects in south Africa to determine the level of labour productivity on construction projects. It can be inferred from this findings that across construction projects (building, roads and other infrastructure developments), TLP and ALP are often used extensively when determining the level of labour productivity.

4.5.3 Contextual factors that impact on labour productivity

From the perceptions of the respondents, it is established that contextual factors that impact the productivity of labour on site and consequently the project performance vary across projects, organisations and location of the project (Senthilkumar and Shafee, 2013). Factors synthesised from literature were aggregated for this research and evaluated using the RII ranking to establish those central to the effect of labour productivity across all project types. The top ten contextual factors were selected and are discussed.

Inclement weather (rain/cold/heat) (RII = 0,662) is ranked first. This finding is purported by previous studies (Motwani *et al.*, 1995; Chan and Kumaraswamy, 1997; Radosavljevic and Horner, 2002; Senthilkumar and Shafee, 2013; Jarkas, 2015; Naoum, 2016). Park (2006) asserts that the construction industry, in its nature, projects are built outside and as a result, it is imperative that the effect of weather are significantly considered pre-construction. Furthermore, the ranking of this factor aligns with this assertion as it can be seen that weather plays a pivotal role in the development of a project. In the event that a construction site is exposed to excessive rain, it is reported that labour productivity will be diminished and as a result some of the construction work that is scheduled to take place, will be affected (Park, 2006). This further results in the inability for the construction work to continue as the construction activities are interlinked (Love *et al.*, 2002). Similarly, on construction projects where extreme cold weather are experienced, the productivity of labour can be affected and additionally, in extreme heat temperatures, the level of labour productivity diminishes as the health of labourers will be susceptible to heat strokes and exhaustion (Love *et al.*, 2002).

Change orders from designers/consultants (RII = 0,656) was also ranked highly with regards of being a core factor affecting the productivity of labour on construction projects. There seems to be a consensus across literature that purport that the variation orders or changes in designs and in some instances, errors on the drawings certified for the project significantly affect the productivity of labour (Kaming *et al.*, 1997b; Park, 2006; Jarkas, 2015; Naoum, 2016). Change orders not only impact the cost aspect of the construction project, but as can be seen from the ranking of this factor so high across a list of contextual factors, the performance of labour is directly affected by change orders as well. This assertion agrees with literature that also looked at the impact of the change and variation orders on the level of the productivity of labour on construction projects (Park, 2006). A link is drawn between the communication link and response time adequate to action a required change order between the consultants and the contractor in order to address the variation order by Love *et al.* (2002). Furthermore, the emergence of change orders from consultants, seldom consider the contractor's program of works and as a result, any change in that program gives rise to labour being unproductive as the change in the programme requires an adjustment of the construction works (Doloi, 2008; Naoum, 2016).

Another factor ranked high is the fluctuations in material/equipment prices (RII = 0,648). Across the various projects analysed, this factor impacts not only the viability of the profitability of the project, but also the productivity of labour on site. Fugar and Agyakwah-Baah (2010) purports this finding in that the changes in the prices of both material, equipment and plant that are essential for the project execution, significantly affects the project delivery and subsequently, the productivity of labour on site. This assertion was inter-alia validated by Park (2006) in that the planning of acquiring material and equipment as well as their procurement, is necessary to ensuring that the productivity on a construction project is not halted and as a result, deemed unproductive due to poor projection of the changes in process and materials or the resources on site. According to the findings, fluctuations in material/equipment prices has the potential to affect the productivity if not considered well in advance in the execution of the construction process.

As part of the ranking, unexpected ground conditions (RII = 0,646) is ranked high according to the level of its perceived impact on the level of labour productivity on construction projects. The lack of knowledge of the geographical context of the soil as well as the geotechnical composition of the soil has been shown to have a detrimental impact on the productivity of labour and as a result, this finding is not in contention as it aligns with other studies (Gidado and Millar, 1992; Durdyev and Mbachu, 2011). The uncertainty in ground conditions is not limited to the soil composition but can also refer to the services and the municipal service pipes that pass through a particular erf where the development is happening. As a result, in the case that a service pipe is cut accidentally due to a lack of a clearly detailed service layout, this halts the construction work and inadvertently affect the labour productivity on a construction project (Motwani *et al.*, 1995; Durdyev and Mbachu, 2011).

Lack of experience amongst workers (RII = 0,646) and lack of experience of workers (RII = 0,629) are both ranked highly in the study across the projects and for the purposes of this research, lack of experience among workers include those that are in management and supervisory roles. These two factors are in consensus with the literature and additionally, literature elaborates on the impact of these factors on the level and output of labour productivity across construction projects (Makulsawatudom *et al.*, 2004; Alinaitwe *et al.*, 2005; Alinaitwe *et al.*, 2007; Naoum, 2016). These factors are greatly cited by scholars and the findings of this research are in alignment with these results. Moreover, it has been established that the high ranking of the inexperienced workers in the construction industry, is due to the multiple functions that both the workers and the management overseeing these workers bring to the execution of the project (Park, 2006). It is further argued that the lack of skilled supervisors and managers impede the productivity of labourers in that they lack the proper planning skills essential for the execution of the project, additionally, they seldom possess the critical ability to manage both the materials and labourers.

As a consequence of this, the labour force on the ground or on site is not given the proper scope of work and material schedule that allows them to do their work (Park, 2006; Enshassi *et al.*, 2007; Jarkas, 2015). Notwithstanding this, in South Africa particularly, some of the initiatives and skills development programmes implemented both by the government and contractor to develop the skills of labour, requires that the contractor absorb a certain portion of the working class on their projects in order to train them for specific trades, as a result, the workmanship of these apprentices on site on average brings the productivity of the construction team down as it is not up to standard but rather a requirement of the contract (cidb, 2015; Barbosa *et al.*, 2017; cidb, 2017). It can be further argued that the lack of proper monitoring of the construction industry is due to the fragmented nature of its operations and lack of proper skill as there aren't standardised measures of competency and skills employed on projects (Motwani *et al.*, 1995; Fulford and Standing, 2014).

Inspection delays from engineers (RII = 0,644) is also ranked as being one of the core factors affecting the productivity of labour on construction projects. In the event that the engineers do not action a prompt response to the inspection request from the contractor, this delay impacts negatively on the productivity of labour as it halts the work on site. The data from this study supports earlier studies that reported this finding and the eminent impact on the productivity of labour (Doloi, 2008; Gündüz *et al.*, 2012; Naoum, 2016). This factor affects both the sequential planning of the project activities as well as the labour involved in the project.

Another factor considered significant from a ranking perspective is the economic changes (change in VAT, inflation and foreign exchange rate (RII = 0,641). An organisation is affected by the changes in the inflation and foreign exchange, especially if the material to execute the work is sought from foreign countries. If the material is not delivered on site on time due to inflation, it can be observed that the labour force will remain idle and as a result, the work will not continue to the satisfaction of the client.

Delays in the delivery of material (RII = 0,634) is also another factor ranked high from the perceptions of the respondents. A large part of the construction project is the transformation of material into tangible output which means that without material, labour will not be able to perform their function. Lack of material on a project is the major non-productive factor (Park, 2006). This finding is in alignment and consistent with previous studies (Hughes and Thorpe, 2014; Dzadaza and Crafford, 2015) as it has been found that the delay in the delivery of construction material gives rise to poor productivity and as a result, affects the project as a whole. Additionally, the programme of the construction activities and the morale of the labourers can be drastically affected in the event that material delivery is disrupted and giving rise to idle labour time and overhead costs relating to labour productivity being incurred without expended output (Enshassi *et al.*, 2007). The findings of this study is aligned to previous research in this regard and as a result, substantiating the delay of material delivery as a highly ranked factor that impacts the productivity of labour on construction projects.

Incomplete drawings (RII = 0,631) is another factor that is ranked as being core to the productivity of labour in the construction industry. The level of information and the scope of the construction project is largely carried by the drawings and the details of the design. It further follows that drawings that are not complete affect the productivity of labour as the findings suggest. Throughout literature, this finding is asserted and thus is valid (Alinaitwe *et al.*, 2007).

The last factor ranked high across the various project types as affecting the productivity of labour, is the poorly designed projects (RII = 0,629). Similar to incomplete drawings, this factor is ranked high due to it being core to the information necessary to execute the work and give guide to the construction team and the labourers of the impending scope of work. It further means that poorly designed projects make the project susceptible to unforeseen complexities that affect productivity of labour from an execution point of view (Soekiman *et al.*, 2011). The survey responses in the present study are in alignment with previous studies in that incomplete drawings are a significant factor that affects poor labour productivity (Moselhi and Khan, 2012).

4.5.4 Differences in contextual factors affecting labour productivity on projects differentiated by project type, organisational type and location

The study identified 33 contextual factors that according to extensive literature review, are core to affecting labour productivity on construction projects. The perception of the respondents on the impact of these factors were further analysed to establish their related differences across the project types, organisational type and the location type. The analysis of these factors was conducted using the Kruskal-Wallis test and the findings are presented.

