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Construction payment automation through a BIM-Blockchain (BIM-Bc) and Smart Contract framework

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CONSTRUCTION PAYMENT AUTOMATION THROUGH A BIM-BLOCKCHAIN (BIM-Bc) AND SMART CONTRACT FRAMEWORK.

RESEARCH REPORT

Submitted by

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A research report submitted to the Faculty of Engineering and Built Environment, University of the Witwatersrand, in the fulfilment of the requirements for the degree of Master of Science in Building: Project Management in Construction.

Cape Town

May 2021

DECLARATION

I declare that this Research Report is my own, unaided work. It is submitted in partial fulfilment of the degree of Bachelor of Science (Masters) in the field of Construction Project Management at the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination in any other university.



Michelle Matthews (1798041)

Signed on this 24th day of May 2021.

ABSTRACT

At the onset of a future that will inevitably be *"intelligent"* it is important to understand how innovation in technology and artificial intelligence may facilitate payments throughout the supply chain by integrating stakeholders, activities, and events throughout the project. Payments are the lifeblood of all construction projects together with a steady flow of funds (cash flow) throughout the project, which are essential for project success. Literature reveals that the construction industry is filled with disputes resulting from primary issues namely, late payments and the ambiguity of contractual terms.

The South African construction contract, facilitates payments, through its supply chain by enforcing obligations, terms, and conditions. Due to the fragmentation of the South African construction industry, the management of these manual payment processes is are more complexed and inherently difficult to manage. due to Moreover, payments (or lack thereof) are affected by factors such as lack of clarity in deliverables, specifications, responsibilities, and obligations between the contracting parties. This may lead to payment delays and even non-payment, straining relationships and breaking trust, which ultimately leads to disputes and long legal battles. This research investigates how innovation in technology between BIM, Blockchain and Smart Contracts can be infused into a single application or framework, to elevate the current problems associate with construction payments and disputes, but perhaps more importantly, to attain trust and transparency and to enhance collaboration in a complex, fluid, and highly complexed industry.

KEY WORDS: Smart contract, BIM, Blockchain, Automation, Payments.

DEDICATION

This work is dedicated to my children. It is never too late to follow what is in your hart. Always try and better yourself. Passion, perseverance, and self-discipline shall bring success, in all your life endeavors', and you shall reap the benefits.

ACKNOWLEDGEMENT

Undoubtedly, many people many people have contributed towards the completion of this research.

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To all the participants who were willing to assist me with this research, I thank you for taking the time to provide me with your inputs, it is truly valued.

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To the highest power of all!

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LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial Intelligence
AR	Augmented Reality
BIM	Building Information Modelling
BIM-Bc	BIM-Blockchain
iBIM	Cloud-based BIM
IoT	Internet of Things
VR	Virtual Reality
FIDIC	Fédération Internationale des Ingenious Counseils
IT	Information Technology

1 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

1.1.1 Purpose of the Study

The advancement of Artificial Intelligence (AI) is already been seen to reduce the need for human intervention as more and more functions are being atomized (Pmi.org.in, 2019). Subsequently, collaborative tools like Building Information Modelling (BIM) have paved the way for change and collaboration in the construction industry (McNamara & Sepasgozar, 2018).

Moreover, new technology such as Blockchain and other distributed ledger technology has permitted for legal contracts to expand into more complex Smart Contracts. This allows for a self-executing computer program to operate and enforce legal obligations (Farrell, Machin& Hinchliffe, 2017). A Smart Contract is a digital protocol built within the Blockchain network, which will allow the implementation of the conditions of a contract. Every node will contain the necessary contract data as per the contractual agreement and the conditions under which the contract will to be executed (*ibid*.).

Essentially, smart contracts shall be computer based which shall follow a system procedure that will facilitate, verify, or enforce the negotiation or performance of a contract (Cardeira, 2015). Evolving technologies like BIM and Blockchain have advanced significantly in recent years. Although still in their nascent stages, the transformative potential of these new advancements is evident, showing increasing interest in integrating BIM workflow towards streamlining several operations (Olawumi & Chan, 2019).

1.1.2 Background to the Study

The rapid advancement in science, technology and innovation is revolutionizing industries and changing how we will beconducting business in the future. It is known that the role of a construction project manager has a plethora of different functions and responsibilities. Essentially, the construction project managers bridge the connection between the various technical parameters and communication to stakeholders from the beginning of the project to completion. Artificial Intelligence, automation and robotics are rapidly developing and is transforming the world

around us, providing unparalleled opportunities in many sectors which are likely to have a significant effect on the construction industry. (Farrell *et al*., 2017).

1.1.2.1 The current technological climate in the South African Industry

As a developing country, South Africa is constantly faced with the difficult task to balance the scale between job creation and economic objectives. The biggest influencing factor being the high level of unemployment in the country. (Nahman, Wise and De Lange, 2010).

South Africans are heavy reliant of the socioeconomic systems which makes South Africa vulnerable to global change. As the need and application of new technologies are increasing to match world class standards, so does the skills gap in the built environment increase. (*ibid*.) Digital adoption in South African construction has been slow compared to all other industries. The construction industry spend on average between 1 and 1½ per cent of turnover on information technology (IT) compared to about 3 per cent across all industries, and between 5 and 10 per cent on industries, such as banking. (RIB CCS, 2021).

Some may even argue that AI technology will be the precursor to increase unemployment, but the information technology industry, which is one of the largest industries for job creation, have shown that if technology actually increases and creates jobs, which enhances sector sustainability. (Construction industry can no longer delay adoption of technology, 2021).

Subsequently, an article published by RIB CCS, supports the statement that where unemployment is high, AI technology are treated with suspicion. The benefit of technological advancements should be seen as a tool to modify mundane work rather than displacing jobs. (RIB CCS, 2021).

It is however evident, that the digital status quo of the construction industry, does need to adapt or it will be left behind in a fast-evolving world where collaboration, transparency and digital innovation are driving change. (*ibid*.).

1.1.2.2 The construction industry and technological readiness

According to Praveen (2018), construction projects are complicated and risky endeavors' andas the construction contract is the cornerstone of any project (which sets out both parties' obligations), BIM and Blockchain, can be the next logical step in being a catalyst for the automation of the legal or standard form of construction contracts to a smart contract.

According to the GCR South Africa Corporate Sector Risk Scores. the construction industry risk is underpinned by by the complex nature of work undertaken and relatively low margins that can be extracted. It further highlights that because of this fact, construction companies face ongoing threats in terms of delays and cost overruns, which can result in loss making contracts and substantial cash outflows. (GCR South Africa Corporate Sector Risk Scores 12 April 2021, 2021)

Further argued by GCR South Africa, is that a gradual adoption of digital transformation is needed to increase operating efficiencies, which shall improve profit margins. (*ibid.)*

Supported by RIB CCS, the ability to leverage technology from conception through to operation is where the fundamental change needs to occur which will ultimately enhance productivity at every stage of the construction process. (RIB CCS, 2021)

1.1.2.3 Conventional and traditional contracts can no longer accept the status quo

It is known that construction projects are information intensive and access to accurate data is critical with making decisions to ensure the project is managed in accordance with the pre-defined parameters that was agreed at its onset, which in turn may limit disputes (Zhao, Seppänen, Peltokorpi, Badihi & Olivieri, 2019).

The transition from conventional standard form of agreement to smart contracts will also involve a translation of legal rights, obligations, and remedies into a digital framework. It is critical that this translation is conducted carefully, so that nothing is unknowingly lost with the change in expression. Further, it gives rise to issues of legal recognition, which do not arise from traditional contractual frameworks and to which harmonized cross-border solutions need to be found (Farrell *et al*., 2017).

1.2 SUBSTANTIATION OF THE PROBLEM

The construction industry plays a vital role in generating wealth and improving the quality of life of people through infrastructure like of schools, hospital, houses, roads, airports, ports etc. It is linked to the whole supply chain that enables other industries to prosper alongside the construction industry. It is therefore crucial to ensure that construction projects are managed in an effective and efficient manner. Inadequate cash flows as a result of late payments and payments disputes have a detrimental impact on both the contractor and the entire supply chain. Moreover, construction projects involve big amounts of money (mostly upfront) and any payment delays can impact the entire project negatively (Sambasivan & Soon, 2006). According to Luo, Das, Wang & Cheng (2019), the solution to payment problems in construction projects greatly depend on the execution of the construction contracts as the contract regulates the behavior of stakeholders. Contractual accountability (commitments, prohibitions, and obligations) is the foundation in information management, claims and payments.

Finally, being slow to start, BIM is now beginning to have a major impact both in the UK and internationally, in many areas of the construction and civil engineering industries. It is forecasted that a wider adoption of BIM may unlock further savings in the global market, which is estimated between 15 -25% by the year 2025. (Barnes, 2019).

1.2.1 The need for technological disruption in the construction industry

Long stable business models are crumbling (Jones, 2017). Advancement in technology has made operations faster and more efficient. The era of digital disruption is here with new revolutionary technology applications such as Augmented Reality (AR), Virtual Reality (VR) and the Internet of Things (IoT). Artificial Intelligence promises to disrupt the construction landscape forcing change in the industry, which shall boost some companies where others might perish (*ibid.*).

1.2.2 Root causes of contractual disputes

There is a thin line between disagreements, conflicts, and disputes (Love, Davis, Cheung & Irani, 2011). Additionally, it is further stated that disagreements or conflicts exist in almost every project worldwide due to the differences in cultures, values, and personal interests. By the same token Murdoch and Hughes (2008) reiterates that conflicts are dispute precursors,

which occur where mismatches of objectives and opinions exist amongst parties to a contract; while disputes often result from unresolved conflicts, based on issues of rights, regarding the interpretation of the contract.

According to Cheung and Chan (2014) incomplete contracts are the route of construction disputes. In addition, where conflicting parties fail to address a conflict in the onset (negotiations), the conflict are proven to escalate into a dispute.

Moreover, McKinsey Global Institute (2017) argues that the root cause of disputes is a misaligned contractual structure, which has led to hostility and change orders rather than productive and trusted collaboration.

1.2.3 Top 3 causes of construction contract disputes in Northern America, United Kingdom, Continental Europe, and Middle East for 2017 and 2018.

Table 1.1: Top three causes of disputes in Northern America.

Source: Arcadis Global Construction Dispute Report 2019

2018 RANK	DISPUTE CAUSE	2017 RANK
1	A failure to properly administer the contract	1
2	Employer/Contractor/Subcontractor failing to understand and/or comply with its contractual obligations	2
3	Failure to serve the appropriate notice under the contract	3

Table 1.2: Top three causes of disputes in the United Kingdom.

Source: Arcadis Global Construction Dispute Report 2019

2018 RANK	DISPUTE CAUSE	2017 RANK
1	Differing site conditions	New in 2018
2	Third-party or force majeure events	New in 2018
3	A failure to properly administer the contract	2

Table 1.3: Top three causes of disputes in Continental Europe.

Source: Arcadis Global Construction Dispute Report 2019

2018 RANK	DISPUTE CAUSE	2017 RANK
1	Poorly drafted or incomplete and unsubstantiated claims	New in 2018
2	A failure to properly administer the contract	2
3	Owner/contractor/subcontractor failing to understand and/or comply with its contractual obligations	New in 2018

Table 1.4: Top three causes of disputes in the Middle East.

Source: Arcadis Global Construction Dispute Report 2019

1.2.4 Why construction payments are negatively affected.

Conventional payment methods are made upon delivery or made on time once the goods have been provided, however these conventional characteristics does not suit construction projects purely because construction projects require large investment, associated with high risk and lengthy transaction cycles.

Payments in the construction industry differs significantly from other industries like manufacturing. In most cases the payment delay starts from the bottom of the supply chain which accumulates to the top tier of the supply chain. However, in the construction industrythe payment delay starts with the top tier or the supply chain for two main reasons.Contractors are sensitive to cash flow constrains as they need to lay out a great capital expense

the beginning of projects and do not always have large reserves. Hence, delayed paymentfor construction work can quickly escalate to suspension of works and disputes and adversarial relationships which have a direct and critical impact on the completion of projects.

Luo *et al*. (2019) argues that one of the main construction disputes are related to payment delays. Disputes arise due to a lack of clarity in the definitions of obligations, responsibilities, and liabilities of various stakeholders in construction contracts. The problem intensifies dueto the manual process and where different stakeholders are bound by different contracts at different levels of the project. As a result, these disputes, and delays in construction payments

leads to additional expenditure, cash flow problems and lack of trust. He further highlights that construction projects often suffer payment problems due to the adversarial working relationships of different stakeholders over and above the complexity and uncertainty of the construction environment. Reporting that in 2015 outstanding payments in Hong Kong totaled over $20 billion (*ibid.).*

1.2.5 The attractiveness of BIM

The capacity of BIM as a platform that allows for multi-disciplinary data to be embedded ina single model Azhar (2011) states it allows project teams the opportunity to analyze performance of construction projects. Coupled with Blockchain to ensure that the data are decentralized among serval nodes that hold identical information with no single actor which holds complete authority of the network would enable transparency of activity and enhancement of data security (Olawumi *et al*., 2019).

Moreover, by embedding source code in the BIM models, this smart code will in turn assist smart contracts assist charting out payment plans with contractors and subcontractors by setting up contractual automated provisions (Trivedi, 2020). Developing intelligent source code which addresses all the aspects of quantity take-off, construction scheduling andpayment budgets could assist in resolving the issue of payment (*ibid*.)

1.3 PROBLEM STATEMENT

The knowledge gap in this study is that there are insufficiencies (payment delays and disputes) when it comes to execution of payments in the supply chains within the construction industry. The question is whether leveraging of single technological applications into one single framework can support and reduce these insufficiencies in the supply chain.

1.4 RESEARCH QUESTION

There is an empirical need to investigate how a theoretical framework such as a BIM-Blockchain (BIM-Bc) and Smart Contract framework can support the automation of construction payments by formalizing them into smart contracts.

1.4.1 Primary Research Question

The primary research question emanates from the need to understand how automation of construction payments and contracts will influence the construction project management industry. **The research question is as follows:**

How can a theoretical framework, such as a BIM-Blockchain Smart Contract framework; increase trust and collaboration in the supply chain, whilst decreasing payment delays and reducing disputes within the South African construction industry?

1.4.2 Secondary Research Questions

From the primary question, the secondary research questions are identified as:

Is the industry ready to move away from traditional payment methods toautomated or semi-automated payments?
Would the automation of payments assist to reduce disputes associated withpayments?
Would the automation of payments assist in better cashflow for the contractors?

1.5 RESEARCH AIM

The primary aim of the research is to investigate and access how a theoretical framework, such as the proposed BIM-Blockchain (BIM-Bc) and Smart Contract framework, may facilitate with delays and disputes relating to paymentsthrough the automation of construction payments and the respective contractual obligations, by way of leveraging BIM and Blockchain technologies. The second aim is to investigate how this theoretical framework could increase efficiency, trust, collaboration, information- sharing, administrative relieve among multiple parties, using a single decentralized share file.

1.6 STUDY OBJECTIVES

The study will rely on investigating both literature and empirical findings in order to providean understanding on how the theoretical BIM-Blockchain and Smart Contract framework may assist the with payment automation and potentially reducing payment delays and disputes.

The study objectives are to:

i. Investigate the potential and benefits of a BIM framework for Smart Contracts.

ii. Review the automation of payments using Smart Contracts with BIM Blockchain technology.

iii. Identify the benefits of a payment automation process.

iv. Identify the benefits of smart contracts by harnessing a BIM-Blockchain framework.

1.7 PROPOSITION

From the above, the following propositions are put forward for testing.

- Current problems have been reported in the construction industry resulting in poor levels of collaboration, payment delays and payment disputes. These issues contribute to additional costs, cash flow problems and late delivery of project due to continuous interruption.
- Smart contracts and the digitalization of the construction industry holds tremendous potential for project management, and that the digital disruption oftraditional contracts will provide the construction industry with the much- needed boost that shall provide better project performance to an underproductive industry.
- The increasing scope for the application of automation within the constructionindustry (which offers the sector a more efficient and cost-effective methods to

run certain processes) than that of the current (manual and time-consuming) practices.

1.8 SIGNIFICANACE OF THE KNOWLEDGE

The study investigates the new technology available which can have a positive impact on the entire construction supply chain, and which may also possibly also alleviate payment delays and disputes.

1.9 ASSUMPTIONS AND LIMITATIONS

1.9.1 Limitations

The following limitations have been identified in this study:

The research does not explore the impact of South African law or any other countries law pertaining to electronic contracts and the effects it poses on smart contracts, nor does this study aim to explore each and every standard form of agreement for automation, but rather this study aims to identify the holistic benefits from contract and payment automation in theconstruction industry leveraging BIM and Blockchain.

The research participants were only limited to Structural and Civil Engineer, Professional Quantity Surveyor, BIM Architect, Senior Contracts Manager, BIM Technologist and Construction Contract Attorney. No expert input was received from a Blockchain or Smart Contracts Specialist.

Technological advancements and applications of e-procurements and Smart Contracts in other industries such as Banking, Real Estate and or Insurance, have not been investigated for this study.

This study is not meant to investigate single applications in their stand-alone form, but rather a blend or an infusion of various application into one single theoretical framework.

In addition, the study does not address the conditions required for the security of informationin

construction projects, such as confidentiality and information integrity in a multi-party environment.

1.9.2 Assumptions

The following assumptions have been made in this study:

Assumption 1: Different construction project vary in terms of agreements and payment terms. For this investigation it is assumed that the interim payments apply over the construction period.

Assumption 2: Payment automation of construction projects can only be used with a BIM-Blockchain framework. No other alternative frameworks were investigated for this study.

1.10 RESEARCH METHODOLOGY

In literature review section of this paper, information was obtained from journals, research papers, articles, books, and internet sources. In addition, the WITS library was also accessed through remote login via the internet. In total 142 literature resources were reviewed although not all were referenced in this study. This identified a series of topic areas that informed the questions posed in the subsequent semi-structured interviews.

Data was collected from a purposive sample of various disciplines and professional roles in the construction industry namely construction manager (principal contractor), principal agent, quantity surveyor, lawyer, developer (employer). Respondents were invited to participate by way of an email. The topic and reason for the study was discussed with them by way of an initial personal telephone call. All respondents are knowledgeable and from professional backgrounds with years of working experience.

Thus, the research design adopted for this study is used an abductive approach, to collect qualitative data which was analyzed through content analysis generate a series of emergent themes of importance to the participants which was then compared to the findings in the Literature Review in order to develop a practical understanding of the technology available and its applicability to the South African.

1.11 ETHICAL ISSUES IN THE STUDY

Ethical considerations were given according to Bryman and Bell (2007), ten most important principals namely:

- Participants should not be subjected to any harm.
- Full consent should be obtained from participants prior to the study.
- Ensuring the protection and privacy of participants.
- Ensuring adequate level of confidentiality of research data.
- Ensuring anonymity of participants.
- Avoiding any deception or exaggeration about aims and objectives of the research.
- Declaring any possible conflict of interests and sources of funding.
- Conducting any type of communication for this study honestly and transparently.
- Avoid misleading and representing primary data findings in a biased way.
- Respecting dignity of participants.

Ethical clearance was obtained from the School of Construction Economics and Management which is part of the Faculty of Engineering and Built Environment at the University of the Witwatersrand. An official application was made to the School of Construction Economics and Management. As part of the Ethical clearance all participants were informed prior to participating that the information provided shall be kept confidential and that their identities would remain anonymous and by using a code.

Each respondent was provided written consent in order to voluntary participate in the interview, which was also recorded. The consent forms are attached as per Appendix A, hereto.

1.12 STRUCTURE OF THE RESEARCH REPORT

The research report comprises five chapters which are outlined below:

Chapter 1: Introduction; this chapter provides an n overview of the study and the research topic, the problem statement, research questions, aims, objectives and the structure of the research report.

Chapter 2: Literature review; this chapter outlines the inevitable change that the construction industry is facing. The literature review investigated the current manual payment methods associated with traditional (standard) contracts. It further investigated the possibility and the benefits associated with payment automation and how it could be incorporated into the Building Information Modelling Management system with the assistance of Blockchain to manage the construction as a holistic whole in order to increase performance.

Chapter 3: Research methodology; this chapter delineates the research methodology as wellas the choice and method of data collection and how data was analyzed.

Chapter 4: Presentation, discussion, and analysis of the results; this chapter data from the research the qualitative data is summarized in categories that relate to the research questions and to each participant input and views to support or to contradict a particular question.

Chapter 5: Conclusions and recommendations; this chapter presents and discusses the research findings of the empirical study followed by recommendations and conclusions.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The overall aim of this study is to investigate how the theoretical BIM-Blockchain (BIM-Bc) and Smart Contract Framework may facilitate with payment delays and disputes through the automation of construction payments and the respective contractual obligations by leveraging BIM and Blockchain technologies to increase efficiency, trust, collaboration among contractual parties. In this chapter, an overview is given pertaining to the current challengesthe industry faces with manual payment methods stemming from traditional contracts. The concept of Smart Contracts and the digital twinning of BIM and Blockchain is explored andthe importance of Blockchain and Smart Contracts and BIM and Smart Contracts, as well as the possible implications of Smart Contracts on the project manager.

2.2 CURRENT CHALLENGES OF MANUAL PAYMENT METHODS

Reported by the McKinsey Global Institute (2017) the construction industry is responsible for approximately $10 trillion spend globally and is one of the largest sectors of the world economy, which employs seven percent (7%) of the world's working population. It is forecasted that the construction industry will grow by 85% to $15.5 trillion worldwide by 2030 with the leading countries to be China, US, and India, according to the new report released by (Global Construction 2030 GCP Global, 2019).

Subsequently, in a report released by KPMG NZ (2014), the figure of revenue lost to poor contract management is between 17% and 40% of a contract's value. The report further state that companies are unable to use templates or standard form of agreements even if stored in a single repository. Construction projects are naturally complex, which involves unpredictable and external interrelated factors. Conversely, sometimes beyond the control ofthe contractual parties. As a result, disputes are more frequent between the contracting partieswhich is in most cases critical and difficult to resolve.

Moreover, litigation is time consuming and expensive process. and favorable litigation outcomes are not guaranteed. The construction industry has created systems to facilitate disputes by way of mediation, adjudication, and arbitration, nevertheless it does not guarantee

a successful outcome in resolving disputes. The implementation of smart contracts or an extension thereof may assist in the prevention or reduction in disputes, perhaps even in estimating the outcome of such a dispute (Praveen, 2018).

The transition from conventional contracts to automation should improve transactional efficiency and risk management (Kumaraswamy, Ugnu, Paramesware & Rahman, 2004).

Automation of the standard contract and that of semi-automated payments may add value and reduce minor disputes, thus all contractual actions and communication throughout thelifecycle of any contract would force action and compliance from both parties. Central to theSmart Contract is the flow of data (to and from) the BIM-Blockchain framework, resulting inreal time analysis which can highlight or flag problems (on a pre-agreed payment logic and not on individual judgement) by way of measuring information to the companies' data assetsin order to detection and identifying potential problems early on.

It may further assist in de-risk of the construction process through a more efficient and transparent contract mechanism, assist with positive cash flow and regular contractual payments, resulting in a greater confidence due to the transparency of real-time analyses.

The BIM-Blockchain and Smart Contract Framework could: -

- By leveraging Blockchain, resolve a variety of legal issues such as warranties, guaranties, and liabilities etc., created by its reliance on BIM.
- Include all project participants as parties to access and contribute to the BIM model.
- Single bank account that can automize payments after compliance withobligations.
- Automation and security of data regarding project obligations to the relevant stakeholders.

Possible Limitations: -

- The concern regarding sensitive information and data protection.
- The possibility to digest, digitize the scope of works to co-ordinate intelligent protocols.

Contracts and the contract process serve as a tool for aligning expectations, managing performance, uncertainty, and risk. Contract is a means of communication, coordination, collaboration, and control which define relationships, establish structure, and allocate and protect values (Cadeira, 2015).

It is therefore the responsibility of the construction project manager to negotiate and implement the construction contract as part of his function. Big, complex projects may engagein several participants thus exposing the project manager to human mistakes in risk allocationof which standard contract processes require human intervention which may lead to oversights (Tomas, 2018).

Conversely, BIM is becoming more and more associated with the delivery process of a project and the current shortcomings of standard contracts are becoming more apparent. The industryis known as being highly complexed, risk adverse and fragmented, which causes high levelsof conflicts and low levels of productivity. The adoption of technical solutions in the construction industry can address these existing shortcomings. (Manderson, Jefferies, Brewer, 2015).

Thomas (2018) identified the current Inconsistencies and ambiguities found in construction contracts are: -

1. Standard Contracts are an adversarial tool due to the fragmentation and "master servant" relationship of the current contracts.
2. Back-to-back contracts can cause issues in terms of inconsistencies.
3. Identification and understanding of risk.
4. Dispute management.
5. Data Analysis.

In addition, one of the biggest problems in the construction industry is the fragmented interface with the traditional procurement method. The concept of Design-Bid -Build, createsadversarial relationships due to the fragmentation of the organizations (Bernstein & Dreamer,2012).

Fragmentation is the major cause of friction and mistrust. Researchers have observed that this fragmented traditional approach arises as the flow of essential information between

relevant parties are limited. In addition, the traditional procurement between the interchangeof client, designer and contractor is low which results in problems at contractual and implementation level, Bernstein *et al.* (2012) identified the following possible contributing factors namely: -

1. Inadequate capturing of client needs.
2. Poor prioritization and implementation.
3. Late and costly design changes.
4. Unnecessary liability claims.

Construction projects have temporary relationships and as the industry is complex and fragmentation puts further strain on these temporary relationships (Nawi, Baluch & Bahauddin, 2014).

In his book, BIM in Principle and in Practice, Barnes (2019) highlights that most contracts are traditionally bipartite agreements, namely agreements between two parties only. He further states that these contracts tend to isolate parties rather than to encourage collaborationbetween the parties.

Likewise, Bernstein *et al.* (2012), supports that standard construction contracts are known to delineate the relationship, responsibilities, and boundaries very carefully between that of the owner, designer, and the contractor. The result is a highly fragmented process, which has been proven to reduce efficiency, productivity, and quality.

According to research done by Hunt (2018) the primary causes of disputes are contract administration followed by the secondary cause namely lack in communication failure. Their research found that good communication improves transparency, reduces surprises, and facilitates negotiations. They also state that poor communication typical of an adversarial culture and mistrust, undermines the rationality that enables projects to be delivered free of disputes. It follows that the third biggest contributor to disputes are quality in leadership. As project teams typically operate in hierarchical structures, risk of the quality of information they receive from the decision makers are not always relayed properly. This can be seen in complex projects or in megaprojects where senior leadership may be removed from a project management level (*ibid.*).

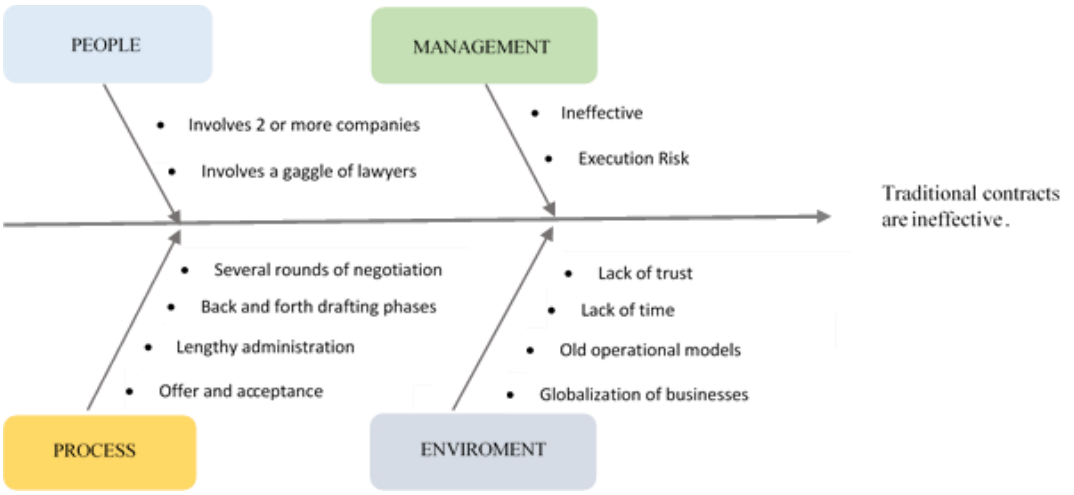


Figure 2.1: Traditional contracts process flow. Source: (Cadeira, 2015).

Equally Luo *et al.* (2019) substantiates that the construction contract facilitates payments through a supply chain by integrating people, activities, and events throughout the projects. He proffers that manual payment processes are more difficult in construction projects as thereis multiple stakeholders at different levels of a project. Subsequently payments are strongly affected by the lack of clarity in the definitions of responsibilities and obligations of the various project stakeholders in a construction contract. In turn, this intensifies disputes and cause construction delays, not to mention additional expenditure, cash flow problems and lack of trust between parties. He suggests a framework to automate construction payments byformulating them into smart contracts utilized by a decentralized block chain framework. Formulating payment logic that binds the prohibitions and liabilities associated with financialcommitments, for instance, interim payments on completed construction work into a computer-executable code shall allow for automated actions such as the triggering ofpayments to be executed upon consensus among relevant project stakeholders. (*ibid*.).

Barnes (2019) suggests that BIM Level 3 shall raise significant contractual, legal and insurance issues namely:

- Contract Documents Priority.
- Multiple model relationship.
- Conflict prioritization.
- Design liability.
- Professional indemnity insurance.

- Matters concerning intellectual property rights.

The execution of construction contracts is a complex process. Parties involved in a construction contract for interim payments are the employer, contractor, quantity surveyor, project manager and the engineer. Contact management process is slow due to delayed stakeholder consensus and decision making. In order to achieve consensus, several levels ofauthorization are required, supported by an immutable audit trail which shall support or prevent future disputes. Typically, the contractor submits his interim payment with supporting documentation. This in turn is verified by the quantity surveyor and again by theproject manager for correctness and valuation of the claim, before submitting same to the employer for payment execution. Where payment delays are as a result of a default on payment due to lack or funds or disputes about unsatisfactory quality of work, typically the contract is said to have been breached (*ibid.*).

