

An Investigation on The Level of Use of Lean Principles in the Small and Medium Enterprises; The Case of The South African Construction Industry: Literature Review

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Abstract

This study is a desk study that reviews the impact of lean principles in the Small and Medium Enterprises in the construction industry. The study used a systematic approach to review books, thesis, conference material, and journal articles that were written on lean principles. The review process covers construction micro, small and medium companies involved in civil engineering projects, residential and non-residential buildings. The results revealed that lean principles were poorly implemented and that most SMEs had minimal knowledge of lean principles. There was a clear understanding of some lean tools, and in most cases, they were applied on an activity and not for the entire duration of the project. This revealed that most SMEs were using lean tools but were not aware of their usage in their organizations. These findings assist local construction companies to identify opportunities for reducing operating costs. The researcher proposes interventions that the local and central governments should make in order to help the SMEs develop into a competitive segment of the industry. The interventions assist in; growing the SMEs, creating more job opportunities for the citizens, and generating revenue for the treasury.

Keywords

Lean principles, Lean construction, Subcontracting, BEE and construction industry.

1. INTRODUCTION

Small and Medium Enterprises are the backbone of South Africa's economy. They represent more than 98 percent of businesses and they employ between 50 and 60 percent of the country's workforce across all economic sectors (Aigbavboa and Thwala, 2014; Tshikhudo et al., 2015; Rajagopaul et al., 2020). SMEs in general usually encounter difficulties in securing projects over their immediate rivals, thus affecting their performance. In South Africa, a business strategy that large construction firms use to reduce costs, complete projects on time and enhance competitiveness is subcontracting. Large construction firms have an influence on an SMEs access to work. Subcontracting is very common in the South African construction industry, with up to 70 percent of building and 30 percent of civil construction projects being subcontracted to SMEs (CIDB, 2013).

Another act that offers inclusion of SMEs to participate in large construction projects is the Broad-based Black Economic Empowerment (BEE). The Act seeks to, "*empower rural and local communities by enabling access to economic activities, land, infrastructure, ownership and skills; and promoting access to finance for BEE start-ups, small, medium and micro enterprises, co-operatives and black entrepreneurs, including those in the informal business sector*" (Act No. 46, Government Gazette). Under this act, the South African government set targets for a percentage in each sector to be controlled by SMEs. This has seen large construction companies selling their assets to achieve this objective (Thwala and Phaladi, 2009). With this arrangement SMEs have been encouraged to participate in the main stream economy, thereby opening doors for employment creation. However, research in South Africa has shown that SMEs in the construction industry do not have the requisite skills for proper project delivery, (Hall and Sandelands, 2009; CIDB, 2015; Maake et al., 2016; Jones, 2018). The industry is overwhelmed by inefficiencies, delays, reworks, corruption and operational wastages. Several projects have not been delivered on time and within their budgets (Assaf and Al-Hejji, 2006; Nicholson, 2013; Kgosi et al., 2018). For example, Medupi power station, the 4th largest coal-powered power station in the world, was delayed by 30 months and the estimated

completion costs were R56 billion (Shunmugam and Rwelamila, 2014). Cotterill, (2019) points out that these cost overruns and errors in designs caused a debt crisis and late completion of the project. On the other hand, an article written by Gosling (2020), suggests that the delays and cost overruns of Medupi were caused by Eskom's decision to be the designer and project manager at the same time. Projects of that nature require a separation of the two functions. Worse still Eskom had neither the resources nor the skills to handle a mega project of that nature (Gosling, 2020).

The Gautrain project was another project that experienced delays. It was completed two years after its baseline completion date and the cost exceeded the budget by R14 billion (Shunmugam and Rwelamila, 2014). Transnet's pipeline project from KwaZulu Natal to Gauteng had similar challenges. It was commissioned in 2008 and it had a budget of R12.7 billion. The project was however completed nine years beyond the planned completion date and the cost overrun was R30.4 billion (Groenewald, 2020).

Besides shortages of skills in the sector, it is also affected by corrupt practices. It is alleged that South Africa's large construction firms colluded to secure the 2010 world cup stadium construction projects (Nicholson, 2013). These levels of corruption have adverse effects on the fragile construction industry.

These cost overruns and time delays on the mega projects that the SMEs are a part of point to a number of challenges. The SMEs in most cases cannot fund the projects on their own. No wonder why they are sub-contracted by the large companies that have the capital to do the projects with minimum funding from commercial banks. SMEs can perform smaller projects in remote locations which may be unattractive to large companies (Thwala and Phaladi, 2009).

