



The Construction Sector Post-Lockdown

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Acronyms

BER	Bureau For Economic Research
CCMA	Commission for Conciliation, Mediation and Arbitration
CIDB	Construction Industry Development Board
DBSA	Development Bank of Southern Africa
DFI	Development Finance Institution
DIY	Do It Yourself
DOEL	Department Of Employment and Labour
DPWI	Department Of Public Works and Infrastructure
GDP	Gross Domestic Product
IDC	Industrial Development Corporation of South Africa
IDD	Infrastructure Delivery Division
IMF	International Monetary Fund
IoT	Internet of Things
ISA	Infrastructure South Africa
LIDAR	Light Detection and Ranging
MBSA	Master Builders South Africa
MFMA	Municipal Finance Management Act
NDP	National Development Plan
NIP	National Infrastructure Plan
NPC	National Planning Commission
PFMA	Public Finance Management Act
PMG	Parliamentary Monitoring Group
PPE	Personal Protective Equipment
PPP	Public-Private Partnership
QFS	Quarterly Financial Statistics
SAFCEC	South African Forum of Civil Engineering Contractors
SAICE	South African Institute of Civil Engineering
SAPS	South African Police Services
SIDS	Sustainable Infrastructure Development System
SOE	State Owned Entities/Enterprises
STATSSA	Statistics South Africa
WBHO	Wilson Bayly Holmes Ovcon

Abstract

This research has shown the adverse impact that the COVID-19 pandemic has had on the construction sector causing major job losses, supply chain disruptions and revenue losses for construction companies. Many construction companies have been forced to close due to financial losses caused by the lockdown restrictions and those still operational have changed their day-to-day operations to comply with COVID-19 regulations. However, the COVID-19 pandemic has also provided an opportunity for innovation within the sector as new disruptive technologies have come to the fore as measures to maintain productivity while mitigating the spread of the virus. Increased infrastructure investment, delivery and maintenance is a key driver of economic recovery post the COVID-19 lockdown and will assist in reviving the construction sector and creating employment. The lessons learnt during this pandemic can also be incorporated into current infrastructure projects within the DBSA for better project and expenditure planning during any future pandemic or infrastructure delivery disruption.

1. Introduction

The global COVID-19 pandemic and subsequent economic activity restrictions have negatively affected global economic growth. The effects have been regionally specific and varied, with advanced economies and emerging markets and developing economies experiencing different levels of contractions. The construction sector is one of the largest sectors locally and internationally and affects both economic and social aspects of economies. The COVID-19 pandemic has adversely affected construction projects across the world in numerous ways resulting in the closure of many. Safety measures such as social distancing, travel restrictions and economic activity lockdowns have resulted in unprecedented delays and supply chain disruptions which have led to a financial recession with consequent increases in unemployment, uncertainty, and unrest.

The goal of this paper is threefold. Firstly, to document the impact the COVID-19 pandemic on organisational processes and the supply chains within the construction sector both locally and internationally. Secondly, to document the response of firms within this sector to the COVID-19 pandemic. Thirdly, to provide an analysis of how the lockdown has shaped the post-lockdown architecture of the construction sector, focusing on infrastructure projects and the likely future scenarios to inform the business of the Bank.

1.1 The Construction Sector

The construction sector is an economically significant sector in any country as it contributes to the gross domestic product (GDP) through social and economic infrastructure development. The construction sector is the backbone for economic growth in any country as it plays a vital role in the prosperity, social progress, and quality of life of any country's citizens. The absence of adequate infrastructure development may result in subdued economic growth and lead to a country's economic failure (Alaloul, et al., 2021). Globally, the construction sector is estimated to account for USD1.7 trillion while averaging in most countries to between 5 and 7 per cent of total GDP (Kenny, 2017).

In South Africa, the construction sector is a key driver of socio-economic development and a key employment multiplier. The sector adds significant value to the country and its citizens as the stakeholders in the sector include employees, their families, the unions that represent them, the government as the regulator, suppliers of construction material, customers, and investors (Rossouw & Naidoo, 2016).

The sector has experienced extended periods of negative growth which have resulted in the sector being in recession. In the third quarter of 2019, the sector contributed R106 billion to total value added which was lower than the fourth quarter of 2016 at R110 billion (StatsSa, 2019). The year 2016 is also the year in which the South African government entered into an agreement with seven large construction companies to promote transformation in the sector and settle outstanding and potential civil claims relating to a number of infrastructure projects (SAFCEC, 2017).

The agreement included financial contributions by the construction companies to a trust fund as well as transformation commitments in the sector, above the current broad-based black economic empowerment sector requirements. The agreement also focused on increasing employment and investment, creating entrepreneurial opportunities for young South Africans, supporting black-owned construction companies and small business development. The Construction Industry Development Board register of contractors has shown that small and medium enterprises outnumber established firms. However, the failure rate of these small and medium enterprises has been increasing over time and remains a source of concern (Smallwood & Wentzel, 2016).

The stagnant South African economy and low infrastructure spending have resulted in major job losses and retrenchments in the construction sector that are higher than in any other sector. This has caused some local construction firms to diversify into other sectors while others have gone out of business completely. For small and medium enterprises, poor strategic leadership and financial management as well as their lack of business knowledge contributed to their woes (Ranjit, et al., 2011). In their study, Smallwood and Wentzel (2016) also highlighted external factors such as compliance with legislation, resources scarcity, crime, corruption, and rapidly changing technology as challenges.

Windapo and Cattell (2013) also analysed the key obstacles preventing growth and development in the sector, which included; lack of public sector capacity, global issues, procurement practices and the capacity for sustainable empowerment, access to affordable credit and interest rates, mismatches between available skills and required skills, increased cost of building material and statutes and regulations. Other issues include sector unrest such as strikes which causes delays, disruptions and even violence in the sector and site invasions (see also 3.1.6).

The lack of sufficient working capital in many construction companies has increased their exposure to liquidity risks and affected their ability to grow. Increased competition in the sector has also driven margins down. Volatility in commodity prices and the exchange rate has also limited the expansion of many contractors into new markets. These were challenges facing the construction sector even before the COVID-19 pandemic which further exacerbated the challenges.

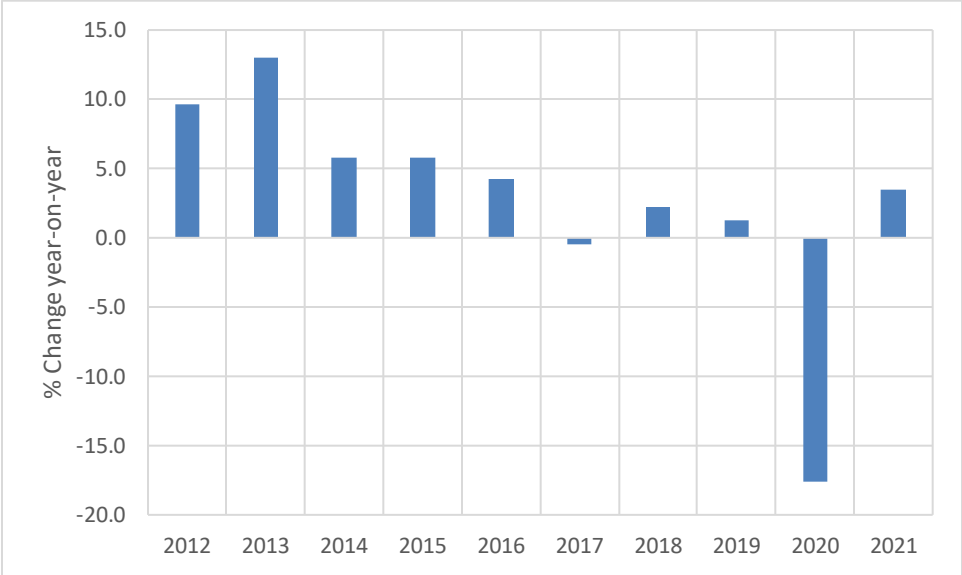
The sector is expected to rebound in the period 2023-25 on the back of expected infrastructure investment as per the plan of the South African government (Wood, 2022). This will heavily depend on the execution of the plan. Encouragingly, StatsSA has reported an increase of 37,3 percent in buildings completed in March 2022 (StatsSA, 2022).

