DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

A COMPARATIVE STUDY OF THE CONSTRUCTION OF ROAD FORMATION LAYERS USING LABOUR-INTENSIVE VERSUS TRADITIONAL MECHANISTIC METHODS ON ROAD 1264 IN KZN

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Submitted in fulfilment of the requirements for the degree of

MASTER OF ENGINEERING: Civil Engineering

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Date: 21 June 2022

DECLARATION

I hereby declare that the study entitled: **A comparative study of the construction of road formation layers using labour-intensive versus traditional mechanistic methods on road D1264 in KZN** is my work and all the sources that I used or quoted are indicated and acknowledged by means of references.

This research study compiled by Mongezi S. Mkhize (student number: 20301605) is being submitted to the Durban University of Technology (DUT), Civil Engineering Faculty for the degree of Master Engineering (MEng): Civil

I, **Mongezi S. Mkhize,** further declare that I have not previously submitted this work, or part of it, for any degree and any qualification purpose to DUT or any other Institution.

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DEDICATION

This research study is dedicated to my Lord Jehovah and Saviour Jesus Christ, my wife Londeka Mkhize,my children Asembo, Velembo and Athandwa,my parents and the rest of my family who have supported me.

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I am forever thankful to my Lord Jehovah and Saviour Jesus Christ for blessing me with the opportunity to complete this study research. Thank you.

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To my supervisors, Mr Tom Mckune and Professor Mark Walker, thank you for your patience, advice and support: I am very grateful for your help.

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ABSTRACT

The urgent need to upgrade and construct roads in South Africa is one of the many critical utility provision challenges faced by the municipalities, consultants and departments involved in road construction. The biggest challenge that is faced by the government is to minimise unemployment and increase skills transfer through the training of inexperienced local communities on road construction. The road can be constructed using traditional mechanistic methods (TMM), commonly known as plant machines, which makes more use of plant machine than labour. On the other hand, the road can also be constructed using the labour-intensive construction (LIC) method which utilises more labour involvement during construction and minimal machine usage.

The purpose of this research is to provide insight into the time and cost comparison between LIC and TMM of constructing road formation layers. Road D1264 in Bergville, KwaZulu-Natal will be used as a case study in the research to compare the difference between labour-intensive and traditional mechanistic construction of road formation layers, using cost and time to reach the same quality. This research aims to promote the use of LIC roadbed construction to be used more frequently in the road construction industry in South Africa. The Expanded Public Works Programme (EPWP) encourages road construction to be undertaken using labour- intensive methods to allow unemployed people to be given more job opportunities.

Municipalities, consultants and departments involved with road construction will be assisted through this research in making informed decisions and selections thereafter of the most reliable road formation construction method in terms of time and cost. Available cost, time and quality data from the Road D1264 will be used to compare the construction of road formation layers using LIC versus TMM in KZN. The decision making process will lie in the hands of the municipalities and consultants based on the cost and time required to complete the project.

Furthermore, a quantitative survey questionnaire was developed by the researcher. This questionnaire was aimed at the road construction technical experts in the Department of Transport, Department of Works, consultants and the roads

departments of districts and local municipalities. The results of the survey questionnaires revealed that the road construction experts agree with the finding of this study that LIC is more expensive when compared to TMM. LIC is also more time-consuming than TMM. LIC and TMM produce the same quality. The survey questionnaire revealed that South Africa may be advancing over the years in the use of LIC methods; however, more education in the form of training, seminars and other methds of marketing must be undertaken, starting at the universities, municipal level, the Department of Transport, Department of Works, and consultants.

The comparative research in this study using the available data from Road D1264 revealed that during the construction of the road formation layers, using LIC is more expensive when compared to TMM. LIC is also more time-consuming than TMM. LIC and TMM produce the same quality. But it cannot be ignored that LIC creates employment particularly for women, youth and the disabled within the community. LIC maximises the use of local materials and plant owners as suppliers of goods and services. LIC can be the country’s solution to unemployment and porvety.

ABBREVIATIONS

AASHTO – American Association of State Highway and Transportation Officials

EPWP – Expanded Public Works Programme

km – Kilometres

KZN – KwaZulu-Natal province

LIC – Labour-Intensive Construction

MOD – Modified

SA – South Africa

TMM – Traditional Mechanistic Methods

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CHAPTER ONE: INTRODUCTION

1.1. Background

Throughout the world, labour- intensive construction (LIC) is used as a method of employment creation and poverty relief. South Africa has seen this used before, but it is only in the past few years that it has been considered again in a serious light. The commonly held view amongst engineers is that machinery is more efficient than labour. It transpires that this is not so, and the comparison must be made for different construction activities (Little, 1990: 15). In this research, the comparison will be made between the constructions of road formation layers using labour- intensive versus mechanistic methods in KZN.

The labour-intensive projects are awarded to unskilled contractors, and they are required to produce sustainable projects. The unskilled contractors are still in the process of learning and building skills. One major influence that labour-intensive projects will have is the use of manual or people labour rather than machine work, to create work for the unemployed. This can make a sustainable difference in the time frame of a project (Coetzer, 2010:6, 14).

Furthermore, labour-intensive methods involve the use of an appropriate mix of labour and capital equipment in construction of infrastructure, with a preference for labour where technically and economically feasible, while maintaining established quality standards (Mason, 1997:9). Preference is commonly made for the use of light construction equipment for such work activities that cannot be replaced by labour.

International and local experience show that, with well-trained site supervisory staff and an appropriate employment framework, labour-intensive methods can be successfully applied to certain types of infrastructure works without increasing the cost or compromising quality (Asare, 2013: 1-2). LIC is the use of labour-intensive methods to provide opportunities to local unemployed people, providing training and skills development to those locally employed workers (Guidelines for the implementation of labour-intensive infrastructure projects under the Expanded Public Works EPWP, 2005: 1).

1.1.1. Traditional Mechanistic Methods

According to Rehnberg (2011:1), traditional mechanistic methods in construction is the use of plant machines during construction. Construction machines, also referred to as engineering vehicles or earth movers, are used in a variety of tasks related to infrastructure development and material handling. Since the origin of the first construction machines in the 19th century, they have been crucial for the development of modern infrastructure. It is the combination of different types of plant machines during construction to complete a construction activity within the required time, cost and quality under proper supervision.

1.1.2. Labour-Intensive Construction

LIC is part of the EPWP programme. The Expanded Public Works (EPWP) is one of the government's short- to medium-term programmes aimed at alleviating and reducing unemployment (Guidelines for the implementation of labour-intensive infrastructure projects under the Expanded Public works EPWP. 2005: i).The EPWP will achieve this aim through the provision of work opportunities coupled with training.

Labour-intensive work methods involve the use of innovative approaches to execute projects or manufacture products to maximise employment and also transfer skills to the target worker groups without compromising the quality of the final asset or product.

In infrastructure projects, this is achieved by substituting machines with manual labour when carrying certain work activities while still maintaining the quality of works and cost competitiveness.

The following photos were taken by the researcher during the Road D1264 formation construction in 2013.

Figure 1. 1. Excavation using LIC during the formation construction on Road D1264 in 2013

Figure 1. 2. Clearing and grabbing using LIC during the formation construction on Road D1264 in 2013

Figure 1. 3. Cutting of levels using LIC during the formation construction on Road D1264 in 2013

Figure 1. 4. Widening of the existing road using LIC during the formation construction on Road D1264 in 2013

LIC addresses the high rate of poverty and unemployment (Fransen, Scot & Esch, 2002:6). LIC promotes skills development. The formation layer can be constructed using either LIC or the TMM (Johannessen, 1997:3). LIC promotes the employment

creation for people in rural communities. LIC provides job opportunities for women and youth. Thus, improves social security protection to vulnerable groups. Skills transfer to workers (essential for routine road maintenance by labour). LIC mitigates rural urban migration. LIC promotes local economic development and livelihoods, especially in rural road low-income urban areas where economic activities are limited (Asare, 2013:2-1).

1.2. Problem Statement

The poor employment rate in the road construction industry results from the use of plant machines instead of local labour, and this increases the poverty rate and decreases the employment rate (Johannessen, 1997:3). During TMM road construction the total cost profit is benefitted by one main contractor. In LIC the total cost profit is spent on the local labour. This reduces poverty and increases the employment rate (Tajgman & Veen, 1998:3)

LIC produces the same quality versus TMM during the road formation construction. The difference is between time and cost when comparing the two road formation construction methods (Tajgman & Veen, 1998:12). As a result, the government can which method to use during road construction. This research assists by comparing the cost and time during the road formation construction. However, the government can adopt the LIC method to eliminate the high poverty rate that is faced by the country. Hence this study promotes the utilisation of LIC during road formation construction to increase the high employment rate and reduce poverty.

1.3. Research Aim

This research aims to provide insight into the time and cost comparison between labour-intensive construction (LIC) and traditional mechanistic methods (TMM) of constructing road formation layers. Road D1264 in Bergville KwaZulu-Natal was used as a case study in the research to compare the difference between labour-intensive and traditional mechanistic construction of road formation layers, using cost and time to reach the same quality.

1.4. Specific Objectives

This research study serves as a technical support tool during the decision-making process of municipalities and consultants when selecting the construction methods to be used during the construction of the road formation layers between LIC and TMM.

a) Research focuses on cost and time comparison to achieve the same quality on this section using the two alternative construction techniques, LIC and TMM.
b) To compare the density test results obtained from Shenge Soil Laboratory and ensuring the finishing is per the required specification to validate the quality between LIC and TMM formation layers.
c) To identify the circumstances under which LIC methods may be the cheaper option as opposed to the TMM.
d) To promote the use of LIC during road construction.

1.5. Research Hypothesis

It is assumed that the formation layers constructed by the traditional method produces good results in terms of quality, strength and durability compared to a labour-intensive constructed formation layers; however, this is not so. The analysis of the test results obtained from the density test results and finishing obtained from the traditional method and LIC-constructed formation layers will show that the LIC can produce the same quality as the traditional method. This reasarch will show that LIC produces the same quality as TTM during road formation construction.The research will also show that LIC is more cost saving compared to TTM during road formation construction.

1.6. Study Area

The project D1264 is run by the Department of Transport. Road D1264 is situated in the Amazizi Tribal Authority in the foothills of Drakensberg, approximately 40km north-west of Bergville KZN. The road is situated in KZ 235. Okhahlamba Local Municipality that forms part of Uthukela District Municipality. The road is situated in Bergville Road Transport Forum, run by the Bergville Area Office which forms part of the Cost Centre Estcourt, which in turn is part of the Regional Office Ladysmith. This road is 7.2 km long. An investigation was done between 5.9 to 6.5 km to compare the difference between labour-intensive and traditional mechanistic construction of road formation layers, using cost and time to reach the same quality**.**

Chainages from 5.9 to 6.2 km formation were constructed using plant machines. Chainages from 6.2 to 6.5 km formation were constructed using labour-intensive construction methods. The setting out at 6.2 to 6.5 km was achieved by using LIC methods. The setting out at 5.9 to 6.2 kmwas achieved using a professional surveyor. In this research, all the setting out methods are discussed.

Figure 1. 5. Road D1264 Locality Map (Google Earth Pro, 2019)

0km – 1.8 km	**: Road formation with side drains – 93 % Mod Asshto**
Slurry surfacing	: 2 x 150mm layers of G7 – 95% Mod Asshto
	: 1 x 150mm layer of G4 base – 98% Mod Asshto
	: Slurry Surfacing
1.8km – 3.6km	: Road formation with side drains – 93% Mod Asshto
Concrete Surfacing	: 1 x 150mm layer of lime stabilised C3 Base – 95% Mod Asshto : 50mm ultra-thin reinforced concrete pavement
3.6km – 7.2 km	: Road formation with side drains – 93 % Mod Asshto
Slurry surfacing	: 2 x 150mm layers of G7 – 95% Mod Asshto
	: 1 x 150mm layer of G4 base – 98% Mod Asshto
	: Slurry Surfacing

Figure 1. 6. Road D1264 specification from km 0.00 to km 7.200 (Nankhoo, 2011)

0km - 1.8km 3.6km – 7.2km Slurry surfacing	Road formation with side drains 2 x 150mm layers of G7 selected layers 1 x 150mm layer of G4 base Prime Slurry surfacing

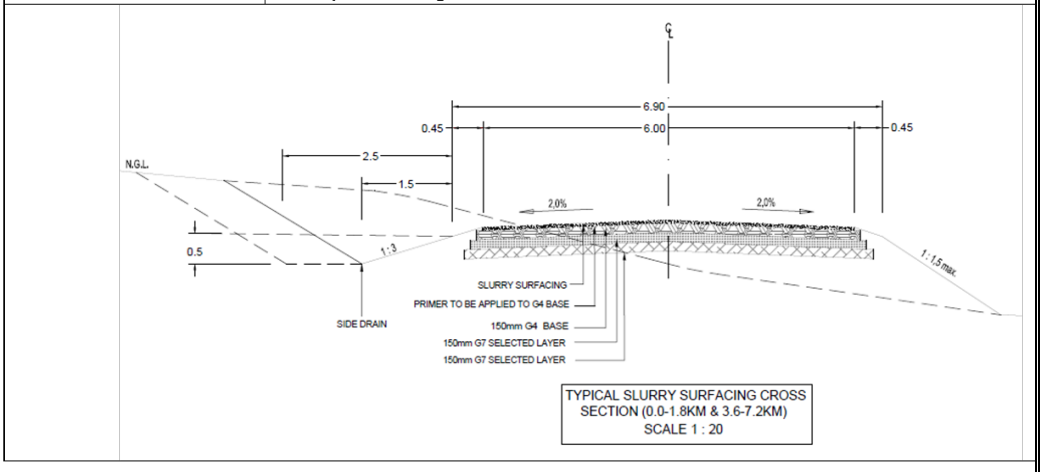


Figure 1. 7. Road D1264 km 0.00 to km 1.800 cross section (Nankhoo, 2011)

Road section	Specification
1.8km – 3.6km Concrete surfacing	Road formation with side drains 1 x 150mm layer of lime stabilised C3 base 50mm Ultra Thin Reinforced Concrete Pavement

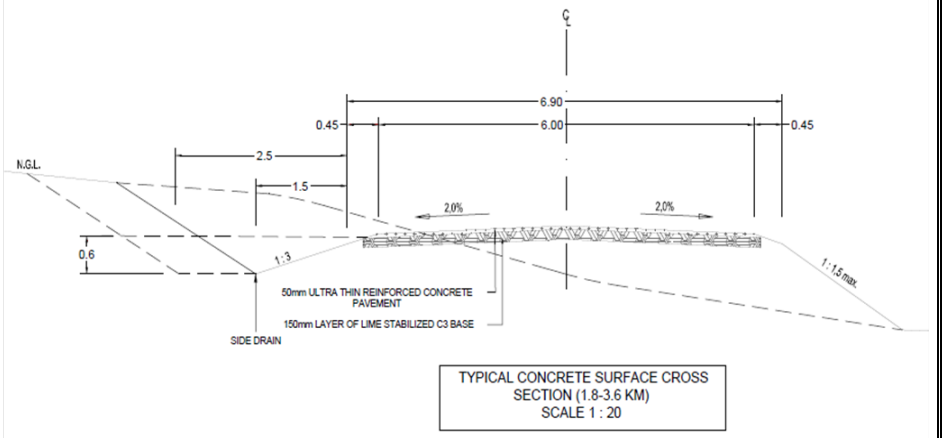


Figure 1. 8. Road D1264 km 1.800 to km3.600 cross section (Nankhoo, 2011)

1.7 Significance of the Study

The significance of the study is to compare a concise application merits and drawbacks by reviewing existing international and local literature, including technical information for the following methods:

i. LIC construction of road formation layers.
ii. Traditional mechanistic method construction of road formation layers.