1.1 Challenges faced by SMEs in the South African Construction Industry

The SMEs' existence in the South African construction industry indicate a presence of an entrepreneurial spirit and a healthy economic society. Despite their challenges they remain a significant contributor to the South African economy (Wentzel et al., 2016). A survey that was conducted by Aigbavboa, (2016) found that there was little that was done to implement practices, such as lean, that could reduce costs in the construction industry. Challenges faced by SMEs in South Africa are many and varied, some of these challenges are: Lack of access to reliable information about tenders and contracts, lack of access to funding from commercial banks, high number of defects, constant design changes and late information and inadequate experience in the construction sector

Projects such as Medupi, Gautrain and the Transnet pipeline are a representation of many projects that suffered losses due to inadequate cost cutting measures and practices.

This situation calls for waste management approaches in the construction industry. In this regard it is necessary to reduce costs, and improve; quality, performance, and productivity. Lean principles are a candidate to help companies to reduce waste and improve their processes (Ramani and Ligan, 2019; Gosling, 2020). Lean philosophy demands that waste be eliminated from every stage of work process whilst adding value in the product by completing value-adding functions effectively and on time.

1.2 Methodology

This is a desk study that reviews the levels of implementation of lean principles in the South African SME construction industry. The researchers reviewed literature on three types of construction projects; civil works, residential, and non-residential (general building). A systematic review was used for this research. To address the issues of reliability and validity, the researchers reviewed literature from credible journals and databases.

To achieve the purpose of this study several reviews on existing literature were conducted. The research first considered an extensive literature review in lean principles in construction SMEs using the institutional database.

An extensive literature review was also conducted on journal articles. The journals that were searched are, Emerald, Taylor and Francis, Science direct, UJ Google and Routledge. The journals were searched using the following keywords, 'lean principles', 'lean construction', 'SME projects', 'lean construction SMEs' and 'lean principles in construction'. This was further filtered using a combination of keywords such as "South African construction

industry” and “lean principles” to narrow down the scope of the limited literature. Seventy journals were identified and thoroughly reviewed. Two books from Google scholar and different publishers that are known to have well researched information on lean construction and lean principles in the construction industry were examined. The researcher further reviewed the use of lean principles in the construction industry the United Kingdom and Malaysia. This was done to provide benchmarks to the South African sector.

1.2.1 Types of construction projects Considered in the Review

Experts classify and analyze construction projects according to their similarities. Abdelhamid groups construction projects into three categories: *Residential building construction* - office buildings, banks, shopping centers, dealerships, sports complexes, hospitals, universities. *Engineered construction* - highways, airports, harbors, tunnels, bridges, dams, pipelines, waterways, sewage plants. *Industrial construction* - Processing plants, refineries, steel mills (Abdelhamid, 2008).

Santana on the other hand categorizes the construction projects based on the number of consultants, specialists and contractors that are involved in the projects (Santana, 1990). The groups that come out of this classification are: *Singular* - tunnels linking countries, inter-continental bridges, dams. *Complex* - industrial projects, public works, town development schemes. *Normal* - buildings, roads, and earthworks (Santana, 1990).

Winch, (2010) also brings another dimension to grouping of construction projects, namely: *Large infrastructure works* - civil engineering, prestige building projects, routine building projects -schools, offices and hospitals, and housing. The first three categories are project-oriented and mass production can hardly be achieved (Gao and Low, 2014). Housing projects allow higher delivery numbers (Gao and Low, 2014).

In South Africa there are six different types of construction projects, and these include:

- Residential and Non-residential building (General Building) - these are primarily concerned with the development, extension, installation, renewal, renovation, alteration, or dismantling of a permanent shelter for its occupants or contents; or cannot be categorized in terms of the definitions provided for civil.
- Civil engineering – associated with the development, extension, installation, maintenance, removal, renovation, alteration, or dismantling of building and engineering infrastructure,
- Mechanical works: primarily concerned with the development, extension, installation, removal, alteration, renewal of engineering infrastructure for gas transmission and distribution, solid waste disposal, heating, ventilation and cooling, chemical works, metallurgical works, manufacturing, food processing and materials handling,
- Electrical works: primarily concerned with the installation, extension, modification or repair of electrical installations in or on any premises used for the transmission of electricity from a point of control to a point of consumption, including any article forming part of such an installation.
- Special works: are different kinds of specialist works classified under one definition such as asphalt works (supply and lay), building excavations, shaft sinking, lateral earth support, demolition and blasting, etc (Marx, 2014; Du Plessis and Oosthuizen, 2018; CIDB, 2017).