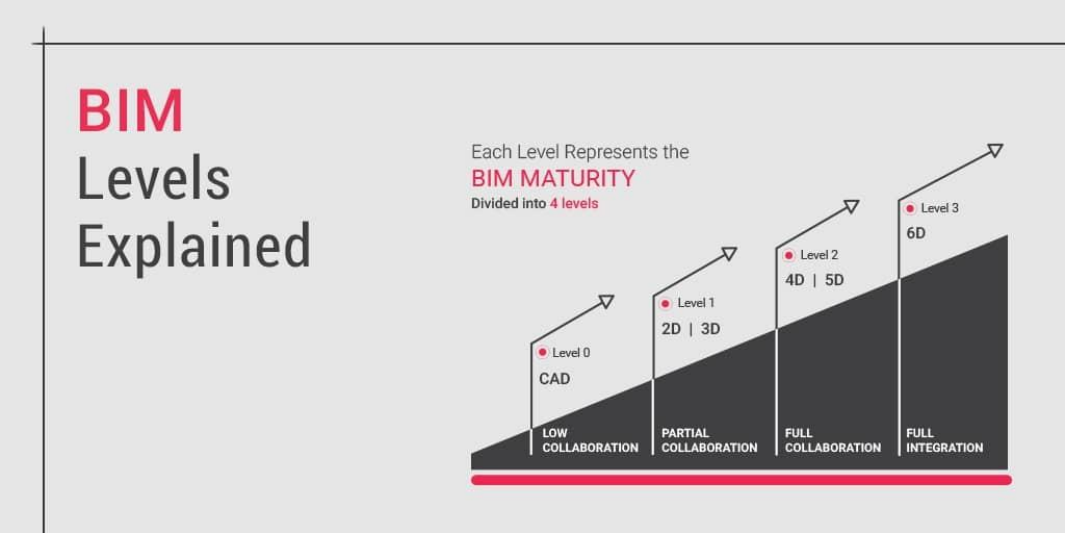


Figure 2.2: BIM Levels of Maturity. Source: united-bim.com

Moreover, these disputes normally escalate due to ambiguity of language in the identifying responsibility and prohibitions in contracts. However, as the BIM maturity is moving into Level 3, allowing accessibility by all team members a single project, changes to building contracts will almost certainly be necessary as the traditional legal positions of and the relationships between the parties are likely to change (*ibid.*). Refer to Figure 2.2 above and Table 2.1 below on the various stages of BIM Maturity.

Table 2.1: BIM Maturity Levels explained. Source: Modified from trace-software.com

BIM MATURITY LEVELS EXPLAINED		
BIM LEVEL 0	LOW COLLABORATION	Simplest step of information gathering. Low collaboration. Computed aided design or CAD tools to create drawings and drawn elements.
BIM LEVEL 1	PARTIAL COLLABORATION	Generate suites from CAD 2D information to non-federated 3D models.
BIM LEVEL 2	FULL COLLABORATION	Focus on the way which information is shared across the various project members.
BIM LEVEL 3	FULL INTEGRATION	Main goal is the attainment of full integration of the iBIM in a cloud-based environment.

For the purposes of clarity, it is necessary to mention that BIM dimensions are different than BIM maturity levels. BIM dimensions are inextricably connected to the type of data that can become available through the process. These dimensions can be found in both BIM Level 2 and Level 3 of which there are four types of BIM dimensions as being illustrated in Table 2.2, below.

Table 2.2: BIM Dimensions. Source: Modified from trace-software.com

BIM DIMENSIONS	
3D	It refers to 3D generated drawings.
4D	Linked to time management.
5D	It concerns data that relates to the cost of the project.
6D	This dimension is dedicated to the life cycle management of a building.

2.3 DIGITAL TWINNING, BIM-BLOCKCHAIN FRAMEWORK

Penze (2018), explains that BIM is concerned with the process of digital representation of real-life assets in the construction industry and although at the core, BIM facilitates the modelling

and information analysis pertaining to 3D geometry, construction project management information such as time, cost, and performance of the project, it does not take into consideration the legal obligations of the parties concerned.

BIM, at the most basic level, a process that is used to design, understand, and demonstrate key physical and functional characterizes. By using virtual computerized models, the building, infrastructure, or facility can visualize it in three dimensions (Barnes, 2019).

At its more advanced levels, BIM is the use of computer software to simulate the construction and the operation of a building, structure, or facility. This digital representation enables various users to analyze and extract information required for decision-making and process improvements. In addition, it can be applied to the entire life cycle of the building or facility (Cheung & Chan, 2014).

Buscher (2019) dubs Blockchain as the start of what the internet was 28 years ago. He further enunciates "that we are witnessing punctuated equilibrium", meaning a long period during which developers and researchers are finding new ways to use Blockchain technologies. Vast amounts of data are created every day within the built environment. From exchanging emails, creation and simulation of designs, there is a need to reflect on how technology not only improve but transform the industry.

Most construction projects currently work with BIM Level 2. Digital "twinning" BIM and Blockchain, would allow acceleration and advancement of BIM-to-BIM Level 3. Thus, it would enable all parties to work on a single decentralized collaborative shared model. Increased levels of security, reliability and live data collection would be possible (*ibid*.).

BIM enables coherent, cooperative, and integrated designs of buildings. It generates collaboration between architecture, engineering and construction professionals in a single digital process or tool. In additional digital assets can be derived from 3D models (Zong-Brisbois, 2019).

Blockchain technologies can add value to the Building Information Modelling (BIM) as it provides an opportunity to harness a new and secure way of trusted interactions between users and machines. Additional advantages are that of self-executing coded tasks using the disturbed ledger, completing processes automatically when preordained conditions are met. In the same

way a smart contract linked to activities and attributes in a 3D model that releasesthe interim or final payment once activities are verified on the distributed immutable ledger will give reassurance on the flow of payments between a client and contractor (Proctor, 2019).

The digital immutable ledger allows for the project to be mapped and tracked at every stage, further to this Zhong-Brisbois (2019*)* outlines that BIM-Blockchain technology can facilitate security, liability, transferability, and live data collection. Increasing transparency of externalan internal data paves the way for trust between stakeholders, reducing the opportunity for corruption, inefficiencies, and contractual disputes.

2.4 SMART CONTRACTS

Smart contracts refer to the computer protocols that defines the terms and conditions of a contract (Thomas, 2018). These protocols facilitate, verify, and enforce the negotiation and performance of the contract (Cadeira, 2015). The terms are not found on a paper, but rather compiled within a source-code. Contractual provisions can be partially or fully self-executing and self-enforcing. Encouraging and forcing parties to comply with their obligations (Thomas, 2018). In contrast, Cavendish argues that the use of the word “smart” is misleadingas smart contracts are not produced based on data, but rather programmed to execute the agreement if a set of conditions are met (Cavendish, 2019).

It is a digital form with embedded code in the hardware and software. Technology and rule-base operations can perform duties such as releasing payments. Once initiated the smart contract is irrevocable, thus the outcomes for which the smart contract is coded to perform, cannot be stopped therefore the performance is automatic (McNamara et al., 2019).

Smart contracts have numerous advantages from streamlined operations, heighted speed, and efficiency of transactions to low-cost enforcement of contracts. According to Temte (2019) smart contracts are advantageous as they force parties to honor the original agreements as the risk of breach is more expensive for the party in breach. Consequently, smart contracts can also address the myriad of issues associated with building contracts such as insurances, health and safety requirements, sub-contracting, liabilities and who is responsible for cost- overruns.

2.5 PAYMENT AUTOMATION THROUGH SMART CONTRACTS

According to Buscher (2019) we are at the beginning of connecting technologies with current technologies such as BIM, the Cloud, platform technologies, and the internet of things (IoT). Blockchain technology is still in its infancy within the built environment.

Technology supporting smart contracts is typically rule based and would follow a scrip exactly. Thus, the development of smart contracts is not built through artificial intelligence or machine learning, but rather smart contracts would be programmed to execute theagreement should a set of conditions are met (Cavendish, 2019). Likewise, smart contracts would apply industry standards and would form the bases for provisions that needs to be recognized in order to verify that certain tasks have been completed and then proceeding to the next required steps (Word, 2019).

Blockchain technology would be leveraged to automate payments and transactions between parties. The conditions of the contract and payment schedules can be designed upfront and solve problems in terms of keeping positive cash flow for contractors and the payment of contractors and subcontractors for completed work. In addition, it can be designed to keep a retainer and release partial payments. By using Blockchain there is no room for ambiguity and only follows a strict set of rules. Funds are held on the decentralized system and releasedwhen work is verified. This would be a positive step forward in solving late payments and cash flow problems as a result. This framework could prove a more trusted and controlled environment as it could help to prevent clients withholding funds from contractors and subsequently contractors withholding funds from subcontractors (Cavendish, 2019).

In the payment process all parties, to the contract would agree on the construction milestones and associated payments. The payment could be automatically released upon verification by the parties. Tracking payments from employer to contractor to subcontractors and suppliers could speed up payments to lower tier parties, thereby reducing payment disputes (Word, 2019).

Further, parties could verify the owner’s availability of funds at the start of a project. Thus, parties could be assured that automated releases of payments would be done upon completing their work as set out in the agreement. The smart contract shall permit real time information

available to the lender, employer, architect, contractor, subcontractor, suppliers, and all other parties required to track the flow of funds. In addition to the above, the Blockchain ledger can also be used to track and speed up construction tasks like submittals, inspections, variation orders. These tasks would work on a chain of command process and instant notice is sent to all project participants. Integrated with the BIM process it can further assist in accurate list of materials and quantities.

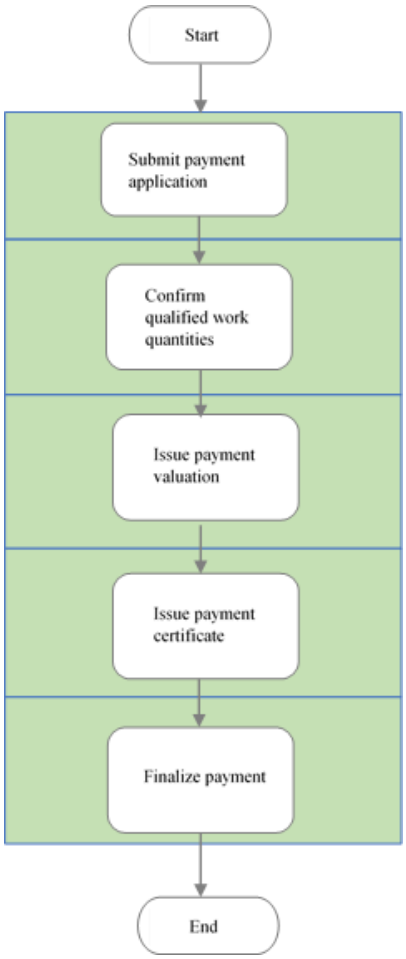


Figure 2.3: A typical level of relationships pertaining the payment process. Source: (Luo et al., 2019).

A typical sequence of relationships in the payment process, has been identified to involve a construction contractor, inspector (can be an engineer or project manager), quantity surveyor, engineer, and the employer (Luo *et al*., 2019).

In Figure 2.4, the high-level data is identified which shall be required for coding of the smart contract. Contract clauses are analyzed to identify and extract key information such as the details of the parties, activities, triggering events, conditions, actions, and resultant events (Luo *et al*., 2019).

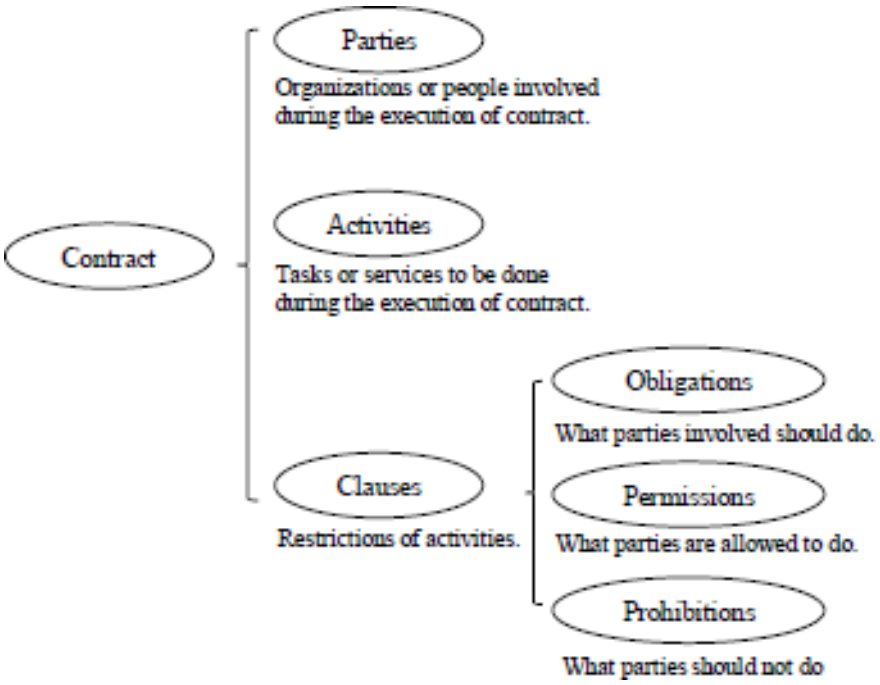


Figure 2.4: High-level data logic identified for smart contracts execution. Source: (Luo et al., 2019).

Luo *et al*. (2019) illustrates by way of a diagram (Figure 2.5) the proposed execution of the semi-automated payment through the smart contract by leveraging Blockchain. In his methodology he explains that execution is done through a permission which is done in two parts. First an automated consensus must be researched based on the pre-defined conditions of the smart contract and secondly the manual authorization of a project stakeholder by way of consensus.

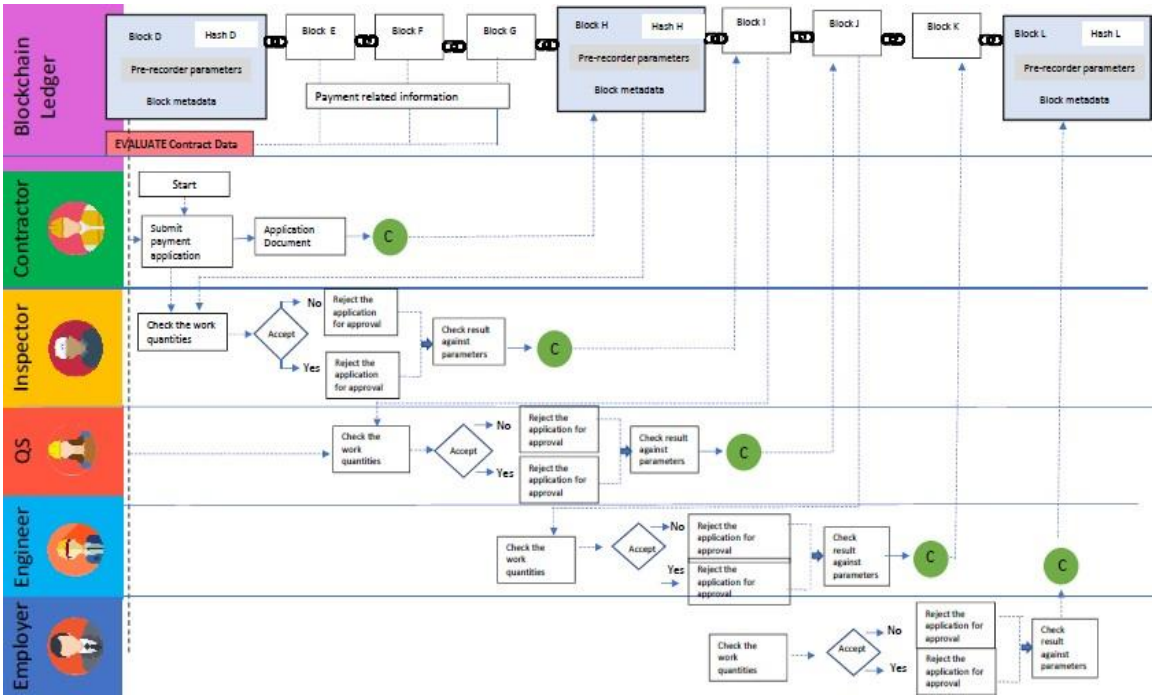


Figure 2.5: Proposed Execution flow of semi-automated payments. Source: (Luo et al., 2019)

The semi-automated payment process is triggered once the contractor submits a payment claim. The data from the payment claim is stored locally in a pre-defined data model, accessible to the project stakeholders for evaluation. The smart contract would automatically check parameters against the set pre-defined data model, conditions, prohibitions, andobligations. In addition, the smart contract would assess the incoming payment claiminformation's such as price, quantities, and other information such as the historical records of payments and variations which is part of the local asset model.

Payment consensus will start with inspector (could also be engineer or project manager). On each level there is a manual and an automated consensus required. The authorized party may approve or reject payment based professional judgement, existing information in local asset model or on-site inspection. Once consensus has been research, the transaction is added to the Blockchain. Information is recorded on Blockchain with a timestamp of details whom digitally approved (consensus), quantity verification and quality control verification. In addition to this the information would also be updated onto the local asset model for validating future transaction.

These steps shall be reiterated by the quantity surveyor, engineer and customer until consensus has been reached on all levels which shall trigger the automated payment release (Luo *et al*., 2019).

To summarize, in a Blockchain based framework, all information is stored in two data models. One for recording transactions (the ledger) that requires action by authorizedstakeholders and the other a data model (asset model), for checking and recording current values of construction data assets such as tasks and payments against the history data. The ledger can be described as the backbone of Blockchain which is an "unmodifiable cryptographically linked store structure and trusted source of information" and the asset model is based on the transactions recorded in the ledger.

2.6 BLOCKCHAIN AND SMART CONTRACTS

Blockchain is a database technology that ensures exchange and storage of any information uploaded to the database. This information is uploaded and compiled into immutable and time-stamped blocks. These blocks are then linked together creating the block-chain. These links between blocks of information are constantly verified on a peer-to-peer basis by other computers forming part of the same database (Thomas, 2018).

Equally Blockchain possesses over the technological infrastructure to reduce transaction cost, challenge the current contractual model, and improve transparency. By using Blockchain in smart contracts, it could assist in reducing delays across the lifecycle of the project by exchanging monies that took days down to minutes or even seconds (Cavendish, 2019).

Accordingly, cryptocurrency is the digital currency which operates independently from a central bank. This digital currency is used to regulate the generation currency units and verify the transfer of funds. Blockchain is the trading platform for cryptocurrency, with Bitcoin being the most popular. Introduced by Mr. Satoshi Nakamoto in 2008, he created Bitcoin andthe platform known as Blockchain as a means to operate cryptocurrency transactions. Each Blockchain encodes a debit and credit to the cryptocurrency and store it in blocks. Each node evaluates the transaction and maintain its own ledger of all transactions which reduces the risk of hacking and altering information (Temte, 2019).

Thus, the information is stored chronologically and can be viewed by a community of users. Once published the information on Blockchain cannot be changed (ICE, 2019).

In fact, supported by Thomas (2018) he states that once compiled, the model can continuously update during the execution of works and serve as a repository of project information afterwards. The potential to accurately record every single change made to the model leads to transparency and reliability of information allowing for better tracking and increased accountability. Blockchain could assist to resolve issues between construction projects and longstanding contractual procedures. Further, the legal industry has discovered that Blockchain technology can be used as a medium for smart contracts. Smart contracts as beingdefined as – "contracts that self-execute once the parties meet agreed-upon conditions" (Temte, 2019).

Mason states that BIM's establishment appears to be a pre-cursor to smart contracts in orderto build a platform where the latter can operate (Mason, 2017).

2.7 BIM AND SMART CONTRACTS

Improvement in the industry has been sought through collaborative practices and the need to shift from historical adversarial attributes (Egan, 1998). Developing a collaborative culture with BIM which as a tool can encourage open and collaborative working relationships (HMG, 2013). There is a growing interest in the roles that multi-party contracts play in successfully supporting BIM enable projects (Mosey, Howard & Bahram, 2016). The co-operative natureof these contracts creates the necessary environment for BIM to be optimized. It will also provide a competitive advantage where stakeholders can collaborate effectively.

According to Thompson (2018) BIM details the project to a far greater level which allows for greater confidence in pricing and analysis of risk. The transparency makes it easier to assign risk and can simplify negotiations where traditional contracts are facilitated through time-consuming back and forth negotiations, which requires large resources and based on the assumption of good faith and professionalism and understanding by both parties. BIM can assist with scope and specification protocols, even clash detection and can highlight contradictions within contract documents and short comings against legislative standards and specifications. BIM software will not be limited to 3D project models but could also compile

within its software all project information and documentation such as variation orders, invoices, payment information, lien waivers etc.

Moreover, BIM can therefore serve as a single source of truth for all project participants for better tracking and increased accountability (Do, Sutrisna, Hammand & Ramanayake, 2018).



Figure 2.6: Proposed Collaborative project ecosystem showing all stakeholders / parties and how it can tie back to parties to an intelligent contract. Source: (ICE, 2019).

Each party will have their own but same copy of the Blockchain which shall include and record every transaction and interaction that was made between parties. The interactions and transactions are tamper-proof and cryptographically signed, which creates an easy and traceable record of the past and in this way complexity of project control and the risks and cost associated with it could be significantly reduced. In such a system, trust and collaborationwould improve between all parties (ICE, 2019).

2.8 PROJECT MANAGEMENT AND SMART CONTRACTS

Smart contracts made possible the use of Blockchain technology will pave the way for unimaginable improvement in the construction industry. Cadeira (2018) predicts that the three primary areas that will progress significantly are the processing of data, financial transactions such as prompt payments and the implementation of contractual terms and

agreements. The project manager who will implement the smart contract would be able to offer significant benefits and competitive advantage (*ibid*.).

As the volume of project data shall continue to grow exponentially, the industry shall continueto find it difficult to digest the overload of information. Failure to digest the information impedes communication required for decisions or actions. Data driven decision making shallreduce the risk of instinctive decision making, thereby increasing the quality of decisions. Collaboration and digital maturity of organization will improve communication and reduce the prevalence of an adversarial culture (Hunt, 2018).

The lack of visibility of reliable real-time data, projects are suffering from broken handoffs, errors, omissions, extended lead times and unexpected bottlenecks. Automation of contractual obligations will allow Blockchain (in a similar way as trading cryptocurrencies) record all financial transactions in a quick and secure manner. Penalties and rules can be imposed automatically should a party fail to fulfil their obligations (Cadeira, 2018).

According to Mason (2017), project success is also reliant on effective project monitoring. Delays and cost overruns can be attributed to a lack in monitor and control of project work. Forecasting modules measuring variances from the baseline linked to schedule, cost, scope, and quality must be reviewed on a regular basis, and sometimes not done frequently enough due to the erroneous nature of the reports. Smart contract features will allow stakeholders to proactively participate by reviewing projects on a real-time basis and providing necessary inputs as highlighted by Mason (2017) which are: -

1. Project Insurance.
2. Construction Contract Obligations.
3. Pay/build.
4. Instruct/obey.
5. Set deadlines/Meet deadlines.
6. Give Access/Take Possession.
7. Give Design/ Follow or Complete Design.

Smart contracts can offer many benefits, however because the terms of the agreement are written into lines of code, once this “self-executing” contract has been created, it cannot be

altered. The lack of flexibility smart contracts offers (once inserted into Blockchain) to amend the contract is of concern. Parties would mutually have to agree to reverse the contract. Perhaps a self-destruct feature can be created to delete the block in the Blockchain, will be an alternative (Temte, 2019).

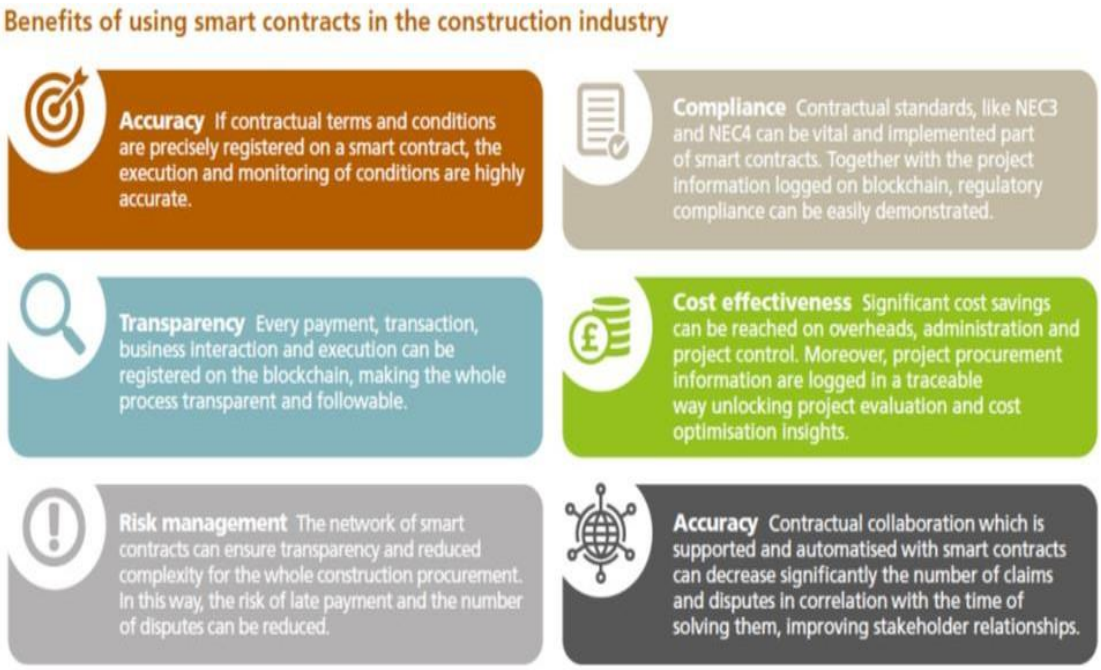


Figure 2.7: Benefits of using smart contracts in the construction industry. Source: (ICE, 2019).

Blockchain is in its infancy and there are various issues to be resolved. The first would be regulatory issues (authorization and compliance) on how these contracts will be applied. Secondly, Blockchain has many different ecosystems that need to agree to common standardsin order to work together. The third issue is scalability. The use of smart contracts on a platform such is Blockchain is power hungry. More efficient power usage will have to be considered when working with Blockchain. Other issues involve the control and processing of personal data and system security (Kemp, 2018).

2.9 IDENTIFIED GAPS IN LITERATURE

The literature review has revealed that there are problems in the construction industry in South Africa and indeed worldwide pertaining to payment delays and non-payment. The

construction industry is known to be one of the most difficult industries to partake in, especially for contractors, subcontractors, and other industry players that need to get paid infull and on time. Construction delays and payment disputes have become quite the norm in the industry. These prevalent problems lead to payment disputes, lack in trust and poor construction performance. The causes of these problems that have been identified in the literature are disconnect between the obligations as set out in the construction contract and the "master servant" relationship of standard agreements, providing the client with the sole power.

Though the literature is rich literature on the topics of construction delays and payments disputes, the following gaps were identified in the literature:

The is limited understanding of Artificial Intelligence and how these new technologies can transform the construction industry and especially how these technologies (such as BIM and Blockchain) could be leveraged which could be beneficial to current problems of payment, delays, and disputes. According to Doctor Rehana Parveen, Artificial Intelligence promises the construction sector a chance to transform the efficiency and quality of developments Praveen (2018), however she does not indicate how it could be implemented. Kumaraswamy*et al*., (2015) points out that transition from conventional contracts to automation should improve transactional efficiency and risk management, however there is vagueness on how this could be achieved. Supported by Luo *et al*. (2019), Cadeira (2015) and Barnes (2019), payment problems in construction industry depend on the execution of the construction contract and BIM and Smart Contracts could provide the solution. Studies in literature indicates that all current studies have been done on single problems providing a single solution utilizing a single technological solution. It fails to provide a holistic solution with aproposed framework and how this framework could be achieved or optimized. Thus, this study is intended to investigate a holistic approach that would harness single technologies of BIM, Blockchain and Smart Contracts to form one proposed framework and to understand how the framework could be achieved and benefit the construction industry in terms of payments, delays and disputes.

2.10 CONCLUSION

Time is money and it is precious. New innovative methods leveraging automation to re-think how we are administrating cost management in construction projects. To address the causes of this problem, the idea of an automated approval process is proposed. By adopting a framework of leveraging technology associated with BIM and Blockchain and linking it to a Smart Contract, payments can be paid automatically when work has been authorized which prevent payment delays. If successful, the benefits may include: -

- Cost saving & efficiency.
- Saved time.
- Improve and positive cash flow.
- Mechanism to detect problems early on.
- Fraud risk reduction.
- Improved relationships and transparency.
- Reduced process costs.
- Reduced number of disputes.

3 RESEARCH METHOLDOLGY

3.1 INTRODUCTION

Research methodology is a method to systematically solve the research problem. It may be understood as how research is done scientifically. This chapter provides the detail of the research design and methodology used in the study. Various steps are adopted in the study. Not only are the research methods and techniques important to gauge the researcher, but also the methodology. Whilst the research method defines the research approach; the research strategy refers to whether the research is qualitative or quantitative; the research design is the map of howthe study shall be conducted (questions involved and where research will take place, what time dimension, in what environment); the research study the methodology discusses the data collection using a control group. Research methodology has many dimensions (research methods) which make up the research methodology. Different kinds of methods may be used by researchers whilst performing their research. Methodology refers to the "theory of how research should be undertaken, including the theoretical and philosophical assumptions uponwhich research is based and the implications of these for the method or methods adopted". (Saunders, Lewis, and Thornhill, 2016).

Table 3.1: Objective versus Research Method employed. Source: Author

Objective	Research Method
1. *Investigate the potential and benefits of a BIM framework for Smart Contracts*	Literature and Empirical
2. *Review the automation of payments using Smart Contracts with BIM and Blockchain technology*	Literature and Empirical
3. *Identify the benefits of a payment automation process*	Literature and Empirical
4. *Identify the benefits of smart contracts by harnessing a BIM-Blockchain framework*	Empirical

3.2 METHODOLOGY

Methodology refers to the philosophy or logic that underlines a specific method (Buckingham& Saunders, 2007). "Through the methodology, we study the various steps that are generally adopted by a researcher in studying his/her research problem and the underlying logic behind

them. The selection of the research method is crucial for what conclusions you can make about a phenomenon. It affects what you can say about the cause and factors influencing the phenomenon". (Signh & Warwyn, 2017).

3.3 RESEARCH STRATEGY

Research must consider the first methodological choice between quantitative, qualitative, or mixed methods for the research design. Quantitative research differs from qualitative research. Quantitative research involves collecting numeric data (ways to measure two or more variables) whist Qualitative research focusses on collecting of non-numeric(characteristics that are not easily deductible to numerical values) data such (Saunders *et al.,*2016). Where a researcher employs a quantitative research approach, it is generally to measure variables which would provide statistical outcomes, quantifications, and graphical techniques. Consequently, where a researcher employs a qualitative research approach, the researcher is more concerned about testing a theory. (*ibid.*).

This research employed a qualitative approach to establish whether a BIM-Block and Smart Contract framework could overcome the manual payment delays and associated disputes. As the topic area is in an incipient nature, this research is of an exploratory nature. The topic areais relatively new to practitioners and therefore their understanding is limited. The qualitativedata was collected through interviews after which the data, which was reviewed, scrutinized,and assessed. The raw data was organized into conceptual categories and themes that emergedfrom the data for the purpose of comparison to the literature as well as to understand issues around its application to the SA context. Qualitative research collection usually operates in a natural setting or research context in order to establish trust and participation of which interviews are illustrative of this. Although the interview was guided by a pre-set question(s)as a guideline and to keep the interview on tract, it is less rigid in the answering of these questions focusing on an open answer format. The focus is mostly on the participant's knowledge and experience which usually involves non-standardized observations and interviews. The qualitative research involved a small sample, having conducted six interviews, and is typically used in exploratory research.