1.2 Short and Long-term impacts of COVID-19

Prior to the COVID-19 pandemic outbreak, the domestic construction sector was faced with challenges such as lack of construction projects, late and non-payment of contractors and professionals as well as the uncontrolled illegal construction site invasions by syndicated organized crime. COVID-19 has introduced additional challenges such as delays, disruptions, suspensions, and termination of contracts as well as difficulties with supply of material and workforce unavailability due to illness and lack of safety measures. In South Africa, the construction sector suffered the biggest economic growth contraction compared to other sectors of the economy due to the lockdown restrictions (StatsSA,

2021). Figure 1 below shows the sector value added and GDP constant prices percentage change year-on-year for the construction sector.

Figure 1: Construction sector value added and GDP for South Africa



Source: StatsSA (2022)

A survey by the Construction Industry Development Board (CIDB, 2020) highlighted the top concerns facing South African contractors registered as Grades 2 to 9 on the CIDB register. The maximum contracting value of a Grade 2 contractor is R 1 000 000 while that of a Grade 9 contractor is unlimited. Tables 1 and 2 below show results from the CIDB survey about the short and long-term concerns of contractors in South Africa attributable to the COVID-19 pandemic. The survey highlighted large job losses for construction workers, bankruptcy of construction firms, and labour disruptions as the key concerns. Managing projects and construction risk during the pandemic has been an essential part of mitigating its impact. Project managers and contractors have applied proper risk management processes such as remote working (designing detailed plans for bidding or budgeting can be done with software at home), workplace sanitization, maintaining social distancing at the workplace and making personal protective equipment (PPEs) available to site workers.

Table 1: Short-term impacts

	Grades 2 to 4	Grades 5 and 6	Grades 7 and 8	Grade 9	Overall
Short-Term Impacts	Ranking	Ranking	Ranking	Ranking	Ranking
Job losses for construction workers	1	1	1	2	1
Loss of income/revenue for organisations	2	2	4	5	2
Retrenchment of construction workers by firms	3	3	1	1	3
Non-payment of preliminaries and general during the lockdown	4	6	3	4	4
Significant increase in the cost of materials	4	7	6	9	5
Lack of payment for certified work	6	4	5	2	6

Sources: CIDB (2020)

Table 2: Long-term impacts

	Grades 2 to 4	Grades 5 and 6	Grades 7 and 8	Grade 9	Overall
Long-Term Impacts	Ranking	Ranking	Ranking	Ranking	Ranking
Massive job losses for construction workers	1	1	6	2	1
Bankruptcy of construction firms	2	2	2	1	2
Business interruption	3	4	3	5	3
Labour disruptions	4	5	4	7	4
Interruptions in the delivery of critical infrastructure projects	5	3	4	10	5
Suspension of projects/potential site closure	6	6	7	2	6
Increase in number of claims related to contractual scheduling along with scheduling along with mediations, arbitrations, and litigation over construction delays	9	6	1	8	7

Sources: CIDB (2020)

2. Methodology

2.1 Systematic Review

To address the research goals and objectives, this paper has followed a qualitative method using a systematic review approach. Systematic reviews use repeatable analytical methods to collect secondary data and analyse it. Systematic reviews are a type of evidence synthesis which formulates research questions that are broad or narrow

in scope, identify, and synthesize data that directly relate to the systematic review question (Khan, et al., 2003). The following five steps were followed to conduct the systematic review:

- *Framing questions for a review*

The research goals were clearly and unambiguously stated to give an indication of the objectives of this study. The structured scope clearly identified the main topics as well as the subtopics to be addressed towards achieving the main objectives of this research.

- *Identifying relevant literature*

An extensive search for relevant studies, reports and surveys was conducted and guided by the questions framed within the research scope.

- *Assessing the quality of studies*

Selected studies were subjected to a more refined quality assessment by use of general critical appraisal guides and design-based quality checklists. The type, year, relevance, source, and credibility of each study was assessed for exploring heterogeneity and informing decisions regarding suitability of meta-analysis.

- *Summarising the evidence*

For each subtopic listed in the scope, a data synthesis exercise took place to consolidate data from all the relevant literature included in this study and to draw a conclusion from the body of evidence and address the research objectives.

- *Interpreting the findings*

An interpretation of the findings and results from the literature included in this study was conducted to identify any variability in study outcomes. If variability does exist, then outcomes observed from high level quality studies were used for generating inferences.

2.2 Interviews

An information gathering process was conducted through electronic interviews with key informants such as the CEO of South African Institution of Civil Engineering (SAICE) and the Wilson Bayly Holmes Ovcon (WBHO) construction company. A questionnaire based on the research topics was developed and distributed to relevant stakeholders to receive their inputs on the research objectives.

2.3 Case Study

A case study approach was developed in which a contractor was profiled, and their operations documented to clearly analyse the impact which the COVID-19 pandemic has had on their construction operations at a micro level. The analysis included interviews and a construction site visit for observational data collection purposes.

3. Discussion of findings

3.1 COVID-19 implications on the construction sector

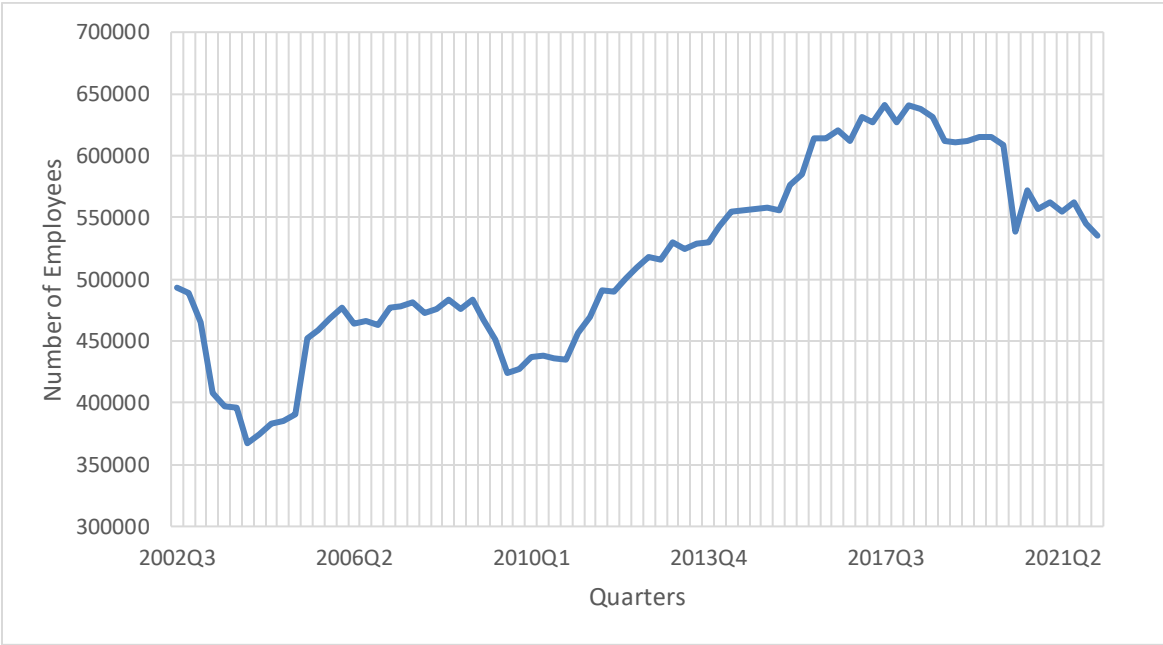
This section reviews and documents the impact of the COVID-19 pandemic on the construction sector in South Africa under each of the following headings which were determined as part of the systematic research approach.

3.1.1 Job Creation in the construction sector

The construction sector has a relatively high employment share to its GDP contribution. The sector uses a range of inputs from other sectors to produce its goods and services and as such the sector indirectly contributes to job creation in other sectors as well. However, employment within the construction sector has been heavily affected by the COVID-19 pandemic. Tables 1 and 2 have shown that the biggest impact of the pandemic amongst contractors of all grades is massive job losses and retrenchments of

construction workers. Figure 2 shows that even before the COVID-19 pandemic, job losses were already evident in the construction sector – with employment on a downward trend since 2017. The CCMA 2018/2019 annual report stated that, compared with other sectors, the construction sector experienced the highest retrenchments due to many contractors experiencing financial difficulties with some having been liquidated (CCMA, 2019).