This research aims for LIC to be used more frequently in the road construction industry in South Africa. Synthesising available international and local published literature will expand knowledge in the broad field of road formation constructing methods. The EPWP will be encouraged to allow road construction to be undertaken using labour-intensive methods to allow unemployed people to be given more job opportunities. Making informed decisions and selections thereafter of the most reliable road formation construction method in terms of time and cost.

1.8. Outline of the Dissertation

The remainder of this dissertation is organized as follows:

Chapter 2: This chapter presents the literature review on LIC, TMM, formation layer, EPWP, cost, time and quality

Chapter 3: Methodology, methods of data collection and analyses used as well as the reasons for their selection is discussed in this chapter

Chapter 4: Results and discussions, this chapter is a presentation and analysis of results of data collected. The data are discussed and interpreted.

Chapter 5: Validation study on the findings of the results from chapter 4.

Chapter 6: This chapter contains conclusions and recommendations based on the limitations.

CHAPTER TWO: REVIEW OF CONSTRUCTION PRACTICE FOR ROAD FORMATION LAYERS

2.1. Road Formation Layers

The urgent need for the road formation layers to be constructed using labour-intensive construction methods is very crucial in the construction industry (Asare 2013:5-2). The formation layer is the most crucial layer in the construction of a road. It comprises in-situ material, often with some imported soil or gravel added to make up the level. The top of earthworks is compacted to the required specification of 90% and 93% Mod ASSHTO. This is done to ensure that the earth, on which the road pavement is to constructed, is uniform in both shape and density (Colto, 1998:3300 - 1).

Failures of the upper selected layers are likely if the formation earth works are not properly constructed, compacted and tested. The formation layer is designed FORMATION gh the pavement layers that are placed above it. This layer can be constructed using either the labour-intensive construction or the traditional method or plant machines. Durability and density test results will be compared between the results obtained from the labour-intensive and traditional method constructed road layer sections. Traditional mechanistic method is the using of plant machines during construction.

According to Jenkins (1999:1), the performance of any road is strongly dependent on the foundation or formation layer quality. Road pavements are no exceptions, and their foundations need to be fundamentally modelled using sound civil engineering principles. Thus, it is very important to have sufficient information about the formation layer, which is obtained through investigation and accumulation of test results. In this way, the risks regarding the formation layer can be estimated. Variation in the formation layer below the pavement cannot be prevented, so it is important not to overload the formation at any place. The primary structural task of the pavement is to prevent too high stresses in the formation layer (Jenkins, 1999:1). The formation layer is the ground below the road layers, which is exposed once the ground has been dug out ready to build the road.

Figure 2.1 and Figure 2.2. show the formation layer and other road layers.

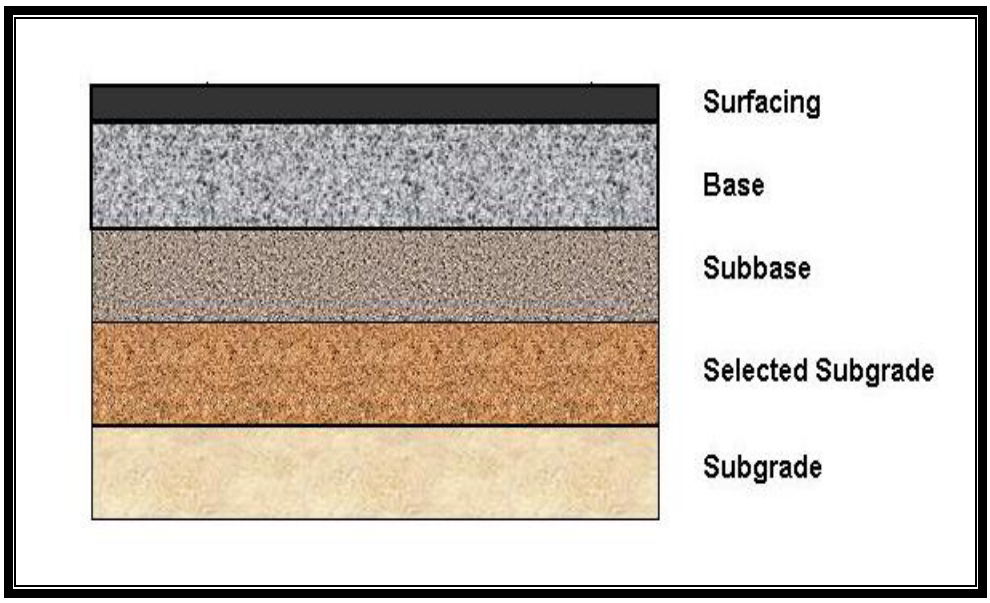


Figure 2. 1. Road cross-section showing road layers (SANRAL,2014)

1. Figure 2. 2. Road cross-section showing road layers (SANRAL,2014)

An acceptable formation level will be free of any soft spots, reasonably parallel to the plane of construction. In road construction, it is a usual practice to reduce and dig to remove all surface vegetation and top soil, and establish formation level upon a compacted layer, bedrock or sub-soil. It must be constructed at high quality. The formation layer must be compacted to the required Mod ASSHTO density of 93% (Johannessen, 1997:106).

Furthermore, the formation layer must be well compacted with different roller types or hand stampers together with water to minimise the air voids between the soil particles. Compaction increases the bearing capacity of the soil. Compaction reduces soil settlement and increases the shearing strength (Tembo and Blokhuis, 2001:172)

The following types of compaction equipment are used to reach the required 93% Mod Asshto on the formation layer construction:

Figure 2. 3. Various compaction rollers (Suryakanta, 2014)

Figure 2. 4. Water cart and smooth roller during Road D1264 road construction in 2014

2.2. Methods of Constructing the Road Formation Layers

This layer can be constructed using both the labour-intensive construction and the traditional mechanistic method or plant machines.

2.2.1. Traditional mechanistic method of road formation construction

The most elementary task for a construction machine is earthmoving, hauling, excavating and cutting of levels. Various machines are used during the construction of the formation layers. The road grader is used for ripping and cutting of the soil material. The tipping trucks are used for soil hauling. The compaction rollers are used for compaction purposes. The water cart is used during compaction, spraying water during the process (Rehnberg, 2011:1). A surveyor is used to set out levels. A registered soil laboratory is then selected to check the quality by conducting density tests using a Troxler or nuclear density machine (Amsterdam, 2000:85).

According to Johannessen (1998:116), proper equipment is essential for the efficiency of any civil work site. The correct construction machine plays an essential role in achieving timely and good quality results. For every construction activity, there is an optimal combination of tools, equipment and labour. Depending on the nature and content of the work, the technical staff needs to know which tools to use and how effectively to combine these with manual labour. Once on site, equipment requires trained operators and supervisory staff who are proficient in its operations and maintenance. Faulty equipment is a common reason for delays on construction sites. The project manager must ensure that all equipment is maintained in good condition and are readily available (Johannessen, 1998:116).

2.2.2. Major concerns when choosing the appropriate type of equipment for road formation construction

The following statements are the disadvantages of using plant machines during TMM: The availability in the region or vicinity to the work site;how to deliver it to the site;finding a properly trained operator with knowledge of operating the machine; cost and reliability; availability of mechanics, spare parts and repair facilities; finding safe and secure camps for parking after work (Rijn 2005:28). Figures 2.6 and 2.7 show the plant machines and equipment used during TMM road formation layer construction.

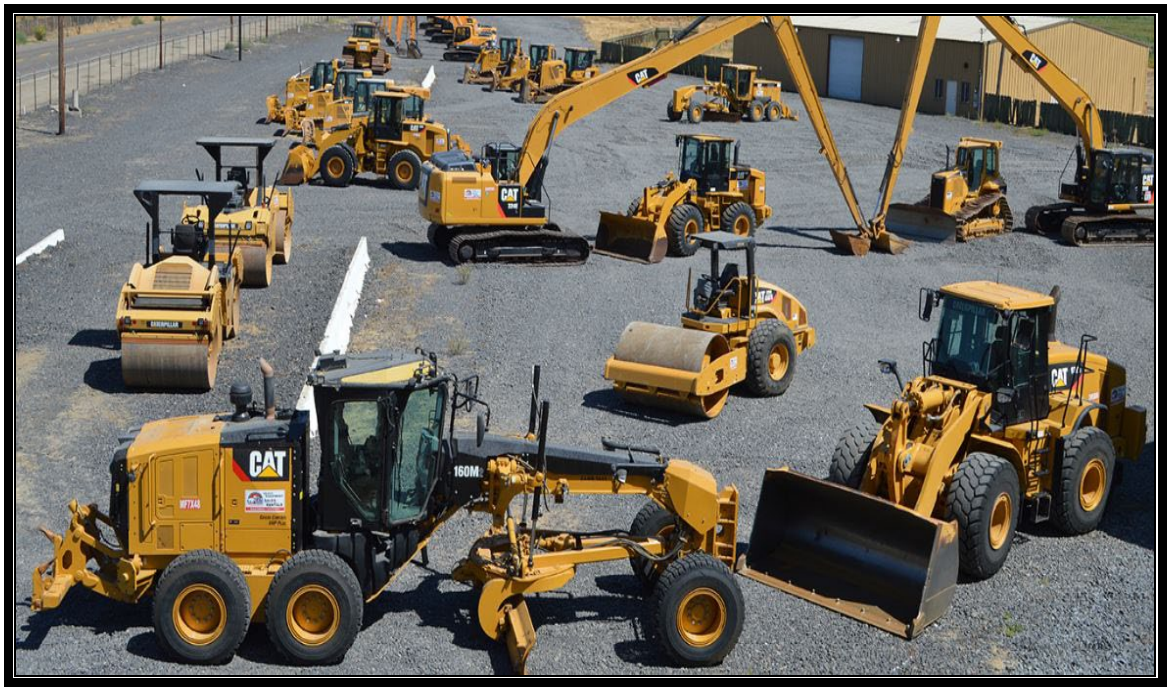


Figure 2. 5. Various types of plant machine used during TMM road formation construction (Anupoju, 2016)

Figure 2. 6. Various types of surveying equipment used during TMM road formation construction (Elementary, topics, surveying, uncategorised:2019)

Figure 2. 7. A TMM completed section on road D1264 formation layer

2.3. Labour-Intensive Construction of Road Formation Layers

Labour-intensive construction can be defined as the construction technology which uses labour instead of traditional machines to execute civil engineering construction activities while maintaining cost competitiveness and acceptable engineering quality standards. LIC maximises the opportunities for employment of labour (skilled and unskilled) together with the support of light equipment and with the utilisation of locally available materials and resources (Johannessen, 1998:1).

According to Rijn (2005:5), when considering the use of labour-based technology in road works projects, it is important to acknowledge its limitations. In some circumstances, traditional equipment-based work methods are more effective and may provide higher quality outputs, such as large excavation works, rock excavation and haulage of materials over long distances. Labour-intensive construction was suitable for the construction of the Road D1264 formation layer. Most of the works are carried out using local labour, and only those activities that labour cannot manage is done using intermediate equipment, such as graders with rollers, tippers, pedestrian rollers, etc.

The result of the labour is expected to be of high quality as stipulated in the contract specifications. To achieve this, and to be able to carry out the work within the given

time frame, good site management and a structured work approach is required from the contractors. The most demanding task is to manage a large, mainly unskilled labour force (Johannessen, 1998:1). According to Asare (2013:1), labour-intensive construction basically involves the use of innovative approaches to execute projects or manufacture products to maximise employment and also transfer skills to the target worker groups without compromising the quality of the final asset or product. This is achieved by substituting machines with manual labour when carrying out certain work activities while still maintaining the quality of works and competitiveness.

According to Amsterdam (2000:259), South Africa is a blend of a developed, developing and undeveloped country, with a range of cultural societies all affected by unemployment and poverty. There is, therefore, a need to create employment opportunities and developing the road construction skills of the people by using labour-intensive construction as an employment tool. LIC is not a new concept. In the early 1970s, a programme of work to explore the increased use of labour in construction was initiated, specifically in road construction. LIC has been successfully implemented in other countries such as Kenya, Nigeria, Zambia, Botswana, Lesotho and Mozambique. It is important that, when seeking labour, the community leaders within a rural environment are approached first for their involvement and commitment. LIC workers are paid on a daily task basis (Tajgman and De Veen 1998:201).

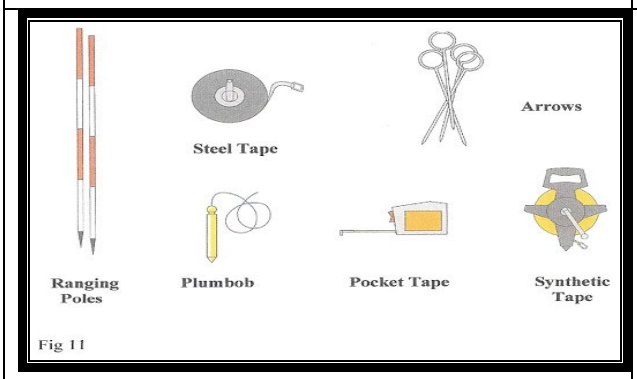
In South Africa, LIC has been applied to the roads and transportation fields because roads form an integral part of our lives and provide means of safe and economic transporting of goods and people for various purposes. Although labour-intensive construction is not the answer to all the country's unemployment problems. LIC presents an opportunity to alleviate poverty and unemployment, LIC increases road construction skills and trains emerging contractors. Certain areas of road construction are better suited for labour-intensive construction, for instance the formation layer is suited for LIC construction (Amsterdam, 2000:259).