3.4 RESEARCH DESIGN

Research design refers to the general plan on how you will approach the answering of your research questions. Clear methods and sources of how data is collected and analyzed are specified (Saunders *et al.*, 2016). These methods include control variables, time horizon and participants perceptions.

3.4.1 Time horizon

The time dimension of research refers to the time which the research was done at a time. The study will provide a snapshot in time, whilst a longitudinal study is developed over time. This research study was a purposive sample study, as it involves exploring a phenomenon that is emergent in the SA context (demonstrated by the absence of local literature). The research was also completed within a specified two-month period.

3.4.2 Research environment

Research can be administered in diverse environments. These environments can include controlled and un-controlled environments. Controlled such as a laboratory environment and uncontrolled which would include the actual environment (Cooper & Schindler, as cited in Schoonraad, 2003). This research was conducted in the actual environment without interference. The interviews were based on real life knowledge, experience, and project-based occurrences.

3.4.3 Sampling design

All research question requires a collection of data from a sample. The selected sample is related to the population that is highlighted in the research questions and its objectives. In thecase of an empirical study the target population refers to questionnaires, case studies and interviews (Saunders *et al.*, 2016). In addition, population studies refer to the complete set ofindividuals (subjects or events) with common characteristics in which the researcher is interested.

For this research, the target population was identified withing the construction industry or built environment. The research sets out to assess perceptions of practitioners of howautomated in construction payments might alleviate problems and disputes associated with late and non-payment. Only participants with the relevant industry knowledge were

considered for this research including the number of years of experience and the seniority of their positions, hence the target population was selected due to their experience and knowledge gained in the industry for increased reliability on their input for this study and thepurposive nature of the sampling used.

3.4.4 Data analysis

Data analysis is a crucial step to illustrate, recap and evaluate data by applying a statically or logical technique. Quantitative research normally employs a deductive reasoning whilst qualitative research may also employ inductive reasoning. Research may use both styles in one study; however, this research used content analysis based on identified themes from the literature review systematic and objective interrogate the qualitative data in order tobuild an understanding of the topic as seen by the local practitioners. A third approach to theory development is to employ an abduction reasoning, whereby themes and patters are identified to generate a new or modify and existing theory which is tested by collection additional data (Saunders *et al.,* 2016), however this study is based on themes largely reflecting in the literature which is compared to SA professional practitioners' views and experience.

Qualitative research is a powerful way to understand complex concepts such as the underlying thoughts and expectations towards smart contracts in the construction project management environment. It creates a deeper insight of the required performances required from this technology that would have been achieved from a large-scale survey.

Rather, the qualitative research focused on qualitative data to understand stakeholders' perceptions of their understanding of standard contract problems and how smart contracts together with BIM-Blockchain technology could possibility overcome the problems associated with traditional standard contracts, cash flow problems and payment delays due todisputes.

3.5 PERSECTIVES AND SCIENTIFIC METHOD OF RESEARCH METHODOLOGY

Research Methodology is the theory on how research should be conducted which require a clear understanding about the research based on a range of philosophical assumptions (Saunders *et al.,* 2016).

Research starts with a specific problem, question, or hypothesis. Collection and interpretationof data must be done in order to attempt in answering the problem, question, or hypothesis. How theory is developed provides the foundation for reasoning and recognizing the relevantresearch questions and objectives. According to Saunders *et al.* (2016) it must be developedin such a way as to test and develop a theory.

3.5.1 Deductive, Inductive and Abductive approaches

A qualitative research approach usually relies on an inductive reasoning processes to interpret and structure the meanings that was derived from data. It is important to distinguish between inductive and a deductive inquiry and an abductive process for this research.

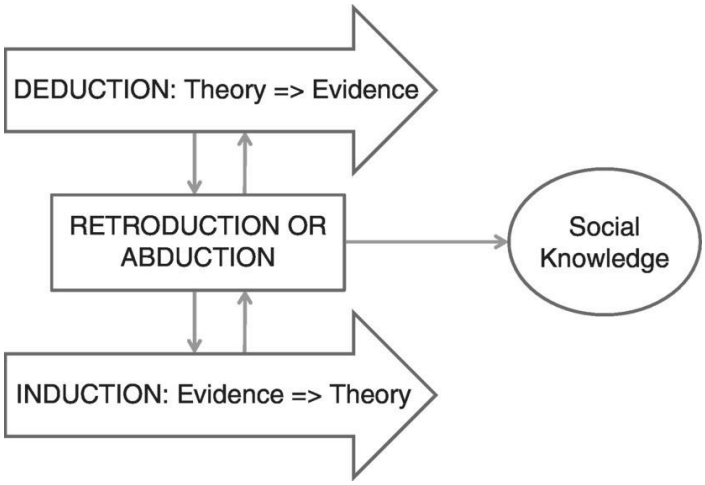


***Figure 3.1: Graphical Illustration: Deduction, Induction and Abduction: (*Bhatti, Ramaswami, Barron, Ventresca, 2018).**

Generally, an inductive approach uses the data to generate ideas (hypothesis generating), whereas a deductive approach begins with the idea and uses the data to confirm or negate the idea (hypothesis testing) (Thorne, 2003). Conversely, an abductive approach explores a

phenomenon, identify themes, and explain patters to generate a new or modified theory by generating additional data for testing.

Table 3.2: Deduction, Induction, and Abduction: from reason to research: (*Saunders* et al., *2016).*

	Deduction	Induction	Abduction
Logic	In a deductive inference, when the premises are true, the conclusion must also be true.	In an inductive inference, known premises are used to generate untested conclusions.	In an abductive inference, known premise are used to generate testable conclusions.
Generalisability	Generalising from the general to the specific.	Generalising from the specific to the general.	Generalising from the interactions between the specific and the general.
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory.	Data collection is used to explore a phenomenon identify themes and patterns and create a conceptual framework.	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection.
Theory	Theory falsification or verification.	Theory generation and building.	Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory.

In this research an abductive approach is followed by exploring a phenomenon and identifying themes and patters to create a conceptual framework (Saunders *et al.*, 2016).

A main question is formulated to start the research to formulate the logical relationship between the concepts of traditional payments, payment automation and contract automation. The research starts with questioning the effectiveness of traditional payment methods to that of automated payment and contract methods in the construction industry. The question therefore highlights whether a proposed automated framework could address the issues relating to payment delays. This question led to the hypothesis.

The research proposition is:

How can a theoretical framework, such as a BIM-Blockchain Smart Contract framework; increase trust and collaboration in the supply chain, whilst decreasing payment delays and reducing disputes within the South African construction industry?

Research requires a systematic and controlled approach that will direct you towards the desired objectives, which this study undertook.

3.5.2 Credibility, dependability, transferability, and confirmability

The research needs to consider quality issues associated with interviews in order to ensure data quality. The lack of standardization can lead to concerns about reliability, dependability,and confirmability (Saunders *et al*., 2016). Caution and care were taken to avoid interview and interviewee bias, as bias is a threat to reliability of the data.

Credibility is the extent to ensure that representations of the qualitative data represent participants intentions. By supplying of relevant information to participants before the interview credibility is promoted. Developing of interview themes would provide valid results as the subject matter is of an incipient nature. The method is also reliable as it has beenused has been used in other similar studies. Consequently, dependability means to record andproduce a reliable and dependable account of the emerging research that may be understoodand evaluated, which will support confirmability to ensure that this study results conforms toa degree which could be confirmed and corroborated by others. By providing a full description of the research design, findings and interpretations, the findings in this study canbe transferred to other contexts or settings.

3.6 RESEARCH DESIGN

The research design provides a framework for a study. The importance of the research approach will determine how relevant information for the study will be collected and there are many interrelated decisions to consider (Kumar, 2000).

The research uses the philosophy of interpretivism primarily due to the exploratory and investigative research approach. As each individual experience the objective reality indifferent ways it will support the research to establish whether the proposed Smart Contract BIM-Blockchain framework, may facilitate semi-automatic construction payments and contract execution by way of consensus leveraging BIM and Blockchain technologies.

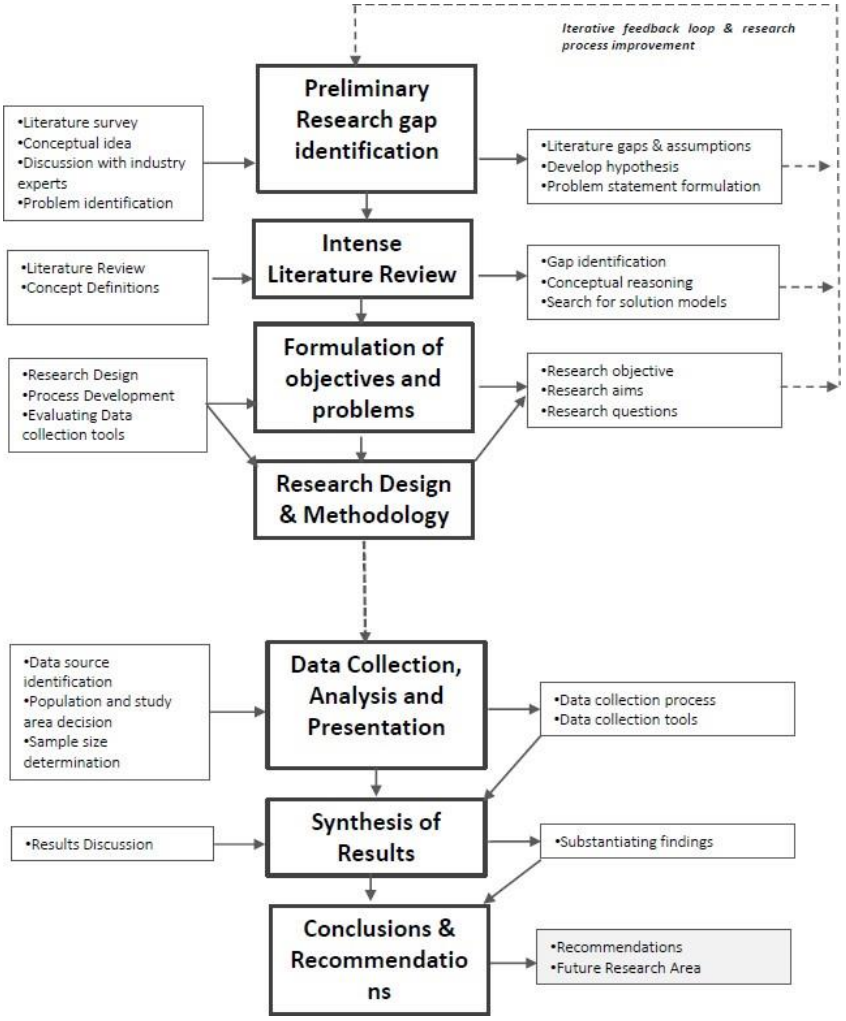


Figure 3.2: Research Design process flow for study. Source: Author

The subjective nature of the research is best suited to be addressed using a qualitative approach in order to answer the research phenomenon. An inductive approach shall be usedas this shall best test the hypotheses and a prediction can be drawn from the outcome.

Due to the incipient nature of the subject, primary research data will be collected through selecting 6 interviewees across the construction industry to be interviewed.

The interview shall be conducted using semi-structured interview approach, which shall be recorded and transcribed. The interviewees shall be chosen from the respective fields of

construction manager (principal contractor), principal agent, quantity surveyor, lawyer, developer (employer), as their inputs shall provide richness to the research.

The alternative approach to collect the data is from a bigger group, but the outcome will be more generalized and unreliable due to the limited knowledge of the subject matter that currently exists.

Research methods used for the empirical research was mainly performed using journal articles, and industry publications. Due to this topic still being in its infancy, limited peer reviewed literature associated with the research topic was found as well as no case studies were not found to exist.

A qualitative research interview seeks to cover both factual and meaning level, through it is usually more difficult to interview on a meaning level (Kvale, 1996). Interviews are a useful tool to understand the participant's experiences due to their in-depth industry experience (McNamara, 1999). The main task in interviewing is to understand the meaning of what the interviewees say (Kvale, 1996).

Interview shall be conducted with 6 industry professionals using a semi-structured interview process, which shall be achieved in the following steps.

Step 1: Thematizing: the why and what of the investigation. Establishing topic questions in terms of behaviors, opinions/values, feelings, knowledge, sensory, background and demographics.

Step 2: Designing: Develop interview themes. As "how" questions rather than "why"questions to get their viewpoints. Develop probes that will prove more elaborate responses to key questions.

Step 3: Consider cultural and power dimensions of the interview situation.

Step 4: Draft a short summary of your research report and supply it to the interviewees priorto the interview. This shall provide them with the opportunity to understand the heart of the study and to provide rich and detailed feedback on their experiences.

Step 5: Do Pilot testing to identify and solve confusing points.

Step 6: Data Collection: Conduct and record the interview based on an informal discussion. All interviews were planned, a date and time was scheduled with the individual interviews which was conducted via ZOOM. All discussions were recorded and used as the interview data.

Step 7: Data Processing: Analyses interview material.

Step 8: Data Analyses: Interpretation data.

Step 9: Reporting: Communicate the key findings of data with conclusion.

3.7 RESEARCH INSTRUMENT

For the purpose of this study, the researcher used semi-structured interviews, which involved both direct questioning using open-ended relating to their industry knowledge and experience, based on themes that emerged from literature. This demographic data was to confirm whether the interviewees are members of the population.

Table 3.3: Secondary Research Question, Topic Questions and Literature Source

Secondary RQ	Topic	Literature Source
Would the automation of payments assist to reduce disputes associated with payments?	Participant views and experience pertaining to: • Reasons for payment disputes and late payments and the lack of contractual understandings. • Poor leverage to enforce payments. • The need for transparency and trust. • Litigation and the effects of the litigation process. • Would it be an efficient mechanism to assist with disputes and variations. • The need for a collaborative approach.	Busher (2019), Cadeira (2015), Luo *et al*. (2019), Praveen (2018), Word (2019), Zhong-Brisbois (2019).

Is the industry ready to move away from traditional payment methods to automated or semi-automated payments?	Participant views and experience pertaining to: • Views on the current traditional contractual processes and the industry role-players desire for change. • Need for a seamless and integrated framework.	Barnes (2019), Bernstein (2019, Cadeira (2015), Cavendish (2019), Egan (1998), HMG (2013), Manderson, Jefferies and Brewer (2015), McNamara *et al*. (2019), Mosey, Howard and Bahram (2016), Temte (2019), Word (2019).
Would the automation of payments assist in better cashflow for the contractors?	Participant views and experience pertaining to: • Whether such framework can assist with better cashflow and reasons. • Views on benefits that participant foresee of the proposed framework.	Barnes (2019), Cavendish (2019), Do, Sustrisna, Hammand and Ramanayake (2018), Proctor (2019), Zhong-Brisbois (2019).

The interviews were loosely structured on purpose so as to not impose the researcher's viewson the respondent and allow the participants who are particularly knowledgeable about the topic of interest to talk to what they considered was important. The semi-structured interviewis traditionally conducted in a face-to-face setting which permits the researcher to seek new insights, ask questions, and assess phenomena in different perspective, however due to the COVID-19 pandemic this was not permitted. Instead of a face-to-face setting, the interviews were conducted using a virtual platform, Zoom. All interviews were recorded and transcribed.

3.8 DATA ANALYSIS

Data analysis can be described as a taxonomic process. Sorting and classifying of the collected data essentially done in a systematic manner. Data analysis occurs alongside the interviews to generate the data. The process of data analysis is a reiterative process which istime consuming. Four key steps are identified in research namely, 1. Immersion, 2. Coding,

3. Categorizing, and 4. Creation of themes. During the immersion stage, the researcher will familiarize himself with the data which requires active reading and re-reading of interview transcripts and contextual data which allows for the process of idea creation (Green, Wills, Hughes, Small, Welch & Daly, 2007).

The second step is coding. This process involves examining the information contained for each interview. The research sorts the transcripts into blocks which are coded and given descriptive labels. Data is revised and categorized, which makes up the third step under the data analysis. Linking codes to categories enables the continuous examination under investigation. Once no further information could add to the category, the category will be tagged as saturated.

The fourth and final step of the data analysis process are the identification of themes. This isan expansion on the categories. It requires testing and explanation of data. Which links the results from the interview with other settings. (Green *et al*., 2007).

3.9 ETHICAL CONSIDERATIONS

The purpose of this study was explained to potential participants for their willingness to partake in the study. The participants were then given the subject information sheet, (see Appendix A), which also explained the purpose of the study. Confidentiality and anonymitywere assured. All participants were also informed that they could withdraw from the study atany time without any negative consequences. A consent form was obtained from each participant. Consent to recording the interview was also obtained. All respondents were treated respectfully during email, contact sessions and discussion. All input received from respondents were valued and appreciation for participation and input was expressed to respondents. This research did not expose either the participant or the researcher to any potential risks or harm that they would not otherwise be exposed to. The ethical considerationswere held in high regard throughout the course of this study, listed in Table 3.4 below.

Table 3.4: Ethical Considerations and Mitigation Strategy

Ethical Consideration	*Mitigation Strategy*
Respect for participants	Treated all participants and data collection with respect and professionalism.
Non-Discrimination	This researched aimed to be free from discrimination whether it be race, sex or social status and background.
Intellectual Property	Obtained necessary permission where intellectual property is involved.
Plagiarism	Avoided passing off work of others as writers own.
Sensitivity	Sensitive information was treated with the appropriate respect.

Confidentiality	Abide to confidential information and followed guidelines on how to treat confidential information.
Integrity	Reported honestly.
Objectivity	Avoided bias influencing and reporting.

3.10 RESEARCH CONSTRAINTS

This research study is limited to a small, selected group of participants and therefore any interpretation of the data is limited and may be insufficient for statistical measurement. Dueto the infancy of the research topic the empirical literature has limited peer reviewed journals.

3.11 CONCLUSION

This chapter provided the foundation for the overall process in collecting of the datathroughout to processing and analyzing of the data. The chapter begin with the research problem and provided the philosophical positioning of qualitative research. Lastly, the ethicalconsiderations for the study were highlighted.

4 DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

This chapter presents the data from the six semi structured interviews conducted for this study. The aim of the interviews was to obtain professional opinions of professionals in the construction industry or in the built environment who are actively involved in the construction management processes and related fields, to obtain their views on the current traditional processes and that of a more automated process in terms of the proposed framework. Their views and knowledge are seen as essential for richness of the data. The interviews were conducted to obtain data pertaining to the proposed BIM-Blockchain and Smart Contract framework and how that may assist the construction industry with payment delays through automation, payment disputes and to move away from the traditional fragmented approach toa more collaborative and trusted approach.

The interviews were primarily aimed to broadly discuss the follow areas with each participant:

4.2 PARTICIPANT PROFILES

The six participants are all registered professionals that has been operating within the construction industry and or built environment for more than 15 years. Their contribution in terms of their experience and knowledge assisted with richness in data. They are also directorsof their respective consulting firms they are highly respected members within the industry onthe delivery of South African and international construction projects. Collectively these six participants have a clear and in-depth understanding of deliverables during the construction process and from project initiation to close out and a clear understanding and interest in the proposed framework. The participants include Senior Contracts Manager, Structural and Civil Engineer (Principal Consultant), Professional Quantity Surveyor, BIM Architect and Design Manager, BIM Technologist and Construction Contract Attorney.

The interviews were carried out utilizing a virtual platform called Zoom, to facilitate a one-to-one interview during COVID-19. These interviews were recorded and transcribed accordingly. One of the key aspects were to avoid biased data collection.

The table below highlights the six participants and their respective designations within the Built Environment. Of the six participants one is a Construction Contracts Manager, one is a Structural and Civil Engineer who acts as Principal Agent on many projects, one is a Professional Quantity Surveyor who is responsible for cost control of projects, one is a BIM Architect and design manager specializing in the life cycle management of all the BIM models, one is a BIM Technologist that understand the programme and trains manyprofessionals and one attorney that specializes in contractual disputes within the constructionindustry.

Each of these participants have years of experience working with construction projects with a project value exceeding R100 million. They have highlight skilled knowledge on how to deliver large projects successfully and therefore understand the many obstacles the construction industry face within the traditional processes. All the participants have a significant curriculum vitae and track record and are regarded as reliable and trustworthy.

Table 8 lists the six participants and their respective designation and area of expertise they work in. Of the six participants, one is a construction attorney, one is a contracts manager, one is a professional quantity surveyor, one is a BIM Technologist, one is a BIM Architect and Design Manager, and one is a Senior Structural and Civil Engineer.

Table 4.1: Participant Profiles

Participant	Area of Expertise	Designation	Professional Registered	Gender	Number of Years Working in the industry
Participant One	Construction Law	Attorney	Yes	Male	20 - 30
Participant Two	Construction	Contracts Manager	Yes	Male	20 - 30
Participant Three	Quantity Surveying	Professional QS	Yes	Male	15 - 20
Participant Four	BIM Technologist	BIM Technologist	No	Male	15 - 20
Participant Five	Senior BIM Architect & Design Manager	BIM Architect	Yes	Male	20 - 30
Participant Six	Engineering	Senior Structural & Civil Engineer	Yes	Male	20 - 30

The summary of the key participant statements per theme are outlined below. This is followedby the conclusions on the general viewpoint. For the purpose of anonymity, the identity of the participants has been disguised using participant numbers in place of the names of the councils and associations.

4.3 IMPLICATIONS OF KNOWLEDGE SHARING

(Samadi *et al*., 2013) explain that the human brain creates knowledge which is not visible. In order for creation, revealing and sharing to be activate the right climate is needed. Motivational factors allow for the desirability to create and share knowledge. It is not only needed to obtain tacit knowledge which is transformed to explicit knowledge by also to createrepositories of knowledge and best practices.

In addition, (Krogh, 2000) highlights that even though knowledge allows for development of norms and standards in an organization, the knowledge must also be successfully managedand shared to allow further creation of knowledge. He further states that knowledge management is thus capturing of expertise from one person while distributing this internal knowledge to other individuals.

4.4 EMPERICAL FINDINGS

Key statements made by participants 01 to 06, from the interview were highlighted per themein a tabular format.

A total of 16 themes were identified during data collection process. Table 4.2 identifies the themes and the frequency of the theme during the data collection for each participant. Each theme is presented with the supporting comments in the following sections.

Table 4.2: Theme identification and frequency of occurrence of themes during the data collection process.

Themes	Participant One	Participant Two	Participant Three	Participant Four	Participant Five	Participant Six	Totals
Support for automated payment	5	2	7	1	1	2	**18**
Industry role-players set in their ways	5	5	6	1	3	3	**23**
Proposed implementation of the BIM-Blockchain & Smart Contract Framework	17	8	16	7	13	9	**70**
Industry experience regarding Cash Flow problems	3	2	4	2	1	2	**14**
Elements that can contributes to a more seamless process	1	2	3	2	4	4	**16**
Current fragmentation due to traditional processes	6	2	9	1	1	5	**24**
The need for payments to be guaranteed	2	1	3	3	1	2	**12**
Increased performance: time and money by implementing the proposed framework.	4	5	4	1	2	4	**20**
Lack of transparency in the industry	2	2	5	1	1	3	**14**
Lack of trust in the industry.	3	3	4	1	1	2	**14**
Disputes are left in the hands of the court to resolve and cost of litigation.	9	2	3	1	1	3	**19**
The need for collaboration	1	3	3	2	1	3	**13**
Reasons for payment disputes	11	6	7	1	2	7	**34**
Poor contract management practices	6	2	7	1	1	3	**20**
Poor leverage to enforce payment	1	2	2	1	1	3	**10**
Construction Variations	1	1	2	1	5	2	**12**
Totals	**77**	**48**	**85**	**27**	**39**	**57**	**333**

4.4.1 Theme One: Automated payments.

Table 4.3: Key Participant Quotes regarding Automated Payments.

Participant ID	Supporting Key Participant Quotes regarding Automated Payments.
PC01	• *"At each stage, the client must have access so that he can say, I am happy with this. And once he says I am happy with this, it should be like a tick mark, it automatically allocate some kind of payment instruction or the ability to generate the ability from the client, whilst still protecting his financial side of things."* • *"So, it will lessen his exposure and at the same time it will guarantee that the contractor will be able to get his payments, when as is the work gets done, as it was paid."*
PC02	• *"I suppose that if BIM and the measuring system with Block chain work as good as you say it will, it should. Effectively certificates can be done by one person in the office. It will take away the admin it will take away from ten different site agents on different sites."*
PC03	• *"I know of a couple of cases where lawyers contacted me to be either expert witness or just to be a mediator in the beginning. Try and settle those disputes, because 90% of those disputes are about payment as you know. I think it is a very good idea that we try to streamline (or to make it more fix in stone), but one needs to obviously look at the contract as well."* • *"And that is perhaps that is one of your links and it's also a link to your cash flow. Normally you can draw out exactly from that what your cash flow is going to be."* • *"I think there need to be certain criteria or certain tick boxes that you need to do. I think definitely a dispute will be minimized. And as we all know (I mean) disputes are …90% are about money."* • *"I always say let's be fair and I mean everyone is entitled to his mark-up, but from my side I think if the system is in place everyone knows what needs to be done, it happens automatically its less stress for all the parties"*
PC04	• *"I don't understand the technicalities, but I understand from what I see and what you have put together that it is dependable on multiple entities that then carry the encryption forward into the future and you can't unroll it. So, one person can usurp the process and roll it back. And that is great, and getting triggers where people get paid is perfect."* • *"I get frustrated because my clients do not get paid what they need to get paid. When they don't get paid, I don't get paid."*
PC05	• *"All the programs' controls, cash flow and then ultimately it goes into what you want to do is control when do we get paid what. The BIM model can tie in with the Blockchain which will allow for payments to be automated."*
PC06	• *"He (the contractor) will get paid for the work done automatically after receiving approval. And for time spent to do it. At the end I*

	think it is a big advantage to have all of that together so that gives you your BIM aspect your Blockchain aspect."

Table 4.3 illustrates all participants key quotes regarding theme: Automated Payments. The frequency of the theme was cited 18 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.1: Weighted average rating per participant for Theme: Automated Payments

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	6.4	**6**	**6.86**	**9**	**7**	**7**

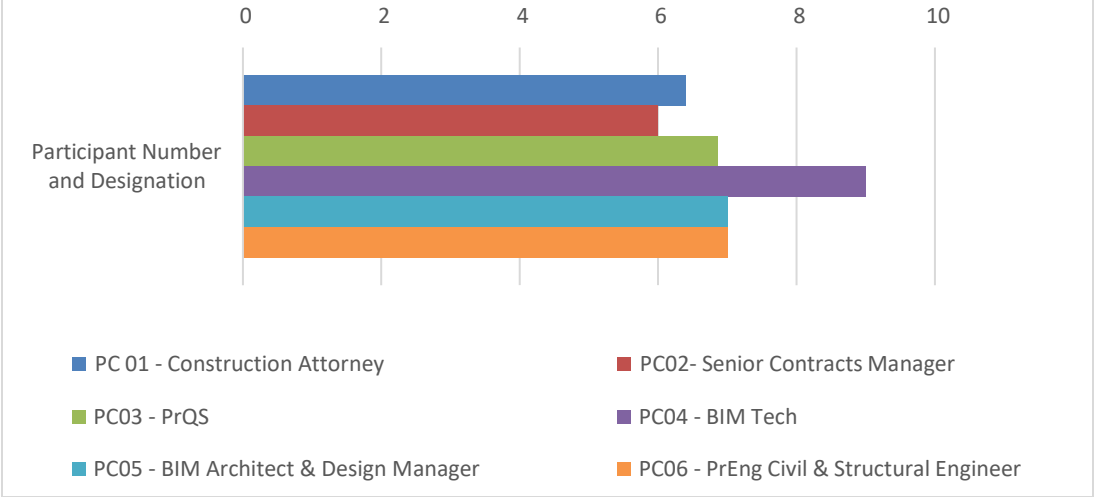


Figure 4.1 illustrates the weighted average rating on the level of importance for each participant pertaining to Automated Payments. PC02 illustrating the lowest ranking of 6 to PC 04 highest ranking of 9 on the level of importance for this theme. At the core of this study, is to investigate the need for automated payments and whether automation can alleviate problems associate with late payments and payments disputes. The theme is important to understand the viewpoints of participants level of importance when it comes to payments being automated.

4.4.2 Theme Two: Industry role-players which are set in their ways.

Table 4.4: Key Participant Quotes regarding industry role players which are set in their ways.

Participant ID	Supporting Key Participants Quotes regarding the industry role players which are set in their ways
PC01	• *"I think the majority of the people still refer down to written contracts."*
PC02	• *"I will only talk from my perspective and our company or what I perceive our company perspective to be. There might be other construction companies that are trendsetters. In my opinion I think construction people and contractors particularly, are stuck in their ways."* • *"When you look at what they call little blocs and chained links. I don't want to say advanced stuff, but the old school paper file and measurement sheets and stuff like that, that has worked for years. Old construction contractors are hard ships to turn for a new thing. Even as far as new products."*
PC03	• *"in a perfect world the client will pay what is certified etc. And I think most of the hiccups is because …ja I think when the principal agent needs to sign off the quality as well. So, we as QS's, when I am on the QS on project, I try to look at quality as well. Obviously, it needs to be a fair reflection of the work that was done."*
PC04	• *"Let me quickly tell you how they work overseas. You have a guy on the side of the client to make sure the supply chain meets their needs. But what is the other part of it. Pre contract award execution plan. That is before they award the contract. Let suppose you and I each have our own supply chains and competing against each other for a contract. I want to prove that my supply chain is better than yours. And that we have a better track record and better technology and better skills. And you are going to do the same from your side because you want the contract as well. We are not only going to look at our design side but also the contractor (he's going to be part of it). The sub-contractor is also going to be part of it. And that all happens before the contract gets awarded. And if they have not got the skills or the technology there is a road map, that is actually mapped out in the contract to say, ok fine you don't yet know what to do, it is not a problem but we need to do is train you up so by the time you need to do what you need to do you can do it."* • *"We have got great skills we have fantastic everything. I get so frustrated as I can see the opportunity. And the framework like you is proposing it would work, but it takes a change in thinking."* • *"There is lots of potential. The general culture out there is we think too small. We think like South Africans and not like New Yorkers, Tokyo or Hong Kong."*
PC05	• *"South Africans are a bit slow on BIM, why? Well, it is much smaller projects and notoriously very lazy. Most of my colleagues left behind 12 years ago. Some of them ask me what is BIM? I am talking architect's and stuff."*

	• *"CAD can get you out of the ground quickly and that is how people are still set. Especially people in South Africa. It's been helping them for years, that is what they know. That is all they have to worry about. Whereas BIM is a long process, and you are building up momentum and once you get going you really have momentum."*
PC06	• *"People are generally concerned to get to the job at hand at more than often neglect the contract. It is a very administrative process. It is in the nature of people to give attention to familiar territories and contract management may not be one of them."*

Table 4.4 illustrates all participants key quotes regarding theme: Industry role players which are set in their ways. The frequency of the theme was cited 23 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.2: Weighted average rating per participant for Theme: Industry role-players which are set in their ways.