Figure 2: Number of employees in the construction sector in South Africa



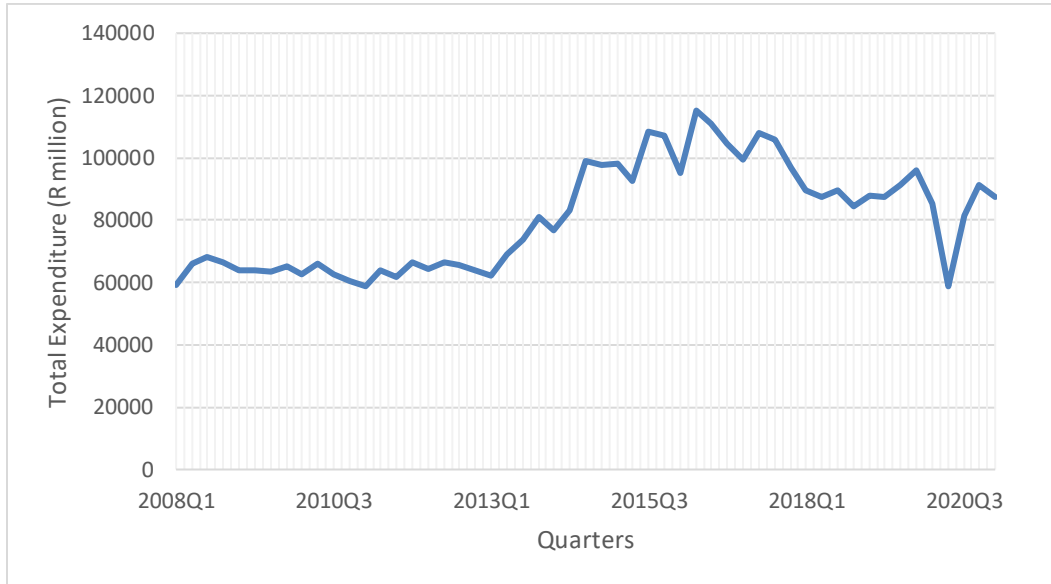
Source: StatsSA (2022)

3.1.2 Expenditure on construction projects

Total expenditure on construction projects has been on a steady decline since 2016, however, due to the COVID-19 pandemic, it decreased sharply in the first and second quarters of 2020. The expenditure has remained low in 2021 due to persistent electricity interruptions, low business confidence and low capital spending from public corporations’ contribution. State-owned companies have attributed recent contractions in investment to COVID-19 related restrictions in the construction sector, longstanding project delays and credit rating downgrades that have significantly slowed capital expenditure programmes (National Treasury, 2021). The decline in construction projects’ expenditure is also

attributed to the reallocation of funds from construction projects to learning and culture, social development, and healthcare to tackle the pandemic.

Figure 3: Total expenditure on construction



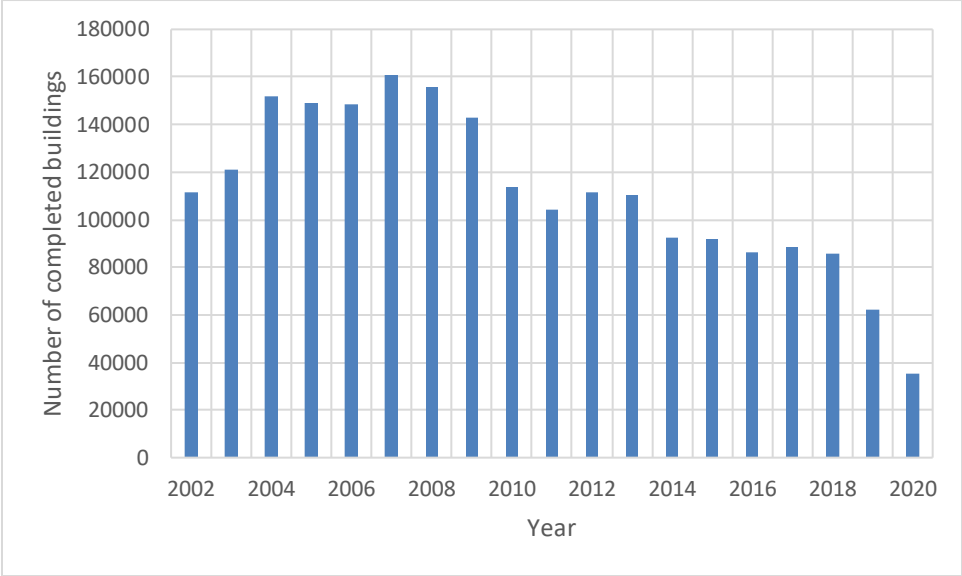
Source: StatsSA (2021)

3.1.3 Timing and postponements of projects under construction

Significant delays have been experienced in the construction sector by many contractors CIDB (2020). Delays in the awarding of already priced tenders and delays in the delivery of projects has been a major concern. The pandemic has caused interruptions to supply chains, labour supplies and financial impacts which have adversely impacted the timely completion of construction projects. Postponements of construction projects have caused problems within the sector as tendering is a costly exercise and the promise of pipeline work means contractors must hold on to resources that could have been utilized elsewhere. Postponements of construction projects increased by 6 percent in the 2nd quarter of 2020 due to poor planning and liquidity concerns caused by the pandemic amongst other things (Industry Insight, 2020). Figure 4 shows the number of completed buildings, and points to a consistent decrease since the year 2013. In the COVID-19 pandemic ravaged year 2020, the number of buildings completed was at its lowest. This

can be attributed to the lack of investment within infrastructure and the lockdown restrictions which led to an abrupt shutdown of the sector.

Figure 4: Buildings completed

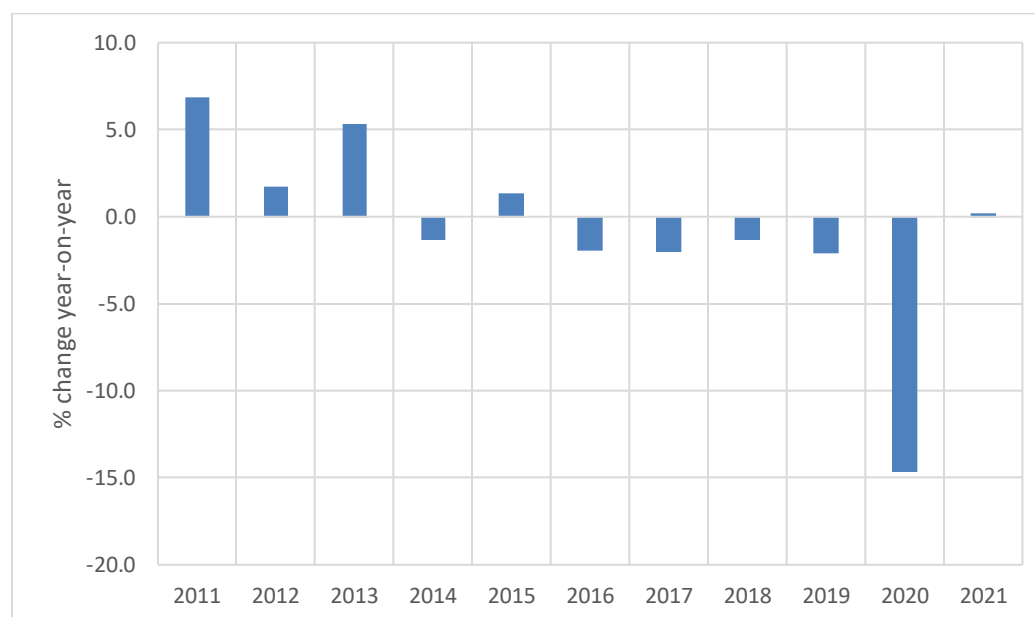


Source: StatsSA (2021)

3.1.4 Infrastructure investment

Investment in public infrastructure has been consistently lower than the National Development Plan (NDP) targets of 10 percent of GDP from 2010 and since the advent of the COVID-19 pandemic the levels of investment dropped to 7,1 percent in the 4th quarter of 2020 (Industry Insight, 2021). The NDP stated that gross fixed capital formation needs to reach about 30 percent of GDP by 2030, with public sector investment reaching 10 percent of GDP to realise a sustained impact on growth and household services. However, gross fixed capital formation in South Africa decreased sharply by **14,6 percent** in 2020 (see Figure 5) and all sectors of the economy recorded lower fixed investment spending with construction decreasing by 14,2 percent (IDC, 2021).

Figure 5: Gross fixed capital formation constant 2015 prices for South Africa



Source: StatsSA (2022)

- **Civil, residential, and non-residential construction**

Investment in the civil industry decreased by 18 percent while investment in the residential and non-residential industry decreased by 20,9 percent and 25,3 percent, respectively (StatsSA, 2021). The civil construction sector has been underperforming since 2016 largely due to the underperforming South African economy, decreasing infrastructure spending (see Figure 4) and underperforming state-owned entities which are the biggest investors in the sector. According to the South African Forum of Civil Engineering Contractors (SAFCEC, 2021), confidence and profitability remain weak, with 100 percent of civil contractors reporting low to very low levels for the 1st quarter of 2021. Residential construction has fallen during the pandemic and subsequent lockdowns as completion of private sector buildings decreased by 49,3 percent year-on-year in 2020.