4.5.4.1 Differences in contextual factors by project types

Two factors emerged as having a strong statistically significant difference in the contextual factors when evaluated by the project type. These are delays in the delivery of material and the mismanagement of resources on site. These findings are consistent with the results of the previous studies conducted by Makulsawatudom *et al.* (2004). Construction projects that are infrastructure based are often developed away from the capital cities and nearest places where material can be delivered with ease, as a result, an alteration in the delivery schedule, can significantly affect the productivity of labour on the projects. Furthermore, other infrastructure projects require that the material that are used be imported from other countries and if the delay in the delivery is experienced, the productivity can be significantly affected. Similarly, road projects are designed in the same manner that they are often remote from the cities or asphalt manufacturing plants and the easiest way to get the required materials where need, is to make plans in advance to procure the material for the development. Building projects are no different from being affected by the delivery of the material. A similar phenomenon where labour can remain idle and be significantly affected by the lack of timely delivery of material may happen if the contractor is not able to procure the necessary equipment, plant or material necessary for the construction operation.

Mismanagement of resources on site further affect the level of labour productivity in that, excessive wastage, constant break down of machine and equipment and constant stealing of material drastically affects the productivity on site. Furthermore, some of the activities are postponed to a later date and time overruns arise as a result.

4.5.4.2 Differences in contextual factors by organisational type

Five factors emerged as having a strong statistically significant difference across the various cidb grading types or across organisation types. These factors are Delays in delivery of material, rework due to poor quality, delays in payment of labour, fluctuations in material/equipment prices and uncertain job security (see Table 4.25). The findings are consistent with literature (Alinaitwe *et al.*, 2007) that postulates to the fact that in the event that material delivery on project site is hampered, this could have a significant impact on the level of productivity of labour. Additionally, labour remains idle and as a result work does not get done and subsequently affect the project performance and output.

Rework of the construction work due to poor quality is another factor that is observed as being significantly different across the organisational types. In smaller firms, especially those that are still establishing themselves in the construction industry, it could be postulated that the scale of work and expertise employed may be the reason for this difference. This is further revealed in construction firms upsizing and taking in more large projects, especially when those firms are not versed with the right expertise and experience to build larger projects. Additionally, rework of the construction work is linked to both the reading and understanding of the specifications and demands of the job as well as the organisation's capacity to execute the work. In the event that a correct specification and demands of the job are not aligned with the job, the likelihood of errors will arise which will give rise to rework of the sections of the work at a later stage.

Delays in payment of labour is another factor revealed to have a significant impact on the level of labour productivity on site. This is a factor that affects the livelihood of the labourers and as a result, if the organisation is not able to pay the labourers on time, this affects their livelihood and give susceptibility to labourers not being able to meet their living standards. This further affects their families and how they engage with the job and as a result their productivity is impacted.

Fluctuations in material/equipment prices is another factor that significantly affect the productivity of labour. In the event that the prices of material and equipment increases, the adjustment and organisational response to that change can impact the productivity on site. A delay in the delivery of the material will affect the output on the project. Labourers that do not have certainty regarding their job security may be distracted and as a result not able to effectively perform on the project.

4.5.4.3 Differences in contextual factors by location type

It was established that there are no significant statistically differences across the various contextual factors when differentiated by location type. This means that no particular factor is considered to affect the level of labour productivity any differently in the various provinces. And these results are consistent with those established with the chi-square test when evaluated by the location type.

4.6 Chapter summary

This chapter reports the data analysis results as well as the findings of the study. The analysis reported the background profile of the respondents. From an academic background perspective, it was established that a large number of the respondents have a BSc degree/Diploma (30%) as their highest academic qualification and 10% of the respondents were in possession of an MBA/MSc. The analysis further revealed that a large population of the respondents had sufficient years of experience in the construction industry thus making the results reliable for the purpose of the study. The scope of the respondents involved in the study had designations or job descriptions ranging from directors of companies, project managers, construction managers, contracts managers, quantity surveyors, construction supervisors, site agents and site engineers. This further reinforced the level of knowledge of the construction projects which this study aimed to evaluate. Additionally, the analysis reported that some of the respondents are registered as professionals as either professional project managers, quantity surveyors, engineers, technical engineers, construction managers and construction project managers. Geographically, the study also found that the respondents range from all the nine provinces of south Africa, most rate being from Kwa-Zulu Natal (23%). In the reporting of the cidb grades of the firms, a high number of respondents were from Grade 1 cidb graded firms (18%) as general building contractors and 14% as civil engineering contractors. This information about the various contracting firms allowed the study to get a range of responses from across different construction sites in order to compare the variances that exists with regards to the level of labour productivity.

In the analysis of the results, it was imperative that the construction costs and time be analysed so as to observe the variances that exists across projects and further assess the variables that gave rise to these variances. These results are presented in Appendix D and Appendix E. The results show that significant overruns and time overruns exists on the projects. Notwithstanding that, the analysis also selected three types of projects for the study and these are building projects, road projects and infrastructure projects. For the proposes of this study, this selection is used to assess the differences in the perceptions of the respondents of contextual factors that impact on labour productivity.

In an effort to evaluate the estimation methods used on construction projects, three trades were selected for this study as they are labour intensive and used as a means to assess what methods of estimation is used on projects. These trades are concrete, masonry and plastering. A mean item score (MIS) was utilised to assess the methods used to estimate the labour productivity component and this chapter reports this in the data analysis section.

In this chapter, the results of what the respondents consider to be the core reasons for the variance between estimated project cost and time was established to be the productivity of labour. This was established by also using the MIS analysis of survey responses and in both the cost and time variances. The study used the relative importance Index (RII) to rank and rate the contextual factors that are perceived by the respondents as causal attributes to the level of labour productivity on projects and these are presented in this chapter. These factors are further evaluated with regards to RII within the site environmental, organisational/construction firm, technical and social factors. Furthermore, the various contextual factors were also ranked by project type and compared against each other and further discussed.

Kruskal-Wallis test was used to evaluate the differences between the impact of contextual factors and the project types, organisational types and the location of the projects. It was established that across the project types, delays in the delivery of the material as a factor affecting labour productivity, is different across project types. Furthermore, when compared across the organisational types, delays in the delivery of the material, rework due to poor quality, delays in payment of labour fluctuations in material/equipment and uncertain job security are significantly different. However, no statistically significant factor was found to be different across the location of the project when the Kruskal-Wallis test was conducted (Appendix F).

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The aim of this chapter is to evaluate the findings of the research and assess how the findings have addressed the research objectives as well as the research hypothesis set out for this study. The study is centred around evaluating contextual factors that affect the level of labour productivity on construction projects and assess how this varies when compared by project type, organisational type (cidb grade) and location type. Furthermore, an evaluation of what specific factors play a role in this regard is evaluated. Additionally, this chapter will conclude on the findings of the study and give recommendations and a critical reflection.

5.2 Summary of findings

5.2.1 Objective 1: Determine labour productivity on construction projects

It was established through literature that various methods are used to determine the level of labour productivity on construction projects. The performance of a construction project within time is considered key to being one of the main determinants of labour productivity. This was found to be the case in this study when it was established that cost is considered to be a determinant of labour productivity on construction projects. Furthermore, the completion of a project within time is also considered to be a determinant of labour productivity, notwithstanding this, other scholars also considered the use of average labour productivity (ALP) as the determinant of labour productivity on construction projects. This is further followed by the use of the total factor productivity (TFP) as the main basis and determinant of labour productivity on construction projects across the different project types.

5.2.2 Objective 2: Establish how construction organisations determine the basis and norms for labour efficiency on construction projects.

It emerged from the findings that construction organisations determine the level of labour productivity based on the project's ability to be delivered within cost. Following this, project being delivered on time is considered the second-best indicator of labour productivity. This finding disregards the contextual factors that affect the level of labour productivity and thus rests the basis and norm for the performance on cost alone, which as can be seen in answering of objective three, it is affected by a host of other factors.

5.2.3 Objective 3: Evaluate contextual factors that impact on labour productivity on site during the execution of construction projects.

In the evaluation of contextual factors that affect the level of labour productivity on construction sites, Table 5.1 shows the factors found to be pertinent and prevalent on construction sites. These factors were grouped into four categories; site environmental factors, organisational/construction firm, technical and social factors. in answering objective 3, a relative importance index (RII) was used to establish which of the thirty-three factors identified are considered to be the main factors affecting the level of productivity on construction sites. Table 5.2 extracts the top ten factors that are ranked high across these categories of factors as well as across all the three project types; building projects, road projects and infrastructure projects.

Inclement weather (rain/cold/heat) is ranked number one and this is in accordance with literature. Construction projects are built in an open environment that is susceptible to impact by weather conditions. It is therefore imperative that when labour is working in this kind of environment, the construction firm become aware of the eminent impacts weather can have on the level of labour productivity. In the event of rain, not only does labour become affected as a way of not being able to perform some of the trades, but their health and safety also become a matter of concern. In the event that workers are exposed to cold, this slows down the labourer's engagement with the work as they are not able to perform to their optimal level and subsequently, jeopardise the level of construction output expected on the project. Lastly, heat is one of the main aspects to consider with weather as the labourers can be susceptible to heat strokes and other implications that arise from the heat. As a result, the impact of weather cannot be neglected in both the planning of the construction work as well as during the construction of a project.

Change orders from the designers/consultants is also found to affect the level of labour productivity on site. once the project has started, it is often the case that a section of the work can have missing information or aspects of the specifications and details are omitted and as a result this necessitates a change order from the consultants. In the event that the work has already been completed to a substantial portion, this change order can require that the constructed work be demolished or done away with as a means to accommodate the change. Labourers are thus demotivated to redo the already completed work and this affects their productivity as a way to continue.