Participant Number and Designation	**PC 01** - Construction Attorney	**PC02**- Senior Contracts Manager	**PC03** – PrQS	**PC04** – BIM Tech	**PC05** – BIM Architect & Design Manager	**PC06** – PrEng Civil & Structural Engineer
	6.6	**7.4**	**6.33**	**8**	**5.33**	**7**

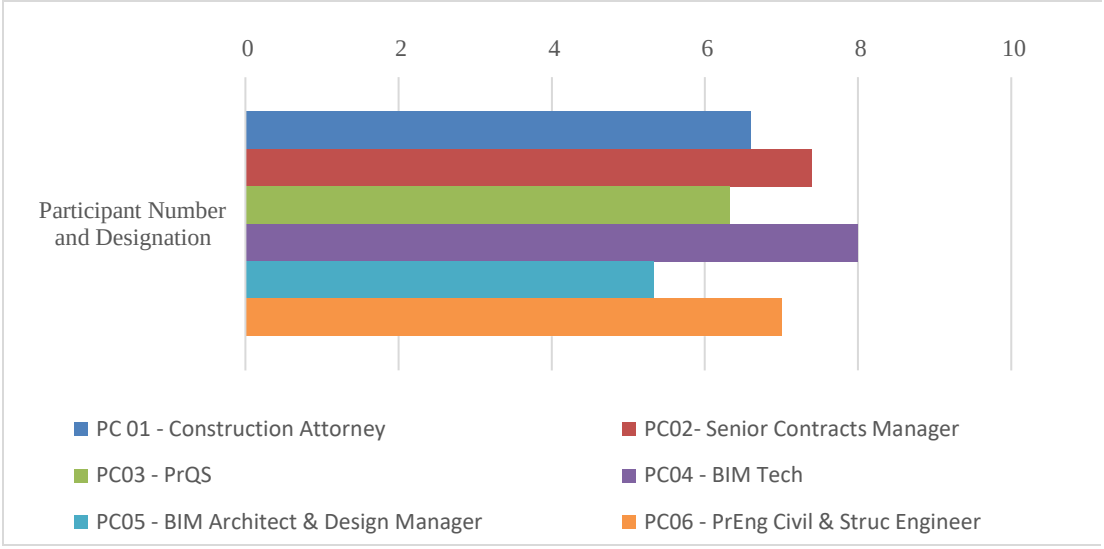


Figure 4.2 illustrates the weighted average rating on the level of importance for each participant pertaining to Industry Role-players which are set in their ways. PC05 illustrating the lowest ranking of 5.33 to PC 04 highest ranking of 8 on the level of importance regarding this theme. To address the secondary research question on whether the industry is ready to move away from traditional methods to automated processes, this theme assist the study to identify the level of importance of each participant.

4.4.3 Theme Three: Proposed BIM-Blockchain Smart Contract Framework.

Table 4.5: Key Participant Quotes regarding the Theoretical BIM-Blockchain Smart Contract Framework.

Participant ID	Supporting Key Participants Quotes regarding theoretical BIM-Blockchain Smart Contract Framework
PC01	***Views on the Theoretical BIM-Block Smart Contract Framework*** • *"So, it will lessen his exposure and at the same time it will guarantee that the contractor will be able to get his payments, when as is the work gets done, as it was paid."* • *"You never need a contract, until there is a problem. Then everybody rushes to the contract. And in litigation one of the main issues, we always need to address is, there was a contract."* • *"I think it is left too late where you now need to look at the court to resolve a contractual issue where if the parties had expanded the original contract by using something like the framework, they could have pinpointed discrepancies and possible future issues at much earlier date."* • *"So, it will lessen his exposure and at the same time it will guarantee that the contractor will be able to get his payments, when as is the work gets done, as it was paid."* • *"I get frustrated because my clients do not get paid what they need to get paid. When they don't get paid, I don't get paid".* • *"that is the reason why you, these three ums, three-legged approach is needed, because your frames trace your progress and variables and any changes and any spec changes to what was originally agreed."* • *"taking into account the actual scope of the contract. The more involved something becomes the more care must be taken in planning this whole thing and I think the framework is very much a comprehensive planning tool."*
PC02	***Views on the Theoretical BIM-Block Smart Contract Framework*** • *"I have never dealt with BIM. My initial take would be that the number of variables is so many to try and capture that it would be a seamless automated process, hard to comprehend."*

	• *"But further to that the general easy payment items of the stuff that should be captured not a problem and payment should go through."* • *"Or a simplified example that the drawings are initially for a four-story building with piles and concrete works, piling and san-ware and all of that. That's all measured, it's on a programme and it might be as simple as clicking on a programme and saying your superstructure is a 100% complete, and it would spit out all the concrete reinforcing piles everything for a process payment certificate…that's amazing."*
PC03	***Views on the Theoretical BIM-Block Smart Contract Framework*** • *"You talk about BIM. I know about BIM. I am an old school QS. I've got people measuring up for me, but they surely know what it is. I think it is the right way to go, but obviously it starts with the actual architect, setting up the layers and do everything so."* • *"I think the BIM framework is a good idea if it is properly set up. It makes our work easier. You can pull it our etc. do a couple of changes like formwork and those kinds of things. And then the next is the builder, do the proper tender documents and do the proper tender evaluation and adjudication."* • *"It can perhaps streamline it and make it easier."*
PC04	***Views on the Theoretical BIM-Block Smart Contract Framework*** • *"We are people with intelligence, capability, and intellect, but we don't demand the position of the world where it's formalized. I think this is also where your proposal and framework come in. To my mind as SA is far behind other countries."* • *"If you look at AURECON, AECOMS those type of guys. Those are bigger and they are better. And they have got create skills. These companies have got the most amazing skills but their framework around them is South African based."* • *"Whereas overseas they have very definite decision points where they say, when this is done a cheque gets written. And then it is done. If you want to come and change something afterward you need to go through the process again. Not mind doing the work, but you need to pay us."* • *"I like the idea more of the Bim-Blockchain framework in that to make the client understand that once they go past the point of no return, it's done. There is no deposits and no returns, it's done."* • *"And also, that the funds are available at the beginning of the project so that the maximum value can be extracted."* • *"That to me makes sense. This entire idea of your framework makes perfect sense to me."* • *"Things are changing and if you are not going to move with the changes you will be left behind. Everyone talks about the 4th Industrial Revolution. AI is here."*
PC05	***Views on the Theoretical BIM-Block Smart Contract Framework*** • *"All the programs' controls, cash flow and then ultimately it goes intowhat you want to do is control when do we get paid what."*

	• *"assist contractor in bid or tender to tender more precisely, peace of mind and confidence to the client that he knows what he is doing, competitive edge, advantage again of winning more work in the future, less abortive work cause if you can identify clash detections timeously you can avoid problems before hitting the site. By the time you get to site you know about the problem and it is already sorted. You don't want to get to site and start building and oh, we have a problem. And you need to know this very very quickly. So, it helps you to avoid abortive work and off course to save money. If you, do it properly (your contract) you can build much faster. You can plan and programme your work. If you avoid clashes and problems and change orders on site, then you don't have to break down or demolish a column or a beam that is in the wrong place. It speeds up and you can plan with all your subconsultants to come in at the right time not the wrong time and sit around and fall over each other's heels for a week or two and waste time and money. Whereas you say listen we won't be ready for you be ready then, but then you have got to be ready."* • *"The best way to do it, is with all your reports, your clash detection, your live models, and you can tie that in with costs. Because every element in a project cost something and you can tie that in with your framework."* • *"Globally the world has changed. And we don't know how long we are going to sit with this COVID problem so, projects can go on and there is less need for people to come out to go inspect the building or whatever the case may be."*
PC06	***Views on the Theoretical BIM-Block Smart Contract Framework*** • *"Nobody wins through litigation. And if you can have some other way or method to avoid this by having a paper trail like you put it. Then definitely it can assist and perhaps avoid litigation."* • *"there is advantage in an electronic process. I don't think paper-based systems will disappear in the near future. Everybody is still set in their ways in that regards. However, where you share information electronically that will definitely contribute to a more effective out roll of communications from professionals to the contractor back and forth and it will also assist in not receiving old information to site. So, the information that you will receive, you will know that is always the latest information on hand. And I think that is a big advantage."* • *"Performance can increase if the system is electronic based and flawless then construction performance will go up."* • *"Less disputes less litigation that basically limit that type of route to be taken by a contractor because everything is measured to date and available and cannot be disputed."* • *"At the end I think it is a big advantage to have all of that together so that gives you your BIM aspect your Blockchain aspect. Your contracts are the underpinning arrangement between all parties that binds everything together."*

	• *"Hopefully, we will get there someday, that this type of process can be available. From an engineering side, I think I am not just speaking for myself. But the contracts we have is sometimes very legally challenging for us and if there is a process that actually help any engineering and or contracts manager on that basis to put it in the right context then industry will benefit from that."*

Table 4.5 illustrates all participants key quotes regarding theme: The Theoretical BIM-Blockchain Smart Contract Framework. The frequency of the theme was cited 70 times by all participants as shown in Table 4.2 during the data collection process. level of importance to this theme and in turn to build up the answer to the primary research question.

Figure 4.3: Weighted average rating per participant for Theme: The Theoretical B I M -Blockchain Smart Contract Framework.

Participant Number and Designation	**PC 01** - Construction Attorney	**PC02**- Senior Contracts Manager	**PC03** – PrQS	**PC04** – BIM Tech	**PC05** – BIM Architect & Design Manager	**PC06** – PrEng Civil & Structural Engineer
	7,35	**7.75**	**7,69**	**8,29**	**7,54**	**7,44**

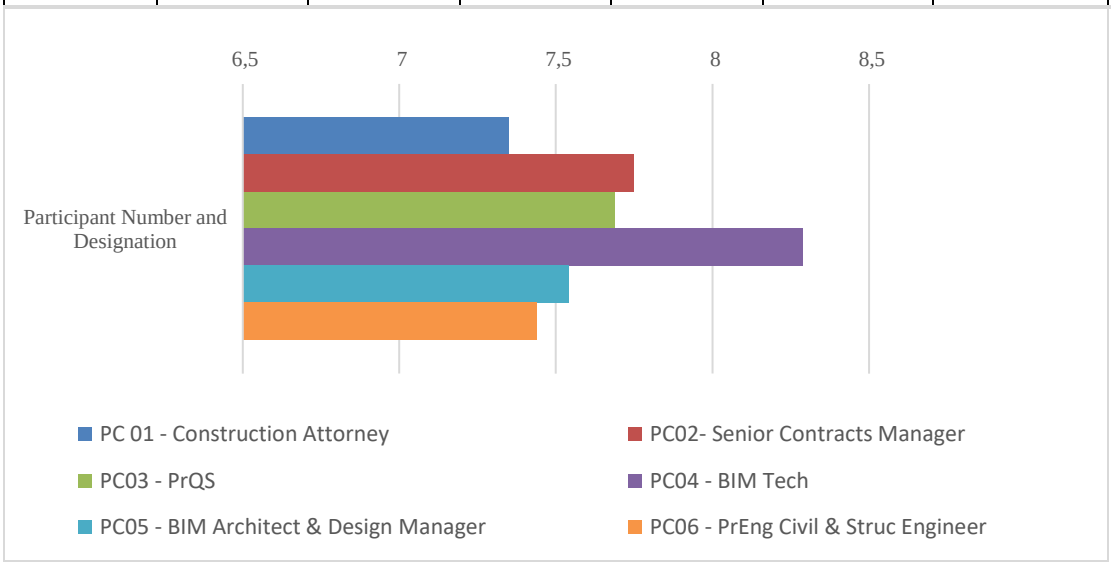


Figure 4.3 illustrates the weighted average rating on the level of importance for each participant pertaining to the Theoretical BIM-Blockchain Smart Contract Framework. PC01 illustrating the lowest ranking of 7.35 to PC 04 highest ranking of 8.29 on the level of importance regarding this theme. Relating directly to the primary question on the need to

understand how automation can influence the construction industry, this theme gives a great overview on the participants

4.4.4 Theme Four: Industry Experience pertaining cash flow problems.

Table 4.6: Key Participant Quotes regarding the industry experience pertaining to Cash Flow problems.

Participant ID	Supporting Key Participants Quotes regarding the industry experience pertaining to Cash Flow problems.
PC01	• *"There can be many reasons. There can be reasons that are valid. The client could have picked up financial problems and suddenly he doesn't have that cash he anticipated for the project, so he can't pay it anymore. It's not the contractor's fault. The client should have made provision."* • *"Or on a milestone that is achieved and not on monthly lump sum payment or monthly payments as per say per payment certificate. But also, if the client does not pay, the contractor is cash strapped."* • *"normally it is the contractor that needs to outlay the cash money to get what is needed. He is then actually at the mercy of the client who is getting the benefit."*
PC02	• *"Off-course cash flow is always an issue. So ja, absolutely 100%".*
PC03	• *"the cash flow on any project is obviously the main thing."* • *"Cash Flow is very important and that is why I try to sell QS's on that side, because if there is a…it works both ways. You can't over certify or over valuate and overpay versus underpayment is also very important and I just think each should be fair."*
PC04	• *"I kind of get where … a lot of the time the supply chain does their work and don't get paid the money upfront, which they should. So, they cannot invest and then they get short changed."*
PC05	• *"With BIM software and Navisworks we could animate videos to project managers programs like PSets, Primavera, MS Projects and so forth. So, the contractor operates two-fold. It has a live camera, his got the animation. It is break down day by day, month by month and it foresee the duration of the contract. 24 months or 36 months and during that you can tweak it and the project manager can go back and tweak his programme. He can feed it back in. And that, Navisworks for example where the 4D comes in on cost. So, you can do proper cash flow projections because critically what a contractor wants to avoid during this whole thing or this whole process is not spending too much money (especially in a country like South Africa)"*
PC06	• *"The contractors normally work on a cash flow chart or like a forecast which they basically compile when they get awarded the contract. They forecast all their payments. The way the cashflow will work is on that forecast and if there is a problem and they don't get paid or full payment there is a problem. More than often this can hamper their performance. Making the contract late or possibly there is a workmanship and quality issues."*

Table 4.6 illustrates all participants key quotes regarding theme: The industry experience pertaining to Cash Flow Problems. The frequency of the theme was cited 14 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.4: Weighted average rating per participant for Theme: The Theoretical B I M -Blockchain Smart Contract Framework.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	7,33	**8.5**	**7**	**6.5**	**7**	**6,5**

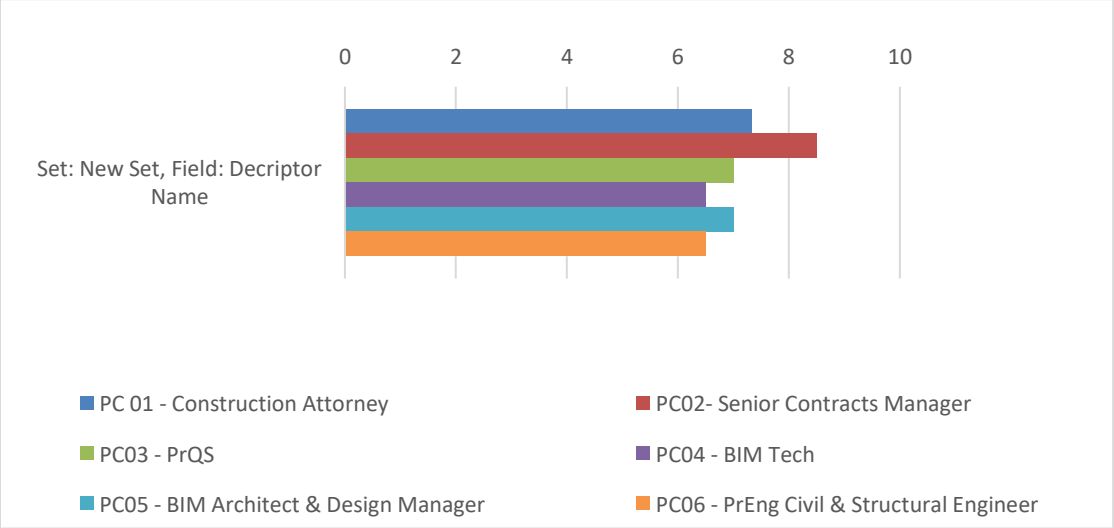


Figure 4.4 illustrates the weighted average rating on the level of importance for each participant pertaining to the Industry experience pertaining to Cash Flow problems. PC05 and PC06 illustrating the lowest ranking of 6.5 to PC 02 highest ranking of 8.5 on the level of importance regarding this theme. Building up data evidence to support in answering the primary research question on the participants level of importance to cash flow problems for the study.

4.4.5 Theme Five: Elements that can contribute to a more seamless process.

Table 4.7: Key Participant Quotes regarding the elements that can contribute to a more seamless process.

Participant ID	Supporting Key Participants Quotes regarding the elements that can contribute to a more seamless process.
PC01	• *"At each stage, the client must have access so that he can say, I am happy with this. And once he says I am happy with this, it should be like a tick mark, it automatically allocates some kind of payment instruction or the ability to generate the ability from the client, whilst still protecting his financial side of things."* • *"if you can't fit everything you have to do in a logical way, then you going to have problems. I think the framework will do that, where if something becomes very convoluted and very big and enormous it can break it down into smaller segments, which are easier to manage and control."*
PC02	• *"It's just their internal systems are notoriously poor and people not doing their work. So, it goes from the one desk to the next desk and sits there for twee weeks before it gets processed."*
PC03	• *"I think we all are professional, and we strive to be better so if we can concentrate on what we need to do and the rest taken care of, I think we will save money and time."* • *"It's all in front of you. Everyone has got the same view or the same screen or the same data in front of them as you got and it's just a matter of clicking yes."*
PC04	• *"I spoke to guy in Group 5 that programmes their buildings. He had 90 construction managers under him. He showed me their models, but he had three people in the office. Five maximum. And you can imagine they are doing shopping centres that are kilometres long. Some of the projects are bigger. Skyscrapers. Great company, nothing wrong with them, but with BIM you need to record information from design through to construction. You cannot do that with 90 construction managers. Programme everything and manage the construction programme. So, the idea behind this Bim-Blockchain Smart Contract is great."*
PC05	• *"So, we use Navisworks as a tool to track the 3D, 4D and 5D elements. 3D you know, 4D is time and 5D is cost and 6D is facilities management which is as built when you hand over a project. So, everything in BIM is gearing towards being 6D compatible which means the architect hands over the project to the client like Old Mutual or Sanlam or whoever the case may be. They now don't just have a stack of drawings gathering dust because we are moving away from this paper environment. So, the stack of drawings that sits in the corner of the office gathering dust is not any use to anybody. So, the client gets a model which is a proper BIM model and been populated correctly from inception to as built to handover to facilities management."*
PC06	• *"in the right context then industry will benefit from that. A semi-automated process will be welcomed to alleviate most of thesetedious processes."*

Table 4.7 illustrates all participants key quotes regarding theme: Elements that can contribute to a more seamless process. The frequency of the theme was cited 16 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.5: Weighted average rating per participant for Theme: Elements that can contribute to a more seamless process.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	7	**8**	**8**	**6.5**	**7,75**	**6,75**

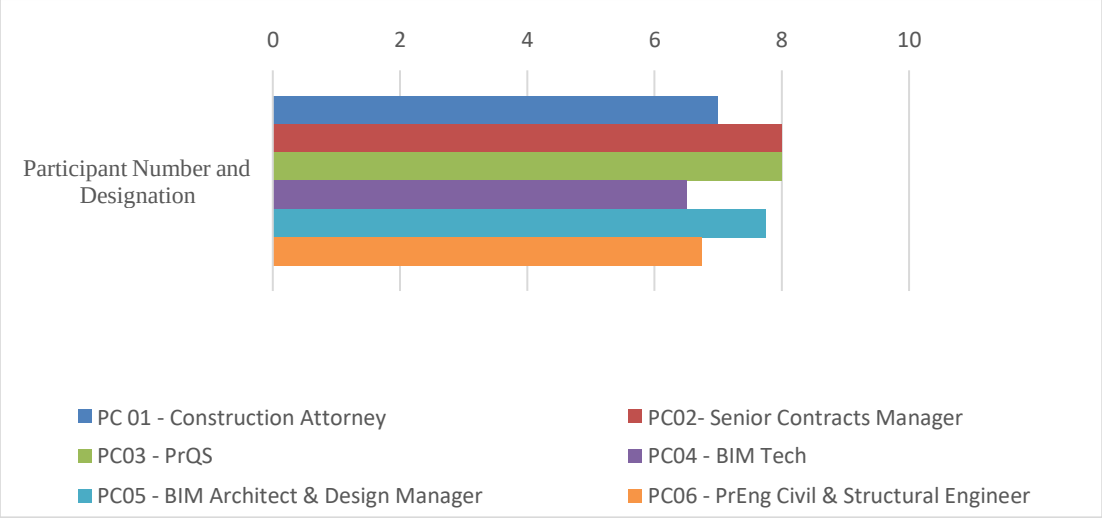


Figure 4.5 illustrates the weighted average rating on the level of importance for each participant pertaining to the elements that contribute to a more seamless process. PC05 and PC04 illustrating the lowest ranking of 6.5 to PC 02 and PC 03 highest ranking of 8 respectively, on the level of importance regarding this theme. In support to understand and assisting in answering the primary research question on how automation can assist the construction industry, it is important to understand the participants view on the importance of a framework that could contribute to a seamless process.

4.4.6 Theme Six: The current fragmentation experienced in the industry because of traditional methods.

Table 4.8: Key Participant Quotes regarding the current fragmentation experienced in the industry because of traditional methods.

Participant ID	Supporting Key Participants Quotes regarding the current fragmentation experienced in the industry because of traditional methods.
PC01	• *"As soon as people put in a variance means that the original contract should actually be redrawn as there is now a new contract in place stipulating this and that. Not just this."*
PC02	• *"We have more claims with the structure at the moment."*
PC03	• *"I can't intervene with a principal agent's payment certificate."* • *"There are obviously the 3 or 4 parties involved in the process. The builder builds he claims. The QS does the payment valuation, and the Principal Agent certifies and then the client needs to pay. That is just to keep the ball rolling."* • *"Cash Flow is very important and that is why I try to sell QS's on that side, because if there is a…it works both ways. You can't over certify or over valuate and overpay versus underpayment is also very important and I just think each should be fair."* • *"I think everybody normally jumps in and starts working instead of having a coordination meeting."*
PC04	• *"I know architects with repeat clients. The clients respect them because they can get repeat business out of them. And they respect each other because they get a certain level of service. But what is a level of service? Is a level of service that you are willing to go the extra mile for him? Are you going to feel special and is it going to build your character? You know when you keep on doing that and that is the accepted way of doing, it's not a…That is not how they work overseas."*
PC05	• *"And by working jointly on BIM 360, they upload and link the models and they can pick up where the problems are. So, ownership of the project is shared between everybody but the architectural model that ownership will always stay with the architect. Everyone is updated and there are no questions on what is required."*
PC06	• *"It is definitely fragmented between all parties up to, I would say up to when after the tender closed. Thereafter there are some collaborations between professionals and contractors and possibly sometimes the client, but before then it is each to their own."*

Table 4.8 illustrates all participants key quotes regarding theme: The current fragmentation experienced in the industry because of traditional methods. The frequency of the theme was cited 24 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.6: Weighted average rating per participant for Theme: The current fragmentation in the industry.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	6,17	**6**	**6.78**	**9**	**7**	**6,6**

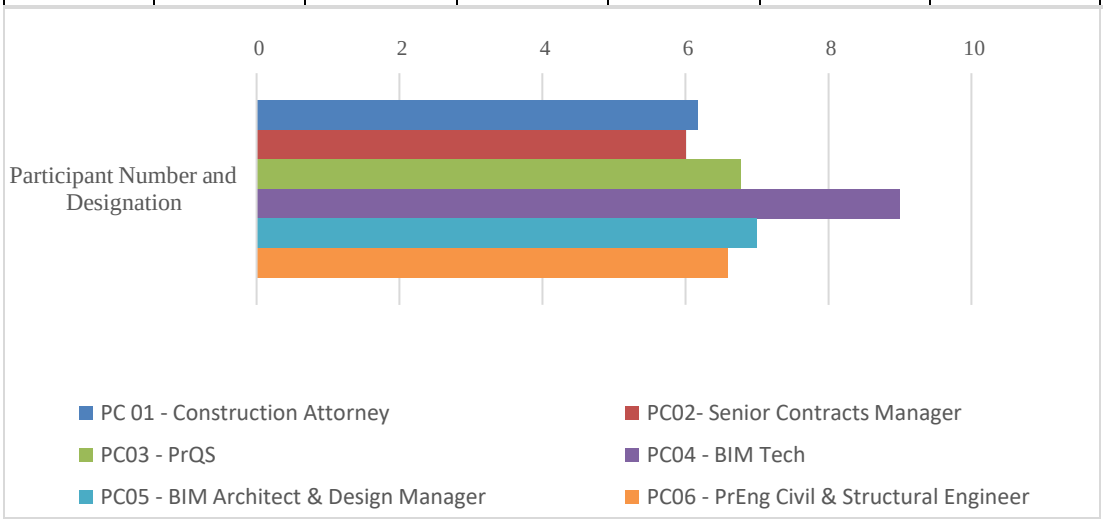


Figure 4.6 illustrates the weighted average rating on the level of importance for each participant pertaining to the current fragmentation experienced in the industry because of traditional methods. PC02 illustrating the lowest ranking of 6 to PC04 highest ranking of 9, on the level of importance regarding this theme. In order to support the primary and secondary research questions it is important to understand the participants view and understand the current fragmentation in the industry and how it contributes to the possible payment disputes and delays.

4.4.7 Theme Seven: The need for payments to be guaranteed.

Table 4.9: Key Participant Quotes regarding the need for payments to be guaranteed.

Participant ID	Supporting Key Participants Quotes regarding the need for payments to be guaranteed.
PC01	• *"So that contractor knows the money is there. And I think that could be one of the issues with the implementation of framework how to*

	guarantee that money in some kind of trust account similar to what an attorney or an estate agent would have."
PC02	• *"payment delays and stuff and those generally have not led to disputes in my case. I like to think we have got a good relationship with most of our clients and hopefully that is what helps."* • *"People, I suppose generally have the best intentions, but if they run out of money, the client runs out of money, with their back against the wall that relationship will fall by the wayside very quickly."*
PC03	• *"I surely agree that there needs to be a more stringent and a more (how can I put it) fixed term payment from a client."*
PC04	• *"They get it through to council and then the client changes his mind and then now they want something new. What the attitude behind it is (I have got my own opinions), but that is not relevant. What is relevant is that the client has power because they hold the money."*
PC05	• *"Because every element in a project cost something and you can tie that in with your framework. So, every screw every bolt, every nut, every door handle has got a price. Once it is installed it is not lying on site. So, you will properly only get paid once it is installed it is therefore beneficial to have software that will guarantee payment, so the contractor does not run the risk of not getting paid."*
PC06	• *"If the construction company does not have strong resources and cash flow, long winding legal action can mean the end of business for them."*

Table 4.9 illustrates all participants key quotes regarding theme: The need for payments to be guaranteed. The frequency of the theme was cited 12 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.7: Weighted average rating per participant for Theme: The need for payments to be guaranteed.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	8,5	**6**	**6.33**	**6,67**	**5**	**7,5**

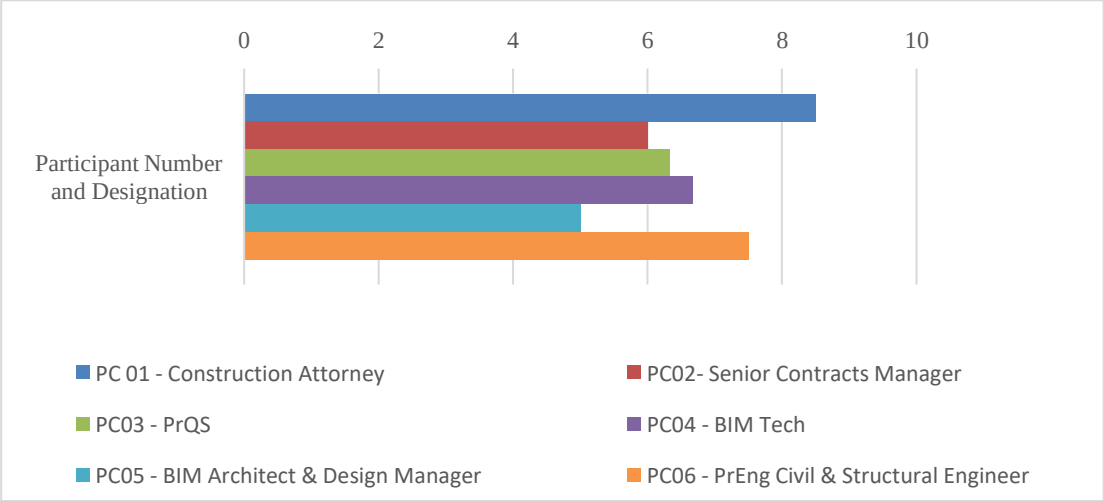


Figure 4.7 illustrates the weighted average rating on the level of importance for each participant pertaining the need for payments to be guaranteed. PC05 illustrating the lowest rating of 5 to PC01 highest ranking of 8.5 on the level of importance regarding this theme. To effectively understand the needs of the industry, this theme is important to understand the participants view and level of importance when it comes to the need for payments to be guaranteed, as their views shall support the primary research and secondary research questions.

4.4.8 Theme eight: Increased performance: Time and money by implementing the theoretical framework.

Table 4.10: Key Participant Quotes regarding the increased performance in time and money by implementing the theoretical framework.