All sub-segments recorded a decline in completions, with flats and townhouses recording the largest declines, followed by luxury and low-cost housing. The wholesale activity of construction building materials, however, increased during the second half of 2020 by 14 percent due to the renovations in the Do-It-Yourself (DIY) market. This increase is attributable to the COVID-19 pandemic which has highlighted the need for

various types of home improvements, further supported by lower interest rates which made home ownership more affordable (StatsSA, 2021). Much like civil and residential construction, non-residential construction was also adversely affected by the pandemic and subsequent lockdown restrictions as demand for both office space and shopping centers was at an all-time low. Because of remote working which will likely continue for the foreseeable future, the demand for office space has been compromised (Alsharef, et al., 2021). Retail space development has also declined due to declining per capita income, high unemployment, and the weak economic climate of South Africa (Industry Insight, 2021).

- **Health infrastructure**

Health infrastructure refers to physical infrastructure, such as buildings, installations, energy sources, water, gas supplies as well as logistics and support systems such as supply systems, communication, information, transport systems and waste disposal systems (Erasmus, et al., 2012). The COVID-19 pandemic has exposed gaps in the healthcare services that require urgent attention in many countries. South Africa's 2020/21 health budget increased in nominal and real terms due to estimated spending on the COVID-19 pandemic during 2020/21. The South African government responded to the COVID-19 pandemic by allocating approximately R20 billion to the health sector to enable it to expand prevention, screening, testing and hospital capacity. To enable the sector to sustain these activities and respond to possible future waves of COVID-19 infection, an additional R8 billion will be allocated to provincial health departments through the provincial equitable share in 2021/22 (National Treasury, 2021).

3.1.5 Supply chain management and financial standing of contractors

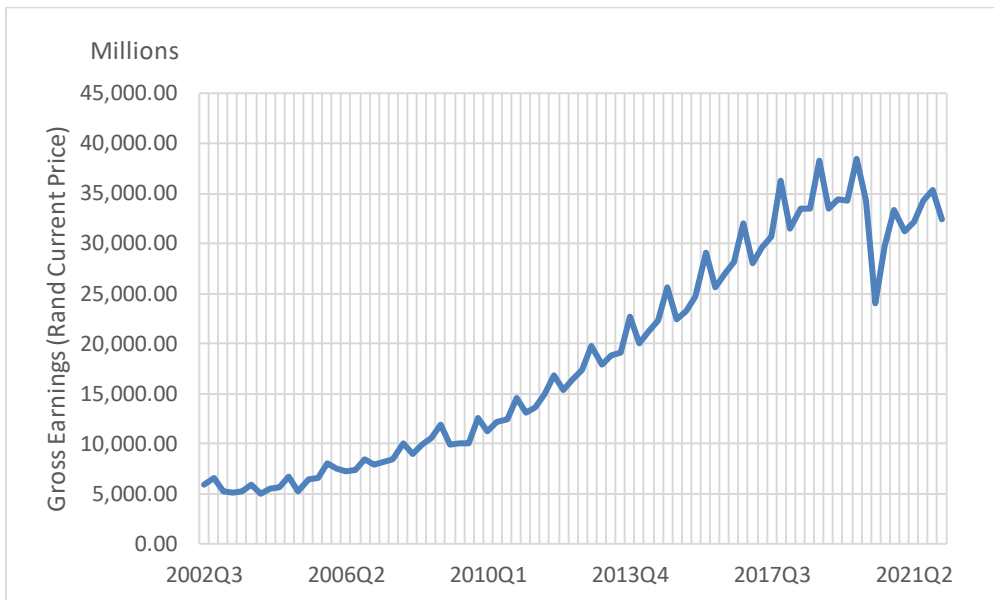
Supply chain management in the construction sector manages the relationship between the suppliers and the contractors involved in the overall construction project (Bray, 2018). Managing the supply chain involves understanding the breakdown and traceability of products and services, organisations, logistics, people, activities, information, and resources that transform raw materials into a finished product that is fit for its purpose (Buildings, 2021).

The construction sector is largely dependent on the continuous availability and supply of materials. The supply chain has been disrupted in various ways due to lockdown restrictions in South Africa and the rest of the world. Various construction materials coming from local or global firms are unable to reach construction sites which hampers the work. The spread of COVID-19 has disrupted and will likely continue to disrupt the scheduling of subcontractors and supply of goods and materials. Manufacturing and production facilities have been impacted based upon their own internal workforce and facility management challenges caused by the pandemic (Chivilo, et al., 2020).

The COVID-19 pandemic has also exacerbated the liquidity challenges that many construction companies had been facing already, accelerating job losses in the process. As can be seen in Figure 6, the gross earnings in the construction sector decreased sharply in 2020 as many construction companies were unable to operate due to lockdown restrictions. Financial losses were also experienced by companies supplying required material to different construction companies, some of which have closed and have disrupted the supply chain.

As can be seen in Table 2, a major long-term concern for all construction firms across all grades is bankruptcy. This is ranked in the top three of all concerns for the firms and results from suspension of projects or potential site closures that cause massive job losses for construction workers or possible pay cuts for workers. An increase in contractual disputes and claims related to contractual scheduling along with mediations, arbitrations and litigation over construction delays is expected and will put further financial strain on construction companies.

Figure 6: Gross earnings in the construction sector in South Africa



Source: StatsSA (2022)

3.1.6 *Illegal construction site invasion by syndicated organised crime*

Master Builders South Africa (MBSA, 2021), which represents 4 000 construction companies, has reported that criminal gangs have taken over building sites across the country. **Site invasions by the so called construction mafia have affected the speedy delivery of infrastructure projects (Irish-Qhobosheane, 2022).** These criminal gangs, which have branded themselves as local business forums target significantly large-scale construction sites, demanding a cut of the project earnings and in some instances forcing the construction companies to subcontract work to certain individuals who are members of the gangs. The modus operandi of these gangs is to intimidate, extort, assault, murder, commit arson even amidst inadequate, if any, protection from the South African Police Services (SAPS).

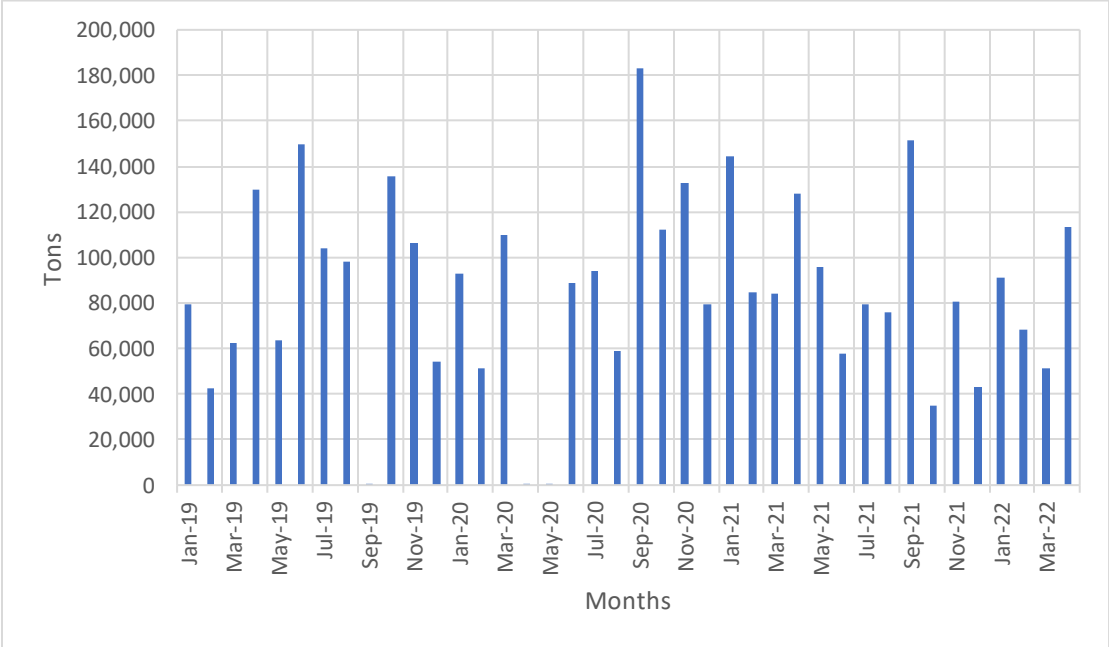
With the decreasing investment levels in infrastructure, the limited infrastructure projects available in the country are being compromised by these criminal gangs which adversely affects contractors and infrastructure development in the country. MBSA believes that, had the police authorities dealt with this problem earlier, it would have been under control. It is now out of control as mainly criminals and thugs are aware of the opportunities for

personal enrichment with no repercussions given weak and largely non-existent law enforcement.