According to Johannessen (1998:117), when applying labour-intensive construction methods, the use of hand tools supported with selected items of light equipment can produce results comparable with those achieved when using traditional mechanistic

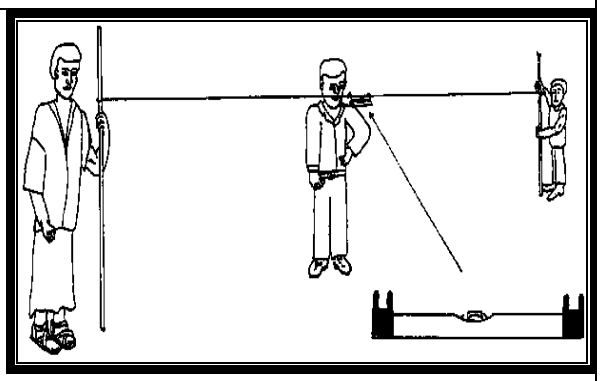
methods of construction. Hand tools are the main instruments used by workers to carry out activities involved in building a road using labour-intensive construction methods. It is therefore important that the project staff know how to select and maintain the tools since they have a significant influence on the work outputs.The combination of local labour, local material, light working equipment and LIC surveying methods are used during the road formation layer construction using labour-intensive construction methods. The pictures below show the different equipment and methods used during the road formation layer using labour-intensive construction. Figures 2.8A, B, C, D, E and F show the tools and surveying techniques used during the LIC of the road the formation layers.

A. LIC tools (Garden set 3D, 2016)

B. LIC tools (Constock photo 2014)



C. LIC survey tools (Macbain, 2012)



D. LIC survey techniques (Simple survey techniques, 2016)

	
E. Hand rammers used on road D1264 for compaction and steel stradish for soil leveling 2013	F. Local labour during the construction of the formation layer on road D1264 2013

Figure 2. 8. A, B, C, D, E and F show tools and surveying techniques used during the LIC of the road D1264 formation layers

2.4. TMM versus LIC

The construction cost, time and quality have been regarded as the major success factors for a construction project (Amsterdam, 2000:259). The three main critical success factors of any project are the lowest cost, high quality shortest time and sustainibility, if the project suffers from one of the mentioned factors it will not be a success (Burke, 2007:24)

2.4.1. The characteristics of time in a construction project

According to Burke (2007:25), project time management includes the process required to ensure timely performance of the project. It consists of activity definition, activity sequencing, duration estimating, schedule, cash flow and time control. Completing the project on time is one of the project manager's critical success criteria, it is, therefore, essential that the project manager understands the characteristics and features of project time management to be able to manage the process effectively. According to Johannessen (1997:55), one of the most frequent problems of labour-intensive projects is the fact that the projects do not get completed in the given time. This causes much frustration in the construction

industry. Timely completion of a construction project is seen as a major factor for the project success by clients, contractors and consultants.

2.4.2. The importance of comparing time between LIC and TMM

The main reason for identifying the aspect of time in the study is to determine the influence of time and the consequence that time, or lack thereof and enough time may have on a labour-intensive construction and traditional mechanistic method projects. It is important to determine the aspects where time management can be introduced or improved. It will also be shown where time control was successfully handled and applied (Burke,2007:174).

2.4.3. The characteristics of cost in a construction project

According to Burke (2007:25), a project's cost management includes the process required to ensure that the project will satisfy the needs for which it was undertaken. It consists of cost estimating, cost budgeting, cash flow and cost control. The project manager must complete the project within the budget. Completing the project within budget is one of the project successes (Burke, 2007:232).

According to Amsterdam (2000:263), in every project, the cost of the project is a major factor. The client provides the funding of the project, and with that funding, the whole project must be completed at the required time and quality. Most LIC projects are funded through the government grant called Expanded Public Works Programme (EPWP).

2.4.4. The importance of comparing cost between LIC and TMM

According to Amsterdam (2000:263), the cost of using LIC is more expensive when compared to the TMM methods. The speed of the construction using LIC will often be slower when compared to TMM. LIC is more time consuming than TMM. This places a constraint on the application for time-sensitive construction activities. However, the LIC produces the same quality TMM in road formation construction. LIC decreases the unemployment rate by offering job opportunities through training. LIC can work in South Africa.

2.5. Advantages of Labour-Intensive Construction

According to Asare (2013:24), the benefits of using labour-intensive construction compared to traditional mechanistic methods or machines are numerous amongst others include:

- Employment creation for people in local communities as per EPWP requirement.
- Provides job opportunities to women and youth. This improves social security protection to vulnerable groups.
- Increase job opportunities by not using machines
- Creation and support of local entrepreneurs
- Skills transfer to workers.
- Requires few skilled operators.
- Minimises cost by not utilising the surveyor, plant and expensive material
- Use of locally available resources.

2.6. Compaction during Road Formation Construction

According to Asare (2013:92), compaction decreases the volume of soil by forcing soil particle to pack closer together, this decreases the amount of air voids between the soil particles, the soil becomes stronger. By applying compaction to the materials used for road formation construction, the layer is strengthened and better withstands the traffic loads and natural erosion. Soil and gravel consist of solid particles, water and air voids. Air voids reduce the stability and density of soil.

An optimum water quantity between 8% to 20% depending on the soil type facilitates compaction and contributes to the soil strength and stability because it lubricates the particles and allows them to settle in a dense mass. If the soil contains too much moisture and is too wet, the soil particles are kept apart by the water. When the soil is too moist and compacted in that condition, it will simply not compress, but flow out sideways (Johannessen 1997:53). According to Johannessen (1997:53), experience shows that if the soil is taken from the ditches or a side borrow, and spread and

compacted immediately, the level of the road will determine if the natural moisture content will be sufficient for good compaction. Sometimes, however, the soil comes from a dry stockpile and then needs to be watered. The moisture content must be checked and not be too wet or too dry.

Methods of compaction

- Dead weight rollers
- Vibrating compaction
- Manual compaction
- Manually or mechanically operated tampers rammers

Hand rammers

According to Mason (1997:14), hand rammers are cheap to produce and consist of a steel handle and cast iron or steel weight at the end. It is lifted and dropped on the surface repeatedly to produce the required compaction on the layer. The hand rammers are used during LIC.

Grid roller, smooth roller and pedestrian roller

According to Mason (1997:16), these rollers will compact to a great depth than the hand rammer. The effect of the vibrating motion will depend on the intensity of the vibrations and the type of material used. They require lower moisture content; however, it is important to maintain an even speed to achieve even compaction. The first roller should be done without vibration, to avoid that the roller gets bogged down into the soil. The speed should be around 3 km per hour or slow walking speed. The operators must run the engine at a slow and constant speed. The grid and smooth rollers are used in TMM on road formation construction. The pedestrian roller is used during LIC on the formation layer.

2.7. Quality Assurance of LIC and TMM

According to Burke (2007:25), project quality management includes the process required to ensure that the project will satisfy the needs for which it was undertaken. It consists of determining the required condition, quality planning, assurance, control and continuous improvement. Quality planning involves identifying the quality

requirements and standards for the project and developing a method to achieve the objectives (Burke, 2007:296).

During the formation layer construction, the compaction density tests results will determine the level of quality for the layer (Johannessen. 1997:55). A registered soil laboratory will perform these tests. According to Johannessen (1997:55), the level of compaction is normally specified relative to a laboratory compaction test. The formation layer is compacted to 93% MOD ASSHTO for both the LIC and TMM. This means that the dry density of samples taken in the field should be 93% of the dry density obtained in a specified laboratory compaction test.

According to Asare (2013:93), the quality measure on the road formation layer construction is achieved by reaching proper and required compaction. It is vital to ensure that 93% MOD ASSHTO for both the LIC and TMM. Achieving less than 93% MOD ASSHTO in compaction will lead to road layers failures and deformation.

According to Henderson (2010:8), the South African government promotes the use of LIC to promote employment and eliminating poverty. EPWP is a nation-wide programme which draws significant numbers of unemployed people into productive work, so that workers gain skills while they work, and increase their capacity to earn an income. EPWP involves the use of labour-intensive construction (LIC) methods to deliver medium to large scale projects. The LIC method involves the use of an appropriate mix of labour and machines for infrastructure delivery, with a preference for labour without compromising the quality of the finished product According to EPWP rules 55% of youth, 55% of women and 2% of people with disabilities must be employed in a LIC project. EPWP is funded by the Department of Works (Henderson, 2010:9).

2.8. Summary

Chapter two of this dissertation dealt with the literature review on LIC and TMM on road formation construction. Research has shown that the use of LIC on road construction has recorded success and also, TMM is proven to be the most used road construction method. Furthermore, it has shown that the comparison of time and cost to reach the same quality on the road formation construction can be undertaken. With the foundation made in this chapter, the next chapter will be building upon it by reviewing in detail on numerical simulation of LIC and TMM on road formation construction.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

The purpose of this chapter is to describe the method of research used in this study and method of data collection in order to achieve the aims and objectives of this study. It explains how data collection and analysis was achieved.

3.2. The Research Method

Multiple qualitative and quantitative research methods are used in this study to collect and analyse the data. The quantitative approach is based on the measurement of quantity or amount of the collected data. The process is expressed or described in terms of one or more quantities. The result of this research method is a number or a set of numbers. It is applicable to a phenomenon that can be expressed in terms of quantity (Kothari, 2004:3). The qualitative approach is concerned with the qualitative phenomena involving the analysis of quality of the collected data. It can be used to understand the results or information obtained by the quantitative method (Kothari, 2004:3).

3.3. Primary Data Gathering Tools

The primary data are those methods of data collection which are collected afresh and for the first time, and this happens to be original in character (Kothari, 2004:95). The following primary data-gathering tools were used in this study:

a) Literature Survey
b) Survey questionnaires
c) Participant observation
d) Comparative analysis

3.3.1. Literature Survey

The collection of research publications, books, journal articles, online platforms and other documents were made available through the Durban University of Technology library related to the defined problem of the research in order to analyse and study. Data information on up to date research articles and websites were accessed through the internet, collected and analysed.

3.3.2. Survey questionnaires

As an important data gathering tool, questionnaires were used in this research to collect data. This is a research instrument that consists of a set of questions that are sent to the respondents to answer and send back to the researcher to express their views or opinions on the matter that is being studied. A survey is the collection of the data from the respondents to gain information and insights of the respondents on the topic of interest (Gray, 2004:187).

A quantitative survey questionnaire was developed by the researcher. This questionnaire was aimed at the 36 technical experts in the Department of Transport, Department of Works, consultants and the roads departments of district and local municipalities. The purpose of the questionnaires was to get their views on the construction of the road formation layers and the comparison between LIC and TMM in terms of cost, time and quality.

3.3.3. Participant Observation

The participant observation is a qualitative research method in which the researcher observes the research participants and also actively engages in the activities of the research by collecting and analysis the required data (Gray, 2004:241). In this study the researcher was involved as a participant observer by being the resident engineer on site and collected the cost, time and quality data to compare between the LIC and TMM on road formation construction. The researcher was involved from the project initiation, project planning, project execution, project monitoring and up to the project closure.

3.3.4. Comparative analysis

A qualitative approach on the comparative analysis was developed by the researcher. Comparative research has emerged as one of the major researching methods in history to be adopted in the civil engineering industry to analyse two or more different types of construction activities (Meiskins and Smith, 1996:1). A simple comparison of the available time, cost and quality data between LIC and TMM from Road D1264 formation construction was collected by the researcher as a resident engineer participating as an observer. Data was collected and analysed in order to achieve the aim and objective of this study.

3.3.5. Comparing LIC vs TMM during road formation layers construction using cost, time and quality on road D1264

Cost, time and quality form part of the important project management triangle. Every project is expected to be finished at the given cost, allocated time and high quality. These three pillars depend on one another. Poor cost handling will result to affecting the allocated project time, which will also affect the quality of the project. Quality can never be compromised it must be the same between the LIC and the TTM. Quality comparison was determined using available density test results of the road D1264 formation construction between the sections constructed using LIC and TMM. The nuclear gauge or troxler was used during quality testing.

In this research, all three components will be compared on road D1264 formation layer construction using LIC and TMM methods. Available data of time and cost will be collected and examined properly. Every projects success is judged by these factors.

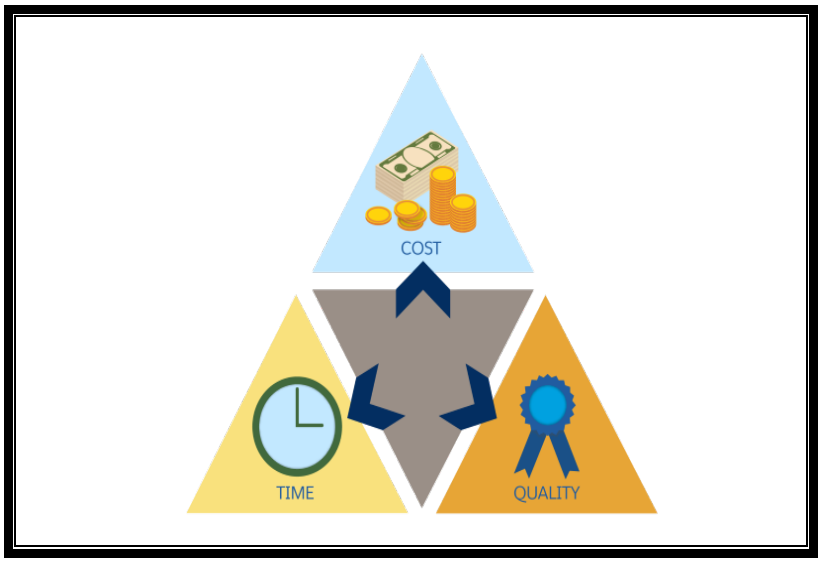


Figure 3. 1. Relationship between cost, quality and time (Alum, 2020)

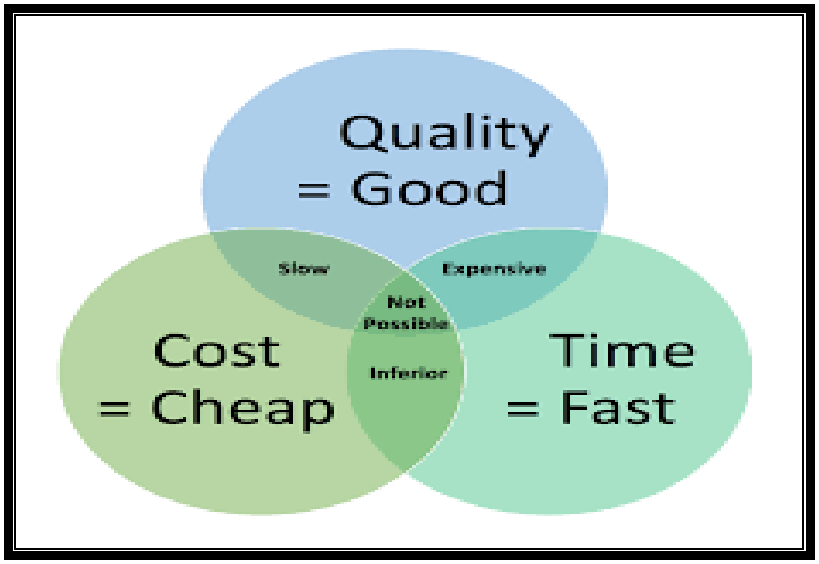


Figure 3. 2. Expected results of cost, quality and time in a project (Bandel, 2020)

Figure 3. 3. Shows the relationship and results between cost, quality and time (Madurai, 2018)

In this study and other projects the cost, time and quality are dependent on each other. Low cost results to poor quality. Long time results in more cost used. Poor quality results in more cost used to reach good quality. In this study cost, time and qualty were compared between LIC and TMM on road formation construction.