For the purpose of this study the researcher will be focusing on three types of construction projects; civil works, residential and non-residential as the majority of SMEs are concentrated in these types of projects.

2 LITERATURE REVIEW

2.1 Introduction

It is suggested that lean can only be successful in the manufacturing industry (Ruan et al., 2017). Research has in some cases established that owners of construction SMEs struggle to identify the benefits of lean in the construction industry (Ruan et al., 2017). However, other researchers argue that applying lean in the construction sector is necessary to complete the projects successfully (Baccarini, 1998). The key element of lean that has been observed to have potential modernizing practices in construction industry are the lean principles (Egan, 1998).

Koskela, in his Stanford report termed lean principles as “the new production philosophy” in the construction industry (Koskela, 1992). A few years later Koskela reinvented the name to lean construction (Koskela, 2000). Lean construction is concerned with designing production systems in order to minimize waste in materials, time, and effort. It generates value (Koskela et al., 2002).

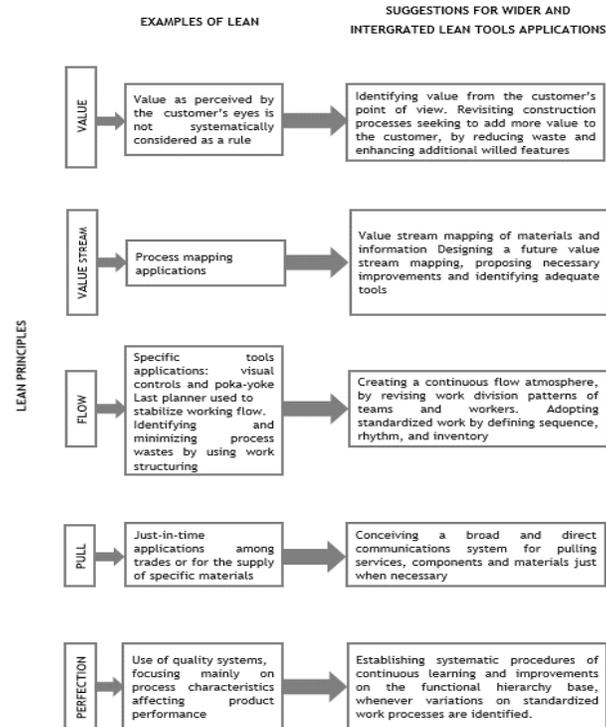


Figure 1: Different tools and their applications in Lean Construction (Picchi and Granja, 2004; Aziz and Hafez, 2013; Ramani and Ligan, 2019)

The tools in Figure 1 were developed mainly for the manufacturing industry, however, they can be taken up in the construction industry to help effect process improvement. On several occasions a single tool is used on a construction site, without being tied to other tools or lean principles (Picchi and Granja, 2004).

2.2 Lean principles for the SME construction industry

Womack and Jones defined lean principles as follows:

- Value – is the critical starting point of lean thinking, it is defined by the customer in terms of a product or service that meets the customers need.
- Value stream – is all the necessary activities required to deliver a product to the customer.
- Flow -is the value-added steps flowing together continuously with no stoppages or rework.
- Pull - design and provide what the customer wants only when the customer wants it.
- Perfection – always striving to offer a better product while reducing waste (Womack and Jones, 1996; Jones, 2018).

The five principles in Figure 1 are elements of the lean philosophy (Waterbury, 2015). For these lean principles to be applicable in the SME construction industry, a set of sequential activities that form individual processes are necessary (Ramani and Ligan, 2019).

2.2.1 Value

According to Womack and Jones, (1996) value is a critical starting element of lean. It is defined by the customers in terms of the products or the services that meet their needs. Chen *et al.*, (2010), describes value as an organized application that uses technical knowledge and common sense in order to eliminate unnecessary costs and ensure value for money. In the construction industry, the value principle regulates practices that influences the quality of the projects (Chavan, 2013). The value principle has been widely exploited in the construction industry, particularly in the civil infrastructure projects (Ekanayake and Sandanayake, 2017). In Malaysia for example, highway construction projects achieved time reduction, cost reduction and quality enhancement by implementing the value principle (Ekanayake and Sandanayake, 2017); Ismail, 2011). Value is not a cost cutting measure, it simply has an ultimate goal of ensuring value for money from a project (Pheng and Chuan, 2001).