3.1.7 Imports in the Construction Sector

The initial impact of the COVID-19 pandemic and the subsequent lockdown restrictions affected imports into the country. For 2020 the value of South Africa’s imports declined to US\$5,7 billion in March from US\$7,2 billion in January and US\$6,4 billion in February (Viljoen, 2020). As shown in Figure 7, the sector has experienced a decline in cement imports in April and May 2020. The import of cement has since rebounded in 2021 with most of the imports coming from Vietnam, Pakistan, and Mozambique.

Figure 7: Cement Imports Statistics in the Construction Sector



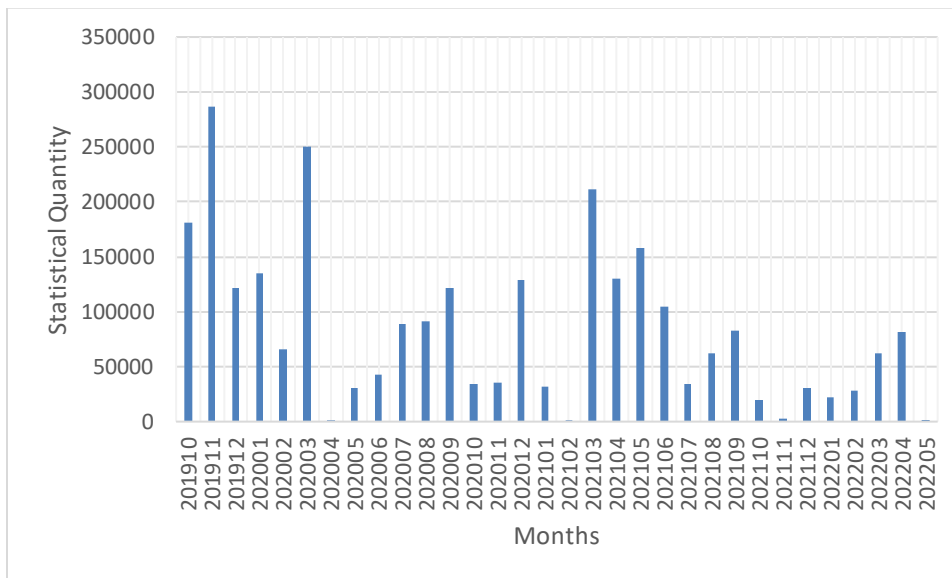
Source: South African Revenue Services (2022)

The South African government has since banned the use of imported cement in state-awarded contracts (Erasmus, 2021). This is an effort to protect the local cement industry from cheaper imported cement coming from countries with excess capacity and lower production costs. Anti-dumping duties imposed on cement imported from Pakistan have been extended by five years from June 2022 (Cokayne, 2022). However, certain

contractors are not pleased with this initiative as they warn that limiting cement imports could have inflationary effects on the construction sector.

As can be seen in Figure 8, the imports of other construction materials such as stone, plaster, asbestos, glass, glassware, and ceramic products have also decreased substantially in the initial months of the pandemic and the rest of 2020.

Figure 8: Imports of selected construction material



Source: South African Revenue Services (2022)

3.2 The response of the construction sector to the COVID-19 pandemic

3.2.1 Managing project and construction risks

The risk management process involves identifying the risks, analysis thereof and generation of response strategies based on expected outcomes, and finally carrying out steps based on feedback received throughout the project cycle (Adhikari and Poudyal, 2021). This risk management process has been applied during the coronavirus pandemic.

The COVID-19 pandemic has presented new challenges such as social distancing on job sites, travel restrictions, site safety and security, labour shortages, supply chain issues,

prolonged and unanticipated delays, cost overruns and reduced productivity. Workers in many sectors have adapted to remote working as a form of risk mitigation due to the pandemic. In the construction sector however, remote work is impossible for workers but certain activities within construction such as meetings, filling in forms, signing contracts, designing, planning, and budgeting can be done with software remotely and many construction companies have adopted this risk mitigation approach. Contractors have also adopted an alternate duties approach to avoid having the entire workforce on site, with workers coming on site on different days. This allows site managers to monitor the number of workers on site and maintain social distancing, as sites are less congested.

The CIDB (2020) highlighted measures taken by certain contractors to ensure a safe return to work for construction workers. These measures include establishing risk-mitigating programmes for employees needed onsite, mandating sick employees to stay at home, keeping record of employees' movements during the pandemic and instituting mandatory sanitation rules in the workplace (construction site). The contractors have also recommended that commercial banks and development finance institutions (DFIs) institute payment holidays on existing loans and credit.

3.2.2 Safety measures to prevent the spread of COVID-19

The health and safety of workers in the construction sector is now, more than ever, a great concern and construction companies have taken measures to ensure safety at construction sites. Deep cleaning at construction sites has taken place where communal areas such as working areas, construction vehicles, mobile plants, eating facilities, security access control rooms and hand washing facilities are disinfected and cleaned. Touch points such as taps, door handles, telephone equipment, machinery and other office equipment are disinfected and cleaned regularly. Screening of all employees entering the construction site has become essential in ensuring that construction sites remain COVID-19 free. There is also usage of no-contact thermometers for medical screening and prescribed personal protective equipment (PPE) for those performing the screening.

3.3 Post-lockdown architecture of the construction sector

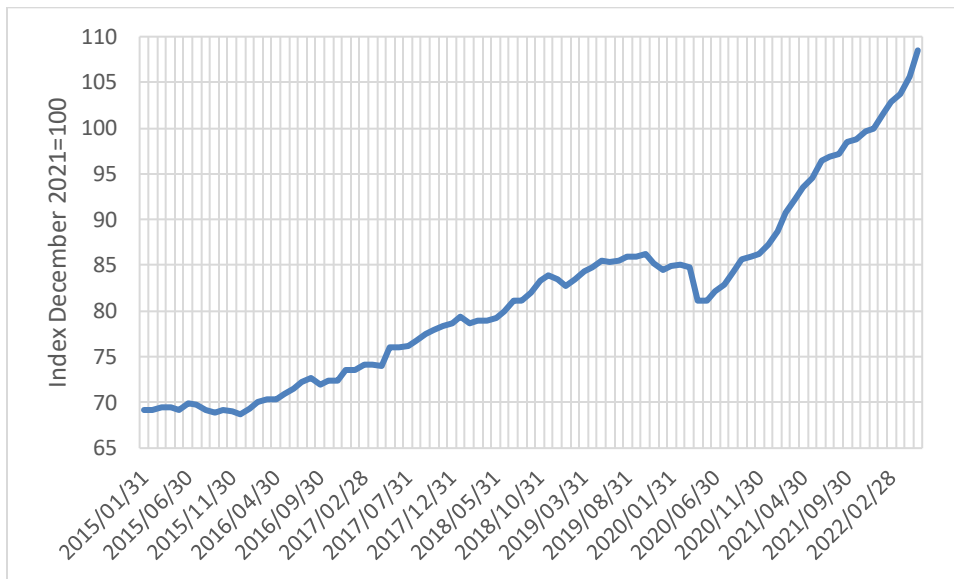
3.3.1 Cost of construction projects and material

Hindered labour productivity by COVID-19 restrictions, extended schedules, and increased project requirements such as additional cleaning and sanitising of common areas, job trailers and additional PPE amongst other factors have contributed to the increase in the cost of construction projects. The cost of construction material is rebounding quickly from the lockdown, as new orders for raw materials and component parts have increased in 2021, suggesting a strong construction economy outlook in the future now that lockdown restrictions have been lifted and vaccination has commenced.

However, as can be seen in [Figure 9](#), the price indices of construction materials have increased substantially by 14 percent since the beginning of the pandemic largely due to inflationary pressures tied to the economic rebound in the sector. The increase in the prices of materials will also increase the cost and financing of construction projects. Currently, inflationary drivers include commodities such as oil, steel and other metals which are critical construction material.