3.3.6. Cost Comparison between LIC and TMM

Available cost data collected during the construction of the road formation layer using LIC and TMM method will be used. For LIC, setting out cost, material cost, labour cost, tools cost and small plant equipment cost will be collected and compared to TMM cost. For TMM the surveyor cost, plant machine cost, operators cost, labours cost and material cost will be collected and compared to the LIC method.

Figure 3. 4. The project cost management phases in a project (Eby, 2017)

3.3.7. Time Comparison between LIC and TMM

Available time data from site daily diaries data collected during the construction of the road formation layer using LIC and TMM method will be used. For LIC, the time data it took to start the formation activity up to be testing of the completed section will be collected and compared to TMM time. For TMM the time it also took to start the formation activity up to the final testing stage of the layer compared to the LIC method.

Figure 3. 5. The project time management commponents in a project (Haughey, 2020)

3.3.8. Quality Comparison between LIC and TMM

Available density test results will be used to determine the quality from the construction of the road formation layer using LIC and TMM method will be used from km 5.9 to km 6.5. Both construction methods must produce the same required 93% MOD ASSHTO. Available test results from Shenge Soil Laboratory will be compared. Quality can never be compromised it must be the same between the LIC and the TTM.

Figure 3. 6. Nuclear gauge or troxler used during density testing (Nuclear density gauge calibration, 2019)

3.4. Summary

The purpose of this research was to do a comparative study between LIC and TMM road formation construction. This methodology brought together the factors to be investigated which are cost, time and quality. The methodology allowed the research to cover all the important aspects on the the investigation of road formation construction comparison between LIC and TMM. The following chapter will elaborate further on the methodology adopted on this reasearch.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents and discusses the qualitative and quantitative data gathered using questionnaires, participantobservation and comparison of cost, time and quality between LIC and TMM road formation construction on road D1264 between 5.9 to 6.5 km. The general overview of data presented and discussed shows the need of using labour during road construction to promote more employment opportunities in the South African construction industry. Despite the difference in time and cost between LIC and TMM when constructing the road formation layer, the quality is the same between the two methods. People should have more experience on LIC road construction.

4.2. Survey Questionnaires

This quantitative data analyses method show that out 36 road experts that were approached for questionnaires, all 36 participants responded to the questionnaires. The questionnaires results and analysis show the respondents perception on LIC and TMM during road construction of road formation layers (Chapter 5). The respondents express their views on the finding of this study that LIC costs more than TMM during road formation construction. LIC uses more time than TMM during road formation construction. LIC produces the same quality as TMM on road formation construction. A total of 82% of the participants encouraged the government to promote the use of LIC to provide more job opportunities and eliminate poverty.

4.3. Participant Observation

This qualitative data gathering tool enabled the researcher to collect data through participating as a resident engineer during the road D1264 formation construction. The researcher was able to collect all the data of time, cost and quality to compare between LIC and TMM during the study research.

4.4. Direct Comparison

The main aim of this research is to compare cost and time between LIC and TMM on road formation construction. It is also vital to show that the quality of the density test

results attached on page 84 is the same between LIC and TMM. Quality can never be compromised during the road formation construction.

4.4.1. Comparison of the time on the road formation construction using LIC versus TMM on road D1264

After the completion of the road formation from 5.9 6.5 km a comparison of time to reach the completion was undertaken.Formation layer from 5.9 to 6.2 km was achieved using LIC and from 6.2 to 6.5km was achieved using TMM. A distance of 8m of road formation was constructed in half widths of 4m.

4.4.2. LIC of 300m road formation layer

ILO EPWP tasks rates were used during the time determination. Ten number of workers were used during this activity.

The duration for the construction of 300m formation layer using LIC method on road D1264 was 21 days.

4.4.3. LIC of 300m road formation layer activities breakdown:

a) Levels setting out using LIC survey methods.

b) Clearing and grubbing using ten number of workers.

c) Rip and spreading of 150mm material using small tools and ten number of workers.

d) Camber formation using ten number of workers.

e) Compaction using the pedestrian roller and water to reach 93% MOD ASSHTO.

Table 4.1. Activities involved in the LIC of 300m road formation layer

Activity	**Unit**	**Quantity**	**Task Rate**	**Person days**	**Estimated People**	**Days**	**Balanced Days**
			T	**PD**	**EP**	**D**	**BD**
From BOQ		Q	ILO INFO	Q/T	SKILLS AUDIT	PD/EP	ACTUAL
Clearing & Grubbing	m2	6000 (10m x 300m) x2 sides	150	40	10	4	4
Excavation (Rip & spreading 150mm)	m3	360 (8m x 300m x 0.15m)	3	360	10	12	12
Earthworks Camber formation	m2	2400 (8m x 300m)	70	34.286	10	3.429	4
Earthworks Compaction (Pedestrian-ride on roller)	m2	2400 (8m x 300m)	700	3.429	10	0.342	1
Work trial							5
							Total = 26 days

Increasing the number of workers decreased the number of working days and increased the cost. Using LIC for levels setting out affected the time because the activity took about 30 minutes to undertake. Using LIC methods consumed more time. This resulted in the work programme being dragged out longer and resulted in the project to be not finished sooner as expected.

An additional 5 days was used at the beginning of the activity as a trial since the workers were all inexperienced local labour with no construction experience. An experienced residential engineer or site agent was based fulltime on site to monitor the tasks. LIC work was measured in tasks per team of 10 workers that completed the formation construction activity in 26 days. This was achieved through the following calculations:

Table 4. 2. Rip and spreading using labour calculation

Activity	**No. of Workers**	**Task to achieve per day**	**Metres per day**	**L / Task per day**	**Days**
Excavation: Rip and spreading half road width	1	5m x 4m x 0.15m = $3m^3$	5m x 10 workers = 50 m	600m / 50m	12
				Total = 12 days	

Table 4.3. Clearing and grabbing using labour calculation

Activity	**No. of Workers**	**Task to achieve per day**	**Metres per day**	**L / Task per day**	**Days**
Clearing and grabbing	1	15m x 10m = $150m^2$	$150m^2$ x 10 workers = 1500 m^2	$6000m^2$ / $1500m^2$	4
				Total = 4 days	

Table 4. 4. Camber formation using labour calculation

Activity	No. of Workers	Task to achieve per day	Days	Days/ Workers	Days
Camber formation	1	$70m^2$ 8m x 300m = $2400m^2$	$2400m^2$ / $70m^2$ = 34.286	34.286days / 10workers = 3.4286 days	4
				Total = 4 days	

Table 4. 5. Compaction with pedestrian roller calculation

Activity	No. of Workers	Task to achieve per day	Days	Days/ Workers	Days
Compaction with pedestrian roller	1	$700m^2$ 8m X 300m = $2400m^2$	$2400m^2$ / $700m^2$ = 3.429	3.429 days/ 10 workers = 0.342 days	1
				Total = 1 days	

4.4.4. Work trial

A work trial for 5days was used as a practice to teach workers how the LIC work is undertaken. A total of 26 days was required to complete 300m of road formation layer using LIC with 10 workers.

Figure 4. 1. Excavating to the top of the formation layer on road D1264 in 2013

Figure 4. 2. Camber formation before compaction on road D1264 in 2013

4.5. TMM Construction of 300m Road Formation Layer

Table 4. 6. Activities involved in the TMM construction of 300m road formation layer

Activity	Unit	Quantity	Activity rate	Plant Type	Days
Clearing & Grubbing	m^2	$6000m^2$	$3000m^2$	Grader	2
Excavation: Rip, spreading & cutting of levels	m	300m	150m	Grader	2
Compaction at 93% MOD ASSHTO with a smooth drum roller & water cart	m	300m	150m	Smooth roller, grid roller & water cart	2
Surveyor setting out levels	m	300m	150m	surveyor	2
				Total = 8 days	

The duration for the construction of 300m formation layer using TMM method on road D1264 was 8 days.

4.5.1. TTM of 300m road formation layer activities breakdown

a) Levels setting out using a professional surveyor

b) Clearing and grubbing using a grader.

c) Rip, spreading and cutting levels of 150mm material using a grader

d) Compaction using the smooth roller, grid roller and water to reach 93% MOD ASSHTO.

Table 4. 7. Clearing and grubbing using a grader calculation

Activity	No. Graders	Task to achieve per day	Meters per 300m section	L / Task per day	Days
Clearing and grubbing using a grader	1	150m per day	150m x 2days = 300m	300m / 150m	2
				Total = 2 days	

Table 4. 8. Excavation: Rip, spreading and cutting of levels using a grader calculation

Activity	No. Graders	Task to achieve per day	Meters per 300m section	L / Task per day	Days
Excavation: Rip, spreading and cutting of levels	1	150m per day	150m x 2days = 300m	300m / 150m	2
				Total = 2 days	

Table 4. 9. Compaction at 93% MOD ASSHTO with a smooth drum roller & water cart calculation

Activity	No. Compaction Team	Task to achieve per day	Meters per 300m section	L / Task per day	Days
Compaction with a smooth drum roller & water cart	1	150m per day	150m x 2days = 300m	300m / 150m	2
				Total = 2 days	

Table 4. 10. Surveyor setting out levels calculation

Activity	No. Surveyors	Task to achieve per day	Meters per 300m section	L / Task per day	Days
Surveyor setting out levels	1	150m per day	150m x 2days = 300m	300m / 150m	2
				Total = 2 days	

Figure 4. 3. Rip, spreading an cutting of levels with grader on road D1264 in 2013

Figure 4. 4. Cutting levels and compaction with a grid roller and grader on road D1264 in 2013

Figure 4. 5. Compaction using smooth roller and water cart on road D1264 in 2013

4.6. Discussion and Conclusion

Direct comparison data collected through the participant observation showed that LIC construction of road formation layers used more time compared to the TMM formation layer construction. The benefits of using LIC methods was increasing the employment ratio by the employment of local labour instead of plant. Poverty was one of the problems that the community faced. Having more road construction projects to be undertaken through LIC minimised the poverty ratio.

Time could be adjusted by adding more workers in the LIC acticity. This minimised the time duration of the activity and increased the employment ratio. During LIC road construction skills were transferred to inexperienced local workers. After the completion of the project local workers used the skills gained to seek more job opportunities on similar projects. It was also vital to have project supervisor who had LIC experience. It was vital that the workers were properly trained so that they met their work tasks on all work activities.The advantages of using TMM were to achieve work at the required time. TMM produced work at the required time. The disadvantage of using TMM was the awarding of the project to one main contractor who received all the funds without sharing it with the community. Fig 4.2.6 shows the graph with time vs LIC and TMM.

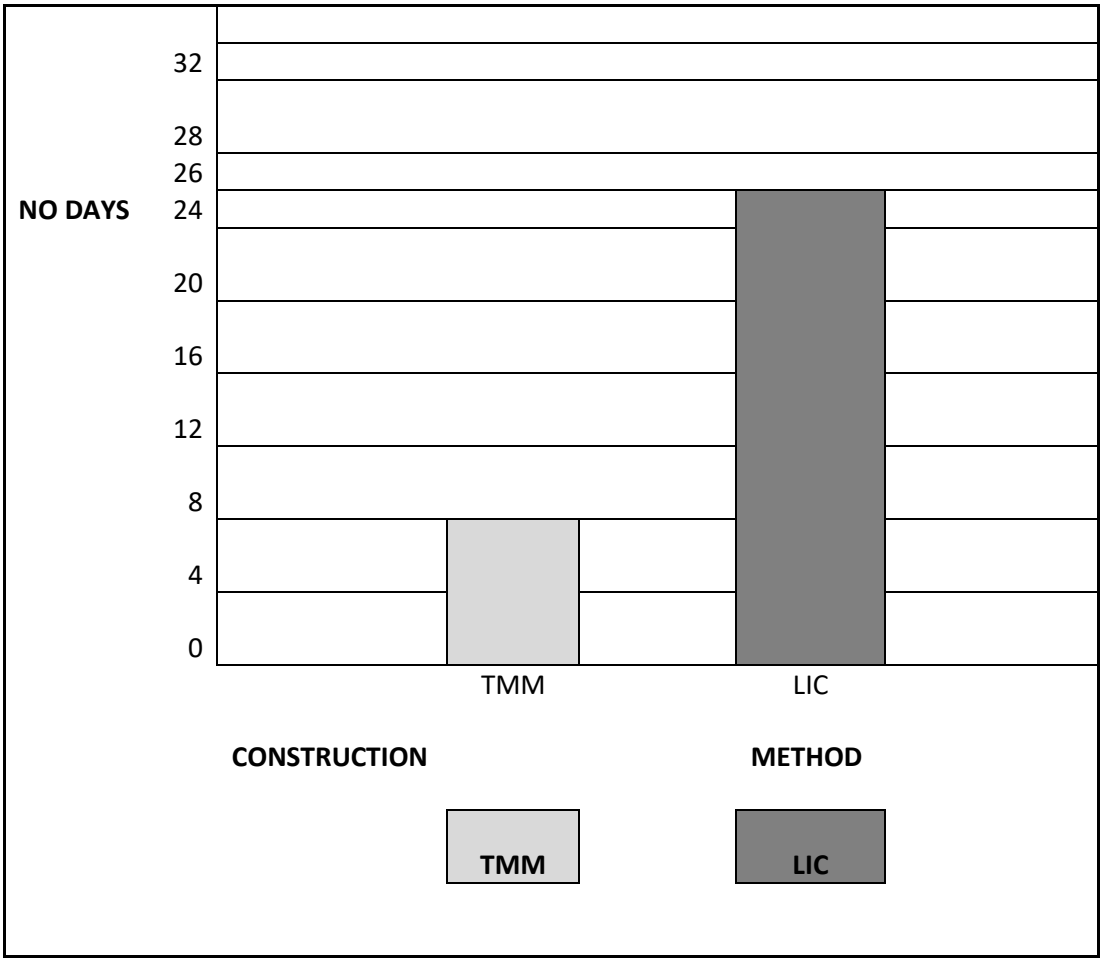


Figure 4. 6. Time comparison between time vs LIC and TMM on 300m of road D1264 formation construction