On an organisational perspective point which has an indirect effect on the labour productivity, fluctuations in material/equipment prices also affect the productivity of labour on site. The dynamism of the economy can give rise to changes in the material and equipment prices. This would mean that the company needs to source and procure necessary equipment and material at a different price than that which is initially tendered for. This further means that in the event that these materials and equipment are not procured on time, labour can remain idle on the project and not able to deliver the required sections of the work on time, and sometimes on cost.

Unexpected site ground conditions play a pivotal role in the level of impact theyhave on the productivity of labour. A thorough site analysis done by the geotechnical engineer sometimes is not done on some projects and as a result, labourers uncover some discrepancies which give rise to the occurrence of a condition in the ground which is not planned for. Thus, the labourers on site can be expected to attend to this as a way to remedy the potential impact it can have on the whole project. This further means that labour has to work more and over the expected activities planned. This adds to the overtime that was initially not planned for. Additionally, the level of labour output that can be expected from this can further affect the approach the labourers have in the proceeding activities going forward.

Lack of experience amongst workers is one of the factors that is prevalent on the construction projects and this affects the team dynamic on construction projects. Some of the labourers absorbed in the construction industry under the training and development programmes, do not have the necessary experience and expertise. As a result, this lack of experience affects the progression of the works as rework and the extensive monitoring of these labourers takes more focus from other labourers. Furthermore, the lack of experience amongst other labourers affect those that have experience and working with those without. Experienced labourers do their work and also ensure that those without, have their work also done to satisfactory standard. This means they are doing double work and as a result tend not to be as efficient or productive as when they are working with experienced workers. Lack of experience of workers also affects the overall project success and organisation's profit margin as the constant rework affect the costs and as a result, the profitability of the project.

Inspection delays from the engineers is one of the factors that actually halts the works on construction projects which renders the labourers idle and as a result, unproductive. Engineers tend to delay their inspections on site and subsequently, affect the contractor's work programme and this affects the to time and cost overruns. Furthermore, labourers that are scheduled for work which is dependent on the portion of work to be inspected are not able to start with their work and as a result their general work productivity is affected.

As much as Economic changes (change in VAT, inflation and foreign exchange rates) don't directly affect the productivity of labour on construction projects, it is imperative to the organisational planning and work schedule. Labourers can be affected in that with inflation rates and (value added tax) VAT increases, companies may retrench and cut their labour force. This further means that the work that would ordinarily be planned for a team of ten, may now need to be distributed amongst a team of seven. This means that the labourers will have to work under arduous conditions which inadvertently can affect their level of productivity. Notwithstanding this, exhaustion and fatigue can arise and thus impacting the productivity of labour.

Delays in the delivery of material on construction projects affect the productivity of labour in that idle time is a result. This means that labour does not have work to do and thus are not productive in expending any output.

Incomplete drawings and poorly designed projects are two factors that are not mutually exclusive. Incomplete drawings halt the work of the contractor and significantly affect the level of output that can be produced. Once the work has started, depending on the efficiency and the pace of the labourers, such work can proceed as planned and be completed on time. However, if a section and part of the work is not available, the job halts and labourers remain unproductive. A poorly designed project necessitates requests for information to the relevant designers and the engineers and as a result, in the time the engineer contrives the response, the construction work is not moving, and the level of labour output is also affected. With the use of the RII, it can be seen that objective four was satisfactorily answered and the results of the objective are congruent with previous studies.

5.2.4 Objective 4: Assess the difference between projected labour productivity and actual outcome on construction projects and compare these variations and contextual factors considered between organisations, projects and locations.

Objective number 4 was answered using the Kruskal-Wallis test. As will further be explained in detail in the answering of the hypothesis, the Kruskal-Wallis test revealed that when differentiated by project type, a strong statistically significant difference exists in two factors; delays in the delivery of material and the mismanagement of resources on construction projects. However, when differentiated by organisational types, four factors have a strong statistically significant difference. These factors are; delays in the delivery of the material, rework due to poor quality, delays in the payment of labour, fluctuations in material/equipment prices and uncertain job security. Lastly, no significant difference was found across the contextual factors and the location type of the project.

5.3 Revisiting the Hypothesis.

Hypothesis 1: The contextual factors such as material shortages, absenteeism, health and safety considered by estimators as affecting labour productivity estimates and outputs on site, are significantly different when differentiated by companies, projects and locations in South Africa.

This hypothesis was answered in two ways. Firstly, a Kruskal-Wallis test was conducted in order to establish the factors that are considered key in either there is a significant difference in the perceived contextual factors impacting labour productivity when differentiated by project type, organisational type as well as location in South Africa.

When the influence of the perceived factors were differentiated by project type, it emerged through the test that delays in the delivery of material and mismanagement of resources are the key factors that are statistically significantly different across the projects. This assertion is supported by literature and can be explored even further in the varying project types. The delays in the delivery of material halts the construction work and as a result no tangible progress in the output can be achieved. Some projects are constructed in remote environments, especially roads and infrastructure projects which means that their plan of works requires that material be delivered on time in order to be able to not affect any other activities that follows. This is the same for the building projects in that if a material for a specific activity are not delivered on site on time, this can delay the proceeding activities delaying the entire project. This significant difference further highlights the degree of impact the delays in material can have on the project in terms of profitability and the production output that gives credibility to the contractor and his team for further work with their client.

The second factor which is the mismanagement of resources is also pivotal to the construction project in that the lack of proper management of the construction project resources (material, equipment and plant) can significantly affect the progress of the work. Equipment that is not maintained and regularly assessed for good working conditions not only give rise to accidents on site, but when they break down, this gives a consequential delay in the construction activities and further delays the job.

Using the Kruskal-Wallis test to evaluate factors that have a statistically significant difference in the organisational context, four factors emerged as having a statistically significant difference. These are; delays in the delivery of the material, rework due to poor quality, delays in the payment of labour, fluctuations in material/equipment prices and uncertain job security. When the payment delays occur, labourers tend to not come to site or perform their functions as their remuneration is tied to their livelihood. Additionally, rework due to poor quality is paramount to the morale of the labourers as the persistent rework can demoralise them and subsequently have them not perform to their desired standard. However, it can also be argued that the significance of the fluctuations in material/equipment prices on projects also affects the labourers work. It further emerged that when the Kruskal-Wallis test was performed across the location type to evaluate the significant occurrence of any factor affecting the level of labour productivity, no significant factor was observed.

Hypothesis 2: There is a relationship between labour productivity and project performance.

A statistically significant relationship was established between the measured level of labour productivity and the project cost variance. This means that as the level of labour increases on site, the level of cost variance decreases and as a result, depicting a strong relationship. In this regard, it is easy for construction companies to establish a rigorous schedule and implore proper planning so as to make sure the level of labour productivity is increased and well regulated.

Additionally, a statistically strong relationship was also established between level of labour productivity and the time variance. This means that as the level of labour productivity increases, the level of time variance also increases which means that the estimated time to complete the project can be reduced.

5.4 Conclusion

Construction industry is one of the industries that forms an integral contribution to the South African's GDP and employment generation programmes. Additionally, the co-dependency of other sectors to the construction industry is undeniable. This can be seen by the development of buildings used to house other sectors such as banking, finance and manufacturing. Furthermore, this can be seen by the development of the infrastructure projects and roads that are the connecting points that allows trade and the mobility of other sectors to be functional. It is this fact that gives rise to the full analysis of the aspect of the construction industry which is instrumental in the actual development of the project, the people or labourers that do the actual building.

Labourers are the larger portion that make up the construction industry's financial cost. With this known fact, it became imperative for this study to critically analyse and explore the contextual factors that affect the said level of labour productivity on construction projects. Much of what the study found was largely corroborated by studies that have been done before but what uniquely distinguished the approach that this study adopted, was that of analysing the south African construction industry. Each project presents with itself factors and conditions that specifically affect the project which varies from another project. However, with each individualised project, labour remains the largest affected component of the construction project. It further emerged that the levels or the degree of the impact of the varying factors are different when compared by project type and organisational type. It is this finding that necessitate a further probe into how these specified factors that affect the level of labour productivity can be mitigated and if not, how can the planning and estimation stage of the development circumvent their impact so as to not compromise the project performance.

Lastly, this study did evidence and interesting finding in that when differentiated across locations type, there is no evidence of a significant perception of respondents on the factors affecting the levels of labour productivity. This is amidst the fact that certain municipalities in South Africa receive a substantial amount of money from the government to develop infrastructure projects and as a result, those projects tend to not come to fruition as labour is said to not have adequate skill and experience.

Based on the findings, the study concludes that there are various contextual factors impacting labour productivity on construction projects. Also, that the delay in the delivery of material is a contextual factor that varies during labour productivity estimation based on project and organisation type. Lastly, the research concludes that there are other factors, not within the boundaries of this research that impacts on project performance, while there is a proportional relationship between labour productivity and project performance.