Participant ID	Supporting Key Participants Quotes regarding the Increased performance: time, money by implementing the theoretical framework.
PC01	• *"Where it would allow a small contractor to effectively also manage his workload and plan his workload, much better." It is a programme similar to what SARS have on e-filing. An attorney gets a code and he issue summons electronically through court. All the documents happen electronically. There is going to be no more paper and things and documents getting lost and I didn't get this, but I sent it to you and all these types of stories. Because whenever you do something, it is like you go to SARS and upload whatever you got. It is stored electronically and in order as these things are being received. So, the courts in Johannesburg is going electronic already and if you can get these contracts to go electronic as well it could become a perfect mesh where the dispute resolution can become instead of having a photocopied and number annexure, it can be added as an electronic annexure."*

PC02	• *"Having a team. I mean they also did studies where to see how much money you can save and time you can save by having that collaborative team from the start from onset, with A client, engineer, architect and contractor from the start rather than having exactly like you say, client and engineer and the contractor only coming in much later."* • *"No, I mean, that's an amazing, if it works, it will save a lot of time."*
PC03	• *"everybody is looking at cost, and at the end it is not normally the cheapest." You must not put much admin on a contractor he already has a lot."*
PC04	• *"It is not just progress, it is also predictive in a sense that if somebody throws a floor, 50mm to high. Suddenly you are going to get clashes next to it. Something is going not going to fit. So, you know that you are going to stop that construction site now for however many weeks and waste how many millions of Rands."*
PC05	• *"With BIM you can get away with a third of the workforce, but the front-end loading of information is much more. In CAD you don't have to put in much effort in the beginning. With BIM your input is much higher in the beginning but at the end it is much easy."*
PC06	• *"Also, the contract is the roadmap, and it needs to be utilized in order to increase the outputs of projects. Automation of these contracts may assist everyone to comply better with the obligations."*

Table 4.10 illustrates all participants key quotes regarding theme: Increased performance in time and money by implementing the theoretical network. The frequency of the theme was cited 20 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.8: Weighted average rating per participant for Theme: Increased performance in time and money by implementing the theoretical framework.

Participant Number and Designation	**PC 01** - Construction Attorney	**PC02**- Senior Contracts Manager	**PC03** – PrQS	**PC04** – BIM Tech	**PC05** – BIM Architect & Design Manager	**PC06** – PrEng Civil & Structural Engineer
	7,25	**7,4**	**8,25**	**6**	**7,5**	**7**

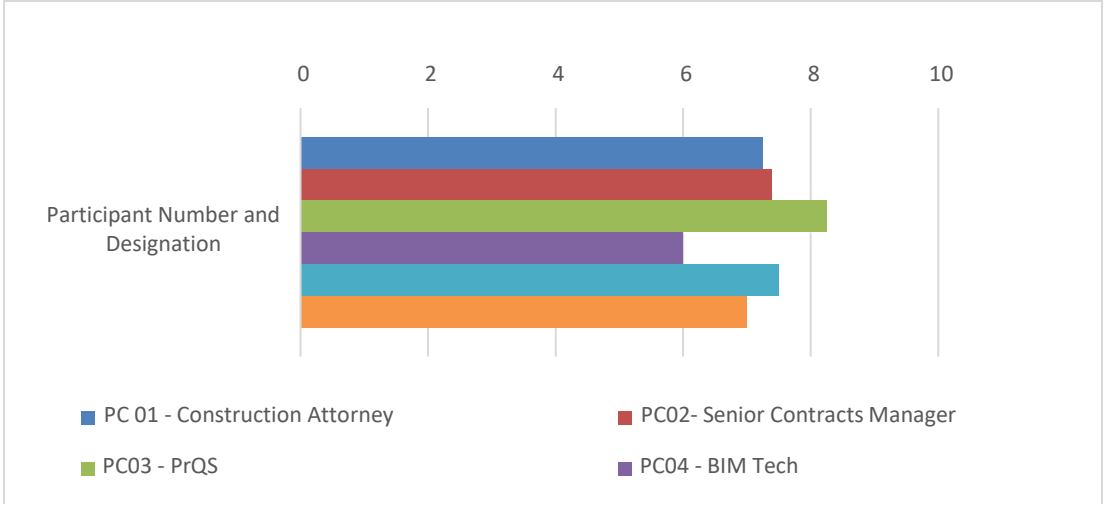


Figure 4.8 illustrates the weighted average rating on the level of importance for the increase performance in time and money by implementing the theoretical framework, illustrating the lowest rating of 6 to PC 03 highest ranking of 8.25 on the level of importance regarding this theme. This theme is important to understand participants viewpoint and level of importance when it comes to processes that can save on time and cost. This theme will also support answering the primary and secondary questions for this study.

4.4.9 Theme Nine: The lack of transparency in the industry.

Table 4.11: Key Participant Quotes regarding the current lack of transparency in the industry.

Participant ID	Supporting Key Participants Quotes regarding the current lack of transparency in the industry
PC01	• *"And that is what people want. They want transparency. And the thing, people with criminal intent hate transparency, because you cannot be criminal if it is transparent. Everybody can see. People are doing things in dark corners behind closed doors, under the table, where with this it will all be above table, and everybody can now see what is going on."*
PC02	• *"clients for competitive bidding they are going to get the lowest price. In South Africa we are stuck on going for the lowest price. The lowest price gets the job, which I find quite frustrating. A lot of the other countries chuck out the top, chuck out the bottom and take the middle or closest to the middle."*
PC03	• *"and a client needs to know the deliverables and responsibilities. That the money is going out of his bank account or the crypto account to the builder and he knows that as the cash flow is there. If that is there everybody manages that. The QS manages that. It's like a wheel, everyone has he's job to do and then the wheel keeps turning."* • *"I've got hope for the QS industry in South Africa. I think everybody, they always say we always try to take the lowest tender. I think we have a pivotal role and I think we need to be fair and the code of conduct. I'm one of the QS's that works on both sides. I am working for contractors and working for clients."* • *"And in the end obviously all is open to negotiation. Like now we got that one project where we said to the builder; "listen we've got to wait three months, and then we are going to carry on again. It's only two months' worth of work". At least we are open and upfront."*
PC04	• *"If people have a specialist to interface with it will make everyone happy. You will not sit with the stress and to manage the project."*
PC05	• *"you update your as-built work on BIM. But even that the engineers they have done a conceptual model and now it develops. Value engineering happens in the BIM model. There is a written agreement*

	that every week has to upload their working stages models. All the changes in the model gets tracked through BIM 360. And you can now say all right it's a variation. It provides teams with transparency in pairing the models"
PC06	• *"Transparency is everything in a contract or a project. I mean if the contractor is going to know that there is a payment issue and he gets notified in advance he can work around it as well as … if the professional team need to update drawings and it is going to take two or three weeks and say with trust this is where we are, surely you can then work around it. So, transparency needs to be basis of the whole construction industry I would say."*

Table 4.11 illustrates all participants key quotes regarding theme: The current lack of transparency in the industry. The frequency of the theme was cited 14 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.9: Weighted average rating per participant for Theme: Current lack of transparency in the industry.

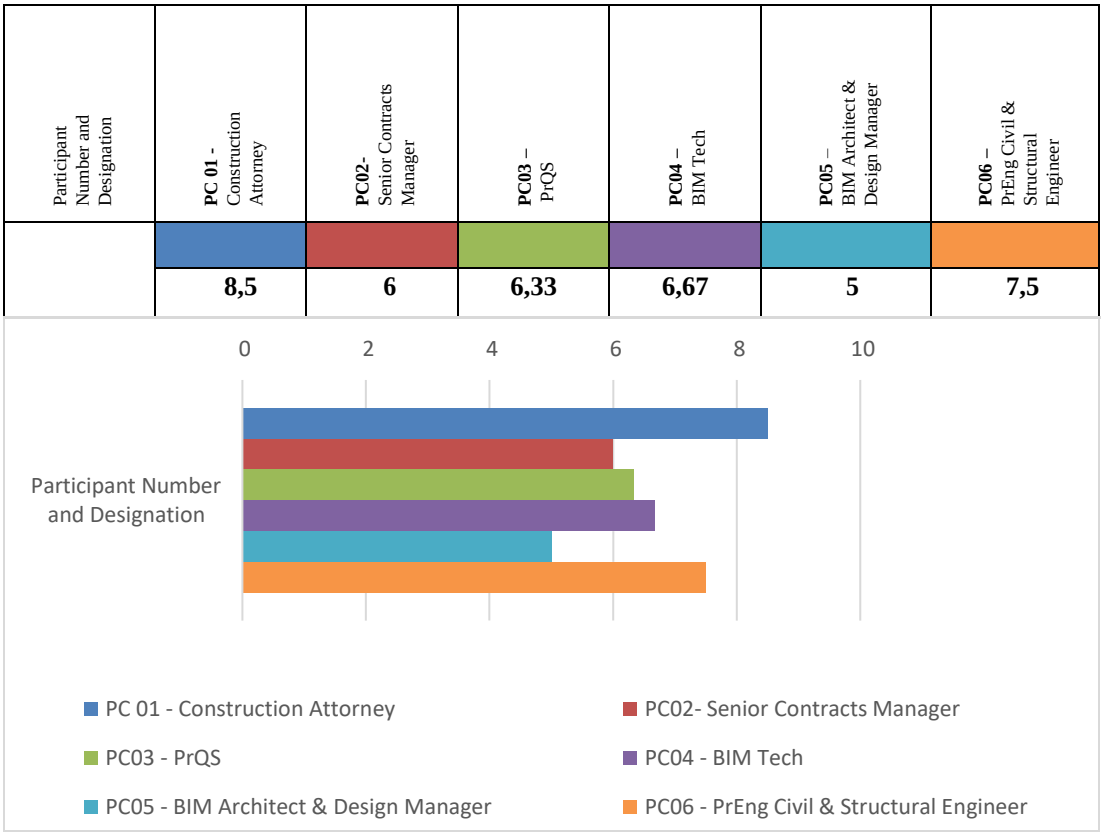


Figure 4.9 illustrates the weighted average rating on the current lack of transparency in the industry. PC05 illustrating the lowest rating of 5 to PC01 highest ranking of 8.5, on the level of importance regarding this theme. The lack of transparency is important firstly to

understand whether this is a phenomenon experienced by the participants and secondly the impact on payment delays and disputes. This theme is therefore important to answer the primary and secondary research questions.

4.4.10 Theme Ten: The lack of trust in the industry.

Table 4.12: Key Participant Quotes regarding the lack of trust in the industry.

Participant ID	Supporting Key Participants Quotes regarding lack of trust in the industry.
PC01	• *"The contractor wants to do the work but doesn't trust you. Pay me, the money lies in my account; he does the work; if you happy you say you are happy, and if you're not happy he fixes it. Until you are happy yes you are happy, I will pay him. So that contractor knows the money is there. And I think that could be one of the issues with the implementation of framework how to guarantee that money in some kind of trust account similar to what an attorney or an estate agent would have."*
PC02	• *"my take on it is unfortunately I think human nature distrusts. No one trusts anyone and there is that (I suppose) expectation for clients for competitive bidding they are going to get the lowest price."*
PC03	• *"there needs to be a more stringent and a more (how can I put it) fixed term payment from a client, because as soon as a principal agent signs the payment certificate, the client normally got (I think 7 or 14 days to pay depends on what you write in that that JBCC) but after that the client still keep back the payment."*
PC04	• *"a lot of the time the supply chain does their work and don't get paid the money upfront, which they should. So, they cannot invest and then they get short changed."*
PC05	• *"With BIM your coordination is just much better as it is transparent, and all users can trust that the data is correct."*
PC06	• *"If you get to a place where you can't trust your professional team or your client, then you have got a problem. I think the whole project would get hampered by it. So, trust is everything in my opinion between all parties."*

Table 4.12 illustrates all participants key quotes regarding theme: The lack of trust in the industry. The frequency of the theme was cited 14 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.10: Weighted average rating per participant for Theme: The lack of trust in the industry.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	6	**7,33**	**7,5**	**4**	**4**	**6,5**

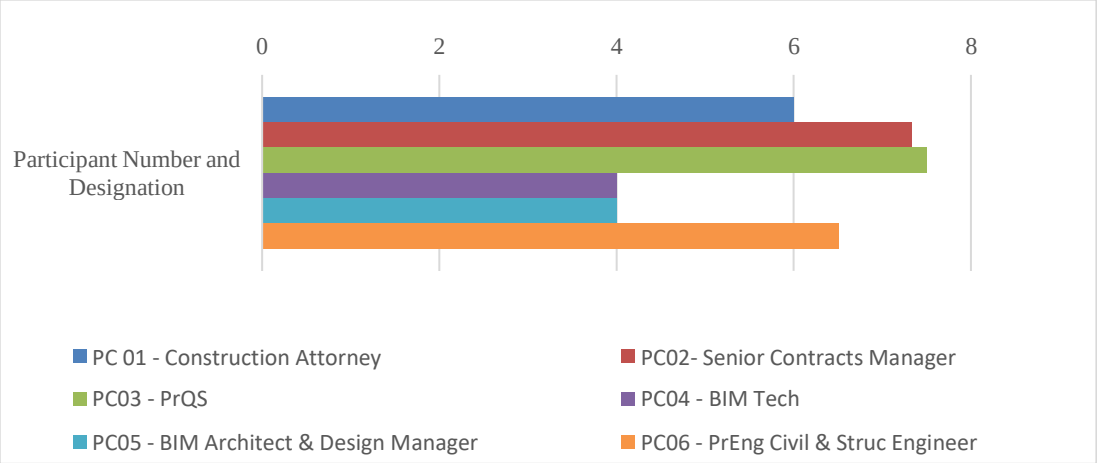


Figure 4.10 illustrates the weighted average rating on the lack of trust in the industry. PC 04 and PC05 illustrating the lowest rating of 4 respectively, to PC03 highest ranking of 7.5 on the level of importance regarding this theme.

4.4.11 Theme Eleven: Where disputes are left in the hands of the courts to resolve and cost of litigation.

Table 4.13: Key Participant Quotes regarding where disputes are left in the hands of the courts to resolve and the cost of litigation.

Participant ID	Supporting Key Participants Quotes regarding where disputes are left in the hands of the courts to resolve and cost of litigation.
PC01	• *"Once there is a big issue, now it takes a lot of money and a lot of time through the courts to argue all these facts and things."* • *"Give that to a lawyer and he will give you back a four-page contract with terms and conditions and all types of things that neither party really understands, but which has a very big influence on the dispute or the performance of the contract at the end of the day."* • *"Where parties can resolve their matters before it becomes a big matter and before you need to go to court and as you know the court the court at the moment. If you get a court date in high court, you are looking at two years down the line. Magistrates court at least six or*

	eight months. So, there is going to be a very long delay for contractors to get paid and for clients to get satisfaction on the job they want finished." • *"Maybe I am one the few attorneys that does not like going to court. It is not because I am afraid of the court, but I do not like putting my client's resolution in the hands of a third person to decide. And that is what happens in the court. You've got two parties and the resolution is given to someone outside and that person. A judge is a judge, he knows the law, but he is not an engineer, or he might be, but generally he is not an engineer or a builder or these things and he does not understand the intricacies."* • *"The BIM and Block chain and Smart Contracts can help parties to resolve their own issues outside of court. It would be an awesome step forward. What is happening in the legal industry at the moment is and it is already happening up in Johannesburg, and it has now started in Cape Town. The courts are enforcing alternative dispute resolution. With the Consumer Protection Act, before a consumer can peruse a supplier, he must first go to the Ombudsman."* • *"you have an outside party doing this, but I believe the BIM-BLOCKCHAIN Smart Contract can become an alternative dispute resolution mechanism."* • *"I think that could be a very good thing in the alternative dispute resolution arena"*
PC02	• *"And to follow the further recourse in terms of GCC you can suspend the works after a period of (I can't remember the number of days) and going into breach: h of contract and termination, but we have never ventured down that route. But as far as I know the recourse is interest and that is not enough of a whipping stick to get a reaction, generally."*
PC03	• *"I think that is the main…that is the problem these days. The people don't talk to each other and everyone wants to sue each other but, in the end, (I mean) the lawyers and advocates and the arbitrators makes money out of these cases."* • *"I think trust like you said, is all about the history as well. I mean how all the arbitrators handles the cases; they go look at court cases. They not construction experts or QS's. They just make an adjustment at that stage. But some of them could not be fair or fair to the other party for instance. It costs a lot of money."*
PC04	• *"But then the client must accept that he needs to put the money down in the beginning and also need to accept that there is a certain timein this process that what is done is done. I get where you are coming from where there are people that blame after the fact and it's a reality. Like you say there is always conflict. Some use Revit and Navisworks. Time lining of buildings (billions of Rands). When they apportion blame, they drag the guys off to court and they get fines which is not pleasant."*
PC05	• *"Because at a very early stage using BIM at pre-tender stage, which is ideal. If it is possible for him to pre-tender to use it for bulk measurements, he's going to be plus or minus 5 -10 percent not having the correct quantity. There is no way that without a proper BIM model you can measure and tender correctly. So, what*

	happens is that the guy that is not using BIM. He has got 6 weeks to sit with all the tender documentation and tender on this project. He's got 10 guys trying to figure out what is going on here. The time is running out. What is the current building rate? Hmm R10 000 a square meter. Is it a complicated building? Do we need the work? Are we hard-up for work? So, we load it. I actually don't like the client.I don't like the type of project so, we tender high. If we get it, we are lucky if we don't, I don't care. Then there is a guy who desperately needs to work. He under quotes and somewhere in between there is people. This can become a serious problem later on as these inaccuracies can turn into disputes and even go as far as going to court."
PC06	• *"So, I would say form a contractor's side they have got only that avenue and if that is taken away, they actually have got no other method to get payment out of the contract except going the legal route."*

Table 4.13 illustrates all participants key quotes regarding theme: Where disputes are left in the hands of the courts to resolve and the cost of litigation. The frequency of the theme was cited 19 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.11: Weighted average rating per participant for Theme: Where disputes are left in the hands of the courts to resolve and cost of litigation.

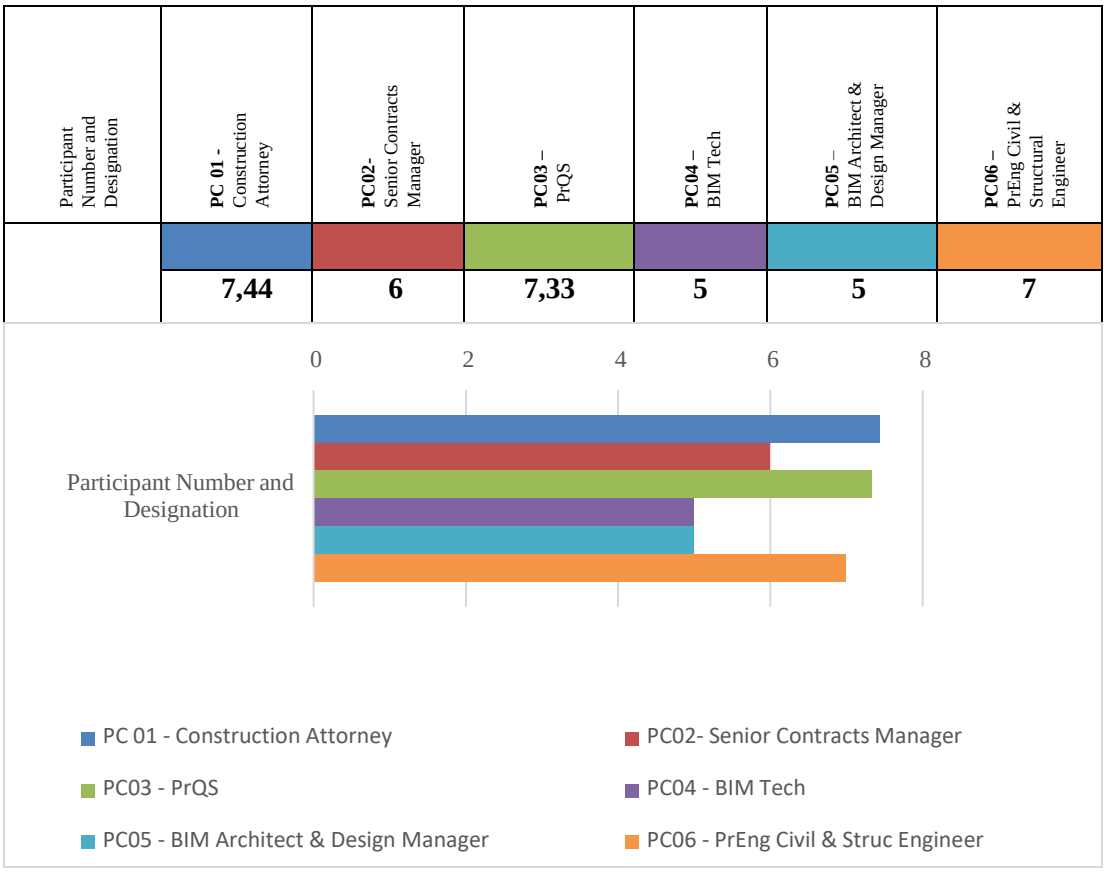


Figure 4.11 illustrates the weighted average rating on the level of importance for each participant pertaining where disputes are left in the hands of the courts to resolve and the cost of litigation. PC 04 and PC05 illustrating the lowest rating of 5 respectively, to PC01 highest ranking of 7.44 on the level of importance regarding this theme. The theme explores the impact where disputes are left in the hands of the courts to resolve and the cost of litigation. This theme and the viewpoints of participants including their level of importance can support the need for change in the industry and will support in answering the secondary research question.

4.4.12 Theme Twelve: The need for collaboration.

Table 4.14: Key Participant Quotes regarding the need for collaboration.

Participant ID	Supporting Key Participants Quotes on the need for Collaboration.
PC01	• *"Absolutely. I definitely think it is a step forward. I think it can help a lot of industries (like you say especially that heavy contract driven) like the building and the engineering field."* • *"you have to keep things as simple and as easy to understand for people as possible."*
PC02	• *"With a collaborative structure we would have less claims. Save money, save time."*
PC03	• *"To set up a coordination meeting and clearly stipulate who needs to do what and what can work further down the project. I think that is very important."*
PC04	• *"Like you say there is always conflict. I would like to get to a place where the protocols are employed simply because everybody gets along. The money gets made; people get jobs. We get respected globally for our skills. "* • *"And that the client knows their own responsibility for the project. And does not see the project as an extension of themselves but rather sees the project as something bigger. So, everybody has a role to play."*
PC06	• *"I would say historically the way we (professionals) work in South Africa and in some other countries they also work like this. So, each body will basically work at his own pace and own view and at the end, like I have said previously just after tender stage, they (the professionals) will get together. So, collaboratives upfront will definitely help."*

Table 4.14 illustrates all participants key quotes regarding theme: The need for collaboration. The frequency of the theme was cited 13 times by all participants as **shown** in Table 4.2 during the data collection process.

Figure 4.12: Weighted average rating per participant for Theme: The need for collaboration.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	7	**6,67**	**8**	**6,5**	**7**	**7**

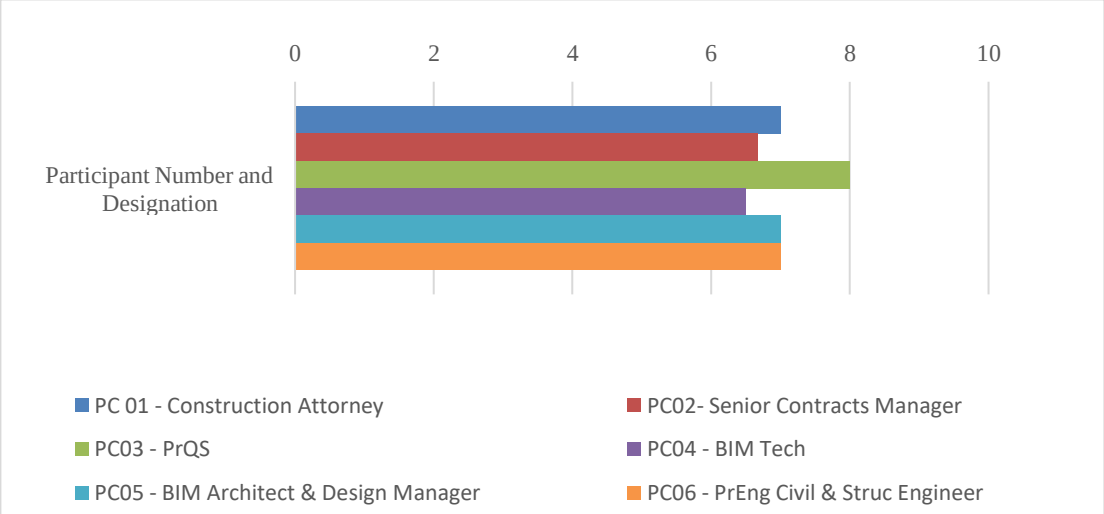


Figure 4.12 illustrates the weighted average rating on the level of importance for each participant pertaining the need for collaboration. PC02 illustrating the lowest rating of 6.67 to PC03 highest ranking of 8 on the level of importance regarding this theme. This theme explores participants viewpoints and the level of importance on collaboration. The outcomes of participants views will support the need for the theoretical framework and would support in answering the primary research question.

4.4.13 Theme Thirteen: Reasons for payment disputes.

Table 4.15: Key Participant Quotes regarding the reasons for payment disputes.

Participant ID	Supporting Key Participants Quotes on reasons for payment disputes.
PC01	• *"They must use the contract as a roadmap and that roadmap must tell them where to go, where not to go, and what to do if you get off course and... A lot of times I think it is left too late where you now need to look at the court to resolve a contractual issue where if the*

	parties had expanded the original contract by using something like the framework, they could have pinpointed discrepancies and possible future issues at much earlier date." • *"The more changes there is, the bigger your changes of a dispute."* • *"Give that to a lawyer and he will give you back a four page contract with terms and conditions and all types of things that neither party really understands, but which has a very big influence on the dispute or the performance of the contract at the end of the day."* • *"you have to keep things as simple and as easy to understand for people as possible."*
PC02	• *"Normally the disputes are about the money and I don't think if you run it correctly, I just think there is a lot of paperwork with the JBCC."* • *"is a full-time job. A lot of people don't take that very seriously."* • *"And another thing that is neglected by the JBCC is the schedule or the programme. Especially on an extension of time claims and those kinds of things. Nowhere does it need to state the detail of the programme and I think that is also one thing that we can also put more focus on. Do a proper schedule from all the contractors and a detailed schedule, I think that is important."*
PC03	• *"Make sure that right through from the start everybody knows that and also you got the construction guarantees and payment guarantees, and payment guarantees vice versa."*
PC04	• *"Payment disputes pertaining to scope changes and so forth put tremendous stress on the supply chain."*
PC05	• *"The contractor engaged BIM and they went to the client and said because of these changes my price has increased. With BIM your coordination is just much better."*
PC06	• *"I think everybody experience payment disputes during sometime of their professional career. The reasons are more than often problems with the measurement of the work performed or tasks completed or not completed. Variation orders that have been brought on during the construction phase and unclear scope of work. Also, what sometimes leads to disputes is construction time that was allowed, and no extension of time may also then cause payment disputes in the end."*

Table 4.15 illustrates all participants key quotes regarding theme: The reasons for payment disputes. The frequency of the theme was cited 34 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.13: *Weighted average rating per participant for Theme: Reasons for payment disputes.*

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03** – PrQS	**PC04** – BIM Tech	**PC05** – BIM Architect & Design Manager	**PC06** – PrEng Civil & Structural Engineer

	7,36	**7,17**	**6.86**	**7**	**6,5**	**6,86**

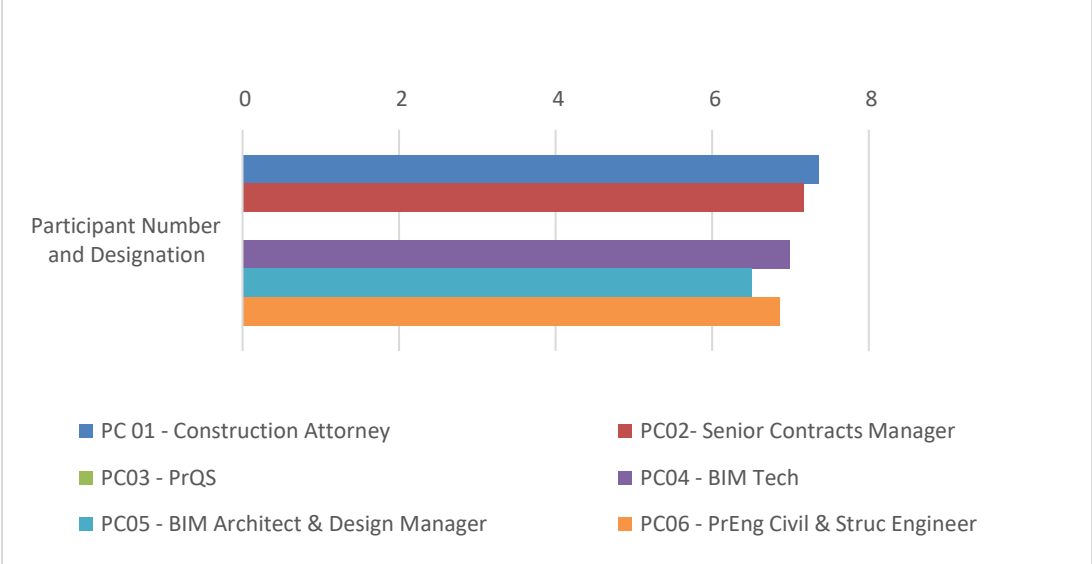


Figure 4.13 illustrates the weighted average rating on the level of importance for each participant pertaining the reasons for payment disputes. PC05 illustrating the lowest rating of 6.5 to PC01 highest ranking of 7,36 on the level of importance regarding this theme. The literature is well resourced on the reasons of payment delays and disputes. Understanding the core issues in analyzing the viewpoints of participants, can unlock the necessary support for the theoretical framework and would support answering the primary research question.

4.4.14 Theme Fourteen: Poor management practices.

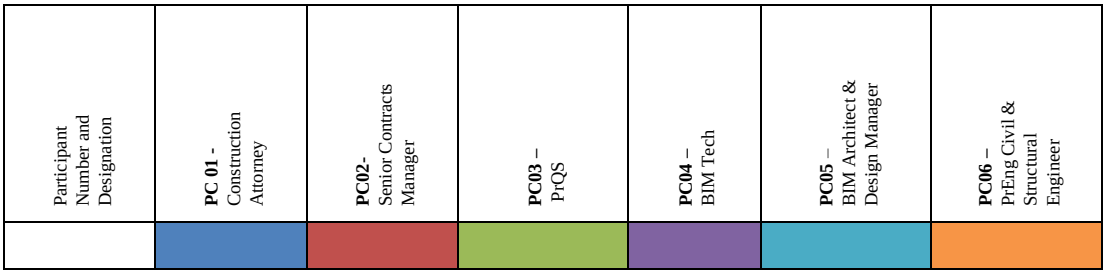
Table 4.16: Key Participant Quotes regarding the poor contract management practices.