4.7. Comparison of the Cost on the Road Formation Construction using LIC versus TMM on Road D1264

Table 4. 11. Cost involved in the LIC of 300m road formation layer on Road D1264

Description	Unit Price	Quantity	Total
Pick Head	R 156.52	10	R 1 565.23
Pick handle	R 104.35	10	R 1 043.48
Steel rake 16T	R 78.26	10	R 782.63
Spade	R 130.43	10	R 1 304.35
Wheelbarrow	R 408.70	10	R 4 086.98
Slasher	R 86.96	10	R 869.57
220l water drum	R 600.00	5	R 3 000.00
Watering can 10L	R 113.04	10	R 1 130.43
Builders line 1mm	R 52.17	5	R 260.85

Spirit level 800mm	R 339.13	5	R 1 695.65
Line level	R 63.04	10	R 630.40
Tape 5m	R 59.13	5	R 295.65
Tape 200m	R 278.15	5	R 1 390.75
Hammer club 1.8kg	R 304.35	5	R 1 521.74
Safety overalls 2 pc orange	R 182.61	14	R 2 556.54
Steel hand rammers	R 292.11	6	R 1 752.66
Steel stradish	R 302.37	6	R 1 814.22
Safety glasses	R 27.83	14	R 389.62
Safety gloves	R 43.48	14	R 608.78
Safety boots	R 321.74	14	R 4 504.36
Floppy hats	R 43.48	14	R 608.72
Plastic Cones	R 179.05	50	R 8 952.50
Delineators	R 146.71	50	R 7 335.50
Ranging Rods	R 198.00	50	R 9 900.00
Stop & go and warning signs	R 398.71	14	R 5 581.94
Labour	R244.00	14 X 26	R 88 816.00
Site Supervisor/Residential Eng.	R 1600	26	R 41 600.00
Registered lab doing sampling and nuclear density testing on 300m formation layer			R 9 570.00
			R 203 565.50

Table 4. 12. Small plant cost involved in the LIC construction of 300m road formation layer

Plant Type	Cat	Subcat	Hours	Rate/Hr	Factor	Rate	Escalation	Total Price
Pedestrian Roler	A4	1	24	93,76	4%	97,51	1,42	R 3 323,14
Flat Truck	A7	IV	24	174,26	4%	386,88	1,42	R 13 184,87
								R 16 508,01

FUEL

Plant Type	Cat	Subcat	Consumption	Hours	Rate/Hr	Total Price
Pedestrian Roler	A4	1	8,6	24	13,42	R 2 769,89
Flat Truck	A7	IV	19,4	24	13,42	R 6 248,35
						R 9 018,24

TRANSPORT

Plant Type	Km	Km Charge	Escalation	Total Price
Pedestrian Roller	500	4,7	1,42	R 3 337,00
Flat Truck	500	19	1,42	R 13 490,00
				R 16 827,00

Total Price = R 42 353,25

The total cost is R203 565.50 + R42 353.25 = R245 918.75

Table 4. 13. Plant cost involved in the TMM construction of 300m road formation layer

Plant Type	Cat	Subcat	Hours	Rate/Hr	Factor	Rate	Escalation	Total Price
Water truck (18000lts)	A19	1	16	199	4%	206.96	1,42	R 4 702,13
Grader (140G)	A1	IV	16	372	4%	386.88	1,42	R 8 789.91
Smooth Roller (12t)	A9		16	208	4%	216.32	1,42	R 4 914.79
Tipper Truck	A10		16	238	4%	216.32	1,42	R 4 914.79
Excavator (12t)	A12		16	311	4%	216.32	1,42	R 4 914.79
								R 28 236,42

FUEL

Plant Type	Cat	Subcat	Consumption	Hours	Rate/Hr	Total Price
Water truck (18000lts)	A19	1	16.07	16	13,42	R 3 450,55
Grader (140G)	A1	IV	19.4	16	13,42	R 4 165,57
Smooth Roller (12t)	A9		23.64	16	13,42	R 5 075,98
Tipper Truck	A10		26.22	16	13,42	R 5 629,96
Excavator (12t)	A12		12.79	16	13,42	R 2 746,27
						R 21 068,33

TRANSPORT

Plant Type	Km	Km Charge	Escalation	Total Price
Water truck (18000lts)	500	4,7	1,42	R 3 337,00
Grader (140G)	500	19	1,42	R 13 490,00
Smooth Roller (12t)	500	19	1,42	R 13 490,00
Tipper Truck	500	19	1,42	R 13 490,00
Excavator (12t)	500	19	1,42	R 13 490,00
				R 57 297,00

Total Price = R 106 601,74

Table 4. 14. Additional cost involved in the TMM construction of 300m road formation layer

Description	Quantity	Unit Price	Total
Surveyor	R 1800	2	R 3600.00
Site Supervisor/Residential Eng.	R 1600	8	R 12 800.00
			R16 400.00

The total cost is R106 601.74 + R16 400.00 = R 123.001.74

4.7.1. Discussion and conclusion

The cost data was collected through participant observation and compared between LIC and TMM. LIC construction of road formation layers uses more cost compared to the TMM formation layer construction. The benefits of using LIC methods is increasing the employment ratio by employing local labour instead of plant. Poverty is one of the problems that the country is faced with. Having more road construction projects to be undertaken through LIC will minimise the poverty ratio.

Cost can never be adjusted. LIC road construction skills are transferred to inexperienced local workers. After the completion of the project local workers can use that skills to seek more job opportunities on similar projects. The advantages of using TMM is achieving work at the lower cost. TMM produces work at the lower cost. The disadvantage of using TMM is the awarding of the project to one main contractor who will get all the fund without sharing it with the community. Fig 4.3.5 shows the graph with cost vs LIC and TMM.

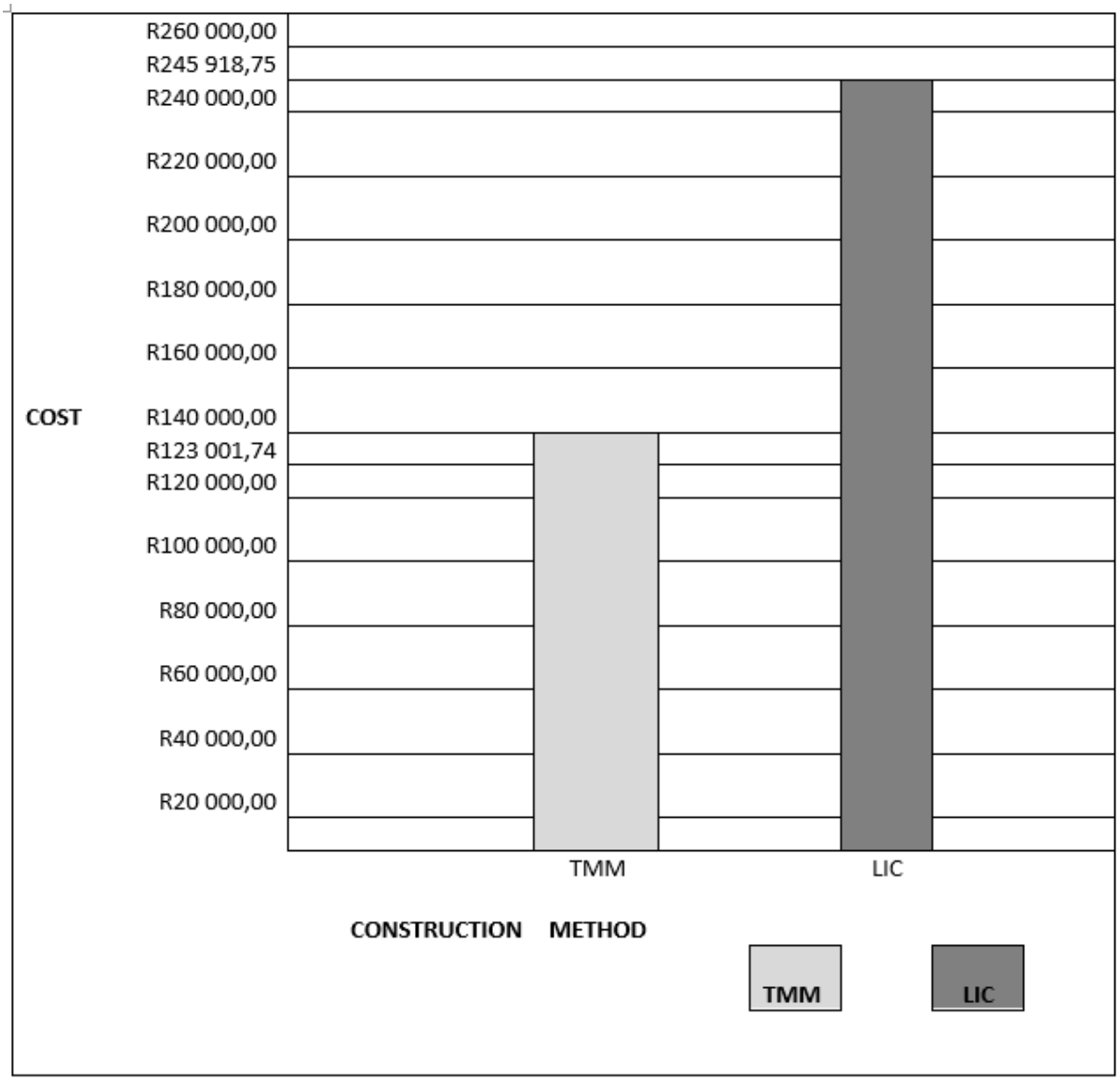


Figure 4. 7. Cost comparison between cost vs LIC and TMM on 300m of road D1264 formation construction

4.8. Comparison of the Quality on the Road Formation Construction using LIC versus TMM

Density test results are used to measure the quality in a road formation construction. Compaction determines if the formation will be strong enough to support all loads on the layer. 93% MOD ASSHTO must be achieved regardless of whether TMM or LIC method was used during construction. Formation layer from km 5.9 to km6.2 was achieved using LIC and from km 6.2 to 6.5 was achieved using TMM. Table 4.14

shows density results obtained from the LIC constructed formation section on road D1264.

Table 4. 15. Density test results obtained from the LIC formation constructed section on road D1264

Road Chainage	5.880	5.920	5.960	6.000	6.040	6.080	6.120	6.160	6.200
Formation Compaction LHS (93%) Mod Asshto		93.7			95.1			95.7	
Formation Compaction CL (93%) Mod Asshto	93.9			94.5			93.8		
Formation Compaction CL (93%) Mod Asshto			93.1			93.4			94.6

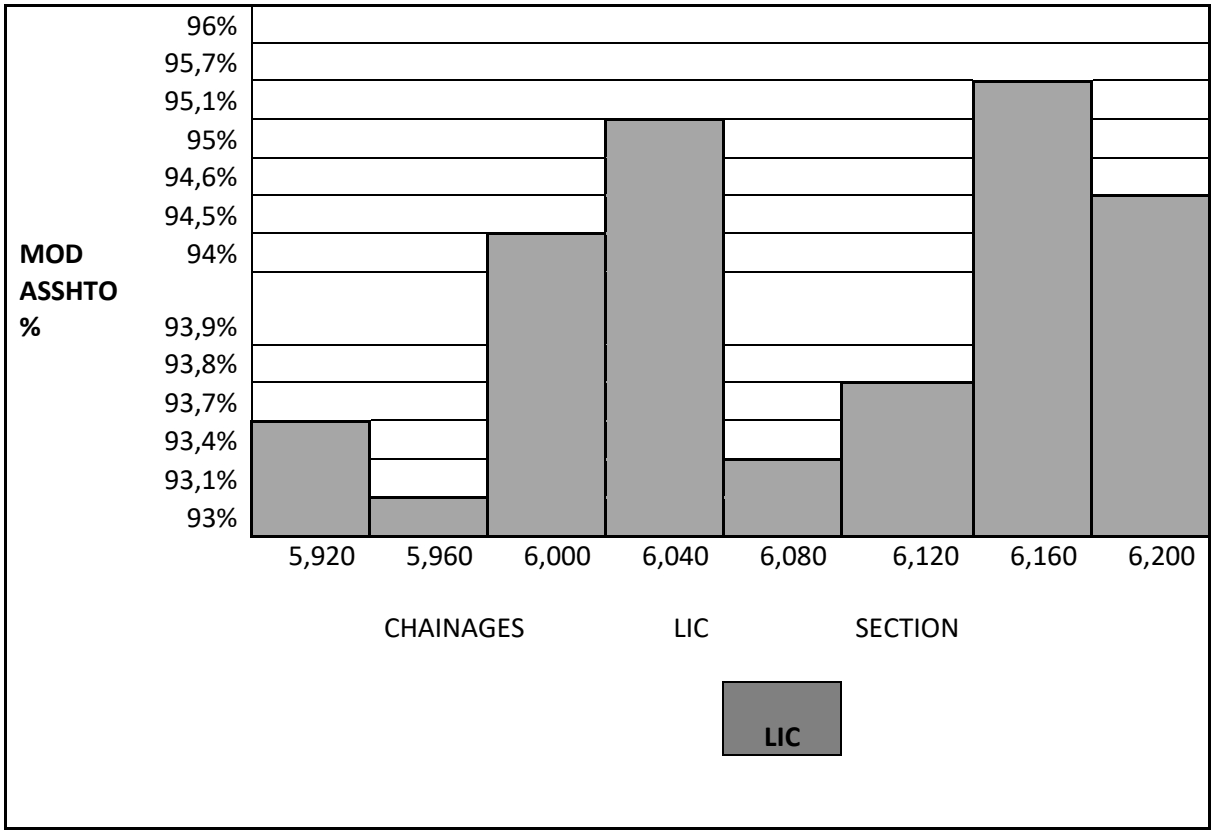


Figure 4. 8. Graph showing density results vs LIC constructed D1264 road section

Table 4. 16. Density test results obtained from the TMM formation constructed section on road D1264

Road Chainage	6.200	6.240	6.280	6.320	6.040	6.400	6.120	6.440	6.480
Formation Compaction LHS (93%) Mod Asshto			94.0			103.0			
Formation Compaction CL (93%) Mod Asshto		93.5							100.7
Formation Compaction CL (93%) Mod Asshto	94.6			94.9				101.3	