Application of the value principle calls for the construction companies to focus on customers' needs. Bertelsen and Emmit, (2005) argued that without an understanding of the customer, the value concept remains undefined. Surprisingly, whilst there are several definitions and models that revolve around the value principle in literature, a universal theory of value in the construction industry has not materialized (Garrido and Pasquire, 2011). It has been recognized that the concept of value is probably the most difficult approach in the new way of managing construction projects (Garrido and Pasquire, 2011).

In the South African Construction industry, the delivering of value on projects has been a challenge in the construction industry for some time. This is due to a number of reasons. Firstly, there has been little investment in human capital development, and this is worsened in some cases by the migration of the skilled manpower (CIDB, 2015). The effective and efficient of provision of infrastructure for the 2010 FIFA Soccer World cup and the Gautrain Rapid Rail Link were affected by skills shortages. This was partly the reason why both projects struggled to meet contractual obligations on cost, time and quality (CIDB, 2015).

Another factor that impacts on delivering of value in construction projects in South Africa is non-availability of experience in the requisite knowledge areas (Maake *et al.*, 2016). The above two factors do not impact the execution of projects only; they impact the maintenance of existing infrastructure and the delivery of basic services in the sector as well (CIDB, 2015).

Corruption has also been cited as another reason why the industry is failing to deliver value on its projects (Oke *et al.*, 2017). Emerging and inexperienced contractors pay their way to winning contracts, yet they are unable to deliver value to the customer. The situation is made worse by poor regulatory environment and poor procurement management (Oke *et al.*, 2017).

Oke *et al.*, (2017) also found that there are times when the client is not provided with adequate information on the ability and capacity of SMEs in undertaking a given construction project. At the end of the day there will be a mismatch between what the client expected and what the contractor delivered. This mismatch defines the value that contractor failed to deliver.

Furthermore, Oke *et al.*, (2017) found out that some unsuitable SMEs that undertake construction projects charge ridiculously low prices. This is done to win a contract or tender. They end up compromising on the quality of the product that they deliver, much to the frustration of the client.

The failure by some SMEs to deliver value on their projects has brought mistrust between the clients and construction SMEs, leading to decline in contracts that they secure. It is therefore imperative that all SMEs in the construction industry embrace the value principle, otherwise they will be left out in realizing the benefits associated with customer satisfaction, continuous improvement, improved quality of services, better chances of completing projects within budget (Aigbavboa *et al.*, 2016). Ekanayake and Sandanayake, (2017) listed the following approaches in establishing value, identify client requirements, establish project objectives from the client's perspective, establish the project scope, establish the perfection evaluation criteria, develop a data package with relevant information that emphasizes on waste minimization and value enhancement, lastly determine the team composition including lean experts (Ekanayake and Sandanayake, 2017).

2.2.2 Value stream mapping

Value stream mapping (VSM) helps in representing the existing process and the necessary improvements to be made in the current process (Ruan *et al.*, 2017). VSM is a principle that was initially established for the manufacturing industry. Some authors believe that VSM is a tool that is used to analyze the existing process state and it seeks to improve productivity through elimination of unnecessary activity, process modification and activity improvement (Ruan *et al.*, 2017; Ciarapica *et al.*, 2016 and Kuiper *et al.*, 2016). Irani and Zhou, (2011) praise VSM as an integral tool that locates and understands the sources of waste, such as reworks, accumulation of waiting products and inventories and lost information in the process. However, Aziz *et al.*, (2017) point out that VSM cannot provide hard facts for decision making; it simply indicates problem areas. It does not analytically forecast the effects on future performance. VSM is sufficient when analyzing simple and linear processes that have relatively consistent patterns (Aziz, 2017).

One essential technique that is associated with value stream mapping is process mapping. Process mapping is used to help understand how value is built into a building project from a customer perspective (Garnett, 1998). This is done by applying a top down approach in identifying value streams that explain how projects of products will be designed, produced and delivered. VSM is also used to identify valuable activities and waste in a particular process (Garnett, 1998; Ballard and Howell, 2003). This identification of waste in processes helps in defining the requirements for a new approach.

The traditional approach of executing projects pursues project delivery and neglects value maximization and the minimization of waste (Kgosi *et al.*, 2018). High levels of non-value adding activities exist in the construction industry, and it is difficult to measure all the wastes (Aigbavboa *et al.*, 2016). The unwillingness of the SME construction industry to change its traditional project execution methods has seen variations showing up in value streams across projects. Maradzano *et al.*, (2019) observed that there is no evidence of the use of VSM in the South African construction industry. The failure to harness VSM in the South African construction SMEs is attributed to the inadequate skills amongst the practitioners (Aka *et al.*, 2017). Gunduz and Naser, (2019) found out that there are no detailed and unified VSM implementation guidelines in the construction industry.