5.5 Recommendations

A combination of factors affects the level of productivity of laborers on construction projects and these contextual factors vary with the degree of impact especially when differentiated by project type and organisational type (cidb grade). Through the ranking of factors perceived to be central to the level of labour productivity, ten were identified as highly ranked and there are; Inclement weather (rain/cold/heat), Change orders from the designers/consultants, Fluctuations in material/equipment prices, Unexpected site ground conditions, Lack of experience amongst workers, Inspection delays from engineers, Economic changes (change in VAT, inflation and foreign exchange rates), delays in delivery of material, Incomplete Drawings and Poorly designed project.

The study recommends that construction companied (cidb graded contractors) establish a proper management strategy to aid the labourers in terms of assessing their capabilities in relation to the job requirement. In this way, some of the factors that affect the level of productivity such as rework due to poor quality, can be eliminated. Additionally, depending on the grade that the contractor is able to do the job, establish the proper management of designs and ensure that omitted information and incomplete sections of the drawings are brought to the attention of the architects and engineers on time. Furthermore, ensure ample time is given to the engineers so as to evade the impact of late inspections of the work.

It is imperative that the labourers that are brought onto a construction project have the proper skill and knowledge of the works. This ensures that there is no uneven delegation of the works and that everyone is able to execute their section of the work accordingly. The lack of proper communication in reasonable time to not deter the productivity of a project is imperative to both the success of a project which is reliant on the productivity of labour. Furthermore, this finding also requires that a specialised spatial assessment and locality of projects belonging to the same category, need to be analysed and evaluated against the project performance and the labour performance. Additionally, this study focused on the level of labour productivity as the labour cost thereof contributes a third of the construction cost. Development programmes that are aimed at skills development and skills training seldom advises on the management and the circumventing of any possible occurrence of external factors not included in the planning schedule, as a result, the results of this study can allow the institutions that train labourers to address contextual factors on projects from a holistic perspective.

5.6 Area for further study

This study recommends that these factors be critically evaluated on the various project types and their degree of impact be assessed against both labour performance on projects as well as the project performance. In this way, it will be easy to identify what contextual factors affect which type of project type and as a result, establish proper preventative measures or develop proper estimation techniques to circumvent their impact. This could further allow the contractors to be able to establish the environmental impacts or possible impacts that can arise from the different locations and manage this accordingly. Furthermore, the study only focused on the three types of construction project; building, roads as well as the infrastructure projects. A further analysis can be done with a larger population size to assess the impact of contextual factors and their degree of impact.

5.7 Critical reflection

The study is relevant in that it explores an area of research that is not extensively conducted in the South African construction industry but affects the level of productivity. This study can be used in the varying institutions that govern the construction industry operations and inform both the construction professionals as well as the contractors on the imperative inclusion and consideration of contextual factors impacting construction projects.

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APPENDICES

APPENDIX A – Ethics Clearance for the study

Application for Approval of Ethics in Research (EiR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form *before* collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the EBE Ethics in Research Handbook (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		MOCHELO MACKSON LEFOKA
Department		CONSTRUCTION ECONOMICS AND MANAGEMENT
Preferred email address of applicant:		LFKMOC001@MYUCT.AC.ZA
If Student	Your Degree: e.g., MSc, PhD, etc.	MPHIL
	Credit Value of Research: e.g., 60/120/180/360 etc.	180 CREDITS
	Name of Supervisor (if supervised):	A/PROF ABIMBOLA WINDAPO
If this is a researchcontract, indicate the source of funding/sponsorship		
Project Title		AN EVALUATION OF THE CONTEXTUAL FACTORS THAT AFFECT LABOUR PRODUCTIVITY IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

SIGNED BY	Full name		Date
Principal Researcher/ Student/External applicant	MOCHELO LEFOKA	Signature Removed	10 Jul 2018

APPLICATION APPROVED BY	Full name	Signature	Date
Supervisor (where applicable)	ABIMBOLA WINDAPO Click here to enter text.	Signature Removed	10 July 2018 Click here to enter a date.
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section1; and for all Undergraduateresearch (Including Honours).	NIEN-TSU TUAN	Signature Removed	11 July 2018 Click here to enter a date.
Chair : Faculty EiR Committee For applicants other than undergraduate students who have answered YES to any of the above	ADENIYI ISAFIADE	Signature Removed	12 JULY 2018

P.P

Page 1 of 2

APPENDIX B – Cover Letter/Consent Form

Dear Respondent,

You are invited to participate in the research study that evaluates the contextual factors that affect labour productivity in the South African construction industry. The study aims to understand the degree of impact these contextual factors have on the productivity and also understand the estimation process adopted to determine the expected level of productivity.

Your participation in the study is purely voluntary. At any point in answering of the questionnaire, if you feel like withdrawing your participation, this will not result in any penalty on your part and will not result in any legal implication on your part.

All the answers of this questionnaire will be treated with utmost confidentiality and will not be shared with any third party. The result analysis of the responses will be done in an aggregate form. This is to ensure that no individual response may be traced to anyone as anonymity is paramount to the protection of your identity.

Furthermore, any personal information provided during the study will be kept confidential and will not be included in the reporting of the results.

If you have any questions, queries or need further information regarding this study, please do not hesitate to contact the researcher on the following contact details.

Mochelo Mackson Lefoka
University of Cape Town (UCT)
Level 5, Snape Building – Office 5.16
021 650 1416
Lfkmoc001@myuct.ac.za

APPENDIX C – Research Questionnaire

LABOUR PRODUCTIVITY IN CONSTRUCTION INDUSTRY RESEARCH QUESTIONNAIRE

The objective of this research is to examine and understand the contextual factors that affect the productivity of labour in the South African Construction industry. Furthermore, understand how these contextual factors create variances between how labour productivity is estimated to that observed on construction projects.

The research is not in any regard linked to the organisation you work for. The company will not have access to your answers to this questionnaire as all the responses will be treated with utmost confidentiality and not linked to you.

Please complete all the sections of this questionnaire as all the questions are important for this study. At any point when answering this questionnaire, if you feel like withdrawing your participation, this will not result in any penalty on your part.

If you have any questions, queries or need further information regarding this study, please do not hesitate to contact the researcher:

Mochelo Lefoka, University of Cape Town (UCT)
Contact: +27 (0) 21 650 1416
Email: lfkmoc001@myuct.ac.za

This research is conducted and sponsored in part by the National Research Fund (NRF).

Thank you for your participation in this research.

PERSONAL INFORMATION

1 Please indicate your highest academic qualification.

Matric certificate	
BSc/BEng degree/Diploma	
Honours/BTech degree	
MSc/MBA	
PhD	
Other (please specify) ……………………	

2 How many years of experience do you have in the construction industry including previous employment from other construction firms?

Less than 5 years	
Between 6 – 10 years	
Between 11 – 15 years	
Between 16 – 20 years	
More than 20 years	

3 What is your current designation/job description?

Director Cadre	
Contracts Manager	
Project Manager	
Site Agent	
Construction Manager	
Site Engineer	
Construction supervisor	
Quantity Surveyor	
Estimator	
Cost Engineer	
Other (specify) ……………………..	

4 Please list all the professional councils you are registered with.

…………………………………………………………………….

5 What professional qualification do you have?

……………………………………………………………………

6 Please indicate the province in which you are currently working in South Africa.

Mpumalanga	
Limpopo	
Gauteng	
North West	
Free State	
Kwa-Zulu Natal	
Northern Cape	
Eastern Cape	
Western Cape	

7 Please indicate the level of grading your organisation/company currently holds on the Construction Industry Development Board (cidb) Register of Contractors. Please tick all the categories that apply to your relevant grade.

	Grade								
Category	1	2	3	4	5	6	7	8	9
General Building									
Civil Engineering									
Electrical Engineering Works - Building									
Electrical Engineering Works - Infrastructure									
Mechanical Works									
Asphalt									
Lateral Earth Support									
Anodic and electrolytic									

Demolition & Blasting									
Sprinkler System and Fire installation									
Curtain walls and shop fronts									
Landscaping and horticultural specialists									
Lifts, escalators and hoisting machinery									
Specialised foundations									
Road markings and signage									
Structural steelwork and scaffolding									
Timber buildings structure									
Waterproofing specialists									
Wet services and plumbing									
Fencing and Hoarding specialists									

LABOUR ESTIMATION AND DETERMINATION OF PERFORMANCE STANDARD

Identify a construction project that has been completed by your company, which you are very conversant with and on which you played a major role. Kindly use the context of that project in answering the following questions.

8 Please identify the type of project.

Building	
Roads	
Other infrastructure (please specify) ……………………………………………………	

9 What was the initial value (in rands) of the tender amount on the completed project?

……………………………………

10 What was the final value (in rands) of the tender amount on the completed project?

…………………………………..

11 What was the estimated completion time (in months) of the project?

……………………………………

12 What was the final completion time (in months) of the project?

……………………………………

13 Kindly indicate the standard production target for labour productivity on site used by your company for the following labour-intensive trades when tendering for projects.

Cubes of concrete batched on site (e.g. $4m^3$/hour)	
Number of bricks laid per day (e.g. 800 stock bricks per day)	
Square meter of plaster applied per day (e.g. $10m^2$/day for internal walls)	

14 Kindly indicate the average production targets achieved on site for the following labour-intensive trades during project execution.

Cubes of concrete batched on site (e.g. $4m^3$/hour)	
Number of bricks laid per day (e.g. 800 stock bricks per day)	
Square meter of plaster applied per day (e.g. $10m^2$/day for internal walls)	

15 If none of the options specified in Question 13 apply to your organisation, please state how you determine the productivity of labour on the **concrete**, **masonry** and **plastering** trade in your organisation.