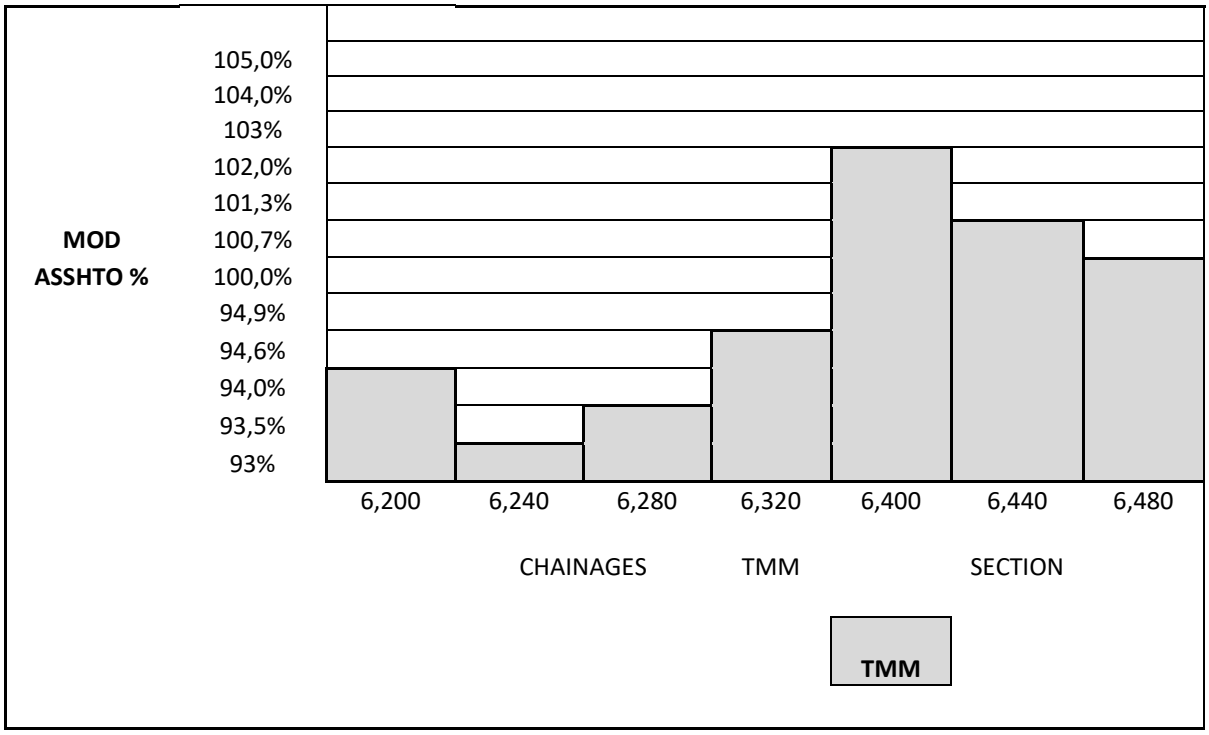


Figure 4.9. Graph showing density results vs LIC constructed D1264 road section

4.8.1. Discussion and conclusion

Available density test results gathered through participant observation from Shenge, a registered laboratory. were used to compare the quality from the construction of the road formation layer using LIC and TMM method. Both construction methods produced the same required 93% MOD ASSHTO. All test results were above 93% MOD ASSHTO. Test results were compared. Quality can never be compromised it must be the same between the LIC and the TTM.

The aim of this research is to compare the construction of road formation layers using the labour-intensive versus the traditional mechanistic methods using survey questionnares, participant observation and direct comparioson. The objective is to provide insight to the time and cost comparison between labour-intensive construction (LIC) and traditional mechanistic methods (TMM) of constructing road formation layers. Road D1264 in Bergville KwaZulu-Natal was used as a case study in the research to compare the difference between labour-intensive and traditional mechanistic construction of road formation layers, using cost and time to reach the same quality.

This road is 7.2km long. An investigation was done between 5.9 to 6.5 km to compare the difference between labour-intensive and traditional mechanistic construction of road formation layers, using cost and time to reach the same quality. Chainages from 5.9 to 6.2km formation was constructed using plant machines. Chainages from 6.2 to 6.5km formation was constructed using labour-intensive construction methods. A further aim of this research was to promote the use of LIC roadbed construction to be used more frequently in the road construction industry in South Africa. Making informed decisions and selections thereafter of the most reliable road formation construction method in terms of time and cost.

This research study will serve as a technical support tool during the decision making process of municipalities and consultants when selecting the construction methods to be used during the construction the road formation layers. It has been found that the construction of the formation layers using LIC is more expensive when compared to TMM. LIC is also more time consuming than TMM. LIC and TMM produce the same quality. LIC creates employment particularly for women, youth and the disabled within the community. LIC maximises the use of local materials and plant owners as suppliers of goods and services.

LIC develops skills through the training of local residents in road construction and supervision techniques. TMM benefits one main contractor who brings plant machines and experienced employers for the job. Through LIC poverty can be

reduced through the high local community employment ratio. It has been proven through density test results that LIC produces the same quality as TMM during formation layer construction and that is a good outcome.

LIC supports the EPWP which is a nation-wide programme which draws significant numbers of the unemployed people into productive work, so that workers gain skills while they work, and increase their capacity to earn an income. EPWP involves the use of labour-intensive construction (LIC) methods to deliver medium to large scale projects. The LIC method involves the use of an appropriate mix of labour and machines for infrastructure delivery, with a preference for labour without compromising the quality of the finished product. According to EPWP rules, 55% of youth, 55% of women and 2% of people with disabilities must be employed in a LIC project. EPWP is funded by the Department of Works).This research proves that road formation layer construction should be offered to EPWP as LIC to maximise the employment ratio in South Africa. In the process poverty will be addressed through employment and skills transfer.

Bergville is considered to be the one of the poorest rural area in the Kwa-Zulu Natal Province with 73 % of the population living below the poverty line level. As at 15 Mar 2017 there have been 1095 job opportunities created of which 624 are women, 569 are youth and 20 disabled. 70 021 workers days has been created indicating that the labour-intensive construction strengthens the socio economic capacity of the community living in the vicinity of this on-going project. Material for various activities was sourced locally from the rivers close to the project. Attempts were made to engage the local business owners and suppliers with success.

Ebusingatha community members and local Grade 1 contractors have acquired skills in the various fields of road construction which can be used in future for projects of similar nature and maintenance of the same road. With this project it been found that Civil Engineering and Project Management qualifications alone does not provide enough skills for efficient supervision of labour-intensive construction. The supervisors must have LIC experience. The key successful factor on labour-based construction is the competence of site supervisors. A training centre focused specifically on the LI construction of roads is required.

More LIC projects are required to ensure that people that have been trained, gain more site experience. It is also accepted that LIC is expensive although its advantages are the employment of local labour, skills development and poverty alleviation. The time taken to load tools and materials in the morning from site camp was lengthy. This was overcome by the loading team starting earlier in the morning. Workers not accepting or buying into task work. This was resolved after intervention from the PSC.

LIC disadvantage is filing the shoes of heavy machine, but through sufficient planning from the site supervisors' success is achieved. LIC must receive a lot of attention. If not well managed the project will lack in performance and cause a delay in construction time.

The Target Groups

Table 4.17. Comparison between the EPWP demographic target and the demographic targets as applied to D1264

Table 4. 27. Summary of EPWP groups

Demographic	**EPWP**	**D1264 Planned**	**D1264 Actual**
Women	60%	60%	**57%**
Youth	20%	50%	**52%**
Disabled	2%	2%	**1.8%**

CHAPTER FIVE: VALIDATION STUDY OF LIC FOR ROAD FORMATION LAYER

5.1. Introduction

The approach used to collect data involved the use of questionnaires collected through an online platform Google form. The analysis of this chapter consists of 36 respondents, the questionnaire used consists of two sections. The first section focuses on demographic characteristics of construction stakeholders such as; age, gender, educational level, civil engineering sector, and civil engineering professional registration status. The second section is composed of multiple choice questions focusing on the construction stakeholders experience in the road construction industry. Questions includes do you have experience in road construction, years of road construction experience, and involvement with TMM and LIC in road construction. The other part of the questionnaire focused on the perception of construction stakeholders on the findings of the study and further recommendations.

The use of chi-square statistical tool was employed to test for the hypothesis relating to the construction stakeholders perception of findings of the study. Thus, the null and alternative hypotheses for the testing were:

H_o: The construction stakeholders' characteristics and experience and perception of findings of the study are independent of each other.

H_i: Null hypothesis is not true

The expected cell frequencies were compared with the observed cell frequencies

using the test chi-square, as estimated.

$$X^2 = \sum \frac{(O_i - E_j)^2}{E_{ij}} \quad \text{.....equation 5.1.}$$

where:

X^2 = chi-square

O_{ij} = observed frequency of the cell in the ith row and jth column

E_{ij}= expected frequency of the cell in the ith row and jth column

The calculated chi-square result was compared with the critical chi-square value (using the table) with (r-1) x (c-1) degree of freedom to make a decision regarding the acceptance or rejection of the null hypothesis, Kothari (2004).

Decision Rule

If $X^2_{tab} > X^2_{cal}$, accept H_o, otherwise reject

5.2. Construction Stakeholders Demographic Information

Survey questionnaires were circulated to stakeholders with the civil engineering experience on road construction. 36 respondents were received and used to investigate the difference between LIC and TMM during road formation construction (Table 5.1).

Table 5.1. Demographic data of the construction stakeholders

Demographic Characteristics	Class	Percentage
Age	18 to 25 years	0
	26-30 years	11.1
	31-39 years	52.8
	40-49 years	19.4
	Above 50 years	16.7
Gender	Female	19.4
	Male	80.6
Education	Grade 1-12	0
	Diploma	16.7
	Bachelor/BTech	61.1
	Honours	13.9
	Masters/PhD	8.3
Civil Engineering Sector	Academics	2.8
	Consulting Sector	47.2
	Contractor	2.8
	Department Sector	25.0
	Municipal Sector	22
Civil Engineering Professional Registration Status	Professional engineers	6.5
	Professional technologists	42
	Professional technicians	29
	Candidate Membership	22.5

5.3. Construction Stakeholders Road Construction Experience

The interviewee experience in the road construction industry was evaluated using multiple choice questions focusing on the construction stakeholders experience on LIC and TMM. It is very important to understand the level of experience on road

construction to be certain that the interviewee has knowledge on LIC and TMM (Table 5.2).

Table 5.2. Construction Stakeholders Experience

Construction Stakeholders Experience	Class	Percentage
Do you have experience in road construction?	Yes	97.3
	No	2.7
Years of road construction experience?	0-3 years	5.4
	4-10 years	27
	11-25 years	51.4
	26-40 years	10.8
	Over 40 years	5.4
Number of road construction projects undertaken?	1-3	8.1
	4-6	13.5
	7-10	16.2
	Over 10	62.2
Have you been involved in TMM road construction?	Yes	100
	No	0
Years of TMM road construction experience?	0-3 years	13.5
	4-10 years	37.8
	11-25 years	37.8
	26-40 years	5.4
	Over 40 years	5.4
Have you been involved in LIC road construction?	Yes	89.2
	No	10.8
Years of LIC road construction experience?	0-3 years	75.7
	4-10 years	8.1
	10-25 years	13.5
	26-40 years	2.7

5.4. Construction Stakeholder Perception of LIC vs TMM

The construction stakeholders perception of LIC vs TMM will assist the researcher in determining how the interviewee feels about LIC during road construction (Table 5.3). The aim of the research is to promote the use of LIC to maximise the rate of employment. Knowing the preference of the stakeholders between LIC and TMM will highlight the road construction method that is preferred by the stakeholders.

Table 5.3. Construction Stakeholder Perception of LIC vs TMM

Construction Stakeholders Perspective	Class	Percentage
Do you recommend LIC for road construction?	Never	2.7
	Rarely	29.7
	Sometimes	51.4
	Often	10.8
	Always	5.4

Do you recommend TMM for road construction?	Never	0
	Rarely	2.7
	Sometimes	18.9
	Often	45.9
	Always	32.4
How conversant are you with understanding LIC in road construction?	Not Conversant	5.4
	Slightly Conversant	10.8
	Moderately Conversant	51.4
	Very Conversant	29.7
	Extremely Conversant	2.7
How comfortable are you working on LIC projects?	Not Comfortable	0
	Slightly Comfortable	11.1
	Moderately Comfortable	50
	Very Comfortable	27.8
	Extremely Comfortable	11.1
Can the road formation layer be successfully constructed using the LIC method?	Strongly disagree	2.8
	Disagree	8.3
	Neutral	52.8
	Agree	22.2
	Strongly Agree	13.9

5.5. Construction Stakeholder Perception on Findings of Study

The construction stakeholder perception on findings of study was compared with the researcher findings on cost, time and quality comparison between LIC and TMM during road formation construction (Table 5.4). It also contributed to present the road construction stakeholders recommendations on LIC.

Table 5. 4. Construction Stakeholder Perception on the findings of the study

Construction Stakeholder Perception on Findings of Study	**Class**	**Percentage**
Do you agree with the finding of this study that LIC provides poverty relief through employment?	Strongly disagree	0
	Disagree	0
	Neutral	11.1
	Agree	38.9
	Strongly Agree	50
Do you agree with the finding of this study that LIC provides construction skills transfer opportunities to the community more so than TMM?	Strongly disagree	0
	Disagree	0
	Neutral	13.9
	Agree	33.3
	Strongly Agree	52.8
Do you agree with the finding of this study that LIC costs more than TMM does for road formation construction?	Strongly disagree	2.8
	Disagree	8.3
	Neutral	19.4
	Agree	25
	Strongly Agree	44.4
Do you agree with the finding of this study that LIC take more time than TMM in road formation construction?	Strongly disagree	2.8
	Disagree	2.8
	Neutral	2.8
	Agree	30.6

	Strongly Agree	61.1
Do you agree with the finding of this study that LIC produces the same quality as TMM in road construction?	Strongly disagree	5.6
	Disagree	30.6
	Neutral	19.4
	Agree	27.8
	Strongly Agree	16.7
Do you agree with the finding of this study that TMM generally favours one main contractor in terms of providing work and finance?	Strongly disagree	5.6
	Disagree	8.3
	Neutral	8.3
	Agree	52.8
	Strongly Agree	25

5.6. Cross Analysis of Construction Stakeholders and Study Findings

Evaluation of the six questions under this theme was conducted to evaluate the relationship between the agreement of the study findings, and demographic characteristic of the construction stakeholders with regards to age, education, civil engineering sector, and years of experience in road construction and number of road construction project undertaken.

5.6.1. Cross-Classification Analysis of Construction Stakeholders Age and Study Findings

In the cross-classification analysis of age and the perception of the agreement of stakeholders with TMM generally favours one main contractor in terms of providing work and finance, the results are presented in Table 5.5. Considering 5% level of significance, the chi-square value is 21.03. However, the calculated chi-square values (26.62) for the perception of stakeholders were larger than the critical value, thus, indicating that there are some reasons to believe that the variables are dependent. Additionally, since the $Xcal^2 > Xtab^2$, reject the Ho, meaning the age and the perception of stakeholders to findings of the study are dependent on each other. However, it is worthy to note that age do not have a significant influence on other findings of the study. More exposure to LIC will determine the knowledge of finance between LIC and TMM.