This failure to apply VSM in construction projects has made it difficult to eliminate waste in all the phases of construction projects. Desai and Shelat, (2014) argue that waste can arise at any stage of a construction project starting at commencement, right through the design, construction, and operation of the built facility. Du Plessis and Oosthuizen's, (2018) study of the project life cycle for construction projects showed that the implementation phase of the projects costs more and requires more time than the other phases. This is then the phase where there are higher chances of reducing waste (Du Plessis and Oosthuizen, 2018). Aka *et al.*, (2017) found that most of the waste experienced during the construction phase of a project was largely due to the problems that were not discovered or anticipated in the design phase. However, VSM is not the panacea to all the wastes experienced in the construction industry. Some of the waste emanate from the failure by some of the practitioners to comply with the terms of the contracts. This non-compliance invariably leads to failure to complete the projects efficiently and on time (Du Plessis and Oosthuizen, 2018).

2.2.3 Flow

Once all waste has been eliminated in the value stream, the value-adding steps flow together continuously without stoppages and rework. Flow can be summed up as one of the most important principles to achieve complete removal of waste (Ramani and Langan, 2019). The goal is to have the product from design phase to the customer without interruption. Sacks, establishes that most construction professionals lack a clear understanding of the concept of flow (Sacks, 2016). The reason being, its absence from traditional construction management training and practices (Sacks, 2016). Traditional construction projects adopt Gantt chart plans and schedules which are activity based and allocates productivity rates haphazardly, thus endangering high and low production peaks (Zhang *et al.*, 2017). However, such representations fail to show flow and linkages between tasks. This may cause delays and cost over runs, leaving the construction market in an uncompetitive position when compared to other lean implementing construction industries. Conceptually companies have a difficult time applying beyond internal departments (Yassine *et al.*, 2014).

An assessment by Low and Mok, (1999) suggested a practical approach to Just in Time (JIT) for reducing and minimizing waste on-site. They concluded that the Kanban technique of ordering and delivering materials can be

modified to suit the construction industry (Low and Mok, 1999). Pheng and Chaung, (2001) support the Kanban technique which has the potential to erode logistical aspects that are not properly managed in the construction industry (Picchi and Granja, 2004). While partnering remains a partial solution in achieving seamless flow delivery of a product, gives purpose to a partnering relationship (Garnett et al., 1998). True integration of functions in a company into product teams organized along the value stream enable and promote flow of information and materials (Yassine et al., 2014).

Several South African projects have exceeded their planned completion dates, and it has been considered as a common problem in the construction industry (Kgosi et al., 2018). A test conducted by Thomas et al., (2003) to see whether improving flow reliability improved construction productivity concluded that, the more reliable the workflow was the more productive construction became. This discovery showed that, variability in daily labor productivity was highly correlated with project performance (Zhang et al., 2017).

The flow of work is important in the construction industry. Zhang et al., (2017) mention that reliable workflow has the potential of reducing construction waste, improve project performance and improve labor productivity.

The challenges that can be linked to the failure to implement flow in the South African construction industry are the lack of thorough project briefings, lack of coordination between design department and construction departments and a lack of coordination and organization among various trades on the construction sites. Such barriers deny construction SMEs in realizing the benefits of employing flow, such as the reduction of project duration, reduction of waste, and improved supplier relationship.

Yassine et al., (2014), believe that the first requirement of creating continuous flow is to identify takt time and producing accordingly. They further define takt as time set for supplying certain processes and it is derived from the customer demand. Takt time introduces benefits to projects such as decreasing the entire project duration, minimizing project costs and a reduction in variability (Yassine et al., 2014).

2.2.4 Pull

Pull is defined as a system of cascading production and delivery instructions from downstream to upstream activities in which nothing is produced by the upstream supplier until the downstream customer signals a need (Yahya and Mohamad, 2011). Gao and Low, (2014) refer to pull or Kanban as a system that can be used to procure material at the right time and in right quantities based on actual demand on-site. The pulling concept in the construction industry can be interpreted as material supply, labor and equipment to the customer (workstation) immediately when they are required. There usually is a tug of war on the amount of resources and the time required to complete a project. Gade, (2016) observed that rushing to complete projects within their baseline dates, leads to a related project cost increase. Traditional construction processes push customers in a protracted development process where risk and uncertainty are prevalent (Dulaimi and Tanamas, 2008; Garnett et al., 1998). In the event of shortages on necessary resources, rescheduling of construction activities should be made in order to avoid unnecessary delays (Ng et al., 2013). Therefore, a buffer on equipment, labor and materials should be kept in order to prevent disruptions on a project.