Participant ID	Supporting Key Participants Quotes on poor contract management practices.
PC01	• *"From a legal perspective, um, I believe that good fences make for good neighbours."* • *"Either verbal or in writing and that contract must then be explained to show what the actual contract entails. Um, and I think a lot of times people are in such a hurry to get the job done that they do not look."* • *"So, I find that lot of the contracts becomes so convoluted and difficult due to using unnecessary legal terms and the people don't understand the essence of what is supposed to happen"* • *"there's been a very big drive in the past few years, umm, to step away from what is referred to as legal lees. Legal lees are the language of the legal fraternity. For some reason, and not all the attorney's and advocates or lawyers, but many of them like to use language when they draft documents, letters, or pleadings which the ordinary laid man does not understand."*

PC02	• *"Effectively certificates can be done by one person in the office. It will take away the admin it will take away from ten different site agents on different sites. So, it is certainly time saving is big. Take away that responsibility and hopefully capture the items more effectively that there would not be oversight and items that are there not claimed."*
PC03	• *"One needs to look into the actual contract and what is written in there."* • *"I mean a contract is only as good as the people who runs it. So, your principal agent is very important and I think you even can say you need to do a proper course or get a certificate or agree on a principal agent in the JBCC as that is a full-time job. A lot of people don't take that very seriously."*
PC04	• *"that is how they do it overseas. In South Africa it is (jeez). So, look the owner wants to get it certified through council and once they got it through council then they want to do changes. Then they want to push the boundaries and get away with it. Now he (the client) is not paying extra money for that. That is coming out of the pocket of the architect. What good it that for the architect? It does not gel. So, these BIM processes, how it should work. I don't know of one person in South Africa who is properly perfectly situated who support the client."*
PC05	• *"it is a confirmation, and it is peace of mind that I am not sucking figures out of the air. So, it gives you the confidence to tender more precisely, more profitability because at the end of the day if you use BIM you are able to control your changes. This will better align with the contract and contract obligations."*
PC06	• *"I do not think all the practices are bad, but yes in general it leans towards a poor side to it. Not all is bad. There are some systems that does work."* • *"people don't understand how the contract management practices should be applied and therefore you get to a point where you can't implement practices the way you should."*

Table 4.16 illustrates all participants key quotes regarding theme: Poor contract management practices. The frequency of the theme was cited 20 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.14: Weighted average rating per participant for Theme: Poor contract management practices.



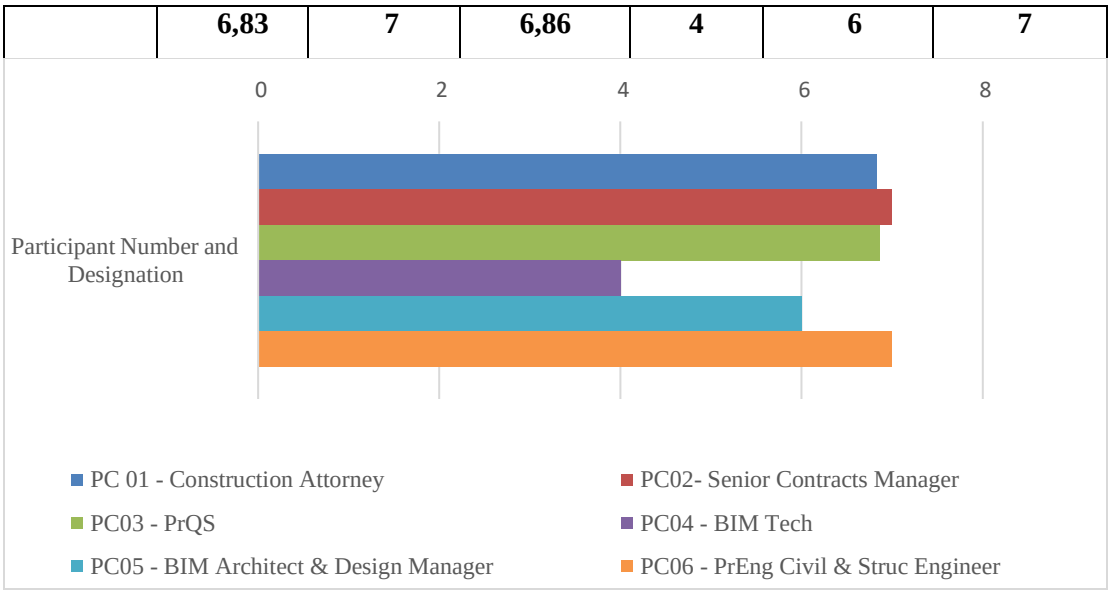


Figure 4.14 illustrates the weighted average rating on the level of importance for each participant pertaining poor contract management. PC04 illustrating the lowest rating of 4 to PC02 and PC06 highest ranking of 8 respectively, on the level of importance regarding this theme. Poor construction management practices have been identified in literature as one of the key reasons for delayed payments and disputes. This theme is important to understand the participants view and in order to assist in answering the primary and secondary research questions.

4.4.15 Theme Fifteen: Poor leverage to enforce payment.

Table 4.17: Key Participant Quotes regarding Poor leverage to enforce payment.

Participant ID	Supporting Key Participants Quotes on Poor leverage to enforce payment.
PC01	• *"Absolutely, the only remedy that the contractor has (what we know as in the industry) is a claim for unjustified enrichment. It is where a loss is suffered by the contractor has resulted in the equivalent (or more) enrichment of the client."*
PC02	• *"Our recourse was interest on overdue payments, but interest is generally not a huge motivating factor to get a client to pay."*
PC03	• *"but I mean, back in the day it was a handshake,* and you build. I think working with the attorneys and the advocates, I think they are the only one making money and at the end it could have been settled on a mediation basis and agreement."
PC04	• *"Currently the leverage contractors have to enforce payment takes a long time and is often referred to litigation."*
PC05	• *"at the end of the day if you use BIM, you are able to control yourchanges. This will better align with the contract and contract*

	obligations and you know you will have sufficient support for any claim than with the current way of doing things where it may be more difficult to support your claim."
PC06	• *"The only leverage they have legally in the contract that normally gets used, NEC or JBCC is the Builders Lien. That is the only leverage they have."*

Table 4.17 illustrates all participants key quotes regarding theme: Poor leverage to enforce payment. The frequency of the theme was cited 10 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.15: Weighted average rating per participant for Theme: Poor leverage to enforce payment.

Participant Number and Designation	**PC 01 -** Construction Attorney	**PC02-** Senior Contracts Manager	**PC03 –** PrQS	**PC04 –** BIM Tech	**PC05 –** BIM Architect & Design Manager	**PC06 –** PrEng Civil & Structural Engineer
	8	**8,5**	**6,5**	**9**	**6**	**6,67**

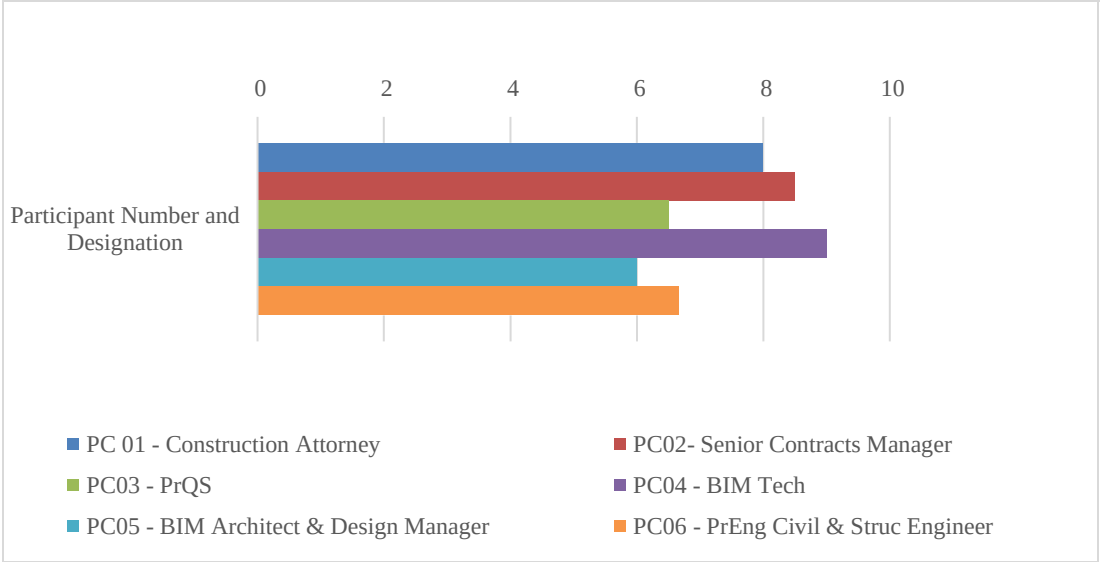


Figure 4.15 illustrates the weighted average rating on the level of importance for each participant the poor leverage to enforce payment. PC05 illustrating the lowest rating of 6 to PC02 highest ranking of 8,5 on the level of importance regarding this theme. This theme is important in understanding the remedies available to effect payment on time. The participants viewpoints are important to support findings in literature and in answering the secondary research questions.

4.4.16 Theme Sixteen: Contract Variation/s.

Table 4.18: Key Participant Quotes regarding Construction Variation/s.

Participant ID	Supporting Key Participants Quotes on Construction Variation/s.
PC01	• *"The majority of the litigation matters I have handled in contracts, usually happens as soon as there is a variation."* • *"The more changes there is, the bigger your changes of a dispute."* • *"As soon as people put in a variance means that the original contract should actually be redrawn as there is now a new contract in place stipulating this and that. Not just this."*
PC02	• *"those are the items, generally the contentious items that would hold the process up."*
PC03	• *"they also say that there is now 10 to 15% increase in health and safety because of COVID so, I don't think anybody budgeted for that so that is also something. You need a contingency in your cash flow."*
PC04	• *"Correct and the supply chain is desperate because they are working in an environment where they are not getting paid the right amount of money upfront. That is where most of the money can be saved, where you spend at the beginning. So, they get short-changed to start with and then at the end of the project something new is thrown in and that is already after the critical decision points. Whereas overseas they have very definite decision points where they say, when this is done a cheque gets written. And then it is done. If you want to come and change something afterward you need to go through the process again. Not mind doing the work, but you need to pay us."*
PC05	• *"if the contractor is clever, he invests in this as well and his got a team because it's kind of a live…you can download the models and here is the thing now with variation. So, you can compare models. The one I gave you last week as opposed to the one I gave you today. On BIM 360 you can compare the models and BIM 360 would give you a printout, a markup of all the changes happened automatically. Whereas before, you are going to struggle to keep track of all of this."*

PC06	• *"The reasons are more than often problems with the measurement of the work performed or tasks completed or not completed. Variation orders that has been brought on during the construction phase and unclear scope of work."*

Table 4.18 illustrates all participants key quotes regarding theme: Construction Variation/s. The frequency of the theme was cited 12 times by all participants as shown in Table 4.2 during the data collection process.

Figure 4.16: Weighted average rating per participant for Theme: Construction Variation/s.

Participant Number and Designation	**PC 01** - Construction Attorney	**PC02**- Senior Contracts Manager	**PC03** – PrQS	**PC04** – BIM Tech	**PC05** – BIM Architect & Design Manager	**PC06** – PrEng Civil & Structural Engineer
	8	**8**	**5,5**	**6**	**6,6**	**7,5**

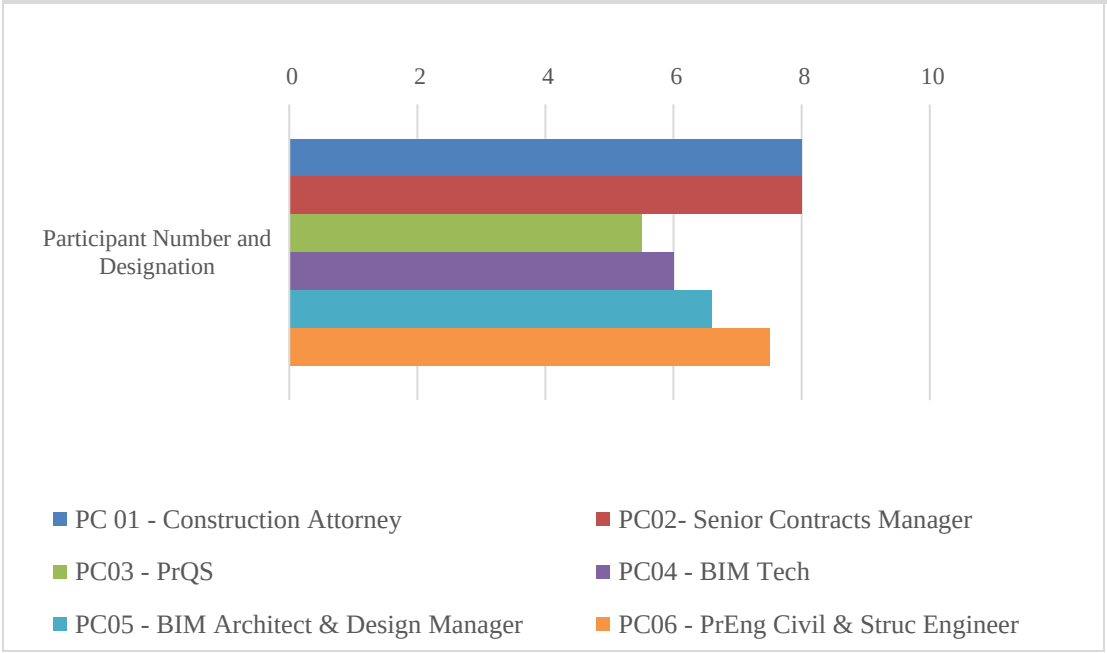


Figure 4.16 illustrates the weighted average rating on the level of importance for each participant on Construction variance/s. PC04 illustrating the lowest rating of 6 to PC01 and PC02 highest ranking of 8 respectively, on the level of importance regarding this theme. It is well documented in literature that variations are a major contributor to disputes and thus

payment delays. Practical experience in the participants viewpoints is crucial in supportingthe theoretical framework and answering the primary research question.

4.5 SUMMARY OF KEY FINDINGS

This chapter presented the data and initial analysis from the key informant interviews and documentary analysis of the procurement documents from the eight organizational cases of framework contracts investigated in this study. The data elicited from the case organizations via the key informants includes: the organizations and key informants' characteristics; framework contract description and motivation for its adoption; performance of framework contracts; appropriate attributes required of contractors to successfully perform in framework contracts; signals that encourage and indicate contractors' suitability for long-term collaborative relationships; tactics for identifying and evaluating required attributes for long-term collaborative relationships, and communications in the procurement documents on characteristics and expectations for framework contracts, given the demand for long-term collaborative relationships. The findings are presented in a case-by-case analysis using matrix tables with supporting direct quotes from the key informants and word clouds depicting the most prominent words in the data across the cases and summary details.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the summary and conclusion of the research study. The study consists of a literature review and empirical research. The study investigated automating payments by leveraging BIM and Blockchain technology and by incorporating a third leg namely that of Smart Contracts. Further to this, the study aimed to examine the importance of the study and the impact of the theoretical framework on the construction industry.

This research report consists of five sections namely the Chapter 1 (Introduction and Background), Chapter 2 (Literature Review), Chapter 3 (Research Methodology), Chapter 4 (Data Presentation and Analysis) and Chapter 5 (Empirical research findings and conclusions).

The premise of this study is based on the fact that the construction industry has been criticizedin being too slow in embracing new technology which could increase industry performance.The increase use of BIM software is one of these examples. By incorporating other technologies such as Blockchain and Smart contracts into one framework could herald and potentially transform the construction industry.

The primary research was to understand how automation of construction payments and contracts will influence the construction project management industry and the primary research question was:

Can a BIM-Blockchain Smart Contract framework, increase trust, collaboration and performance around payment delays and disputes in the construction industry.

The secondary research questions were:

Is the industry ready to move away from traditional payment methods to automated or semi-automated payments?

Would the automation of payments assist to reduce disputes associated with payments?

Would the automation of payments assist in better cashflow for the contractors?

5.2 STUDY OVERVIEW

Late payments continue to put contractors and the entire supply chain in the construction industry at risk, threatening their very survival. Contractors who rely on their clients to pay them promptly in order to keep their cashflow positive and their business afloat. The construction contracts are the cornerstone of the industry which regulates the behavior of the parties to the agreement and effective construction contract management practices aretherefore needed in order to protect the interests of those parties and by preventing or limiting the possibility of construction delays.

In this study, a BIM-Blockchain and Smart Contract framework is theoretical for the execution of semi-automated construction payments. By leveraging technology, the traditional processof payment certification and payment can be done achieved automatically. Moreover, digital twinning of Building Information Modelling (BIM) and Blockchain can create a powerful tool for both contractor and client when it comes to initiating, approving, and executing payments. By including the contractual aspect, all elements are present to execute payment legal, functionally, and practically. Interim and Final payments can be affected by way of automation. Using traditional contraction conditions and developing the data into an electronic format, the Smart Contract model would be able to represent contractual obligations, prohibitions and allowable actions which would be read and executed automatically.

A customized consensus mechanism is theoretical in order to facilitate semi-automated interim and final payments. This mechanism regulates the conditions for approval for the architect, engineer, quantity surveyor and client by automatically providing them with necessary information at the time of approval.

In addition, the theoretical framework protects the possibility of fraudulent approval by confirming each consensus to all co-approvers. This provides transparency to all and framework automatically verifies the approval against certain pre agreed parameters which is then relayed to all. Payment can only be completed one all approvals by way of consensuswere received.

5.3 CONCLUSIONS

A few years ago, the entire concept about Artificial Intelligence were merely seen in movies,a concept of creative thinkers that was so farfetched that no-one would ever have thought thatit would become reality. It was unthinkable to postulate that that physical money would oneday become digitalized. Technology has developed at a rapid pace over the past decade. Fromstoring information in the cloud to software models that can nearly be fully automated and by way of self-executing codes.

The world is becoming paperless and the physical tangible assists are becoming digitalized. It is therefore important that the construction industry carefully consider the benefits that automation have to offer the industry as the landscape in which we are currently operating in,is set for a dramatic change.

5.4 RESEARCH QUESTION OUTCOME

After considering the data from the literature review and empirical findings the investigation the primary and secondary research questions are concluded as follows:

5.4.1 The Primary Research Question

Can a BIM-Blockchain Smart Contract framework would be able to increase trust, collaboration, and performance in executing payments preventing payment delays and limiting disputes in the construction industry?

The outcome from the data collection indicated that the theoretical framework can indeed increase trust and collaboration, and that it would be able to increase performance whilst reducing disputes. Information management, transparency and trust among project participants are critical to ensure project success and BIM can provide the needed informationto all project participants as a single source of truth.

Information contained within the project model are also hold in the Blockchain technology which is incorruptible, reliable and a transparent database. This provides accurate records of every single change made to the model and show clear and transparent steps as and when it occurred within the project. Moreover, contractual provisions / parameters that was created

within Smart Contract can be partially or fully self-executing flagging and forcing parties to comply with their obligations as set out in the agreement. This has the potential to lead to increase confidence and reliability of the information it contains and further supports better tracking and increased accountability of events to each contributor should a problem occur.

As the contributors will be professionals, the contractor and the client the theoretical framework will offer all involved online access to a single project model, hence every contributor shall have access and able to view the project as a whole and to the extent permitted, make changes to the model content. This theoretical framework has demonstrated that by enabling prompt payment by way of automation could increase performance whilst reducing disputes and late payments for the construction industry.

5.4.2 Secondary Research Question 1:

Is the industry ready to move away from traditional payment methods to automated orsemi-automated payments?

The study found that there although professionals in the construction industry are set in their ways, that they shall consider moving away from the traditional payment method once the industry has tried and tested the process. Contracts are structured to allocate rights, obligations, and liability to each party in an agreement, therefore if the property is not mine,it is yours and if I have a right to be paid you must pay me, etc. By encouraging collaboration,the parties will base their decisions and actions on trust and transparency which is clearly visible within the theoretical framework, thus, to verify payments becomes easier as it is aligned with all provisions of the agreement. The theoretical framework is therefore a tool which can encourage that all parties align their interest with that of the project.

5.4.3 Secondary Research Question 2:

Would the automation of payments assist to reduce disputes associated withpayments?

The study found that automation of payments within the theoretical framework could significantly reduce disputes. Disputes can be a source of frustration and inconvenience for any supply chain. In addition, disputes are expensive to resolve. The theoretical framework isa

three-legged approach whereby each leg offers a digital trail of occurrences as and when it occurred thereby providing a wholistic narrative should a dispute occur between parties.

Lawyers will no longer need to prepare lengthy fact gathering evidence and as all of the information will be available on a decentralized system which cannot be changed. The information thus recorded in the BIM-Blockchain and Smart Contract Framework is therefore distributed and available on demand to provide clear record of contract events from an unbiased perspective, therefore the evidence will be strong enough to solve any disputes before it goes into litigation.

5.4.4 Secondary Research Question 3:

Would the automation of payments assist in better cashflow for the contractors?

The research findings found that it can absolutely assist in better cash flow for the contractors. Cash flow is king for any business, more so when the contractor needs to pay for materials up front.

Construction companies require special cashflow management strategies to help them overcome indirect and direct cost associated to projects and achieve profitability. In some instances, construction invoices are only settled between 60 and 90 days. In addition, for every interim payment retention up to 10% are deducted from each paymentcertificate, thus only 90% of the completed work are being paid.

Moreover, additional resources may increase resources under circumstances relating to variation orders or change orders. Normally the contractor will have to cover the cost first before being reimbursed.

Finally, the construction industry relies on equipment and inventory to complete works. Too much inventory can tie up cash that could have been better utilized on another project. Similarly, plant and equipment that is bought, needs to generate income otherwise these plant and equipment is a capital and cash flow outlay without generating any return.

Automation can assist in better cash flow through flagging prompt payment reminders in line with the obligations as set out in the Smart Contract. It also has the potential to flag and deal with any disputes before it becomes a big problem.

5.5 RECOMMENDATIONS

AI based solutions can benefit construction processes in many ways. It is already assisting with construction planning, sequencing, and execution of activities.

In addition, AI based tools have also been used to detect possible clashes, delays, and changes within the construction project by the use Building Information Modelling (BIM). The implementation of drones and robots to manage site and the use of laser scans is also nothing new anymore.

The only manual process remaining, is that of the contract management and payment process. By implementing AI based tools such as the BIM-Blockchain and Smart Contracts framework, the current traditional methods can be automated to fit in with the other already used AI tools. A full spectrum of AI driven tools should therefore be the key enabler for just-in-time delivery of construction projects.

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APPENDIX A – INTERVIEW TOPIC GUIDE

As automation is developing, more and more applications within the construction industry (which offers the sector a more efficient and cost-effective way to run certain processes) than that of the current manual and time-consuming practices.

Time is money and it is precious. The study investigates new innovative methods leveraging automation to re-think how we are administrating cost management in construction projects.



APPENDIX B – PARTICIPANT INFORMATION SHEET

Participant Information Sheet

Dear Sir / Madam,

My name is Michelle Matthews, and I am a master's student in the Faculty of Engineering and Built Environment at the University of the Witwatersrand in Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating Construction Payment Automation through a BIM-Blockchain and Smart Contract framework. The aim of this research project is to find out how the theoretical technology shall change the future of the construction and engineering industry.

As part of this project, I would like to invite you to take part in an interview. This activity will involvean unstructured discussion in the form of an interview on the abovementioned research topic.

You will not receive any direct benefits from participating in this research, and there are no disadvantages or penalties for not participating. You may withdraw at any time. The interview will be recorded in order to be transcribed. Any information will be treated as confidential. I will not be asking for your name or any identifying information, and the information you give to me will be heldsecurely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent yourparticipation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me or my Supervisor on the details listed below. This study will be written up as a research report which will be available online through the university library website.

Yours sincerely,

Michelle Matthews

Student name, email. phone number	Supervisor name, email, phone number
Ms. Michelle Matthews	Professor David Root
1798041@students.wits.ac.za	David.root@wits.ac.za
0836519121	011 717 7664

APPENDIX C – CONSENT FORM

TITLE OF RESEARCH: CONSTRUCTION PAYMENT AUTOMATION THROUGH A BIM-BLOCKCHAIN AND SMART CONTRACT FRAMEWORK.

NAME OF RESEARCHER: MICHELLE MATTHEWS

I,....., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. Please circle the relevant options below.

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotesin his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that the information I provide may be usedanonymously by other researchers following this project provided they receive their own ethics clearance.	YES	NO

…… (signature)

…… (name of participant)

…… (date)

APPENDIX D - INTERVIEW TRANSCRIPTS

Note: Each participant identity has been changed to ensure identity protection.

INTERVIEW ONE:

Interviewer: Good afternoon John. Thank you for joining me in this Zoom interview.

Interviewee: Hi Michelle, it is a pleasure.

Interviewer: So, I believe you have already read up on my topic

Interviewee: Yes.

Interviewer: The whole system or this whole theoretical framework will then look at parameters and once achieved it can trigger an automated payment.

Interviewee: Um yes, I think, um what would be needed from the viewpoint from the client. The must have access to the BIM and for instance we have got a project that consists out of various small tasks.

Interviewer: Yes.

Interviewee: We want to build this we want to lay that; we want to paint this, and we want to change that.

Interviewer: Yes.

Interviewee: At each stage, the client must have access so that he can say, I am happy with this. And once he says I am happy with this, it should be like a tick mark, it automatically allocates some kind of payment instruction or the ability to generate the ability from the client, whilst still protecting his financial side of things.

Interviewer: Hmm

Interviewee: So, it will lessen his exposure and at the same time it will guarantee that the contractor will be able to get his payments, when as is the work gets done, as it was paid.

Interviewer: Yes, most definitely, because that creates trust, transparency and it creates also, you know, trust between all the parties which I feel that sometimes in contracts or traditional contracts (and I will come to a few things that I just want to address so I can transcribe it properly) where traditional contracts…If I may ask you…what is your view on traditional contracts and the traditional procurement methods, that is used in the industry.

Interviewer: Do you feel it something people do and just shelve it and never actually manage it actively?

Interviewee: I think, well well...From a legal perspective, um, I believe that good fences make for good neighbours.

Interviewer: Hmm

Interviewee: You never need a contract, until there is a problem. Then everybody rushes to the contract. And in litigation one of the main issues, we always need to address is, there was a contract. Either verbal or in writing and that contract must then be explained to show what the actual contract entails. Um, and I think a lot of times people are in such a hurry to get the job done that they do not look. They must use the contract as a roadmap and that roadmap must tell them where to go, where not to go, and what to do if you get off course and... A lot of times I think it is left too late where you now need to look at the court to resolve a contractual issue where if the parties had expanded the original contract by using something like BIM, they could have pinpointed discrepancies and possible future issues at much earlier date.

Interviewee: Once there is a big issue, now it takes a lot of money and a lot of time through the courts to argue all these facts and things.

Interviewer: No most definitely. And that is the reason why you, these three ums, three-legged approach is needed, because your BIM traces your progress and variables and any changes and any spec changes to what was originally agreed. And then, um, you're your automation makes sure that as things or when consensus are reached, say for instance by the client, that he accepts this change. It automatically triggers the response for him to pay for that change.

Interviewee: Now, what we say now is actually quite important. The majority of the litigation matters I have handled in contracts, usually happens as soon as there is a variation. People say I want this wall painted and I say it is going to be an R100.00. He's happy, I'm happy. WhileI am busy painting, he says now I want a whole drill in the wall. No suddenly the parameter changes. And the price is going to change. The more changes there is, the bigger your changes of a dispute. People, and I am just speaking out of own experience. I go to the shop, and I've got a budget of R500.00, and I want to buy fishing gear. I know I need some sinkers and I need some hooks and I need some line and oh this is a nice knife and hat and I need a pale and I need some shoes. And at the next minute I am standing at the till with R700.00 worth of goods in my basket.

As soon as people put in a variance means that the original contract should actually be redrawn as there is now a new contract in place stipulating this and that. Not just this. It happens when people realizes it is no longer a R100.00 to have the wall painted it is now a R150.00 because we have to get somebody to come drill it, we need electricity, we need the drill bit and we need to clean up after the whole was made. And these costs are not taken into account.

Umm, so I hope that is a bit of an answer to your question and statement.

Interviewer: Yes, no definitely it is one of the factors. And also research show, umm, just not does disputes get triggered by variations, but the research also does show in contract management that most of the people don't manage their contracts or they don't understand the interpretation of the responsibilities of a contract. Do you think that something that you experienced in any of your procedures or any of your litigation you might have had in the past?

Interviewee: Absolutely, there's been a very big drive in the past few years, umm, to step away from what is referred to as legal lees. Legal lees are the language of the legal fraternity. For some reason, and not all the attorney's and advocates or lawyers, but many of them like to use language when they draft documents, letters or pleadings which the ordinary laid man does not understand. You actually need to get a legal expert to translate legal lees into English for whatever language this person is busy with. So, I find that lot of the contracts becomes so convoluted and difficult due to using unnecessary legal terms and the people don't understand the essence of what is supposed to happen. The contract should state I will paint your wall white. You will pay me R100.00.

Interviewer: Yes, most definitely.

Interviewee: Give that to a lawyer and he will give you back a four page contract with terms and conditions and all types of things that neither party really understands, but which has a very big influence on the dispute or the performance of the contract at the end of the day.

Interviewer: The one contractor that I interviewed yesterday said: Contractor are common folk; we don't understand all these things. We just want to do the work. So essentially that's a hampering factor for them as

they are not used to all these high legality terms. They just want to know this is the work involved, now let's build it.

Interviewee: It's absolutely, with engineers they sit with this tremendous amount of scientific knowledge that they use in the planning of something, but what the guy that does the building wants to see is, where this thing must be, how high must it be and how many bricks must he put side by side. Umm, so you have to keep things as simple and as easy to understand for people as possible.

Interviewer: Yes, because everyone has got different expertise and although the law is very important, everybody is not (you know) …can't always do everything in a legal way. They are very more simplistic, just… I did the work just pay me.

Interviewee: Absolutely, that is one of the very basic contracts. You come to my house, you clean my yard and I give you R150.00. Straight forward, both parties know exactly what is required,

Interviewer: So, I don't know if you know or is familiar with something like a standard form of agreement like JBCC, but if you look at the JBCC, it is very much a "master servant" type of contract. Instruct and do type of contract and in terms of those type of contracts do you feel that like a smart contract coupled with a BIM and a Block chain…do you think that will level it out so that there is not a master servant relationship as everybody sits around one table, everybody agrees from the onset what is required and what is going to be paid and as soon as consensus is reached, he gets paid. Do you think that would be a more beneficial way of doing work in the industry?

Interviewee: Absolutely, um and I definitely think so, but also taking into account the actual scope of the contract. The more involved something becomes the more care must be taken in planning this whole thing and I think the BIM is very much a comprehensive planning tool. I

was brought up in my previous work where we had what we referred to as an ops list. An ops list is like a to-do list, but a little bit more comprehensive than that. It's something that helps you plan your days; you can get the most done and the more things you have to do the better your planning must be to make everything fit. Because if you can't fit everything you have to do in a logical way, then you going to have problems. I think the BIM will do that, where if something becomes very convoluted and very big and enormous it can break it down into smaller segments, which are easier to manage and control. How do you eat an elephant? Bite by bite. It is the same type of thing. So, I think the BIM will help a lot in that. In taking a very big contact and breaking it down into smaller more manageable parts. Where all the parties have input into…this needs to be done, this has been done. Are you happy, yes pay me.