Table 5. 5. Age * Do you agree with the finding of this study that TMM generally favours one main contractor in terms of providing work and finance?

	Do you agree with the finding of this study that TMM generally favours one main contractor in terms of providing work and finance?	Total

			Agree	Disagree	Neutral	Strongly agree	Strongly disagree	
Age	26-30	Count	1	0	0	1	2	4
		% of Total	2.8%	0.0%	0.0%	2.8%	5.6%	11.1%
	31-39	Count	12	0	2	5	0	19
		% of Total	33.3%	0.0%	5.6%	13.9%	0.0%	52.8%
	40-49	Count	2	1	1	3	0	7
		% of Total	5.6%	2.8%	2.8%	8.3%	0.0%	19.4%
	Above 50	Count	3	2	0	1	0	6
		% of Total	8.3%	5.6%	0.0%	2.8%	0.0%	16.7%
Total		Count	18	3	3	10	2	36
		% of Total	50.0%	8.3%	8.3%	27.8%	5.6%	100.0 %
Chi-square test statistic			26.62 (df = 12)					
Ho rejected?			Yes					

5.6.2. Cross-Classification Analysis of Construction Stakeholders Educational Background and Study Findings

Using the cross-tabulation with the chi-square analysis, it is worthy to note that there is a significant association between educational background of the stakeholders and the perception of agreement that LIC produces the same quality as TMM in road construction. Table 5.6 shows that the calculated chi-square value is 22.79 and considering 5% level of significance of the chi-square value 21.03, thus, indicating that there are some reasons to believe that the variables are dependent. However, it is worthy to note there is no significant association between educational background and other findings of this study. The level of experience determines the knowledge of quality on LIC vs TMM during road formation construction.

Table 5.6. Education * Do you agree with the finding of this study that LIC produces the same quality as TMM in road construction?

			Do you agree with the finding of this study that LIC produces the same quality as TMM in road construction?					Total
			Agree	Disagree	Neutral	Strongly agree	Strongly disagree	
Education	Bachelor/ BTech	Count	6	3	7	5	1	22
		% of Total	16.7%	8.3%	19.4%	13.9%	2.8%	61.1%
	Diploma	Count	1	5	0	0	0	6
		% of Total	2.8%	13.9%	0.0%	0.0%	0.0%	16.7%
	Honours	Count	1	3	0	0	1	5

		% of Total	2.8%	8.3%	0.0%	0.0%	2.8%	13.9%
	Masters/PhD	Count	1	0	0	2	0	3
		% of Total	2.8%	0.0%	0.0%	5.6%	0.0%	8.3%
Total		Count	9	11	7	7	2	36
		% of Total	25.0%	30.6%	19.4%	19.4%	5.6%	100.0%
Chi-square test statistic		22.79 (df = 12)						
Ho rejected?		Yes						

5.6.3. Cross-Classification Analysis of Construction Stakeholders Sector and Study Findings

Table 5.7 presents the cross-classification analysis of construction stakeholders sector and perception of the agreement of stakeholders with the finding of this study that LIC costs more than TMM does for road formation construction. The result shows that the chi-square value is 28.08 and considering a 5% level of significance the chi-square value is 26.30, the calculated chi-square is greater than the critical value, thus, indicating that the variables are dependent. This implies that construction stakeholders sector and their perception with the finding of this study that LIC costs more than TMM does for road formation construction are dependent of each other. To understand the cost of LIC during road formation construction requires undertaking more than one project to fully understand cost.

Table 5. 7. Civil Engineering Sector * Do you agree with the finding of this study that LIC costs more than TMM does for road formation construction?

			Do you agree with the finding of this study that LIC costs more than TMM does for road formation construction?					Total
			Agree	Disagree	Neutral	Strongly agree	Strongly disagree	
Civil Engineering Sector	Academics	Count	0	0	0	1	0	1
		% of Total	0.0%	0.0%	0.0%	2.8%	0.0%	2.8%
	Consulting Sector	Count	1	0	5	11	0	17
		% of Total	2.8%	0.0%	13.9%	30.6%	0.0%	47.2%
	Contractor	Count	0	0	1	0	0	1
		% of Total	0.0%	0.0%	2.8%	0.0%	0.0%	2.8%
	Departmental Sector	Count	2	1	0	5	1	9
		% of Total	5.6%	2.8%	0.0%	13.9%	2.8%	25.0%
	Municipal Sector	Count	5	2	1	0	0	8
		% of Total	13.9%	5.6%	2.8%	0.0%	0.0%	22.2%
Total		Count	8	3	7	17	1	36

	% of Total	22.2%	8.3%	19.4%	47.2%	2.8%	100.0 %
Chi-square test statistic	28.08 (df = 16)						
Ho rejected?	Yes						

5.6.4. Cross-Classification Analysis of Construction Stakeholders Years of road construction experience and Study Findings

Table 5.8 presents the cross-classification analysis of construction stakeholders years of road construction experience and perception of the agreement of stakeholders with TMM generally favours one main contractor in terms of providing work and finance.

The result shows that the chi-square value is 27.41 and considering a 5% level of significance the chi-square value is 26.30, the calculated chi-square is greater than the critical value, thus, indicating that the variables are dependent. This implies that construction stakeholders' years of road construction experience and their perception with the finding of this study that TMM generally favours one main contractor in terms of providing work and finance are dependent of each other. Stakeholders with past experience on LIC will understand more.

Table 5. 8. Years of road construction experience? * Do you agree with the finding of this study that TMM generally favours one main contractor in terms of providing work and finance?

			Do you agree with the finding of this study that TMM generally favours one main contractor in terms of providing work and finance?					Total
			Agree	Disagree	Neutral	Strongly agree	Strongly disagree	
Years of road construction experience?	0-3	Count	0	0	0	2	0	2
		% of Total	0.0%	0.0%	0.0%	5.6%	0.0%	5.6%
	10-25	Count	11	2	3	3	0	19
		% of Total	30.6%	5.6%	8.3%	8.3%	0.0%	52.8%
	26-40	Count	3	0	0	1	0	4
		% of Total	8.3%	0.0%	0.0%	2.8%	0.0%	11.1%
	4-10	Count	4	0	0	4	2	10
		% of Total	11.1%	0.0%	0.0%	11.1%	5.6%	27.8%
	Over 40	Count	0	1	0	0	0	1
		% of Total	0.0%	2.8%	0.0%	0.0%	0.0%	2.8%

Total	Count	18	3	3	10	2	36
	% of Total	50.0%	8.3%	8.3%	27.8%	5.6%	100.0%
Chi-square test statistic	27.41 (df = 16)						
Ho rejected?	Yes						

5.6.5. Cross-Classification Analysis of Construction Stakeholders Experience (Number of road construction projects undertaken) and Study Findings

Unlike other characteristics of the construction stakeholders, the number of road construction project undertaken have a significant influence on the findings of the study such as Do you agree with the finding of this study that LIC provides poverty relief through employment, Do you agree with the finding of this study that LIC provides construction skills transfer opportunities to the community more so than TMM, and Do you agree with the finding of this study that LIC produces the same quality as TMM in road construction. Results (Table 5.9 - 5.11) show that there is a significant association between the number of construction project undertaken and the findings of the study as the calculated chi-square values for the perception of stakeholders were larger than the critical values.

Table 5. 9. Number of road construction projects undertaken? * Do you agree with the finding of this study that LIC provides poverty relief through employment?

			Do you agree with the finding of this study that LIC provides poverty relief through employment?			Total
			Agree	Neutral	Strongly Agree	
Number of road construction projects undertaken?	1-3	Count	2	0	1	3
		% of Total	5.6%	0.0%	2.8%	8.3%
	4-6	Count	0	2	3	5
		% of Total	0.0%	5.6%	8.3%	13.9%
	7-10	Count	4	2	0	6
		% of Total	11.1%	5.6%	0.0%	16.7%
	Over 10	Count	7	0	15	22
		% of Total	19.4%	0.0%	41.7%	61.1%
Total		Count	13	4	19	36
		% of Total	36.1%	11.1%	52.8%	100.0%
Chi-square test statistic		17.87 (df = 6)				
Ho rejected?		Yes				

Table 5. 10. Number of road construction projects undertaken? * Do you agree with the finding of this study that LIC provides construction skills transfer opportunities to the community more so than TMM?

			Do you agree with the finding of this study that LIC provides construction skills transfer opportunities to the community more so than TMM?			Total
			Agree	Neutral	Strongly agree	
Number of road construction projects undertaken?	1-3	Count	2	0	1	3
		% of Total	5.6%	0.0%	2.8%	8.3%
	4-6	Count	1	2	2	5
		% of Total	2.8%	5.6%	5.6%	13.9%
	7-10	Count	4	2	0	6
		% of Total	11.1%	5.6%	0.0%	16.7%
	Over 10	Count	4	1	17	22
		% of Total	11.1%	2.8%	47.2%	61.1%
Total		Count	11	5	20	36
		% of Total	30.6%	13.9%	55.6%	100.0%
Chi-square test statistic			16.70 (df = 6)			
Ho rejected?			Yes			

Table 5. 11. Number of road construction projects undertaken? * Do you agree with the finding of this study that LIC produces the same quality as TMM in road construction?

			Do you agree with the finding of this study that LIC produces the same quality as TMM in road construction?					Total
			Agree	Disagree	Neutral	Strongly agree	Strongly disagree	
Number of road construction projects undertaken?	1-3	Count	0	0	2	1	0	3
		% of Total	0.0%	0.0%	5.6%	2.8%	0.0%	8.3%
	4-6	Count	0	2	2	1	0	5
		% of Total	0.0%	5.6%	5.6%	2.8%	0.0%	13.9%
	7-10	Count	1	3	0	0	2	6
		% of Total	2.8%	8.3%	0.0%	0.0%	5.6%	16.7%
	Over 10	Count	8	6	3	5	0	22
		% of Total	22.2%	16.7%	8.3%	13.9%	0.0%	61.1%
Total		Count	9	11	7	7	2	36
		% of Total	25.0%	30.6%	19.4%	19.4%	5.6%	100.0 %
Chi-square test statistic			22.85 (df = 12)					
Ho rejected?			Yes					

Overall, age, education, civil engineering sector, and years of experience in road construction have a certain influence on the perception of the agreement of stakeholders with the finding of this study. Nevertheless, the number of road

construction project undertaken have a significant influence on the findings of the study. This implies that the more construction undertaken by the construction stakeholders, the more likelihood of considering LIC for the road formation layer.

5.7. Construction Stakeholders Recommendation of LIC

Evaluation of the three questions under this theme was conducted to evaluate the relationship between the agreement of the study findings, and demographic characteristic of the construction stakeholders with regards to Age, Education, Civil Engineering Sector, and Years of Experience in road construction and number of road construction project undertaken. More construction stakeholders believe that LIC can be the country solution to unemployment which agrees with the finding of this study. More construction stakeholders recommend the government to have more roads constructed using LIC which agrees with the main aim of this study. More construction stakeholders recommend the universities to have formal studies on LIC during their formal study programmes to increase the knowledge of LIC (Table 5.12 – 5.14).

Table 5. 12. Construction Stakeholder LIC country solution

Can LIC be the countries solution to unemployment?	
Never	2.8%
Rarely	19.4%
Sometimes	36.1%
Often	16.7%
Always	25%

Table 5. 13.Construction Stakeholder LIC recommendation to the government

Should the government have more road construction projects carried out using LIC?	
Strongly disagree	2.7%
Disagree	18.9%
Neutral	24.3%
Agree	37.8%
Strongly agree	16.2%

Table 5. 14. Construction Stakeholder LIC proposal to Universities

Do you agree that civil engineering technicians, technologist and engineers should have more LIC exposure during their formal study programmes at University?	
Strongly disagree	0%
Disagree	8.1%
Neutral	8.1%
Agree	45.9%
Strongly agree	37.8%

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion and Recommendation

Despite of all negative aspects certain projects also have very positive outcomes in labour-intensive construction projects. Positive outcomes however are only possible through consistent supervision and experienced supervisors in the project team. The key successful factor on labour-based construction is the competence of site supervisors. More training centres focused specifically on the LIC construction of roads are required. Regular training and supervision is required during LIC road construction due the inexperience of workers engaged on the project.

It is necessary to have adequately experienced labour-intensive supervisors to manage the project effectively, including the management of task work. Using only Grade1 contractors with no road construction experience makes labour-intensive projects even more supervision-intensive. Good quality in road construction is determined by good compaction from density test results. Good compaction requires understanding of what is actually taking place when applying compaction to soils and surfacing materials.

Good knowledge of the properties and performance of the materials, combined with the correct use of available equipment will result in reaching the prescribed quality levels. Regardless of whether LIC or TMM methods of road construction was used during road construction will not have an impact on density results achieved. LIC and TMM on road construction will have the same good quality density test results. It is recommended that LIC is used the same way as the TMM is used during road construction.

When selecting a method for the road formation construction in South Africa, municipalities and all other departments involved in road construction must assess the advantages and disadvantages of each method. The choice of method to be used must be based on the total cost, time duration, quality expected and project location. The location of the project will determine whether local labour will be available for LIC. The LIC projects are highly suitable to be carried out in rural areas more than in urban areas.

The high ratio of poverty in an area will favour LIC since more job opportunities will increase the employment ratio and provide construction skills that can be utilised in future road construction projects. The budget available will also determine which method to select between LIC and TMM. LIC costs more than the TMM, which means with a sufficient cost budget LIC can be selected and with a low budget TMM can be selected.

The duration and the urgency of the completion of the road will also determine which method to select. Projects which must be completed at short time period must be carried out in TMM and projects that are not in too much urgency can be carried out using LIC. In the aspect of quality, it does not matter which method is used between the LIC and TMM because they produce the same good quality.

In this research study a comparison between time, cost and quality was carried out on road formation construction using LIC and TMM. The following table show the results outcomes that can be used by municipalities and other departments that are involved in road construction. The survey questionnaires revealed that the consultants, municipalities and other departments that are involved in road construction recommend that the government should have more road construction projects carried out using LIC. The engineering technicians, technologist and engineers should have more LIC exposure during their formal study programmes at University. LIC can be the countries solution to unemployment.