………………………………………………..

16 Which of the following methods do you use in establishing and estimating the productivity of labour with respect to expected output when determining productivity of labour on the **concrete trade**?

	Never	Rarely	Sometimes	Often	Always
Time-study					
Work-Sampling					
Activity Sampling					
Labour performance output rates					
Experience from previous projects					
If other (please specify) …………………………………………..					

17 Which of the following methods do you use in establishing and estimating the productivity of labour with respect to expected output when determining productivity of labour on the **masonry trade**?

	Never	Rarely	Sometimes	Often	Always
Time-study					
Work-Sampling					
Activity Sampling					
Labour performance output rates					
Experience from previous projects					
If other (please specify) …………………………………………..					

18 Which of the following methods do you use in establishing and estimating the productivity of labour with respect to expected output when determining productivity of labour on the **plastering trade**?

	Never	Rarely	Sometimes	Often	Always
Time-study					
Work-Sampling					
Activity Sampling					
Labour performance output rates					

Experience from previous projects					
If other (please specify) ………………………………………..					

19 Please rate in order of priority, which of the following factors contributed to the variation in the value (in rand) of the identified project you worked on. Where 1 represent “Not significant”, 2 represent “Slightly significant”, 3 represent “mildly significant”, 4 represent “Very significant” and 5 represent “Extremely significant”.

	1	2	3	4	5
Productivity of labour					
Lack of equipment and tools					
Material availability					
Project complexity					
Inadequate information from professionals.					

20 Please rate in order of priority, which of the following factors contributed to the variation in the time period (in months) of the identified project you worked on. Where 1 represent “Not significant”, 2 represent “Slightly significant”, 3 represent “mildly significant”, 4 represent “Very significant” and 5 represent “Extremely significant”.

	1	2	3	4	5
Productivity of labour					
Lack of equipment and tools					
Material availability					
Project complexity					
Inadequate information from professionals.					

LABOUR PRODUCTIVITY ON CONSTRUCTION PROJECTS

SITE ENVIRONMENT

21 According to your experience on the identified construction project, please indicate the level of impact of the following factors on labour productivity during the execution of the construction project. (where 1 = Very low; 2 = Low; 3 = Undecided; 4 = High; 5 = Very High)

	1	2	3	4	5
Inclement weather (rain/cold/heat)					
Unexpected site ground Conditions					
Site location/environment					
Lack of experience amongst workers					
Delays in delivery of material					

Working overtime					
Poor Site supervision					
Lack of tools and equipment					
Mismanagement of resources on site					
Rework due to poor quality					

22 Please mention any other site environment factors not listed above in "Question 21" that affected the productivity of labour during the execution stage according to your experience and the identified project you worked on.

…………………………………………………………….

ORGANISATIONAL/CONSTRUCTION FIRM FACTORS

23 According to your experience on the identified construction project, please indicate the level of impact of the following factors on labour productivity during the execution of the construction project. (where 1 = Very low; 2 = Low; 3 = Undecided; 4 = High; 5 =Very High)

	1	**2**	**3**	**4**	**5**
Non-payment of labour					
Delays in payment of labour					
Fluctuations in material/equipment prices					
Changes in management structure					
Shortage of labour/manpower					
Inexperienced supervisors					
Change in government legislature/policy					
Economic changes (change in VAT, inflation and foreign exchange rates)					

24 Please mention any other organisational/construction firm factors not listed above in "Question 23" that affected the productivity of labour according to your experience and the identified project you worked on.

……………………………………………………………..

TECHNICAL FACTORS

25 According to your experience on the identified construction project, please indicate the level of impact of the following factors on labour productivity during the execution of the construction project. (where 1 = Very low; 2 = Low; 3 = Undecided; 4 = High; 5 = Very High)

	1	**2**	**3**	**4**	**5**
Poorly designed project					
Incomplete drawings					

Methods of construction (prefabrication vs onsite)					
Poor co-ordination/planning of activities					
Complexity of the project					
Buildability of the structure					
Inspection delays from engineers					
Change orders from the designers/consultants					

26 Please mention any other technical factors not listed above in "Question 25" that affected the productivity of labour according to your experience and the identified project you worked on.

…………………………………………………………….

SOCIAL FACTORS

27 According to your experience on the identified construction project, please indicate the level of impact of the following factors on labour productivity during the execution of the construction project. (where 1 = Very low; 2 = Low; 3 = Undecided; 4 = High; 5 =Very High)

	1	**2**	**3**	**4**	**5**
Lack of experience of workers					
Personal problems					
Drug abuse					
Alcohol abuse					
Long commute periods to site					
Relationship between supervisors and labourers					
Labour unrest/rioting					
Uncertain job security					

28 Please mention any other social factors not listed above in "Question 27" above that affected the productivity of labour according to your experience and the identified project you worked on.

…………………………………………………………….

29 How much do you agree with the following statements regarding improvement/encouragement of labour performance on site.

Please tick one answer for each question or statement

	Strongly disagree	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
a. Incentivising labourers improves productivity					

b. Training labourers increases productivity					
c. Motivation is essential to labour productivity					
d. Skilled supervision on site improves labour productivity					
e. Employing new technology on site improves labour productivity					

30 Which of the following do you use to measure labour productivity after the completion of a project? In this question, you may tick more than one block applicable to you.

Total Factor Productivity (TFP)	
Average Labour Productivity (ALP)	
Completion of project within cost	
Completion of project on time	
Other (Specify) …………………………….	

31 Given your responses in "Questions 21", "Question 23", "Question 25" and "Question 27"; do you believe these factors must be taken into consideration when estimating the initial labour productivity expected on a construction project?

Yes	
No	

32 If your answer in Question 27 is "Yes", at what stage of the project cycle should these factors be considered?

Please tick only one applicable block.

Concept/Inception stage	
Design phase of the project	
During construction phase	
Consider their impacts post-construction depending on cost and time delays	

END OF QUESTIONNAIRE

APPENDIX D – Cost Variations Between Projects

Cost variances in building projects

	Respondent number	Initial Value (R)	Final Value (R)	Percentage Difference (red represent cost overrun)
	74	4 000 000	4 000 000	0%
	164	4 000 000	4 000 000	0%
	9	2 300 000	3 400 000	48%
	14	2 300 000	3 400 000	48%
	2	3 500 000	3 600 000	3%
	110	1 800 000	2 100 000	17%
	34	5 000 000	5 500 000	10%
	123	5 000 000	6 000 000	20%
	116	5 000 000	5 000 000	0%
	105	489 670	596 785	22%
	166	400 000	577 000	44%
	15	30 000 000	29 500 000	-2%
	6	6 500 000	7 200 000	11%
	83	6 500 000	7 800 000	20%
	8	3 000 000	3 000 000	0%
	10	3 000 000	3 000 000	0%
	133	3 000 000	3 000 000	0%
	71	3 000 000	3 000 000	0%
	119	55 000 000	62 000 000	13%
	11	1 860 000	2 600 000	40%
Building Project	13	21 000 000	21 000 000	0%
	162	2 400 000	2 400 000	0%
	114	3 800 000	7 800 000	105%
	134	2 590 000	2 720 000	5%
	16	14 000 000	22 000 000	57%
	18	14 000 000	17 000 000	21%
	19	6 800 000	8 200 000	21%
	141	6 800 000	7 600 000	12%
	151	3 049 000	3 049 000	0%
	122	10 000 000	11 000 000	10%
	35	10 000 000	10 000 000	0%
	145	13 000 000	13 500 000	4%
	21	50 000 000	50 000 000	0%
	41	12 000 000	12 200 000	2%
	22	35 000 000	37 800 000	8%
	23	9 000 000	12 000 000	33%
	30	350 000	1 290 000	269%
	156	2 000 000	2 000 000	0%
	57	2 000 000	2 300 000	15%
	31	2 000 000	2 000 000	0%

	32	3 200 000	3 200 000	0%

169	12 000	12 000	0%
36	1 200 000	4 500 000	275%
38	32 000 000	44 000 000	38%
39	150 000 000	150 000 000	0%
137	1 500 000	4 700 729	213%
43	1 500 000	1 500 000	0%
144	1 500 000	1 500 000	0%
45	49 000 000	49 000 000	0%
46	3 400 000	3 400 000	0%
47	7 560 000	8 250 000	9%
49	4 500 000	4 750 000	6%
25	6 000 000	6 000 000	0%
50	11 000 000	11 000 000	0%
103	17085434,00	25061574,00	47%
51	756 627,57	1 068 245,56	41%
53	92 000 000	95 000 000	3%
54	23 000 000	23 000 000	0%

Cost variances in road projects

	Respondent number	Initial Value (R)	Final Value (R)	Percentage Difference (red represent cost overrun)
Road projects	55	4 000 000	3 625 127	-9%
	146	4 000 000	3 000 000	-25%
	61	2 300 000	2 300 000	0%
	64	1 800 000	1 800 000	0%
	132	5 000 000	6 000 000	20%
	68	2 500 000	2 500 000	0%
	70	2 500 000	1 485 000	-41%
	72	2 400 000	2 600 000	8%
	140	81 000 000	81 000 000	0%
	143	188 000	950 000	405%
	100	161 000 000	175 000 000	9%
	75	2 436 000	2 133 000	-12%
	76	1 400 000	1 400 000	0%
	165	4 700 000	4 500 000	-4%
	149	1 350 000	1 350 000	0%
	79	6 000 000	6 000 000	0%
	81	650 000	650 000	0%
	127	500 000	530 000	6%