The invasion of Ukraine by Russia has exacerbated the cost of construction projects significantly through high logistics costs. The sanctions on Russia have caused a massive shock to energy and commodity prices which have a ripple effect on the South African construction sector. This increased the price of building material significantly which further squeezes contractor margins. The higher crude oil prices are impacting on oil derivatives such as bitumen which is used in the construction of roads in South Africa. Higher fuel prices have also increased construction site operations costs and preliminaries (Reaper, 2022).

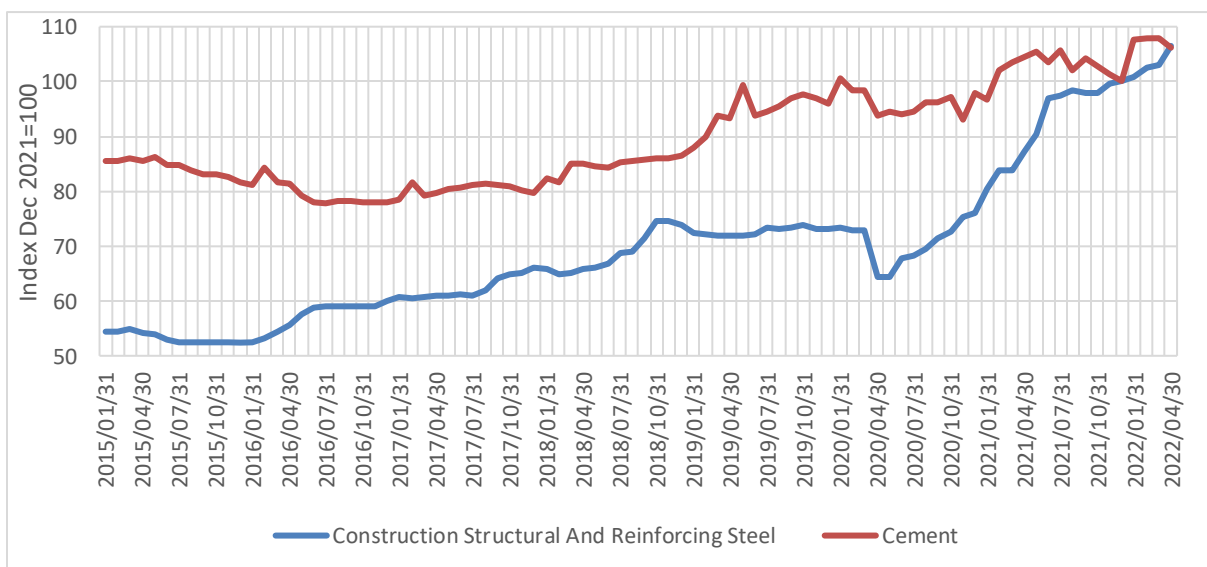
Figure 9: Construction Materials Price Indices



Source: Stats SA (2022)

Russia’s invasion of Ukraine has also had an enormous effect on prices of steel, as both Russia and Ukraine are amongst the top ten exporters of steel in the world (Statista, 2022). Figure 10 shows that prices of steel have grown significantly during the pandemic and continue to rise due to the invasion-induced low supply. This is worsened by the shutting down of some global steel mills due to higher energy costs.

Figure 10: Construction input price index



Source: Stats SA (2022)

3.3.2 Development of resilient local supply chains

The current COVID-19 pandemic reinforces the criticality of business resilience in the construction sector, not just for dealing with immediate issues but for planning for recovery and securing a stable long-term future. The resilience of the sector is highly dependent on a reliable, flexible, and sustainable supply chain. The economic reconstruction and recovery plan by the South African government highlights that in the delivery of infrastructure, local industries will be privileged and prioritized. The empowerment of women, young people, persons with disability and military veterans will also be strengthened in a manner that fosters competitiveness and resilience. This will include the development of local supplier industries for infrastructure delivery (The Presidency, 2020).

A study by Das, *et al.* (2021) identified critical factors affecting global building supply chains and evaluated strategies for risk reduction in the supply chain network by making it more resilient. The risk reduction strategies include the use of process automation and artificial intelligence and inventory management as a buffer required by firms to deal with unanticipated demand. The strategies also include outsourcing of business operations, geographical integration of supply chain agents, human resource management, government support, cost optimization and contingency planning. Proper implementation of these strategies can develop a more resilient supply chain for future occurrences of unanticipated pandemics.

3.3.3 Use of disruptive technologies in the sector

The construction sector has throughout the years been labour-intensive, heavily dependent on a manual workforce, both skilled and unskilled, while the appetite for technological innovation has been limited. Due to the COVID-19 pandemic, the construction sector has, however, embraced technological innovation and disruptions throughout the lifecycle of construction projects. The use of disruptive technologies is increasing in this sector with innovations such as drones, prefabrication, radio frequency identification, smart wearables, immersive solutions, 3D printing, modular construction,

big data, artificial intelligence, and the Internet of Things (IoT). Below is an analysis of some of the disruptive technologies in the construction sector.

- **Modular construction**

Although COVID-19 has presented a decrease in the work supply to the sector, it has also offered several opportunities such as modular construction. Modular construction is a process in which a building is constructed off-site under controlled plant conditions using the same materials and designing to the same codes and standards as conventionally built facilities – but in about half the time. Buildings are produced in “modules” that when put together on site reflect the identical design intent and specifications of the most sophisticated site-built facility – without compromise (Modular Building Institute, 2021). By making use of modular structures, prefabricated material, a huge workforce and great planning, China was able to build a hospital with 1000 beds to isolate the sick and prevent new COVID-19 infections in under 2 weeks. A significant amount of time is saved by using structures that are completely assembled beforehand with their facades, windows, and installations already in place (Sacyr, 2020).

Figure 11: Work continues on Wuhan Huoshenshan hospital in Wuhan, China

Modular pieces are maneuvered into place



Source: CNBC (2020)

The Chinese success story showed the importance of the usage of modular construction especially during the COVID-19 pandemic. Considering the essence of operator safety and social distancing during the pandemic, modular construction provides key advantages such as reducing the risk of community spread as when dealing with on-site construction. Many craft workers are required to perform different tasks simultaneously, and in many cases these transient workers will be newcomers to the community. Adding more people to the area can promote the spread of COVID-19 (Villegas, 2021). As modular construction is off-site, this risk is significantly reduced. Modular construction also reduces the risk of exposure to the labour force as modular assembly requires a smaller workforce which allows for social distancing during work activities and easier workforce management.

Modular construction offers reduced costs and schedule risk, as customers could see a 25-30 percent cost reduction with modular construction compared to field construction (Villegas, 2021). During a COVID-19 environment, with fabrication occurring offsite, the ability to continue module fabrication when field construction sites would otherwise be shut down or materially impacted by COVID-19 reduces the potential for an extended schedule and increased costs associated with delays.

As seen from the China example, modular construction can also increase productivity as building a full system in a controlled environment has many benefits as the workforce is not subjected to weather related delays and inherent efficiencies when working in a purpose-built fabrication facility. During the pandemic, fabrication shops have not been experiencing the same level of productivity decreases being experienced in the field during construction. Decreased productivity, schedule delays, rising project costs among others, resulting from a COVID-19 environment, present themselves eventually as commercial and contractual risks, such as liquidated damages and a possible force majeure. By leveraging the inherent benefits of modularization, suppliers and owners can minimize the likelihood and/or severity of such commercial and contractual risks (Villegas, 2021).

- **Use of innovative technology (Artificial intelligence, 3D printing)**

Due to the uncertainty regarding how durable the COVID-19 pandemic is going to be, the construction sector has adopted sophisticated technologies such as artificial intelligence (AI) to do a variety of construction related work. Artificial intelligence and machine learning can be used to increase efficiency throughout the entire value chain – from the production of building materials to the design, planning and construction phase itself, and facility management as well. AI-based technologies such as robots are being used to monitor jobsite progress in real time and are used to conduct repetitive work in construction to improve jobsite productivity. Autonomous drones and rovers equipped with high-definition cameras and LIDAR (light detection and ranging) are used in construction sites for transporting materials and in taking photographs and scans of the construction site.

Figure 12: DJI Matrice M300 Drone with Hovermap LIDAR System and GoPro Colourisation



Source: SAICE (2021)

3D printing technology has also gained popularity during the pandemic in the construction sector. 3D printing is the computer-controlled sequential layering of materials to create three-dimensional shapes. It is particularly useful for prototyping and for the manufacture of geometrically complex components. 3D printing can be

used to create construction components or essentially print entire buildings as in construction.