6.1.1. Comparison and guide of cost, time and quality between formation layers constructed using LIC and TMM

Table 6.1. Summary of the data results of cost, time and quality between LIC and TMM in the road formation construction on road D1264

CONSTRUCTION METHOD	COST	TIME	QUALITY
LIC	HIGH	LONGER	SAME
TMM	LOW	SHORTER	SAME

REFERENCES

Amsterdam, E. 2000. *Construction Materials for Civil Engineering*. Everbest, Kenwyn: Juta & Co Ltd

Asare, A.O. 2013. *Construction of Low Volume Sealed Roads Good Practice guide to labour-based methods*. Switzerland: ILO

Bandel, N.2020. *Software Architecture with shortest time to market* (online). Available: https: //security boulevafrd.com/2020/01/software-architecture-with-shortest- time-to-market-consideration/ (Accessed 20 March 2020)

Benson J. & Lay, M. 1999. *Cross-section of modern road pavement*. Available: https: //www.britannica.com/technology/road/The-modern-road. (Accessed 13 March 2020)

Best Practice Guideline – Part – 2 – 1 Labour-based construction methods for earthworks. 2005 1st ed. Brooklyn Square: cidb)

Burke, R. 2007. *Project Management Techniques*. 2nd ed. Everbest, HK/China: Burkepublishing

Coetzer, J.A. 2010. *Labour-intensive construction*. Pretoria: University of Pretoria

Colto. 1998. Lyttelton: South African Institution of Civil Engineering

Contractor's Handbook of Labour-Based Road Works. 2004. Zambia: ASIST

David, M. 1997. *Labour-based technology, a review of current practice*. Jinga, Uganda: ILO Publications

David, M. and Venkatesan, A. 2009. *Practise of Microsoft Project.* Johannesburg: Masterskill

David, T. and Jan, V. 1998. *Employment –Intensive Infrastructure Programmes: Labour policies and practices.* Geneva, Switzerland: ILO Publications

Elementary and advanced surveying equipment and their users.2017.Available:https://bookscivil/elementary-surveying-advanced-surveying

Ethekwini Municipality Expanded Public Works Programme (EPWP) Policy framework. 2006. Pinetown: Procurement and Infrastructure Cluster)

Fransen, J. Scot, H. Esch, W. 2002. *Sustainable community managed and labour based upgrading of urban low income settlements*. Geneva: International Labour Office

Garden tools, wheelbarrow, bucket and watering can.3d rendering.214.Available:www.garden tools.com (Accessed 14 March 2020)

GCC. 1st ed. 2004. Midrand: South African Institution of Civil Engineering

GCC. 2nd ed. 2010. Midrand: South African Institution of Civil Engineering

GCC. 3rd ed. 2015. Midrand: South African Institution of Civil Engineering

Garden tools set 3D (online). 2016. Available:https://flatpyramid.com/3d-models/industrial-3d-models/tools/grade-tools-set/ (Accessed 14 March 2020)

Gravel Roads Construction and Maintenance Guide.2015. Federal Highway Administration. U.S. Department of Transport

Gray, D. 2004. *Doing research in the real world*. London. Sage Publications Ltd

Guidelines for the Implementation of Labour-Intensive Infrastructure Projects and Expanded Public Works Programme. 2000 1st ed. Pretoria: Department of Public Works

Guidelines for the Implementation of Labour-Intensive Infrastructure Projects and Expanded Public Works Programme. 2005 2nd ed. Pretoria: Department of Public Works

Guidelines for the Implementation of Labour – Intensive Infrastructure Projects and Expanded Public Works Programme. 2015 3rd ed. Pretoria: Department of Public Works)

Haughey, D. 2020. *Six time-management tips for project managers* (online). Available: https://www.projectsmart.co.uk/six-time-management-tips-for -project-managers. hph (Accessed 20 March 2020)

Henderson, S. 2016. *EPWP Defined, Overview & Prospects*. Pretoria: Department of Public Works

Implementing employment intensive road works Manual 3 Gravel pavement Layer. 2007. Pretoria: CIDB

Johannessen, B. 1997. 1ST ed. *Technical Manual Labour – Based Road Construction Methods*.Vientiene: Prepared for the International Labour Organisation by Bjorn Johannessen Engineering Construction

Johannessen, B. 1997. *Labour based road construction and maintenance technology*. Vietiane. Internatioal Labour Organization.

Johannessen, B. 2013. *Building Rural Roads*. Bangkok: ILO

Kangethe, A. and Mason D. 1997. *Labour based Technology–A review of Current Practice*. Uganda: ASIST

Khontari, C. 2004. *Research methodology methods and techniques*. 2nd ed. Jaipur(India): New age (P) Ltd

Kumar,R. 2011. *Research methodology a step by step guide for beginners.* 3rd ed. Carlifonia. Sage Publications Ltd.

LIC Colto. 1998. Lyttelton: South African Institution of Civil Engineering

Little, R.D.1990.*Labour Intensive Construction*.Durban:UKZN

Macbain, G. *Basic principles of surveying* (online).Available: construction site – surveying-resources.org/basic principles of surveying-46.html

Madurai, V. 2018. *Quality, time and money*. Available: https://medium.com/@vivekmadurai/quality-time-and-money-39278f990092 (Accessed 20 March 202)

Manage Labour Intensive Construction Projects. 2019. Pretoria: SARF

Manual for the labour-*based construction of bituminous surfacing on low – volume roads.* 2003. Berkshire: Limited

Manual Pavement labour based technology for rural road works.2015. Comoro: ILO & Don Bosco (Accessed 14 March 2020)

Eby, K. 2017. *The ultimate guide to project cost management with templates* (online). Available: https://www.smartsheet.com/ultimate-guide-to-cost-management-and-templates (Accessed 20 March 2020)

Mcdonals, S. and. Headlam , N. 1986. *Research methods handbook introductory guide to research methods for social research*. Manchester. CLES

Meiskins, P. Smith, C. 1996. *Engineering labour technical workers in competitive perspective.* New York: Verso

Nuclear density gauge calibration (online).2019. Available: https:www.phoenixcalibrationr.com/en/nuclear-density-gauge-calibration-3/ (Accessed 20 March 2020)

Piepmeier, B.H. 1921. *Manual on Road Construction for Resident Engineers and Inspectors*. Springfield: Windham Press

Prof Kim. J. Hitchhikers *Guide to Pavement Engineering*

Quality Assurance Handbook for Rural Roads. 1997. India: National Rural Roads Development Agency

Rehnberg, A. 2011. *Suspension Design for Off-Road Construction Machines.* Stockholm: KTH Royal Institute of Technology

Simple survey techniques (online). 2006. Available: fao.org/3/U3160OE/U3160eoa.htm

South African Pavement Engineering Chapter 3 Quality Management. 2013. South Africa: The South African National Road Agency

Suryakanta, P. *Factors affecting field compaction of soil*.Avalable:https://civiblog.org/2014/2/04/5-factors-which-affect-field-compaction-degree-of-compaction. (Accessed 13 March 2020)

Tembo, S. and Blokhuis F. 2001. *Manual for Supervision of Labour-Based Road Rehabilitation Works.* Zambia: ILO

The project management triangle (online).2020. Available: https://trailhead.salesforce.com/de/content/learn/modules/project-risk-management-for-partners/monitor-communicate-risk?trail_id=consulting_partner (Accessed 20 March 2020)

TMH10 Manual for the completion of As–Built Materials Data Sheets.1993. Pretoria: Department of Transport

TRH9 Construction of Road Embankments. 1982. Pretoria: Department of Transport

Van Rijn, J. 2005. *Labour-based Road works*. (In development)

Ebusingatha Location.Available:www.google earth pro.co.za (Accessed 01 July 2020)

Nankhoo, P. 2011. *Road D1264 Specification*. Pietermaritzburg: Department of Transport

Nankhoo, P. 2011. *Road D1264 Cross Section*. Pietermaritzburg: Department of Transport

SANRAL. 2014. *South African Pavement Engineering Manual*. South Africa: South African National Road Agency

APPENDICES

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3100

ORIGINAL- SITU DENSITY REPORT

CLIENT	Nankhoo & Associates
PROJECT	D 1264 (Bergville)
DATE TESTED	24/10/13
TEST METHOD	**Troxler / Hamboldt**
TECHNICIAN	**N.M Buthelezi**

REPORT NO: 750

KILOMETER COMPACTION AND POSITION	DESCRIPTION LAYER TESTED	DEPTH MM	MOD AASHTO	OMC %	WET DENSITY	DRY DENSITY	MC %	%
6 + 400 LHS	Drk. Formation	150	1642	11.0	1947	1692	15.1	103.0
6 + 440 RHS	Reddish				1928	1663	15.9	101.3
6 + 480 CL	Top				1924	1654	16.3	100.7
6 + 520 LHS	Soil				1920	1633	17.5	99.5
6 + 560 RHS					1915	1625	18.1	99.0
6 + 600 CL					1935	1665	15.8	101.4

REMARKS:

SIGNATURE FOR SSDL: MANAGER

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ORIGINAL- SITU DENSITY REPORT

CLIENT	D.O.T (Bergvile)
PROJECT	D 1264 CH:5+840 – 6+320
DATE TESTED	02/12/2013
TEST METHOD	**Troxler / Hamboldt**
TECHNICIAN	**N.M Buthelezi**

REPORT NO: 870

KILOMETER COMPACTION AND POSITION	DESCRIPTION	LAYER TESTED	DEPTH MM	MOD AASHTO	OMC %	WET DENSITY	DRY DENSITY	MC %	%
5+840 RHS	Drk.	Formation	150	1642	11.0	1660	1535	8.2	93.5
5+880 CL	Reddish					1683	1542	9.2	93.9
5+920 LHS	Top					1644	1538	6.9	93.7
5+960 RHS	Soil					1642	1529	7.4	93.1
6+000 CL						1680	1552	8.3	94.5
6+040 LHS						1712	1561	9.7	95.1
6+080 RHS						1692	1533	10.4	93.4
6+120 CL						1665	1541	8.1	93.8
6+160 LHS						1686	1572	7.3	95.7
6+200 RHS						1679	1554	8.1	94.6
6+240 CL						1680	1536	9.4	93.5
6+280 LHS						1718	1544	11.3	94.0
6+320 RHS						1716	1557	10.1	94.9

REMARKS:

SIGNATURE FOR/ SSDL:_____

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DURBAN UNIVERSITY OF TECHNOLOGY, MIDLANDS CAMPUS.

29th May, 2020

TO WHOM IT MAY CONCERN

The Interviewee

Dear: Sir\Madam

M.ENG THESIS: A COMPARATIVE STUDY OF THE CONSTRUCTION OF ROAD FORMATION LAYERS USING LABOUR INTENSIVE VERSUS TRADITIONAL MECHANISTIC METHODS ON ROAD D1264 IN KZN

Firstly, I would want to thank the interviewee for the willingness in taking time out to assist us in answering this questionnaire regarding the research about the above mentioned topic. This survey is part of a research project aimed at investigating the comparative study of road formation layers using labour intensive (LIC) versus traditional mechanistic methods in road construction.

This research aims to investigate the insight into the time, cost and quality comparison between labour intensive construction (LIC) and traditional mechanistic methods (TMM) of constructing road formation layers. Field test results show that LIC and TMM produce the same quality. The overall results at the test section that was studied between 5.9 to 6.5kilometres on road D1264 formation layer construction show that LIC is more expensive when compared to TMM. LIC is also more time consuming than TMM. The density field test results show that LIC and TMM produce the same quality. Chainages from 5.9 to 6.2kilometres formation was constructed using plant machines. Chainages from 6.2 to 6.5kilometres formation was constructed using LIC methods. Please note that the confidentiality of your response is assured. Thank you in anticipation of your response.

Mongezi S. Mkhize
(DUT Meng Civil student: 20301605)
For Further Information, Contact:
Mr. M.S Mkhize
E-mail: mongezisikhululiwe@yahoo.com
Tel: +27 (0) 723 19 1266

Note: This survey should take approximately 15 minutes of your time

QUESTIONNAIRES ON THE CONSTRUCTION OF ROAD FORMATION LAYERS USING LABOUR INTENSIVE VERSUS TRADITIONAL MECHANISTIC METHODS IN ROAD CONSTRUCTION

Demographic Information (Please tick where appropriate)

Age	18-25 □	26-30 □	31-39 □	40-49 □	Above 50 □
Gender	Male □	Female □			
Education	Grade 1-12 □	Diploma □	Bachelor/Btech □	Honors □	Masters/PhD □
Civil Engineering Sector	Municipal Sector □	Departmental Sector □	Consulting Sector □	Contractor □	Specify if other:
Civil Engineering Professional Registration Status	Pr. Technician □	Pr. Technologist □	Pr. Engineer □	Pr. CPM/Pr. CM □	Specify if other:

Interviewee Experience in the road construction industry

Do you have experience in road construction?	NO □	YES □			
Years of road construction experience?	0-3 □	4-10 □	10-25 □	26-40 □	Over 40 □
Number of road construction projects undertaken?	0 □	1-3 □	4-6 □	7-10 □	Over 10 □
Have you been involved in TMM road construction?	NO □	YES □			

Years of TMM road construction experience?	0-3 □	4-10 □	10-25 □	26-40 □	Over 40 □
Have you been involved in LIC road construction?	NO □	YES □			
Years of LIC road construction experience?	0-3 □	4-10 □	10-25 □	26-40 □	Over 40 □
Do you prefer LIC in road construction?	Never □	Rarely □	Sometimes □	Often □	Always □
Do you prefer TMM in road construction?	Never □	Rarely □	Sometimes □	Often □	Always □
How conversant are you with understanding the road LIC?	Not Conversant □	Slightly Conversant □	Moderately Conversant □	Very Conversant □	Extremely Conversant □
How comfortable are you working on LIC projects?	Not Comfortable □	Slightly Comfortable □	Moderately Comfortable □	Very Comfortable □	Extremely Comfortable □
Can the road formation layer be constructed using the LIC method?	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □
Do you agree with this study finding that LIC provide poverty relief through employment?	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □
Do you agree with this study finding that LIC offer construction skills transfer to the community	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □

than TMM?					
Do you agree with this study finding that LIC cost more than TMM in road formation construction?	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □
Do you agree with this study finding that LIC take more time than TMM in road formation construction?	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □
Do you agree with this study finding that LIC produce the same quality as TMM in road construction?	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □
Do you agree with this study finding that TMM support one main contractor in terms of providing work and finance?	Strongly disagree □	Disagree □	Neutral □	Agree □	Strongly Agree □
Can LIC be the countries solution to unemployment?	Never □	Rarely □	Sometimes □	Often □	Always □
Should the government have more road construction projects carried out using LIC?	Strongly discourage □	Discourage □	Neutral □	Encourage □	Strongly Encourage □
Do you agree that civil engineering technicians, technologist and	Strongly disagree	Disagree □	Neutral □	Agree □	Strongly Agree □

engineers should have more LIC exposure during formal study programmes at University?	□				