Interviewer: That is actually a very important point. It breaks it down a little bit more and you can also have (say for instance) a lesser but more frequent payments.

Interviewee: Absolutely, absolutely.

Interviewer: Or on a milestone that is achieved and not on monthly lump sum payment or monthly payments as per say per payment certificate. But also, if the client does not pay, the contractor is cash strapped.

Interviewee: Absolutely. I've got clients on both side of the spectrum. I have got contractors that are not being paid by their clients.

Interviewer: For what reasons?

Interviewee: There can be many reasons. There can be reasons that are valid. The client could have picked up financial problems and suddenly he doesn't have that cash he anticipated for the project, so he can't pay it anymore. It's not the contractor's fault. The client should have made provision. If you go to the shop with money in your pocket

you must make sure that R10.00 is what you need to buy and pay for what you need.

Interviewer: Yes, there is a responsibility.

Interviewee: Absolutely. You can't just take your handbag and say there should be R10.00 in there let's go buy some things. So, on a lot of sides I think it is the client fault that they don't budget but try to get everything done with as little as possible and it create problems for contractors. I tell a lot of people you cannot work on promises. That contractor can't go to a hardware store and say, listen here…My client promised me that he will pay me. I will promise I will pay you, so give me what I need. The hardware store is going to say, ok as soon as your client pays you and as soon as you can pay me, you can get what you want. And normally it is the contractor that needs to outlay the cash money to get what is needed. He is then actually at the mercy of the client who is getting the benefit.

Interviewer: See that is another aspect of all these things is, is that the client has got all power to pay or not pay. All the authority lies with him currently. So, what this framework is supposed to do is that money is place beforehand on a centralized database and form there on released. It must not still be secured. It needs to be secured beforehand and is released as these performance obligations or performance parameters are then achieved. It takes away all these payment guarantees, and all these guarantees and all these things must go. It also creates on the contractor's side…it ensures that the client can pay. There is cash flow. There is a financial obligation.

Interviewee: What I have done for people is, and I think that is the one part where you will have to look at BIM on how you going to cross that specific bridge. An attorney has got a trust account. That account is managed and controlled by various factors and outside parties. There is a lot of reporting and auditing happening on this account, but people pay

money into my trust account and by law I cannot use that money for anything other than their instruction to do something. I don't know how you going to incorporate that into the BIM. But what I have done is, where there is a client, often I as an attorney step in and tell the client, you want the job done, you don't trust the contractor. The contractor wants to do the work but doesn't trust you. Pay me, the money lies in my account; he does the work; if you happy you say you are happy, and if you're not happy he fixes it. Until you are happy yes you are happy, I will pay him. So that contractor knows the money is there. And I think that could be one of the issues with the implementation of BIM how to guarantee that money in some kind of trust account similar to what an attorney or an estate agent would have.

Interviewer: So, see with your BIM-Blockchain; it is a very similar thing to a trust account. And also, it is a very secure way of doing it. Maybe you can link it to a trust account, maybe it does not have to go as sci-fi as what we want to in literature. Maybe it could be linked to a trust account but somewhere the obligation (once the consensus is given by all these peer networks) it must be released. It cannot be withheld. And that's the thing that is currently happening in the industry although you provide him with everything and although everybody is happy, they still don't want to pay it (the client). Some still want to withhold payment in some instances. Which is wrong, in my opinion.

Interviewee: Absolutely, the only remedy that the contractor has (what we know as in the industry) is a claim for unjustified enrichment. It is where a loss is suffered by the contractor has resulted in the equivalent (or more) enrichment of the client. Where the contractor had to pay a R1000 for bricks and he built the security fence, so the client has got a R1000 fence around his house but is refusing to pay. So he has been enriched by that.

Interviewer: Just moving away from the BIM aspect, I just want to concentrate more on the smart contract aspect. When you take traditional forms of contracts, whether it is bespoke or standard would you say there is a; what would trigger in your mind, when you talk about a smart contract? Do think it is still something very young and that there is a lot of elements still needed to be sorted out or do you think it is something as: this is the obligation, this is the deliverables, if you achieve this, bam bam we pay it?

Interviewee: I have never seen something like the smart contract, like what you are referring to. Then I must say I am not in the engineering or building field, but in the legal field the only thing I ever see is a written contract between the parties. So, I think the majority of the people still refer down to written contracts. Number 1 because that is what they know, and I think number 2 is there is a cost factor involved. Where your "bakkie" builder can sign a contract without having to invest in the smart contract software and platforms. And I think that is important, because that could have an ultimate effect on the cost of his work which he has to factor it in.

Interviewer: Yes, it has to do with your economics of scale. The bigger you go the more effective it is.

Interviewee: Absolutely, but for the (calling it a bakkie builder not out of disrespect, just to differentiate between the small contractor and your big Murray and Roberts, and the big contractors.) Where it would allow a small contractor to effectively also manage his workload and plan his workload, much better. Because I have not seen the software, but I can think that if I were a builder what I would do is that I would go on my computer and see the weeks planning. On house number A I must do this, this and that, I must buy this for so much money. House number B, this that and the other and by linking all these things I can make sure there is enough cash

flow coming into my business. So that I can service the other contracts where the cash has not come yet and were, I need to outlay cash. So that Bakkie builder can actually use other people's money for his building instead of using his own.

Interviewer: Maybe the smart contract could be in the form of an app? Who knows?

Interviewee: Absolutely.

Interviewer: It does not have to be a lengthy encumbered detailed document, it could be an app.

Interviewee: Absolutely and I know there are some apps at the moment (and they have been advertised on radio), but it is more for your DIY thing. The people can go onto the app; say what you want. The app will go the contractor with highest rating within that area, give the client their details, and I am sure that smart contract can somehow be linked to something like that as well.

Interviewer: Yes, it will be simplified, really simplified. Not have all the details. It is basically as you do you get paid. It matches what is agreed (pre-determined by the parties) to monitor it the whole time. So, the smart contract is very new, and it is not just for construction. It is inthe legal field, it is for rentals (it can be used for rentals) it is in banking, the financial industry. So, it is more and more. Smart contracts are coming into play as they can use block chain to activatepayments or to activate some or other responses to it. So that is happening. So, where I want to increase it into to the construction sector, the construction sector is very old schooled. They still use pen and paper measurements and everything like that and things arechanging. So how will this change the landscape if you combine your BIM, your Block chain and you're Smart Contracts? Will therebe a benefit for the construction industry going forward and maybe;

you could just answer that as the final question. Do you think there is a benefit for such a framework?

Interviewee: I absolutely think there is a benefit. Maybe I am one the few attorneys that does not like going to court. It is not because I am afraid of the court, but I do not like putting my client's resolution in the hands of a third person to decide. And that is what happens in the court. You've got two parties and the resolution is given to someone outside and that person. A judge is a judge, he knows the law, but he is not an engineer, or he might be, but generally he is not an engineer or a builder or these things and he does not understand the intricacies. He is working on papers before him. This system: The BIM and Block chain and Smart Contracts can help parties to resolve their own issues outside of court. It would be an awesome step forward. What is happening in the legal industry at the moment is and it is already happening up in Johannesburg, and it has now started in Cape Town. The courts are enforcing alternative dispute resolution. With the Consumer Protection Act, before a consumer can peruse a supplier he must first go to the Ombudsman. He must go to the Cape Consumer Protector or one of these guys and they will see whether they can resolve the dispute. Now you have an outside party doing this, but I believe the BIM-BLOCKCHAIN Smart Contract can become an alternative dispute resolution mechanism.

Interviewer: Yes, true

Interviewee: Where parties can resolve their matters before it becomes a big matter and before you need to go to court and as you know the court the court at the moment. If you get a court date in high court, you are looking at two years down the line. Magistrates court at least six or eight months. So, there is going to be a very long delay for

contractors to get paid and for clients to get satisfaction on the job they want finished.

Interviewer: That is an excellent point.

Interviewee: I think that could be a very good thing in the alternative dispute resolution arena.

Interviewer: It is an electronic paper trail, for the lack of a better description.

Interviewee: Absolutely. To give you an idea what is happening in Gauteng. Gauteng is piloting at the moment (um I forget the name now) but works your case lines as they call it. That's the word, Case lines. It is a programme similar to what SARS have on e-filing. An attorney gets a code and he issue summons electronically through court. All the documents happen electronically. There is going to be no more paper and things and documents getting lost and I didn't get this, but I sent it to you and all these types of stories. Because whenever you do something, it is like you go to SARS and upload whatever you got. It is stored electronically and in order as these things are being received. So, the courts in Johannesburg is going electronic already and if you can get these contracts to go electronic as well it could become a perfect mesh where the dispute resolution can become instead of having a photocopied and number annexure, it can be added as an electronic annexure. So, all the parties can have a look and pull it up and see but this and this happened and aahh here is the problem, and why wasn't it sorted out?

Interviewer: John it actually goes further than that. Anybody can go onto the system. It actually tracks any changes an author made (whether it is you, it is the client) so you …If you change anything in that system it actually records it. It actually can't be wiped away. You cannot delete it.

Interviewee: So, it is a digital footprint, of their negations and the story in this building project.

Interviewer: Exactly it is the entire story and there is no-where to hide.

Interviewee: And that is what people want. They want transparency. And the thing, people with criminal intent hate transparency, because you cannot be criminal if it is transparent. Everybody can see. People are doing things in dark corners behind closed doors, under the table, where with this it will all be above table, and everybody can now see what is going on.

Interviewer: I think that will also help a lot of people, whether you are now on the client side or the contractor's side.

Interviewee: Absolutely. I definitely think it is a step forward. I think it can help a lot of industries (like you say especially that heavy contract driven) like the building and the engineering field.

Interviewer: Yes, and people can then focus what they need to do and no so much on the legalities as that would be taken care of automatically?

Interviewee: The guy can get onsite in the morning. 9'oclock him and he's client both go on the app, the trenches must be dug by today. Have they been done? Yes, they have. Contractor click's yes, the client click's yes. Money goes into the contractor account. As simple as that. If the trench is not dug the client is going to say but it has not been dug. Take a photo. The photo can have a date stamp on it to say but this has not been dug. So, the client can't say that the contractor is trying to do him in or vice versa.

Interviewer: Interesting times we are facing and there is a lot of things still going to happen. One thing is clear the landscape is changing in a big way.

Interviewee: And I was born BC – Before Computers so I have got a lot of catching up to do.

Interviewer: Thank you John, I am just going to stop recording…

INTERVIEW TWO

Interviewer: Hi Ronald. Thanks for joining me on this Zoom call.

Interviewee: No problem.

Interviewer: It is storming in Cape Town. I am not a winter's person. I would rather be in Durban.

Interviewee: Durban winters are good.

Interviewer: How is business your end, just in general?

Interviewee: Hmmm, ja it's ok. Well, I mean, ja its ok. The Covid thing is not doing anyone any favors hmm but I've been busy for a while, but we need to pick up some more work. Not many tenders coming through unfortunately.

Interviewer: That's the thing. So, you can actually feel the lag coming through now.

Interviewee: Sure, ja ja

Interviewer: Covid has definitely changed the landscape.

Interviewee: Well, we are doing a decent sized contract (Bridge and roadworks) close to Port Shepstone at the moment. But it's a decent little town. It's a South Coast holiday-ish destination.

Interviewer: Richard firstly thank you so much for your willingness to this interview and just to help me collect some data. Obviously, it is very important for me to speak to a person like you that is a construction contracts manager, in the field, understanding all these problems. You have probably listened to my little presentation. I must apologize the sound was a bit terrible. It was just an idea to help bring the essence of the study to you as I know not everyone wants to read pages and pages of research.

Interviewee: Yes, it helped getting the point through.

Interviewer: So, from my side for you is that, basically maybe we can start off by me asking you, what is your current take on the construction industry in terms of automation? How are you incorporating any change if any?

Interviewee: Well, I suppose first of all I will only talk from my perspective and our company or what I perceive our company perspective to be. There might be other construction companies that are trendsetters. In my opinion I think construction people and contractors particularly, are stuck in their ways and not just something like this. I mean you are talking about a BIM and Block-chain management framework. When you look at what they call little blocs and chained links. I don't want to say advanced stuff, but the old school paper file and measurement sheets and stuff like that, that has worked for years. Old construction contractors are hard ships to turn for a new thing. Even as far as new products. Guy's wants to stick with gabion baskets, and you come with a new technology that no one is interested. So, I think it would be a long road to sell, but umm I suppose, we follow the example more than anything else. If it starts getting used and tested in the industry. I would love to say we are trendsetters, but we are not. We stick with our ways because they work until someone else test the system for years and that new system works, and it is efficient. Then we will say, ok let's get on board.

Interviewer: So, you will probably need a system that is already like, if you look at, your candy and things like that. It will all have to be easy to use and there must be buy-in from everyone. Then it will be easier. So obviously this type of thinking is still very very young and that is why it is sort-off an investigation into where is this going with

automation. How will it affect the construction industry in the future?

Your payment delays and non-payment. What is your experience on the ground when comes to people not paying you and delays? Do you have any examples you can provide or highlight?

Interviewee: Again, only from my perspective, but I would say private clients are normally fairly timeous payers and when they not it is that personal relationship to phone a Stuart or Pierre and say you know what… you're late in payment please expedite it. It's not so much an issue (or hasn't been) to this point an issue of approvals. You said there were, I forget the word you used, but everyone there had to be compliant and four people had to push a button and that would release the payment.

Interviewer: Consensus

Interviewee: Consensus, ja. So not so much an issue of that. Certainly not on private clients. And municipal clients I don't it's that either. It's just their internal systems are notoriously poor and people not doing their work. So, it goes from the one desk to the next desk and sits there for twee weeks before it gets processed.

Interviewer: How will that payment delay affect you? Would you say if you could have been paid earlier it would have added any value to you instead of being paid later?

Interviewee: Off-course cash flow is always an issue. So ja, absolutely 100%.

Interviewer: Okay and would you … Is there anything in your experience or have you seen anything in the industry where people actually...the actual contract not assisting and elevating these payment delays. Say for instance. How can I frame this? Where the employer is not willing to pay or not listening to any reason where he believes he is right?

Interviewee Yes, we have had that a couple of instances. Our recourse was interest on overdue payments, but interest is generally not a huge motivating factor to get a client to pay. And to follow the further recourse in terms of GCC you can suspend the works after a period of (I can't remember the number of days) and going into breach: h of contract and termination, but we have never ventured down that route. But as far as I know the recourse is interest and that is not enough of a whipping stick to get a reaction, generally.

Interviewer: True, then it actually leads into a dispute and then you need to wait for your money. Go through legal and arbitration.

Interviewee: True, fortunately we have not got to that point yet.

Interviewer: Ok

Interviewer: In terms of the traditional procurement method and the contract methods, do you feel it is very fragmented the way it's been done now whereby you typically get your QS and your Architect and they work with the client and then they will do the drawings and plans, and only later on you come in as the contractor. And now you sitting with this fragmented scope or maybe the expectations?

Interviewee: 100%, I read a book a while ago: I think it was the critical chain construction. I think that's what it was called. But that was talking exactly to what you're talking about now. Having a team. I mean they also did studies where to see how much money you can save and time you can save by having that collaborative team from the start from onset, with A client, engineer, architect and contractor from the start rather than having exactly like you say, client and engineer and the contractor only coming in much later. It says exactly that. We have more claims with the structure at the moment. With a collaborative structure we would have less claims. Save money, save time. But my take on it is unfortunately I think human

nature distrusts. No one trusts anyone and there is that (I suppose) expectation for clients for competitive bidding they are going to get the lowest price. In South Africa we are stuck on going for the lowest price. The lowest price gets the job, which I find quite frustrating. A lot of the other countries chuck out the top, chuck out the bottom and take the middle or closest to the middle. Umm, so yes, I think there is definitely a better way to do it and along those lines.

Interviewer: Ok

Interviewer: If you look at my framework and maybe just set aside now that your company likes the traditional way of doing things. But if you envision yourself using this BIM_Blockchain Framework with Smart Contracts – what is the benefits in the future you can maybe see coming from such a framework?

Interviewee: I think you have mentioned the 8th dimension of BIM of Contractual obligations and the rest of it, um but in terms of the payments how we can see that benefitting us…and I think (you know) mentioned it also very early stages of the programme and I have looked at what you shown only. I have never dealt with BIM. My initial take would be that the number of variables is so many to try and capture that it would be a seamless automated process, hard to comprehend. But further to that the general easy payment items of the stuff that should be captured not a problem and payment should go through. It is the additional items, the variation that wouldn't be captured in the BIM to start with to then include it in a later stage. But those are the items, generally the contentious items that would hold the process up. So how those would be captured in this BIM Block chain process?

Interviewer: So basically, your BIM is layering of architectural drawings, your structural drawings. Everything is layered and as you change…you

work on As-built drawings. The As-Built drawings are updated as construction goes along on site. So, you are always up to date with the As Built. It shows you any variations in any way to your baseline immediately. And then it can plug in again what you need to get paid. So ultimately the BIM would just be a single source of truth. It will have your baseline; it will show you all transparency from everything that changed, and it plugs it back into your contract value. It plugs back into when you must pay and then it just plugs back into your smart contract which again just tells you what your obligations in terms of that is. It is a mechanism to show transparency of how work progressed and where the variation came in, if any.

Interviewee: Umm, umm

Interviewer: But that is what this framework would do.

Interviewee: Okay, so say for example. Or a simplified example that the drawings are initially for a four-story building with piles and concrete works, piling and san-ware and all of that. That's all measured, it's on a programme and it might be as simple as clicking on a programme and saying your superstructure is a 100% complete, and it would spit out all the concrete reinforcing piles everything for a process payment certificate?

Interviewer: 100%. That can also be pulled through. And if along the way there is a spec that changed. Now the tiles X spec and now Y spec, you change the spec in the BIM it updates it on the spec sheet, it creates a value and it changes it. So, it just takes up all that working on paper and different types of revisions and really streamlines it to another level.

Interviewee: No, I mean, that's an amazing, if it works, it will save a lot of time. I'm just trying to play devil's advocate and your walking around

and you change the client's spec but now the client walks around with you and then says don't tile those two square meters put a Jacuzzi in there. But you put 100% down on your tiling and programme and it captures that two square meters. You get paid for it; everyone accepts the outcome of the computer. That's the problem with new age society we accept what the computer spits out, but it would be very hard to go back and track that for a simple example.

Interviewer: No, I have never worked on BIM, but I have seen work done on BIM for Dubai and I tell you it's amazing. It's not just a question of you need to update it. There is also acceptance before changes can be executed from the client's side. It just makes it easier to track any changes. Which is nice. It is just a faster update. And then where your block chain will come in. Block chain is just (forget about the technology behind it). It just allows to automate payments. And then your smart contract; instead of having a paper-based contract. It is all linked, so if one thing is done, it triggers the obligation and it triggers the payment. This is the thinking behind this whole framework. Obviously, it doesn't exist. BIM exists and Block Chain exists, and Smart Contracts exists, but none of the three exists together. It's a whole new way of thinking about construction in the future.

Interviewee: Okay

Interviewer: So that is what it is about. It's just a new thinking.

Interviewee: Sure

Interviewer: What are the one or two benefits that you can see coming out from this theoretical framework in the future?

Interviewee: I suppose that if BIM and the measuring system with Block chain work as good as you say it will, it should. Effectively certificates

can be done by one person in the office. It will take away the admin it will take away from ten different site agents on different sites. So, it is certainly time saving is big. Take away that responsibility and hopefully capture the items more effectively that there would not be oversight and items that are there not claimed. Certainly, that is an advantage. Collaboration for me can happen with or without the BIM and the Block chain.

Interviewer: 100% and maybe only a last thought on how else this framework could help. When you get to disputes and arbitration, this whole system can actually. It talks about the block chain is transparent and also reports things (data) and it cannot be changed. When you go to arbitration you have this whole history behind you which is rock solid. You can't change it, so you could also use that to motivate your claim. So that could be another benefit?

Interviewee: You mention payment delays and stuff and those generally have not led to disputes in my case.

Interviewer: I can say you are very lucky.

Interviewee: Sure sure. I like to think we have got a good relationship with most of our clients and hopefully that is what helps.

Interviewer: I think that is one of the most important things it doesn't matter how automated you go, and the end of the day your core is still your relationship.

Interviewee: Absolutely. People, I suppose generally have the best intentions, but if they run out of money, the client runs out of money, with their back against the wall that relationship will fall by the wayside very quickly.

Interviewer: If you think of all the fraud and all the things and perhaps not the environment you work in, there is some horrid stuff going on in terms of paying contractors

Interviewee: Yes, no for sure.

Interviewer: Thank you Ronald for your time and input. Obliviously this is not bias research and your input is valued.

Interviewee: Only a pleasure.

INTERVIEW THREE

Interviewer: Hi Luke. Can you hear me?

Yes, yes now I can hear you.

Interviewer: Thank you and welcome to this Zoom session. Again, thank you very much for setting aside some time for this interview.

Interviewee: No, no problem.

Interviewer: So, to start I thought I might just give a quick overview of the reason behind this interview.

Interviewee: Ok

Interviewer: The investigation just looks on how the BIM with the new Block Chain and then into a Smart Contract can assist all role-players in the industry to quickly verify work. Trace that the work has been done and according to the standards. The money will also already be there and as soon as all those standards (ticks and balances has been checked), it gets verified. Currently the traditional way of doing it is a certification (it gets signed off by the quantity surveyor). Its more paper related where this process might make it more electronically and easier and perhaps just relief some of those notorious works. What is your opinion about the framework when you listen to the idea behind it?

Interviewee: From my side, I've done a couple of projects as the Principal Agent and JBCC as well as well as the QS. I think looking into the contract as well. It's not purely just an obviously you can do the as built and certify the work. Sometimes there is some human intervention necessary. But I surely agree that there needs to be a more stringent and a more (how can I put it) fixed term payment from a client, because as soon as a principal agent signs the payment certificate, the client normally got (I think 7 or 14 days to pay depends on what

you write in that that JBCC) but after that the client still keep back the payment. And I can't intervene with a principal agent's payment certificate. So that is the one thing. One needs to look into the actual contract and what is written in there. Secondly also the cash flow on any project is obviously the main thing. There are obviously the 3 or 4 parties involved in the process. The builder builds he claims. The QS does the payment valuation and the Principal Agent certifies and then the client needs to pay. That is just to keep the ball rolling.

I think that is important. Cash Flow is very important and that is why I try to sell QS's on that side, because if there is a…it works both ways. You can't over certify or over valuate and overpay versus underpayment is also very important and I just think each should be fair. But needs to be a cash flow so the client can say listen guys I am going to run into a problem in the next month or two, what can we do? I think that is the main…that is the problem these days. The people don't talk to each other and everyone wants to sue each other but, in the end, (I mean) the lawyers and advocates and the arbitrators makes money out of these cases. I know of a couple of cases where lawyers contacted me to be either expert witness or just to be a mediator in the beginning. Try and settle those disputes, because 90% of those disputes are about payment as you know. I think it is a very good idea that we try to streamline (or to make it more fix in stone), but one needs to obviously look at the contract as well. How can the JBCC or GCC assist with that process. Make sure that right through from the start everybody knows that and also you got the construction guarantees and payment guarantees, and payment guarantees vice versa. That is also one thing. You don't call it up etc. It also Interviewer: Yes, maybe the thinking is that instead of giving a payment guarantee (you can still give a construction guarantee), but maybe instead of giving a payment guarantee the money is already in a trust account.

Interviewee: Yes, a trust account.

Interviewer: Exactly. Ideally you can use your JBCC and set your parameters up from the start in the smart contract which is also linked to the BIM and then once the work has been done according to the BIM then you as QS will then verify that the work has been done (it will go through all the standard checks and procedures still, the QS and all the role-players). And then automatically that portion of the value of work will be available for payment. So, the only difference I think is that the money will be released easier or sooner.

Interviewee: Another thing we just need to keep in mind is that also the invoicing of that certificate etc. If you do use block chain, or any currency, how is that going to be dealt with invoicing and tax purposes? It's good that there is a … in a perfect world the client will pay what is certified etc. And I think most of the hiccups is because …ja I think when the principal agent needs to sign off the quality as well. So, we as QS's, when I am on the QS on project, I try to look at quality as well. Obviously, it needs to be a fair reflection of the work that was done. So, I can't go into much detail on the quality that is why the architect is there and the principal agent. I can certify R2million and the principal agent can say I am only gonna certify R1.5million for the payment certificate so. I think it is a collective negotiation with all parties. The client obviously needs to know upfront as well what is going to be next month payment certificate. That is why I stress cost control and cost reporting. Ja and the cash flow is especially important. And the client must say, listen the bank (obviously the banks). I am dealing with banks like you won't believe especially residential houses where a bank valuator goes out and he then looks at the work still to be completed and he deducts that off it. So, you can actually plan the actual work to date, he still looks at what needs to be done.

Interviewer: Sjoe!

Interviewee: So, we have got that problem in the banking industry as well on bonds.

Interviewer: They have their own set of rules.

Interviewee: Correct, correct. So, they obviously pay the builder directly and the rest he pays to the client. It is also just one thing that we need to keep in mind that a lot of these clients don't have the money in the bank they also have bonds and loans.

Interviewer: Building loans

Interviewee: Correct.

Interviewer: In your perspective do you think that in South Africa people are very set in their way still or do you that the industry in South Africa is very adaptable or will adapt sooner or later to all this technology coming to our doorstep?

Interviewee: You talk about BIM. I know about BIM. I am an old school QS. I've got people measuring up for me, but they surely know what it is. I think it is the right way to go, but obviously it starts with the actual architect, setting up the layers and do everything so. I think everybody normally jumps in and starts working instead of having a coordination meeting. And the problem with that is also there is. I mean I've worked with developers as well. Developers are undercutting all of the consultants. You save up otherwise it's not feasible. You can't have everybody on board from stage one for instance. Purely the QS and some engineering form, just getting involved … per hourly rate or something, just in the beginning. To set up a coordination meeting and clearly stipulate who needs to do what and what can work further down the project. I think that is very important. Somebody said our health and safety also needs to get

involved it its COVID and I have dealt with a couple of seminars the past two three months. So, they also say that there is now 10 to 15% increase in health and safety because of COVID so, I don't think anybody budgeted for that so that is also something. You need a contingency in your cash flow.

Interviewer: This COVID has increased the P's and G's quite substantially now.

Interviewee: O no, definitely. And I think the BIM is a good idea if it is properly set up. It makes our work easier. You can pull it our etc. do a couple of changes like formwork and those kinds of things. And then the next is the builder, do the proper tender documents and do the proper tender evaluation and adjudication. Not just the cheapest guy but I mean obviously rather look at quality and all those. We normally … everybody is looking at cost cost, and at the end it is not normally the cheapest.

Interviewer: No never, because they may not have the capacity what you need them to do.

Interviewee: Correct, and quality as well.

Interviewer: Yes, quality as well.

Interviewer: And then in terms of…the JBCC it is very "instruct and do" type of contract. What they also call it is a "master servant" contract. NEC is little less like that, but would you say that the current contract (standard contracts) are really treating parties fairly on both sides?

Interviewee: Well, that is what Professor Maritz from the JBCC (I've met him a couple of times). We also had involvement in one project and where we negotiated so, they try to do that. With the latest JBCC 6.2 the Principal Building Agreement they had all parties involved. They had the Master Builders Association they had the Architects they had the QS's and even Developers from SAPOA etc. So, they really

try to fix all the previous wrongs in the contract. I mean a contract is only as good as the people who runs it. So, your principal agent is very important and I think you even can say you need to do a proper course or get a certificate or agree on a principal agent in the JBCC as that is a full-time job. A lot of people don't take that very seriously.

Interviewer: They underestimate it?

Interviewee: Correct. I think the JBCC. Normally the disputes are about the money and I don't think if you run it correctly, I just think there is a lot of paperwork with the JBCC. Notices backwards and forwards, but I think from the start you said the tone right saying, "listen guys we are not going to through each other under the bus, but this is important for us". And another thing that is neglected by the JBCC is the schedule or the programme. Especially on an extension of time claims and those kinds of things. Nowhere does it need to statethe detail of the programme and I think that is also one thing that wecan also put more focus on. Do a proper schedule from all the contractors and a detailed schedule, I think that is important.

Interviewer: Yes, that is very important.

Interviewee: And that is perhaps that is one of your links and it's also a link to your cash flow. Normally you can draw out exactly from that what your cash flow is going to be.

Interviewer: Yes, that is a very valid point thanks.

Interviewer: Would you say that the framework I just mentioned can also assist with less disputes? Think about if BIM can tell you exactly the trail (think about a paper trail) in an electronic version. There was a variation and records everything that happens (any changes, any spec changes any variation in terms of design and scope). Would you then say that something like that type of framework can also

assist in reducing the number of disputes?

Interviewee: It can perhaps streamline it and make it easier and it could also be a reminder for everybody because some contractors as you know has not used the JBCC before. So, if they have some form of reminder or something. You must not put much admin on a contractor he already has a lot, but I think there need to be certain criteria or certain tick boxes that you need to do. I think definitely a dispute will be minimized. And as we all know (I mean) disputes are …90% are about money, so if you can handle the extension of time and the claim by the principal agent as well and take it back to the contract that he is not going to lose money and obviously carry on. I think it is all the best is to get the project within budget on time on quality, but we all know everything is ja…most of the projects are over budget and everyone hopes the projects will get into budget but obviously that detailed design in the beginning was not done. A proper schedule was not done.

Interviewer: Story of our lives.

Interviewee: Another thing is the risk register. We do a risk register and risk analysis and on that we base our contingency on. So if you got a contingency on a project that is enough then obviously it is going to come into budget, so still the client must obviously if he is going to loan the money he is going to pay interest so it might not be feasible. So, it is very tough to put a contingency onto the project. We need to think about it, list the risks.

Interviewer: Yes, that is absolutely true what you say.

Interviewer: I think maybe for a final question. What would you say would you think the benefits would be that you can see coming from this framework? If you can maybe just key highlights three or four type things you can see that can actually assist the industry going

forward?

Interviewee: One is I think you going to save time. I think if the client pays on time and the money is transferred to the builder then obviously, he will not terminate or give notice to terminate. On the minor works of the JBCC I think it is 3 days and he can terminate. So, I would say you going to save time when this is put in place and obviously time is also money. I think we all are professional, and we strive to be better so if we can concentrate on what we need to do and the rest taken care of, I think we will save money and time.

Interviewer: And then perhaps, I don't know if you would agree, but I think trust is also a big issue between parties.