Due to differences between manufacturing and the construction sectors pull serves as a supplier Kanban which helps contractors' better control of their materials and inventory requirements (Gao and Low, 2014). A survey conducted by Gao and Low, (2014) revealed that pull was not a highly appreciated principle by the respondents. This revelation suggested that respondents were using traditional ways of procuring commonly used materials (steel rebar, bricks, cement, etc.), thus generating big batch orders. If the material is ordered according to the requirements on site, then it yields lower levels of inventory.

The procurement of materials is dependent on the project planners forecasting skills and funding. Successful procuring in the South African construction industry improves the performance of delivering projects on time. SMEs encounter challenges of procuring materials because they are usually paid once the project has been completed. Design changes and amendments which are introduced can cause delays and costs to escalate while being implemented (Thwala and Phaladi, 2009; Ogunsanya et al., 2016). Maradzano et al., (2019) did not find any evidence of the application of the pull system in the South African construction industry. Bearing in mind that the construction projects are once off products and this makes procurement difficult as each project is unique. However,

the SMEs are missing out on the benefits associated with pulling such as increased collaboration, continuous improvement and early identification of challenges.

2.2.5 Perfection

Perfection is attained through continuous improvement, and it requires harnessing the skills and knowledge of all stakeholders (Garnett et al., 1998). It requires a company the collective exploitation of the value, value stream mapping, flow and pull principles, and the benefits realized out of this are identification and elimination of waste in a system (Gao and Low, 2018). The environment for perfection is created when there is a cordial relationship between management and workers (Ismail et al., 2010). This is the kind of environment that the SMEs in the construction industry need to create if they are to be competitive (Dulaimi and Tanamas, 2008). The SMEs need to have the patience through the learning phase and not to abandon new processes quickly.

In the South African construction industry perfection should be the core principle but is not the case most of the time. The SMEs should priorities on delivering what the client requires and at reasonable prices. However, in the South African construction industry, projects and construction sites are sometimes abandoned because of financial problems, inexperienced developers, mismanagement and mistakes (Hull, 2020). Furthermore, tenders are awarded to construction companies that are struggling and have no funds to continue with the projects. Insufficient funds have a tendency of prolonging the duration of the project and costs. Gauteng alone has lost over R620 million due to abandoned and incomplete construction projects (Hull, 2020). Awarded tenders dating as far back as 2017 have not started for building projects and renovations (Hull, 2020). Perfection in the construction industry is achieved when the industry attends to the issues raised above.

Some of the benefits that SMEs are missing from perfection are: continual review of their internal processes, and refining of processes. Learning from each project allows the SME to be open to changes and new ideas, and continually innovate in order to add value and eliminate waste. If SMEs can be more profitable by working more efficiently rather than by cutting overheads, there will be economic and social benefits as well as satisfaction among the workers.

3 Conclusion

The review has shown that SMEs subcontracted by large construction companies in the South African construction industry have not done much to adopt lean principles in their practices. It has been found out that there are no deliberate educational programs to support them in this regard. The companies have also not done much to help themselves in this regard. Inadequate knowledge and skills create a barrier to the implementation of the principles. The SME owners may see it fit to manage the businesses themselves in order to minimize operational costs.

The construction SMEs are currently operating in an environment full of uncertainties that have been induced by COVID 19, corruption, skills shortages and a lack of coordination between design department and construction departments. One way to ensure sustainability is through reduction of costs. Among other possible initiatives, the harnessing of lean principles provides an answer. The application of lean principles help reduce and eliminate waste. The reduction of waste creates an opportunity to increase profit margins, thereby making the sector competitive.

It has been noticed that many SMEs in the construction industry have not adopted new technologies that are coming onto the market. They have remained rigid and they lack inspiration to change their old habits. A constant reminder of the benefits of lean principles for the construction SMEs should be a motivation for them to embrace them. A number of channels such as; government gazettes, construction magazines, seminars, Engineering News magazine can be a source of useful information.

The SME project teams in South Africa need to understand the scope, project milestones and the project phases in order to have a smooth construction schedule. Communication among all the stakeholders on the project needs to be increased in order to effectively coordinate the project activities. This reduces costs associated with design changes, and reworks.

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