	86	461 000	461 000	0%
	89	8 000 000	12 000 000	50%
	90	3 590 000	2 800 000	-22%
	92	5 750 000	3 800 000	-34%

Cost variances in infrastructure projects (excluding road projects)

	Respondent number	Initial Value (R)	Final Value (R)	Percentage Difference (red represent cost overrun)
	93	7 000 000	7 500 000	7%
	94	7 000 000	5 000 000	-29%
	107	7 000 000	7 200 000	3%
	95	30 000 000	30 000 000	0%
	153	15 000 000	16 000 000	7%
	174	3 000 000	4 000 000	33%
	96	2 500 000	2 500 000	0%
	97	1 000 000	1 000 000	0%
	99	2 047 000	2 047 000	0%
	101	10 000 000	10 000 000	0%
	108	1 300 000	1 000 000	-23%
	113	9 000 000	11 700 000	30%
	117	9 000 000	10 000 000	11%
	129	1 961 860,70	1 961 860,75	0%
	167	17 000 000	16 200 000	-5%
	125	17 000 000	13 000 000	-24%
Infrastructure projects (excluding road projects)	128	1 500 000	1 500 000	0%
	136	14 687 601	15 153 745	3%
	142	5 700 000	7 000 000	23%
	147	70 000 000	68 000 000	-3%
	176	180 000 000	201 000 000	12%
	148	25 000 000	24 000 000	-4%
	163	34 000 000	59 000 000	74%
	152	34 000 000	42 000 000	24%
	155	7 000 000	7 300 000	4%
	158	7 000 000	4 000 000	-43%
	161	15 000 000	30 000 000	100%
	80	750 000	725 000	-3%
	84	55 000 000	81 000 000	47%
	77	1 906 465	1 906 465	0%
	26	2 800 000	3 000 000	7%
	126	1 300 000,00	1 600 841	23%
	112	12 000 000	12 000 000	0%
	131	4 500 000	4 500 000	0%

	159	1 890 649	2 409 689	27%
	67	43 000 000	43 000 000	0%
	85	1 200 000	1 200 000	0%

APPENDIX E – Time Variations Between Projects

Time variances in building projects

	Respondent number	Initial Time (months)	Final Time (months)	Percentage Difference (red represent time overrun)
	74	4	9	125%
	164	5	6	20%
	9	11	11	0%
	14	6	6	0%
	2	6	8	33%
	110	6	6	0%
	34	12	14	17%
	123	4	4	0%
	116	12	12	0%
	105	4	11	175%
	166	2	4	100%
	15	18	18	0%
	6	9	12	33%
	83	12	14	17%
	8	4	4	0%
	10	3	3	0%
	133	24	24	0%
	71	8	6	-25%
	119	9	12	33%
Building projects	11	18	29	61%
	13	24	24	0%
	162	4	4	0%
	114	4	8	100%
	134	12	8	-33%
	16	14	24	71%
	18	14	12	-14%
	19	14	15	7%
	141	7	5,5	-21%
	151	6	6	0%
	122	3	8	167%
	35	10	6	-40%
	145	12	8	-33%
	21	5	5	0%
	41	11	13	18%
	22	24	22	-8%
	23	12	14	17%
	30	3	9	200%
	156	2	2,5	25%
	57	6	6	0%

31	4	4	0%
32	3	6	100%
169	9	9	0%
36	6	5	-17%
38	12	50	317%
39	18	20	11%
137	4	6	50%
43	6	8	33%
144	4	5	25%
45	24	24	0%
46	9	9	0%
47	6	8,5	42%
49	6	14	133%
25	8	6	-25%
50	10	14	40%
103	17	46	171%
51	6	6	0%
53	15	18	20%
54	12	12	0%

Time variances in road projects

	Respondent number	Initial Time (months)	Final Time (months)	Percentage Difference (red represent time overrun)
Road projects	55	8	8	0%
	146	11	10	-9%
	61	6	6	0%
	64	3	3	0%
	132	4	4	0%
	68	3	4	33%
	70	5	5	0%
	72	6	8	33%
	140	15	22	47%
	143	2	6	200%
	100	20	22	10%
	75	12	6	-50%
	76	2	2	0%
	165	4	4	0%
	149	2	2	0%
	79	6	6	0%
	81	4	2	-50%
	127	6	8	33%
	86	1,5	6	300%
	89	8	11	38%
	90	12	11	-8%
	92	12	12	0%

Time variances in infrastructure projects (excluding road projects)

	Respondent number	Initial Time (months)	Final Time (months)	Percentage Difference (red represent time overrun)
Infrastructure projects (excluding road projects)	93	24	30	25%
	94	6	7	17%
	107	4	3	-25%
	95	18	12	-33%
	153	10	11	10%
	174	3	4	33%
	96	5	2,5	-50%
	97	12	12	0%
	99	3	3	0%
	101	8	8	0%
	108	6	5	-17%
	113	3,5	8	129%
	117	36	40	11%

129	9	9	0%
167	3	3	0%
125	9	8	-11%
128	3	3	0%
136	13	16	23%
142	12	14	17%
147	11	11	0%
176	36	36	0%
148	12	11	-8%
163	18	26	44%
152	18	24	33%
155	6	6	0%
158	6	10	67%
161	6	12	100%
80	2	2	0%
84	30	46	53%
77	6	5	-17%
26	24	24	0%
126	3	2	-33%
112	2	2	0%
131	5	5	0%
159	12	20	67%
67	24	24	0%
85	8	7	-13%

APPENDIX F – Relative Importance Index (RII) Tables

Perception of respondents regarding contextual factors and their impact on labour productivity on building projects

		Low…High impact						
	Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Overall ranking**
1	Delays in delivery of material	6	13	4	15	20	0,703	1
2	Inspection delays from engineers	8	10	8	15	17	0,679	2
3	Change orders from the designers/consultants	8	11	8	12	19	0,679	2
4	Lack of experience amongst workers	5	15	6	19	13	0,669	4
5	Mismanagement of resources on site	9	11	8	12	18	0,666	5
6	Incomplete Drawings	8	13	5	18	14	0,659	6
7	Unexpected site ground conditions	7	12	11	15	13	0,652	7
8	Poorly designed project	9	11	10	13	15	0,648	8
9	Delays in payment of labour	15	8	3	13	19	0,645	9
10	Fluctuations in material/equipment prices	7	15	8	14	14	0,645	9
11	Non-payment of labour	17	5	5	11	20	0,641	11
12	Inclement weather (rain/cold/heat)	6	19	4	16	13	0,638	12
13	Complexity of the project	9	10	14	12	13	0,634	13
14	Relationship between supervisors and labourers	9	13	7	17	12	0,634	13
15	Rework due to poor quality	10	15	6	12	15	0,624	15
16	Poor co-ordination/planning of activities	11	11	7	18	11	0,624	15
17	Site location/environment	6	17	9	18	8	0,617	17
18	Poor site supervision	9	19	3	12	15	0,617	17
19	Labour unrest/rioting	16	9	6	8	19	0,617	17
20	Uncertain job security	13	8	12	11	14	0,617	17
21	Lack of tools and equipment	10	17	5	11	15	0,614	21
22	Inexperienced supervisors	15	10	4	14	15	0,614	21
23	Economic changes (change in VAT, inflation and foreign exchange rates)	11	15	6	11	15	0,614	21
24	Lack of experience of workers	12	13	6	13	14	0,614	21
25	Buildability of the structure	9	13	14	13	9	0,600	25
26	Methods of construction (prefabrication vs onsite)	9	16	10	13	10	0,597	26
27	Shortage of labour/manpower	9	19	5	16	9	0,590	27
28	Change in government legislature/policy	10	18	7	11	12	0,590	27
29	Personal problems	15	11	8	15	9	0,572	29
30	Changes in management structure	14	13	10	12	9	0,562	30
31	Long commute periods to site	15	11	9	17	6	0,559	31
32	Drug abuse	18	15	6	12	7	0,514	32
33	Alcohol abuse	19	17	4	11	7	0,497	33

Perception of respondents regarding contextual factors and their impact on labour productivity on building projects ranked by categories