In Spain, the first pedestrian bridge printed in 3D in the world (3DBRIDGE) was inaugurated on 14 December 2016 in the urban park of Castilla-La Mancha in Alcobendas, Madrid. The bridge has a total length of 12m and a width of 1.75m and is printed in micro-reinforced concrete (Designing Buildings, 2020). The use of AI and 3D printing has the potential to reduce the cost of labour (which constitutes an estimated 40 percent of the cost of construction) and will lead to cheaper construction and the ability to provide more buildings and infrastructure (SAICE, 2021). The use of online software packages in project procurement and analysis as well as automation in project packaging, verification and payment has come to the forefront due to the COVID-19 pandemic and subsequent remote working.

3.3.4 Impact of the use of new technology on employment

In their study, Agenbag and Amoah (2021), investigated the impact of the use of new technology on the workforce in the construction sector. The results showed that the use of new technology equipment will have a tremendous impact on the workforce as it would be able to execute work that could be done by a sizeable number of labourers. Results also showed that the productivity of construction projects in South Africa can be increased by making use of new technology. Agenbag and Amoah (2021) sent out questionnaires to construction sector professionals inquiring on the number of workers that can be replaced by new construction technology. The results show that the implementation of new technology in the construction sector does have the potential to leave workers unemployed.

As Table 3 shows, drone technology for site monitoring and taking pictures can replace 100 percent of the workforce required to complete such tasks. Further, 91 percent of the respondents believe that one robot machine used for inspecting work can replace up to 5 workers while 9 percent believe that it can even replace the work of up to 10 workers. The majority of the respondents also believe that one excavator can replace up to 15

workers for foundation trenches and paving machines as well as self-driven roller compactors can replace up to 5 workers. Results from the survey also showed that 86 percent of respondents were of the view that a premix concrete machine could mix concrete that can be done by about 10 people, which would be more efficient in terms of quality.

Table 3: Number of labourers that can be replaced by construction technology equipment

Modern construction technology	Number manual labour it can replace per day			
	1 to 5	6 to 10	11 to 15	16 to 20
Excavators for foundation trenches	4(19%)	8(36%)	8(36%)	2(9%)
Drone for site monitoring	22(100%)			
Drone for taking pictures	22(100%)			
Premix concrete machine	10(45%)	9(41%)	3(14%)	
Paving machine	13(59%)	6(27%)	3(14%)	
Self-driven roller compactor	21(95%)	1(5%)		
Robot/machine for inspecting works	20(91%)	2(9%)		

Source: Agenbag and Amoah (2021)

However, it would be a mammoth task to fully adopt new construction technology equipment in project execution in South Africa as the construction sector is heavily relied upon by the government to generate employment. There is also lack of knowledge and expertise regarding the use of new technologies amongst the workforce in the construction sector in South Africa. However, the literature suggests that construction companies are investing in these new technologies that will assist labourers and make construction projects more efficient. The government must also look for other areas of the economy to create jobs instead of relying heavily on the construction industry.

3.4 The future of the construction sector

3.4.1 Recovery

The South African Institute of Civil Engineers (SAICE, 2021) reported that the current vaccine rollout is one of the most important drivers of the recovery from the pandemic. A fast paced vaccine rollout to workers in the construction sector will make the workplace

safer and more workers can return to the construction site with a lower risk of transmission of the corona virus. The CIDB (2020) reported that in order to recover from the pandemic, the construction sector will require significant support to cushion the short, medium and long-term effects of job losses amongst construction workers and losses of revenue for construction companies.

Contractors stated that in the medium term, the government can support the sector through tax benefits, fast-tracking tender approvals and award post-lockdown reimbursement of outstanding invoices from stalled projects, obtain support from financial institutions and ensuring the effectiveness of unemployment insurance fund payments. It was also highlighted that increased government spending on infrastructure delivery will assist the sector to gain stability and ensure sustainable recovery from the pandemic.

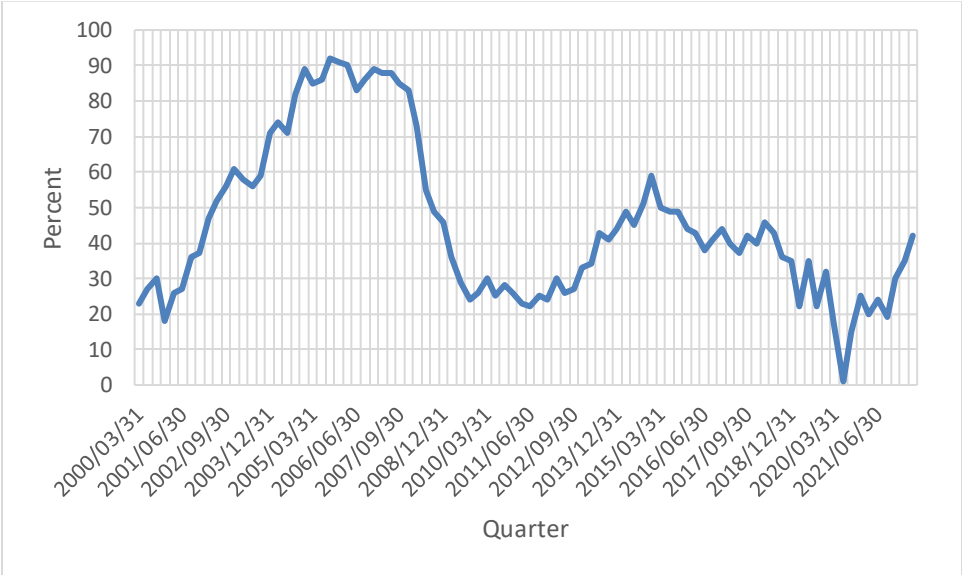
3.4.2 Business Confidence

Business confidence in the construction sector is at record low levels as the combined effects of the declining investment in the sector, the COVID-19 pandemic and even the mass riots that occurred in 2021 knocked business confidence in the third quarter of 2021 (see Figure 13). This is concerning as it is an indication that business conditions in the construction sector are not conducive for the country's planned infrastructure rollout programme which is the cornerstone of the country's economic recovery plan. Figure 10 shows the BER Building Confidence Index (BER, 2021) which is a percentage of respondents that are satisfied with prevailing business conditions in six sectors, namely architects, quantity surveyors, main contractors, sub-contractors, manufacturers of building materials and retailers of building material and hardware.

The lack of business confidence among building contractors was evident even prior to the COVID-19 pandemic, driven by lack of sustainable infrastructure projects, low productivity, slow pace of transformation, corruption, and lack of innovation (Engerineering News, 2021). The pandemic has further decreased confidence as it retarded the pace of awarding tenders while some tenders were also cancelled. Figure 14 shows the Civil Confidence Index which reflects the state of business conditions in the civil engineering sector (BER, 2021). The state of business conditions in the civil

engineering sector has been very low since 2016 as most of the respondents are dissatisfied with prevailing business conditions in the sector.

Figure 13: The Building Confidence Index



Source: BER Building Confidence Index

Figure 14: Civil Confidence Index



Source: BER Civil Confidence Index

3.4.3 South Africa's Infrastructure Investment Plan

The investment plan will prioritise addressing the history of large underspending in infrastructure by all spheres of government and state-owned enterprises. The investment plan is also regarded as a strategy by the country to revitalize the economy and reduce the high levels of unemployment especially since the COVID-19 pandemic and the economic downgrade have worsened the crisis and accelerated the need for investment in infrastructure.

The construction sector has suffered major contraction because of the pandemic which has resulted in job losses, leading the Minister to highlight the urgent need for targeted infrastructure investment and development and implementation of the new Sustainable Infrastructure Development System (SIDS) methodology to guide the country's infrastructure development agenda. A total of 276 projects with an investment value of more than R 2,3 trillion have been submitted as of June 2020 (Parliamentary Monitoring Group, 2020).

The department of public works and infrastructure (DPWI) will be developing the National Spatial Development Framework to address geospatial disparities arising from the former apartheid spatial planning. The apartheid spatial planning separated many black communities from work opportunities and the framework will ensure that communities are well integrated and connected to work opportunities.

The National Infrastructure Plan 2050 (NIP 2050) published by DPWI for comments highlighted the importance of infrastructure delivery as a driving force for South Africa's transition from its historically closed minerals economy to its future as an increasingly global and regionally integrated and inclusive economy, promoting dynamic investment in the industries of the future (NIP, 2021). Public infrastructure investment is important in creating new jobs, improving productivity, increasing competitiveness, and reducing spatial inequality. It has been estimated that to achieve the NDP development objectives, the cost of delivering infrastructure will be more than R6 trillion between 2016 and 2040 and energy and transport account for over 72 percent of that.

The NIP 2050 which has been prepared by Infrastructure South Africa (ISA) ensures the foundations for achieving the NDP's vision for inclusive growth. It provides a strategic vision and plan that links major NDP objectives to actionable steps and intermediate outcomes. The NIP 2050 addresses institutional blockages and weaknesses that hinder success over the longer term and provides a guide to building stronger institutions that can deliver on the NDP objectives.

The key concerns raised by the DBSA on the NIP 2050 include whether it is a vision document like the NDP or a step-by-step plan on infrastructure development. This distinction is important as judging from previous national economic policies and strategies, the lack of specificity in the NIP 2050 will make its implementation a difficult task. Another concern is the lack of clarity in the NIP 2050 with regards to the roles of key players in the infrastructure development landscape such as, national, and provincial departments, municipalities, state owned entities and the private sector for both infrastructure finance and build. The lack of clearly outlined short, medium, and long-term targets as well as envisaged infrastructure financing requirements across the targeted sectors is also a cause for concern.

The National Planning Commission (NPC, 2020) published a report that reviewed progress towards the NDP's vision 2030 regarding public infrastructure delivery and construction sector dynamism. It is reported that state owned entities, public entities and local municipalities have underspent on their infrastructure budgets. Due to the faltering growth in the public sector, the private sector has become the biggest investor in the civil construction industry surpassing general government and public entities investment for the first time. The report suggests that to address the problems facing infrastructure delivery in South Africa, a course correction needs to be implemented which is framed around the building of appropriate public sector capabilities to perform client functions and to create the necessary conditions to attract and secure private sector participation and investment in public infrastructure. Client functions include strategic planning resulting in the business case for a project and delivery management to convert a business case into project outcomes.

3.4.4 Economic Reconstruction and Recovery Plan

The South African government released an economic reconstruction and recovery plan for the South African economy aimed at stimulating equitable and inclusive growth (The Presidency, 2020). One of the priority interventions in the plan is that infrastructure investment, delivery, and maintenance must play a leading role in the country's economic recovery. Large scale infrastructure programs are required to boost aggregate demand, revive the construction sector, and contribute to job creation. The plan states that efforts will be made to attract private sector investment in infrastructure as part of building broad-based public-private partnership (PPP).

The PFMA and the MFMA will be reviewed to facilitate PPP. The economic reconstruction and recovery plan has also highlighted prioritizing infrastructure development for network industries, the modernization of freight and public transport. The plan has also emphasised improving the state's technical, project preparation and financial engineering capabilities, through making use of private sector skills and expertise to fast track the delivery of infrastructure projects.

SAICE (2021) highlighted how social compacting is a key success factor in progressing the economic reconstruction and recovery plan. Social compacting can be defined as an implicit agreement between the government and the governed. The governed include societal groups such as business, labour, and communities. Trust between government and the private sector is required for both parties to collectively deal with risks caused by future pandemics. The government response to the current pandemic suggests the existence of a trust deficit, which hinders effective implementation as government struggles with implementation including matters of graft associated with its agencies.

Parties that embrace amicable relationship building in the spirit of social compacts will see a reduction in conflict and crisis, as well as enhanced implementation. The benefits of creating meaningful relationships between the public and private sectors will lead to the proactive and positive mindset in soliciting private sector investment in infrastructure

projects. However, this does not mean running a paralysis situation that seeks to govern by consensus all the time.

4. Construction site visit

To analyse the impact of the COVID-19 pandemic on the construction sector at a micro level, a site visit was conducted. The chosen construction site was that of WBHO construction, which is one of the largest construction companies in Southern Africa that is also listed on the Johannesburg Stock Exchange (WBHO, 2021). The construction company has recently completed the construction of Castle Gate Lifestyle Centre and is currently involved in the construction of an office park and gym which were inspected at Waterkloof Ridge in Pretoria where an interview was conducted with the site manager during the site visit.

Figure 15: WBHO Pretoria construction site



4.1 Delays due to COVID-19

The WBHO construction faced major delays in the completion of the Castle Gate Lifestyle Centre due to COVID-19 lockdown restrictions. Construction of the Centre was suspended from March to June 2020. However, once the lockdown restrictions were eased, construction resumed, and the centre was completed towards the end of the year and officially opened in November 2020. The construction of the office park and gym in Waterkloof Ridge is however going according to schedule. Since the beginning of the year, there has not been major lockdown restrictions and construction workers are able to carry on with their work.

4.2 Employment and cost of material

As WBHO is one of the largest construction companies in Southern Africa, no construction workers were laid-off during the lockdown, and the company was able to survive the extended period of no construction activity. WBHO also prides itself on empowering women, with many women construction workers on-site in a predominantly male dominated environment. The cost of construction materials, especially steel, has increased substantially. Certain material had to be imported, with the effect of increasing the total cost.

4.3 COVID-19 Regulations on site

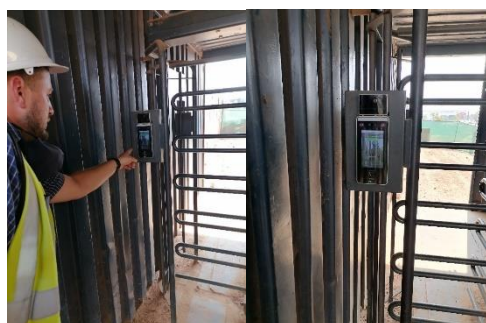
WBHO has implemented COVID-19 regulations and all construction workers are required to wear a mask and sanitize on site. New technology has also been introduced on site for face scans and only opens the gate when masks are worn. The technology also detects the temperature before allowing entrance to the construction site. It keeps a record of who has entered the site and how many workers are on site at a particular point in time. To maintain social distancing, WBHO has introduced a system which regulates the number of workers going to lunch time and workers go on lunch at different times to avoid crowding at the lunch area.

WBHO has also provided training for the construction workers on the COVID-19 protocols. Ultimately, the company has had very few positive COVID-19 cases because of their excellent measures in controlling the spread of the virus. WBHO has introduced a programme where all forms and quality checklists are completed online or on smart phones to avoid close physical interaction between workers. The company has full-time on-site security and has not encountered any acts of illegal construction site invasion by syndicated organised crime. This can also be attributed to the location of the construction site, which is in a relatively safe urban area.

Figure 16: The WBHO construction site



Figure 17: The WBHO Construction site



In picture: An onsite sanitiser, temperature check and mask detector

5. Implications to the DBSA

Like many other sectors, the construction sector was not fully prepared for the COVID-19 pandemic. A pandemic of this nature has not been experienced in recent times. Many construction companies were unable to adapt and survive this pandemic where job losses and closures were experienced. The DBSA as a development finance institution (DFI) was also adversely affected by the pandemic. Due to lockdown restrictions, infrastructure projects were unable to continue and the delivery of economic and social infrastructure was negatively impacted. The lessons noted in this document will be incorporated in the planning of the Infrastructure Delivery Division (IDD) of DBSA to assist with future pandemics or disruptions in infrastructure delivery.

The study has highlighted risk mitigation techniques which can be used to maintain productivity during a disruption. This includes site as well as workforce management and the use of modern technologies. The lessons learnt during this pandemic can also be

adopted in current infrastructure projects within the Bank. There are also lessons learnt in terms of project planning and expenditure – the pandemic has shown that cost structures can change drastically.

6. Limitations

The main limitation of this study was the low response rate during the data gathering process as not all the requested interviews were conducted. However, given that this study is pivoted on the systematic review methodology, much of the data was sourced from existing literature.

7. Conclusion

The research has shown that the COVID-19 pandemic has had an adverse impact on the construction sector, causing major job losses, supply chain disruptions and revenue losses for construction companies. Many small-scale construction companies have been forced to close due to financial losses and construction companies that remained operational made major operational changes to mitigate the spread of the coronavirus on site. However, the COVID-19 pandemic has also provided an opportunity for innovation within the construction sector, as new disruptive technologies have come to the forefront as measures to maintain productivity within the sector while mitigating the spread of the virus. Increased infrastructure investment, delivery and maintenance is a key driver of economic recovery post the COVID-19 lockdown. It will assist in reviving the construction sector and creating employment. The lessons learnt during this pandemic can also be adopted in current infrastructure projects within the DBSA. There are also lessons to be learned in terms of project planning and expenditure, as it was shown that project cost structures can change drastically.

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