	Factors	Low…High impact 1	2	3	4	5	RII	Group ranking
Site Environmental Factors	Delays in delivery of material	6	13	4	15	20	0,703	1
	Lack of experience amongst workers	5	15	6	19	13	0,669	2
	Mismanagement of resources on site	9	11	8	12	18	0,666	3
	Unexpected site ground conditions	7	12	11	15	13	0,652	4
	Inclement weather (rain/cold/heat)	6	19	4	16	13	0,638	5
	Rework due to poor quality	10	15	6	12	15	0,624	6
	Site location/environment	6	17	9	18	8	0,617	7
	Poor site supervision	9	19	3	12	15	0,617	7
	Lack of tools and equipment	10	17	5	11	15	0,614	9
Organisational/Construction Factors	Delays in payment of labour	15	8	3	13	19	0,645	1
	Fluctuations in material/equipment prices	7	15	8	14	14	0,645	1
	Non-payment of labour	17	5	5	11	20	0,641	3
	Inexperienced supervisors	15	10	4	14	15	0,614	4
	Economic changes (change in VAT, inflation and foreign exchange rates)	11	15	6	11	15	0,614	4
	Shortage of labour/manpower	9	19	5	16	9	0,590	6
	Change in government legislature/policy	10	18	7	11	12	0,590	6
	Changes in management structure	14	13	10	12	9	0,562	8
Technical Factors	Inspection delays from engineers	8	10	8	15	17	0,679	1
	Change orders from the designers/consultants	8	11	8	12	19	0,679	1
	Incomplete Drawings	8	13	5	18	14	0,659	3
	Poorly designed project	9	11	10	13	15	0,648	4
	Complexity of the project	9	10	14	12	13	0,634	5
	Poor co-ordination/planning of activities	11	11	7	18	11	0,624	6
	Buildability of the structure	9	13	14	13	9	0,600	7
	Methods of construction (prefabrication vs onsite)	9	16	10	13	10	0,597	8
Social Factors	Relationship between supervisors and labourers	9	13	7	17	12	0,634	1
	Labour unrest/rioting	16	9	6	8	19	0,617	2
	Uncertain job security	13	8	12	11	14	0,617	2
	Lack of experience of workers	12	13	6	13	14	0,614	4
	Personal problems	15	11	8	15	9	0,572	5
	Long commute periods to site	15	11	9	17	6	0,559	6
	Drug abuse	18	15	6	12	7	0,514	7
	Alcohol abuse	19	17	4	11	7	0,497	8

Perception of respondents regarding contextual factors and their impact on labour productivity on road project

	Factors	Very low impact…Very high impact 1	2	3	4	RII	Overall Ranking
1	Economic changes (change in VAT, inflation and foreign exchange rates)	3	3	2	5	0,727	1

2	Inclement weather (rain/cold/heat)	2	2	4	9	0,718	2
3	Fluctuations in material/equipment prices	3	2	6	5	0,682	3
4	Poorly designed project	4	4	2	6	0,655	4
5	Unexpected site ground conditions	2	4	6	7	0,645	5
6	Change in government legislature/policy	4	2	4	9	0,645	5
7	Site location/environment	4	3	5	5	0,636	7
8	Labour unrest/rioting	4	5	3	4	0,627	8
9	Delays in payment of labour	5	5	2	3	0,618	9
10	Incomplete Drawings	5	5	2	3	0,618	9
11	Lack of experience amongst workers	3	6	3	7	0,609	11
12	Delays in delivery of material	4	5	4	4	0,609	11
13	Relationship between supervisors and labourers	3	4	5	9	0,609	11
14	Methods of construction (prefabrication vs onsite)	5	3	5	6	0,591	14
15	Lack of experience of workers	5	4	3	7	0,591	14
16	Inspection delays from engineers	6	4	3	4	0,582	16
17	Change orders from the designers/consultants	6	4	3	4	0,582	16
18	Personal problems	4	6	4	5	0,573	18
19	Non-payment of labour	7	5	1	3	0,564	19
20	Inexperienced supervisors	6	5	2	5	0,564	19
21	Poor co-ordination/planning of activities	6	5	1	7	0,564	19
22	Uncertain job security	6	4	3	6	0,564	19
23	Poor site supervision	6	6	2	3	0,555	23
24	Complexity of the project	6	4	3	8	0,545	24
25	Changes in management structure	6	6	2	5	0,536	25
26	Long commute periods to site	6	5	3	6	0,536	25
27	Shortage of labour/manpower	6	6	2	6	0,527	27
28	Lack of tools and equipment	5	9	3	1	0,509	28
29	Mismanagement of resources on site	6	8	2	4	0,491	29
30	Buildability of the structure	8	5	2	5	0,491	29
31	Alcohol abuse	6	8	2	4	0,491	29
32	Rework due to poor quality	10	4	2	1	0,482	32
33	Drug abuse	9	4	3	4	0,473	33

Perception of respondents regarding contextual factors and their impact on labour productivity on road project ranked by categories

		Very low impact…Very high impact						
	Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Group Ranking**
Site Environment Factors	Inclement weather (rain/cold/heat)	2	2	4	9	5	0,718	1
	Unexpected site ground conditions	2	4	6	7	3	0,645	2
	Site location/environment	4	3	5	5	5	0,636	3
	Lack of experience amongst workers	3	6	3	7	3	0,609	4
	Delays in delivery of material	4	5	4	4	5	0,609	4
	Poor site supervision	6	6	2	3	5	0,555	6
	Lack of tools and equipment	5	9	3	1	4	0,509	7
	Mismanagement of resources on site	6	8	2	4	2	0,491	8
	Rework due to poor quality	10	4	2	1	5	0,482	9
Organisationa l/Const	Economic changes (change in VAT, inflation and foreign exchange rates)	3	3	2	5	9	0,727	1

	Fluctuations in material/equipment prices	3	2	6	5	6	0,682	2
	Change in government legislature/policy	4	2	4	9	3	0,645	3
	Delays in payment of labour	5	5	2	3	7	0,618	4
	Non-payment of labour	7	5	1	3	6	0,564	5
	Inexperienced supervisors	6	5	2	5	4	0,564	5
	Changes in management structure	6	6	2	5	3	0,536	7
	Shortage of labour/manpower	6	6	2	6	2	0,527	8
Technical Factors	Poorly designed project	4	4	2	6	6	0,655	1
	Incomplete Drawings	5	5	2	3	7	0,618	2
	Methods of construction (prefabrication vs onsite)	5	3	5	6	3	0,591	3
	Inspection delays from engineers	6	4	3	4	5	0,582	4
	Change orders from the designers/consultants	6	4	3	4	5	0,582	4
	Poor co-ordination/planning of activities	6	5	1	7	3	0,564	6
	Complexity of the project	6	4	3	8	1	0,545	7
	Buildability of the structure	8	5	2	5	2	0,491	8
Social Factors	Labour unrest/rioting	4	5	3	4	6	0,627	1
	Relationship between supervisors and labourers	3	4	5	9	1	0,609	2
	Lack of experience of workers	5	4	3	7	3	0,591	3
	Personal problems	4	6	4	5	3	0,573	4
	Uncertain job security	6	4	3	6	3	0,564	5
	Long commute periods to site	6	5	3	6	2	0,536	6
	Alcohol abuse	6	8	2	4	2	0,491	7
	Drug abuse	9	4	3	4	2	0,473	8

Perception of respondents regarding contextual factors and their impact on labour productivity on infrastructure project (excluding road projects)

		Very low impact…Very high impact						
	Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Overall Ranking**
1	Labour unrest/rioting	4	8	3	14	8	0,676	1
2	Inclement weather (rain/cold/heat)	5	7	3	15	7	0,665	2
3	Buildability of the structure	7	4	6	10	10	0,665	2
4	Unexpected site ground conditions	4	10	5	11	7	0,638	4
5	Lack of experience amongst workers	5	9	5	11	7	0,632	5
6	Change in government legislature/policy	7	5	8	9	8	0,632	5
7	Shortage of labour/manpower	7	7	7	5	11	0,632	5
8	Alcohol abuse	8	6	6	6	11	0,632	5
9	Complexity of the project	6	9	5	8	9	0,627	9
10	Site location/environment	3	13	3	14	4	0,616	10

11	Change orders from the designers/consultants	6	8	7	11	5	0,605	11
12	Inspection delays from engineers	7	8	4	14	4	0,600	12
13	Incomplete Drawings	9	7	7	4	10	0,595	13
14	Long commute periods to site	5	13	2	12	5	0,595	13
15	Inexperienced supervisors	9	6	6	11	5	0,584	15
16	Poorly designed project	8	8	6	9	6	0,584	15
17	Fluctuations in material/equipment prices	13	4	1	12	7	0,578	17
18	Economic changes (change in VAT, inflation and foreign exchange rates)	14	4	2	8	9	0,568	18
19	Drug abuse	9	6	9	8	5	0,568	18
20	Poor site supervision	9	9	4	11	4	0,557	20
21	Changes in management structure	12	6	5	6	8	0,557	20
22	Delays in delivery of material	7	14	4	7	5	0,541	22
23	Relationship between supervisors and labourers	12	6	6	8	5	0,535	23
24	Methods of construction (prefabrication vs onsite)	13	8	2	9	5	0,519	24
25	Rework due to poor quality	13	9	2	7	6	0,514	25
26	Non-payment of labour	10	13	1	9	4	0,514	25
27	Lack of experience of workers	14	5	7	5	6	0,514	25
28	Personal problems	13	8	4	8	4	0,503	28
29	Uncertain job security	12	8	7	6	4	0,503	28
30	Poor co-ordination/planning of activities	14	6	4	11	2	0,497	30
31	Delays in payment of labour	10	12	9	3	3	0,476	31
32	Mismanagement of resources on site	13	13	2	5	4	0,459	32
33	Lack of tools and equipment	16	11	1	7	2	0,427	33

Perception of respondents regarding contextual factors and their impact on labour productivity on infrastructure project (excluding road projects) ranked by categories.

		Very low impact…Very high impact						
	Factors	**1**	**2**	**3**	**4**	**5**	**RII**	**Group Ranking**
Site Environment Factors	Inclement weather (rain/cold/heat)	5	7	3	15	7	0,665	1
	Unexpected site ground conditions	4	10	5	11	7	0,638	2
	Lack of experience amongst workers	5	9	5	11	7	0,632	3
	Site location/environment	3	13	3	14	4	0,616	4
	Poor site supervision	9	9	4	11	4	0,557	5
	Delays in delivery of material	7	14	4	7	5	0,541	6
	Rework due to poor quality	13	9	2	7	6	0,514	7
	Mismanagement of resources on site	13	13	2	5	4	0,459	8
	Lack of tools and equipment	16	11	1	7	2	0,427	9
Organisational	Change in government legislature/policy	7	5	8	9	8	0,632	1

	Shortage of labour/manpower	7	7	7	5	11	0,632	1
	Inexperienced supervisors	9	6	6	11	5	0,584	3
	Fluctuations in material/equipment prices	13	4	1	12	7	0,578	4
	Economic changes (change in VAT, inflation and foreign exchange rates)	14	4	2	8	9	0,568	5
	Changes in management structure	12	6	5	6	8	0,557	6
	Non-payment of labour	10	13	1	9	4	0,514	7
	Delays in payment of labour	10	12	9	3	3	0,476	8
Technical Factors	Buildability of the structure	7	4	6	10	10	0,665	1
	Complexity of the project	6	9	5	8	9	0,627	2
	Change orders from the designers/consultants	6	8	7	11	5	0,605	3
	Inspection delays from engineers	7	8	4	14	4	0,600	4
	Incomplete Drawings	9	7	7	4	10	0,595	5
	Poorly designed project	8	8	6	9	6	0,584	6
	Methods of construction (prefabrication vs onsite)	13	8	2	9	5	0,519	7
	Poor co-ordination/planning of activities	14	6	4	11	2	0,497	8
Social Factors	Labour unrest/rioting	4	8	3	14	8	0,676	1
	Alcohol abuse	8	6	6	6	11	0,632	2
	Long commute periods to site	5	13	2	12	5	0,595	3
	Drug abuse	9	6	9	8	5	0,568	4
	Relationship between supervisors and labourers	12	6	6	8	5	0,535	5
	Lack of experience of workers	14	5	7	5	6	0,514	6
	Personal problems	13	8	4	8	4	0,503	7
	Uncertain job security	12	8	7	6	4	0,503	7

APPENDIX G – Kruskal-Wallis Test Results

Test Across Project Type

Null Hypothesis	Test	Sig	Decision
Inclement weather (rain/cold/heat) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.512	Retain the null hypothesis
Unexpected site ground conditions is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.953	Retain the null hypothesis
Site location/environment is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.875	Retain the null hypothesis
Lack of experience amongst workers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.754	Retain the null hypothesis
Delays in delivery of material is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.032	Reject the null hypothesis
Poor site supervision is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.417	Retain the null hypothesis
Lack of tools and equipment is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.065	Retain the null hypothesis
Mismanagement of resources on site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.003	Reject the null hypothesis
Rework due to poor quality is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.089	Retain the null hypothesis

Economic changes (change in VAT, inflation and foreign exchange rate) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.644	Retain the null hypothesis
Fluctuations in material/equipment prices is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.633	Retain the null hypothesis
Change in government legislature/policy is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.796	Retain the null hypothesis
Delays in payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.575	Retain the null hypothesis
Non-payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.345	Retain the null hypothesis
Inexperienced supervisors is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.818	Retain the null hypothesis
Changes in Management structure is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.656	Retain the null hypothesis
Shortage of labour/manpower is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.294	Retain the null hypothesis
Poorly designed projects is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.877	Retain the null hypothesis
Incomplete drawings is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.977	Retain the null hypothesis

Methods of construction (prefabrication vs onsite) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.698	Retain the null hypothesis
Inspection delays from engineers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.707	Retain the null hypothesis
Change orders from the designers/consultants is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.464	Retain the null hypothesis
Poor co-ordination/planning of activities is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.231	Retain the null hypothesis
Complexity of the project is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.559	Retain the null hypothesis
Buildability of the structure is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.445	Retain the null hypothesis
Labour unrest/rioting is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.296	Retain the null hypothesis
Relationship between supervisors and labourers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.906	Retain the null hypothesis
Lack of experience of workers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.824	Retain the null hypothesis
Personal problems is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.990	Retain the null hypothesis
Uncertain job security is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.917	Retain the null hypothesis

Long commute periods to site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.860	Retain the null hypothesis
Alcohol Abuse is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.851	Retain the null hypothesis
Drug Abuse is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.822	Retain the null hypothesis

Test Across Organisation Type

	Null Hypothesis	Test	Sig	Decision
1	Inclement weather (rain/cold/heat) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.120	Retain the null hypothesis
2	Unexpected site ground conditions is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.183	Retain the null hypothesis
3	Site location/environment is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.504	Retain the null hypothesis
4	Lack of experience amongst workers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.665	Retain the null hypothesis
5	Delays in delivery of material is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.034	Reject the null hypothesis
6	Poor site supervision is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.081	Retain the null hypothesis
7	Lack of tools and equipment is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.309	Retain the null hypothesis
8	Mismanagement of resources on site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.139	Retain the null hypothesis

9	Rework due to poor quality is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.033	Reject the null hypothesis
10	Economic changes (change in VAT, inflation and foreign exchange rate) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.058	Retain the null hypothesis
11	Fluctuations in material/equipment prices is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.049	Reject the null hypothesis
12	Change in government legislature/policy is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.434	Retain the null hypothesis
13	Delays in payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.005	Reject the null hypothesis
14	Non-payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.330	Retain the null hypothesis
15	Inexperienced supervisors is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.573	Retain the null hypothesis
16	Changes in Management structure is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.712	Retain the null hypothesis
17	Shortage of labour/manpower is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.846	Retain the null hypothesis

18	Poorly designed projects is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.499	Retain the null hypothesis
19	Incomplete drawings is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.363	Retain the null hypothesis
20	Methods of construction (prefabrication vs onsite) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.260	Retain the null hypothesis
21	Inspection delays from engineers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.195	Retain the null hypothesis
22	Change orders from the designers/consultants is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.686	Retain the null hypothesis
23	Poor co-ordination/planning of activities is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.358	Retain the null hypothesis
24	Complexity of the project is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.052	Retain the null hypothesis
25	Buildability of the structure is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.058	Retain the null hypothesis
26	Labour unrest/rioting is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.611	Retain the null hypothesis

27	Relationship between supervisors and labourers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.667	Retain the null hypothesis
28	Lack of experience of workers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.565	Retain the null hypothesis
29	Personal problems is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.333	Retain the null hypothesis
30	Uncertain job security is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.043	Reject the null hypothesis
31	Long commute periods to site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.538	Retain the null hypothesis
32	Alcohol Abuse is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.562	Retain the null hypothesis
33	Drug Abuse is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.523	Retain the null hypothesis

Test Across location Type

	Null Hypothesis	Test	Sig	Decision
1	Inclement weather (rain/cold/heat) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.789	Retain the null hypothesis
2	Unexpected site ground conditions is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.217	Retain the null hypothesis
3	Site location/environment is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.732	Retain the null hypothesis
4	Lack of experience amongst workers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.374	Retain the null hypothesis
5	Delays in delivery of material is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.874	Retain the null hypothesis

6	Poor site supervision is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.418	Retain the null hypothesis
7	Lack of tools and equipment is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.304	Retain the null hypothesis
8	Mismanagement of resources on site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.148	Retain the null hypothesis
9	Rework due to poor quality is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.260	Retain the null hypothesis
10	Economic changes (change in VAT, inflation and foreign exchange rate) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.827	Retain the null hypothesis
11	Fluctuations in material/equipment prices is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.748	Retain the null hypothesis
12	Change in government legislature/policy is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.372	Retain the null hypothesis
13	Delays in payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.402	Retain the null hypothesis
14	Non-payment of labour is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.795	Retain the null hypothesis
15	Inexperienced supervisors is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.519	Retain the null hypothesis
16	Changes in Management structure is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.129	Retain the null hypothesis
17	Shortage of labour/manpower is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.307	Retain the null hypothesis
18	Poorly designed projects is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.570	Retain the null hypothesis
19	Incomplete drawings is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.239	Retain the null hypothesis
20	Methods of construction (prefabrication vs onsite) is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.832	Retain the null hypothesis
21	Inspection delays from engineers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.385	Retain the null hypothesis
22	Change orders from the designers/consultants is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.200	Retain the null hypothesis
23	Poor co-ordination/planning of activities is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.146	Retain the null hypothesis
24	Complexity of the project is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.221	Retain the null hypothesis
25	Buildability of the structure is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.246	Retain the null hypothesis

26	Labour unrest/rioting is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.990	Retain the null hypothesis
27	Relationship between supervisors and labourers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.620	Retain the null hypothesis
28	Lack of experience of workers is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.467	Retain the null hypothesis
29	Personal problems is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.475	Retain the null hypothesis
30	Uncertain job security is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.255	Retain the null hypothesis
31	Long commute periods to site is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.649	Retain the null hypothesis
32	Alcohol Abuse is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.922	Retain the null hypothesis
33	Drug Abuse is the same across category of project types	Independent-Samples Kruskal Wallis Test	0.508	Retain the null hypothesis