Interviewee: No, definitely, but I mean, back in the day it was a handshake and you build. I think working with the attorneys and the advocates, I think they are the only one making money and at the end it could have been settled on a mediation basis and agreement. At the end you need to be fair that is the most important.

Interviewer: So maybe this framework will also create some transparency, so everyone knows exactly where they stand?

Interviewee: Correct and a client needs to know the deliverables and responsibilities. That the money is going out of his bank account or the crypto account to the builder and he knows that as the cash flow is there. If that is there everybody manages that. The QS manages that. It's like a wheel, everyone has he's job to do and then the wheel keeps turning.

Interviewer: And the wheel might just turn a little bit faster. A little bit faster process than to the manual process.

Interviewee: No, definitely. I think trust like you said, is all about the history as well. I mean how all the arbitrators handles the cases; they go look

at court cases. They not construction experts or QS's. They just make an adjustment at that stage. But some of them could not be fair or fair to the other party for instance. It costs a lot of money.

Interviewer: Yes, people who does not work in the industry do not always have understanding of the processes.

Interviewee: Yes, it is an interesting industry. I got three years' worth of CPD points the past two months and we had like three or four discussions on all the contracts and experts from America also sitting in and discussing the FIDIC and the NEC, so I've got hope for the QS industry in South Africa. I think everybody, they always say we always try to take the lowest tender. I think we have a pivotal role and I think we need to be fair and the code of conduct. I'm one of the QS's that works on both sides. I am working for contractors and working for clients.

Interviewer: Oh okay

Interviewee: I always say let's be fair and I mean everyone is entitled to his mark-up, but from my side I think if the system is in place everyone knows what needs to be done, it happens automatically its less stress for all the parties.

Interviewer: And just less paperwork, quite frankly.

Interviewee: Correct, correct.

Interviewer: It's all in front of you. Everyone has got the same view or the same screen or the same data in front of them as you got and it's just a matter of clicking yes.

Interviewee: Your alignment and collaboration, there needs to be collaboration.

Interviewer: Obviously, it is a very high-level definition.

Interviewer: But I do respect that you work on both sides. The reason why I say

that is that most of the times you only work on one side and then they are very bias. It is therefore very refreshing that you can appreciate both sides …like you said everybody deserves their cut. Nobody is doing charity work.

Interviewee: No, no definitely. And in the end obviously all is open to negotiation. Like now we got that one project where we said to the builder; "listen we've got to wait three months, and then we are going to carry on again. It's only two months' worth of work". At least we are open and upfront. Let's get that money in and then we can pay you for the work done. If you start now, me might not be able to pay you end of June for the work done. And if he said, no its fine and carried on, it's obviously a risk for him so. I think everyone takes a certain portion of risk anyway.

Interviewer: Luke thank you for your input, some great pointers.

Interviewee: Pleasure, let me know if there is something else.

INTERVIEW FOUR

Interviewer: Hi Phil

Interviewer: Can you hear me…

Interviewee: Yes, yes hi

Interviewer: Hi Phil. Before we start must I quickly glance over the theoretical framework again, or are you happy with the umm…

Interviewee: I'm happy. I've got it open here in front of me. I take it is what you sent me the other day. I think you said over here…what was it….an informal discussion of the theoretical framework and how you think it can assist the industry when it comes to payment delays and disputes? We will also touch on the legal obligations of parties and performance. I also want to reference the pdf you sent me. You say you are recording this hey?

Interviewer: Yes.

Interviewee: I should watch my language they hey? No, I'm just joking. I am used to teaching.

Interviewee: Good I have your pdf open, so if we need to reference anything there, it will be easy for me.

Interviewer: So just too quickly give you a quick background. So, the theoretical framework is how a combination of BIM with the Block chain (which is actually quite new in the industry now with the development of cryptocurrencies) and then the third element of Smart Contracts. How this framework can potentially increase performance of the contractor and the client in the built industry, built environment, because (you know) research has shown that the biggest problem in the industry is payments. Disputes over payments and work that has been done and verified. As soon as the

scope is settled in the beginning and as the work progress you tend to see the variations are place with the client's request (for additional work) or the contractor does some additional work before they get approval from the client. So obviously that creates disputes. Then comes the payment delays and non-payment. This is a theoretical framework to see how we can overcome this obstacle. If that can be eliminated, then construction performance can be increased, and things can move better. Not only does payment delays cause cash flow problems it can actually cause the entire project to come to a halt. That is why the BIM element for me is so important, because that can be the single source of truth and maybe

before we start into the "nitty gritties", I just want to get your (maybe if you know) …BIM in South Africa, how much is that being utilized at the moment?

Interviewee: Look I am not part of the industry in that sense. I get people who does a lot of projects in United Emirates and who need to conform to certain standards. Normally the British standards and to deliver both to the council in Dubai as well as on the British projects. These things are run by principal agents and then they push out 100 or 200 billion-dollar contracts and then that get farmed out to South Africa or China. In that sense worldwide we are. We are mostly cheap labour. We are people with intelligence, capability, and intellect, but we don't demand the position of the world where it's formalized. I think this is also where your proposal and framework come in. To my mind we are so far behind. There is certain pockets of excellence if you look at our biggest client say SAOTA Stefan Antoni. They do the Atlantic seaboard in South Africa but that is only a small partof their business. They also do Los Angelis, China, America. All over the world. In different languages many different languages. There are many different protocols and they have to develop. Theyfocus on high end residential (high end) and small skyscrapers. If you look

at AURECON, AECOMS those type of guys. Those are bigger and they are better. And they have got create skills. These companies have got the most amazing skills but their framework around them is South African based. Lucky some have been taken up into these international companies who does fantastic workoverseas. Myself I am not a maths guy, I'm a workhorse. These arethe guys that are implementing the standards. So, if they are capableof doing the work (CODI). It is one of the things that SouthAfrican's stay away from and that frustrates me. Codi deliverable is something that the American Military and the British Parliament …which they require, right. It is a spreadsheet-based thing where…it's

not a relational database anymore. They output information onto spreadsheets from where they can then leverage that. It is a different way of recording information for a building over the next 60 or 70 years and how it must be managed. I'm talking about a building, but it could be any infrastructure. During the design process it is normally where I see things and then it goes into construction.

I spoke to guy in Group 5 that programmes their buildings. He had 90 construction managers under him. He showed me their models, but he had three people in the office. Five maximums. And you can imagine they are doing shopping centers that are kilometers long. Some of the projects are bigger. Skyscrapers. Great company, nothing wrong with them, but with BIM you need to record information from design through to construction. You cannot do that with 90 construction managers. Programme everything and manage the construction programme.

So, the idea behind this Blockchain is great. I don't understand the technicalities, but I understand from what I see and what you have put together that it is dependable on multiple entities that then carry the encryption forward into the future and you can't unroll it. So, one person can usurp the process and roll it back. And that is great, and getting triggers where people get paid is perfect. So, I kind of get where … a lot of the time the supply chain does their work and don't get paid the money upfront, which they should. So, they cannot invest and then they get short changed. They get it through to council and then the client changes his mind and then now they want something new. What the attitude behind it is (I have got my own opinions), but that is not relevant. Payment disputes pertaining to scope changes and so forth put tremendous stress on the supply chain. What is relevant is that the client has power because they hold the money.

Interviewer: Exactly, that is a particularly good point.

Interviewee: Correct and the supply chain is desperate because they are working in an environment where they are not getting paid the right amount of money upfront. That is where most of the money can be saved, where you spend at the beginning. So, they get short-changed to start with and then at the end of the project something new is thrown in and that is already after the critical decision points. Whereas overseas they have very definite decision points where they say, when this is done a cheque gets written. And then it is done. If you want to come and change something afterward you need to go through the process again. Not mind doing the work, but you need to pay us.

Interviewer: Would you say it becomes a totally new project?

Interviewee: Yes, that is how they do it overseas. In South Africa it is (jeez). So, look the owner wants to get it certified through council and once they got it through council then they want to change. Then they want to push the boundaries and get away with it. Now he is not paying extra money for that. That is coming out of the pocket of the architect. What good it that for the architect it does not gel. So, these BIM processes, how it should work. I don't know of one person in South Africa who is properly perfectly situated who support the client.

Interviewer: May I just stop you there for a moment. As-built drawings. Am I correct in saying these drawings are updated as per construction progress on site?

Interviewee: Yes. It is not just progress, it is also predictive in a sense that if somebody throws a floor, 50mm to high. Suddenly you are going to get clashes next to it. Something is going not going to fit. So, you

know that you are going to stop that construction site now for however many weeks and waste how many millions of Rands.

Interviewer: So that for me will show me exactly – point in time why there is a, why the site has come to a halt so that could be a contract instruction, or it can be a claim. It can show exactly what the cause was. It is transparent for everybody to see. Is that correct?

Interviewee: That is correct but think about the design. If I don't have space to put my ducks into the ceiling because floors are thrown too low and then two months from now, we are going to find out things don't fit.

Interviewer: Ok, but that has got to do with the design phase, right? But what if you are already in construction how will that work?

Interviewee: It's too late the client will have to pay again.

Interviewer: See but that is exactly the issue. This is where all the problems and disputes come in. It's always a problem from no I didn't give you the instruction, it's always an issue. So, what I'm asking is, BIM will now show you exactly. It's not a paper trail, it's actually an electronic trail. It can actually go into detail to state that that spec change was change was authorized by you.

Interviewee: I like the idea more of the Blockchain in that to make the client understand that once they go past the point of no return, it's done. There is no deposits and no returns, it's done.

Interviewer: It's like a pay as you go type of system.

Interviewee: For everybody.

Interviewer: Yes, and not these elaborated contracts and at the end of the day we will now firstly verify the work and then you will get paid. Now we are saying. This is the work. BIM have quantified the work. The

obligations have been met and now payment is due. Pay now before we move on.

Interviewee: And then you put the money in escrow.

Interviewer: Then everybody knows that the funds are available.

Interviewee: And also, that the funds are available at the beginning of the project so that the maximum value can be extracted.

Interviewer: Exactly, and they also know what the limits are.

Interviewee: That to me makes sense. This entire idea of your framework makes perfect sense to me.

Interviewee: I get frustrated because my clients do not get paid what they need to get paid. When they don't get paid, I don't get paid. Currently the leverage contractors have to enforce payment takes a long time and is often referred to litigation.

Interviewer: Yes, that supply chain you talked about. It ripples far beyond.

Interviewer: Do you think there is a culture of non-payment in South Africa?

Interviewee: I don't know. I know architects with repeat clients. The clients respect them because they can get repeat business out of them. And they respect each other because they get a certain level of service. But what is a level of service? Is a level of service that you are willing to go the extra mile for him? Are you going to feel special and is it going to build your character? You know when you keep on doing that and that is the accepted way of doing, it's not a…

That is not how they work overseas. Let me quickly tell you how they work overseas. You have a guy on the side of the client to make sure the supply chain meets their needs. But what is the other part of it. Pre contract award execution plan. That is before they award the contract. Let suppose you and I each have our own supply chains

and competing against each other for a contract. I want to prove that my supply chain is better than yours. And that we have a better track record and better technology and better skills. And you are going to do the same from your side because you want the contract as well. We are not only going to look at our design side but also the contractor (he's going to be part of it). The sub-contractor is also going to be part of it. And that all happens before the contract gets awarded. And if they have not got the skills or the technology there is a road map, that is actually mapped out in the contract to say, ok fine you don't yet know what to do, it is not a problem but we need to do is train you up so by the time you need to do what you need to do you can do it.

Interviewer: Wow I never knew that.

Interviewee: Yeah, you can find it online. It is all British standards. And it's all detailed, in fine detail. Here we tend to think, yeah o well. You have the Principal Agent, which might be the architect and you have the contractor. Who is the representative of the client? Excuse me how does that work?

Interviewer: The principal agent is not supposed to represent the client or the contractor, he must only represent the contract and enforces the contract.

Interviewee: Who does he answer to?

Interviewer: There is also a problem depending on the type of contract. Some of the contracts are instruct do contracts.

Interviewee: We have got great skills we have fantastic everything. I get so frustrated as I can see the opportunity. And the framework like you are proposing it would work, but it takes a change in thinking in the sense that yeah ok, I might be the client. I might have the money,

but it does not mean I know what is best. If I am not a BIM specialist, why would I pretend I am one?

Interviewer: But if you look at BIM and all the levels of BIM. BIM can do everything in a project except look after contract obligations. Do you think that can be the final level or key to put into BIM?

Interviewee: Yeah definitely, definitely.

Interviewee: You raised some issues which are fair you know. But if it ismanaged correctly. If people use their common sense one can bridgethis. If people have a specialist to interface with it will makeeveryone happy. You will not sit with the stress and to manage the project. But then I must accept I need to put the money down in thebeginning and I also need to accept that there is a certain time in thisprocess that what is done is done. I get where you are coming fromwhere there are people that blame after the fact and it's a reality. Like you say there is always conflict. Some use Revit and Navisworks. Time lining of buildings (billions of Rands). When they apportion blame, they drag the guys off to court and they get fines which is not pleasant. And I would like to get to a place wherethe protocols are employed simply because everybody gets along. The money gets made; people get jobs. We get respected globally for our skills.

Interviewer: I wish people would realise that. Things are changing and if you are not going to move with the changes you will be left behind. Everyone talks about the 4th Industrial Revolution. AI is here.

Interviewee: Correct you are absolutely correct; I have nothing to add to that.

Interviewer: Phil, just to come back to the BIM-Blockchain Smart Contract Framework. Perhaps just some final notes – from your side. Out of the box high level, what do you think are the benefits from your side

on this theoretical framework and what it can offer the industry as a whole?

Interviewee: Firstly, that architectural companies and constructing companies, whoever is responsible for performing the work that they are getting paid the correct monetary value for the project. So that they not under paid for the project. That is step number one. And that will happen because the client will see the advantage of spending at the beginning of a project and that they should have their own representative to look after their interests.

Interviewer: Yes, that is a good point.

Interviewee: And that the client knows their own responsibility for the project. And does not see the project as an extension of themselves but rather sees the project as something bigger. So, everybody has a role to play.

Interviewer: Those are particularly good pointers especially the owner representative. A representative for both sides to be able to ensure their interest are protected and that they can do what is best for the project and not what is best for disputes.

Interviewee: There is lots of potential. The general culture out there is we think too small. We think like South Africans and not like New Yorkers, Tokyo or Hong Kong.

Interviewer: I do like that point.

Interviewer: Where do you see the construction industry in the future?

Interviewee: A lot of construction is going to be pre-manufactured. They are putting a lot of

Interviewer: And assemble on site.

Interviewee: I look at quantum computing and IBM have already created what they call circuits where the amount of optimization is. What it is going to be able to do is just unbelievable. To me the danger is always going to be. It's exactly like they said at the world economic forum about (what not this session the last session). Where they were speaking about automation and how the danger is that it will funnel money into the hands of a few and it will not be spread around. I am not of that thought. Coming from having done third dynamics I've think of automatization as automatically going to create chaos so there will have to be more work. Like when you going to a workshop and you start making a chair you going to make the place dirty. Shavings everywhere. You must clean it up and it's a lot of work. So, you need to hire a cleaner and it is the same thing with buildings and designs. Yes, we are going to have computers, but does that mean that we must get rid of the people in the office?

Interviewer: No, you need to have the human element.

Interviewee: But what do we want to do with the human element. We need to train them and educate them so that can be more valuable, more creative. Optimize the program or even just come up with studies say – ok guys so what is going to be the most efficient design where people are going to work and live.

Interviewee: People see a computer and software and think that is their capital. What about the human being sitting there?

Interviewer: They do, that is a valid point.

Interviewee: Human beings are much more important than computers or software. Computers are not as creative as human beings. They don't have ideas and they don't have emotions and they don't impact us the same way as other human beings do.

Interviewee: We think we do not have to think like New Yorkers we can think like South Africans, but YES YOU DO, it is a global landscape because you are competing against India. You are competing against Russia. You are competing against China.

Interviewer: Yes, I agree. Would you like to add anything else before we end this interview?

Interviewee: No, I think I have given my input and personal viewpoints.

Interviewer: Well thank you Phil, it is very much appreciated.

INTERVIEW FIVE

Interviewer: Hi Mike thank you for your time.

Interviewee: Pleasure.

Interviewer: Just to recap, the study investigates a three-legged framework which is a combination of BIM, BLOCKCHAIN and Smart Contracts. Literature has shown that there is a big problem relating to construction payments where construction payments are made late due to various issues. To overcome this issue, the framework is investigated to see how it can automate payments and overcome payment delays or payment disputes. So, you are a BIM Architect, right?

Interviewee: Yes.

Interviewer: My study mainly focused on the South African construction industry. And within the construction industry we all know that the client has most of the power when it comes to payments and our agreements are also aligned as such. South Africa is still lacking a more collaborative environment and trust between parties. I would like to understand from you as a BIM Architect firstly what would you see would be the benefits of such a theoretical framework? Do you experience or have experienced that there is a problem with construction payments and payment delays?

Interviewee: Yes.

Interviewee: Crucially I think for me there are two things. Do you know the term EPM (Enterprise Performance Management)?

Interviewer: No.

Interviewee: It is a field of performance business management which considers the visibility of operations and a close loop model across all facets

of the business enterprise. Business planning forecasting and financial management. Basically, what that means is that, I mean now a days most contractors have systems in place to help them analysis and report on their business which is from HR to your production to technical delivery, your BIM right through to everything. Time management, everting. So, EMP solutions are primarily used by CFO's and the office of finance. I think lots of them use operating systems like Oracle and these types of things, because that I think is part of this. It all ties together in terms of your contractual, you want to manage the finances in terms of payment so, this all ties in. So, it all depends on who your end user is.

Interviewer: The focus is on developers and contractors. Where the JBCC is used a lot and where you get this "master servant'' relationship which is not as collaborative as say for instance the NEC. The research is therefore really focused on the South African industry and on how these relationships can be changed.

Interviewee: So, we use Navisworks as a tool to track the 3D, 4D and 5D elements. 3D you know, 4D is time and 5D is cost and 6D is facilities management which is as built when you hand over a project. So, everything in BIM is gearing towards being 6D compatible which means the architect hands over the project to the client like Old Mutual or Sanlam or whoever the case may be. They now don't just have a stack of drawings gathering dust because we are moving away from this paper environment. So, the stack of drawings that sits in the corner of the office gathering dust is not any use to anybody. So, the client gets a model which is a proper BIM model and been populated correctly from inception to as builtto handover to facilities management. The facilities management company they use artificial intelligence (AI) where the facilities management company can walk onsite or with a smart phone and they have the software, they can look at the air conditioning or a

duct. It can tell them when it was installed, by whom, the warrantee and when does it need service again. And so, with every light point and fixture. Everything. Every door every door handle. So that all take you towards the final product and then something else we use COBI deliverables which is just process a BIM process. Okay, in Revit this process, what the contractor would (they do it actually) is they set up large cameras on site to track the progress but how do you, you know like, this is week one. It is a record off course. With BIM software and Navisworks we could animate videos to project managers programs like PSets, Primavera, MS Projects and so forth. So, the contractor operates two-fold. It has a live camera, his got the animation. It is break down day by day, month by month and it foresee the duration of the contract. 24 months or 36 months and during that you can tweak it and the project manager can go back and tweak his programme. He can feed it back in. And that, Navisworks for example where the 4D comes in on cost. So, you can do proper cash flow projections because critically what a contractor wants to avoid during this whole thing or this whole process is not spending too much money (especially in a country like SouthAfrica) where he has to store materials and steel and doors and it gets stolen. He just wants to buy enough. He needs to know exactlyhow much steel, rebar, how much concrete how much tiles how much whatever he has to have for month one or stage one or stage two and stage three. Because the other problem is lay by areas, where do you store this? You want to store it as close as possible tosite, probably onsite and you want to plan everything around that, so. All the programs' controls, cash flow and then ultimately it goesinto what you want to do is control when do we get paid what. TheBIM model can tie in with the Blockchain which will allow for payments to be automated.

Interviewer: Mmm.

Interviewee: You know I've bought R100 000.00 of material, it is lying on site.

If it is lying there for two months and I only get paid on invoice and then I have to wait another 30 or 60 or 90 days, it hurts you. When the client refuses to pay for the material upfront you don't have much of a choice that to carry the cost of material lying on site. With BIM you don't have to.

Interviewee: South Africans are a bit slow on BIM, why? Well, it is much smaller projects and notoriously very lazy. Most of my colleagues left behind 12 years ago. Some of them ask me what is BIM? I am talking architect's and stuff. With BIM you can get away with a third of the workforce, but the front-end loading of information is much more. In CAD you don't have to put in much effort in the beginning. With BIM your input is much higher in the beginning but at the end it is much easy. BIM is like getting an oil tanker started and get it up to speed. I mean if you want to uhm I will use the example of a speedboat with two outboards. It's like a Porsche or a big formula one car, I mean your takeoff with a boat is fast but you can only reach a maximum and because of your momentum and size of your boat you've got no momentum if you hit an obstacle or whenever you have to stop you stop abruptly. An oil tanker takes time to build up speed but once it is up to speed, 20 knots it can only stop in a kilometer or two sea mile because it's got so much momentum and that is what BIM is. So, CAD can get you out of the ground quickly and that is how people are still set. Especially people in South Africa. It's been helping them for years, that is what they know. That is all they have to worry about. Whereas BIM is a long process and you are building up momentum and once you get going you really have momentum. From a contractor's perspective, BIM has also changed the contract. The way you see things now cause now you gotta think about... a contractor, a clever contractor will do BIM properly.

Interviewer: What you now talked about, the front-end loading on your BIM

much higher and it is a much better concept but the way things have been done in South Africa is to get a set of drawings and there is always variations because things have not been planned properly. Would you say that something like BIM would also be beneficial to that?

Interviewee: Yes, yes for sure. Because now we work on BIM 360 which is a collaborative platform and on the cloud. So, what happens is the architect does a BIM model, engineers do a BIM model and it gets uploaded on BIM 360 on the cloud. So, if the contractor is clever, he invests in this as well and his got a team because it's kind of a live…you can download the models and here is the thing now with variation. So, you can compare models. The one I gave you last week as opposed to the one I gave you today. On BIM 360 you can compare the models and BIM 360 would give you a printout, a markup of all the changes happened automatically. Whereas before, you are going to struggle to keep track of all of this. This ensures that there are proper records and the changes of disputes are reduced. Should there be a dispute, it can be justified with supporting documentation and quantities very fast. It provides teams with transparency in pairing the models.

Interviewer: Exactly, how does the authorization work. So, who will authorize that? In South Africa if there is a variation order your client will need to sign it off. How will that work in BIM?

Interviewee: In South Africa I use to have a site book with three copies. So, if the client gives me a variation order to change something, I write it down. He has to sign. One goes to the contractor; one is for record and one you keep. So, there has to be a paper trail on who initiated the variation and then obviously who authorized it. The contractor will get the written variation, but it has to be officially ordered by the architect or the principal. Either the project manager or the

architect has to give written notice to get contractors costing. There is thus a paper trail. These methods are dated as is a manual process which happens in parts. There is a confirmation that somebody has changed their minds, or you had to because of site conditions, so there is variation. Now, you update your as-built work on BIM. But even that the engineers they have done a conceptual model and now it develops. Value engineering happens in the BIM model. There is a written agreement that every week has to upload their working stages models. All the changes in the model gets tracked through BIM 360. And you can now say all right it's a variation. So, the contractor if they are clever in South Africa hopefully the construction team for transparency pairing the models. You were talking about ownership where does this start and end. It is easy to control. The architect has got his architectural modal, the engineer has got his engineering model and so forth and so forth. And by working jointly on BIM 360, they upload and link the models and they can pick up where the problems are. So, ownership of the project is shared between everybody but the architectural model that ownership will always stay with the architect. Everyone is updated and there are no questions on what is required. At some point they will pass it onto the engineers and tell them to develop it into a proper construction model, but they don't take ownership, or you start your own model from scratch. As long as at the end of the day the models come over and they look and working together. So, when the architect makes a change, the engineers can immediately see whether it will influence their designs. That whole trail of communication and reports is taken care of. And that ties in with construction. In your contract you will then have to mention all of these processes. Who has got ownership, who is controlling all of this which creates the trust and collaboration you mentioned?

Interviewer: I think you have given me a lot of information without me asking

any questions. What benefits can you foresee for a South African contractor or a South African developer having such a framework?

Interviewee: Number one it is going to give him a competitive edge against anybody else that is not doing BIM. Why? Because at a very early stage using BIM at pre-tender stage, which is ideal. If it is possible for him to pre-tender to use it for bulk measurements, he's going to be plus or minus 5 -10 percent not having the correct quantity. There is no way that without a proper BIM model you can measure and tender correctly. So, what happens is that the guy that is not using BIM. He has got 6 weeks to sit with all the tender documentation and tender on this project. He's got 10 guys trying to figure out what is going on here. The time is running out. It is costing him money, but it is a building of 5000 square meters. What is the current building rate? Hmm R10 000 a square meter. Is it a complicated building? Do we need the work? Are we hard-up for work? So, we load it. I actually don't like the client. I don't like the type of project so, we tender high. If we get it, we are lucky if we don't, I don't care. Then there is a guy who desperately needs to work. He under quotes and somewhere in between there is people. This can become a serious problem later on as these inaccuracies can turn into disputes and even go as far as going to court. Now with BIM you are going to be correctly positioned. So, a cleaver client will only allow a contract to a contractor that is doing BIM. Because he knows that contractor has got a precise idea of what of everything. Ok so, it will help the contractor to secure future work and keep on securing work. It will give him a stand or a kind of a standing in the community that with big end clients like Murray Roberts for example and those kinds of guys. They use BIM they understand BIM. They chance of getting future contracts are just much better than…so that is number one. Number one is much more profitable and more precise to win work. You are going to know I didn't under quote, and I didn't over quote. I want a profit margin of 10-15%. If

the information is correct you gave us Mr. Architect and Mr. Client, this is what we can do it for. So, it is a confirmation and it is peace of mind that I am not sucking figures out of the air. So, it gives you the confidence to tender more precisely, more profitability because at the end of the day if you use BIM you are able to control your changes. This will better align with the contract and contract obligations and you know you will have sufficient support for any claim than with the current way of doing things where it may be more difficult to support your claim.

There was a case study in America, where they worked out roughly, that for every change if would have cost about 500 dollars. Now that is a few years ago, probably 10 years ago. The contractor engaged BIM and they went to the client and said because of these changes my price has increased. With BIM your coordination is just much better as it is transparent, and all users can trust that the data is correct.

So in summary the benefits are: assist contractor in bid or tender to tender more precisely, peace of mind and confidence to the client that he knows what he is doing, competitive edge, advantage again of winning more work in the future, less abortive work cause if you can identify clash detections timeously you can avoid problems before hitting the site. By the time you get to site you know about the problem and it is already sorted. You don't want to get to site and start building and oh, we have a problem. And you need to know this very very quickly. So, it helps you to avoid abortive work and off course to save money. If you, do it properly (your contract) you can build much faster. You can plan and programme your work. If you avoid clashes and problems and change orders on site, then you don't have to break down or demolish a column or a beam that is in the wrong place. It speeds up and you can plan with all your subconsultants to come in at the right time not the wrong time and

sit around and fall over each other's heels for a week or two and waste time and money. Whereas you say listen we won't be ready for you be ready then, but then you have got to be ready.

Interviewer: Those are all good points, but say for instance you look at while a project is being constructed and you specifically look at the automation of payments part where (remember the topic, to use the framework to automate payments) so the contractor can actually get paid for his work as it's been done and not been left in the mercy of the client to get paid and disputing payments being it from a variation or cash flow problems. All the things you hear about here in South Africa. How do you think that can benefit from a construction point where construction has started?

Interviewee: Well again, with this whole process if you tell that if our program is correct and all goes well, we can issue or we can notify the architects that we would need an inspection for a certificate and we can prove without a doubt that by use of BIM and BIM 360 and all these types of things you can actually send these reports to the architect and say listen this is what happened, these are the variations. This is the progress this has been poured and here are live pictures on site. Our estimation was we that our first certificate was going to be 500 000.00 we actually in a good position. On our first certificate Iam only going to ask for 450 000.00. Actually, so we are way ahead.So, my cashflow projections for you is actually, we are saving time,but we are ahead of time. So, you know I don't need 500 000.00 I need 550 000.00 certificate and not as what we planned because I am ahead, but you need proof. And the only way now you can do it.The best way to do it, is with all your reports, your clash detection,your live models, and you can tie that in with costs. Because every element in a project cost something and you can tie that in with your framework. So, every screw every bolt, every nut, every door handle has got a price. Once it is installed it is not lying on site. So, you

will properly only get paid once it is installed it is therefore beneficial to have software that will guarantee payment, so the contractor does not run the risk of not getting paid. You can inspect that it is installed by virtual or visual inspection or virtual tour. Now with COVID and all this type of thing I don't want to come out to site. I can give you a virtual tour. So, we have drones, we have 3D scanning. I can send you all this. There is your proof. I want X amount of payment.

Globally the world has changed. And we don't know how long we are going to sit with this COVID problem so, projects can go on and there is less need for people to come out to go inspect the building or whatever the case may be.

Interviewer: Okay Mike, I think you have given me enough information and I can continue with my data analysis.

Interviewee: Like I say, if there is anything else that you need from me. I just gave you my views and what I understand and so forth. I wish you luck.

Interviewer: Thank you, it is appreciated.

INTERVIEW SIX

Interviewer: Thank you for your time and to provide me with valuable input from your side for my research.

Just to quickly catch up, the theoretical framework looks at how a combination of the BIM-Blockchain and Smart Contracts that is combine can assist the industry to overcome current obstacles that literature has shown in the industry. The obstacles that have been identified are mostly related to payment disputes and payment delays. So, this theoretical framework can hopefully resolve and overcome these obstacles in the industry.

So, the first question I would like to ask you is. In terms of the industryand your current experience in the industry, would you say the industry is currently fragmented in the sense of all the professional teams worktogether and only later on the contractor comes on board. Could that possibly lead to payment disputes?

Interviewee: Yes, no I agree. It is definitely fragmented between all parties up to, I would say up to when after the tender closed. Thereafter there are somecollaborations between professionals and contractors and possibly sometimes the client, but before then it is each to their own.

Interviewer: Would you thus say that a more collaborative approach from the onsetwould assist this process especially to identify early on any warning signs or clashes that may become a dispute later on and to sort it out earlier on, say up to tender stage?

Interviewee: Yes, no definitely. Unfortunately, I would say historically the way we (professionals) work in South Africa and in some other countries theyalso work like this. So, each body will basically work at his own paceand own view and at the end, like I have said previously just after

tender stage, they (the professionals) will get together. So, collaboratives upfront will definitely help.

Interviewer: Then I would like to get your view on contract management (currently) in the industry. What is your view on South African Professionals that is actually actively managing the contract, and do you think they refer to the contract as regularly as they should?

Interviewee: Yes, your question is whether contract management is poor or not or contract management practices bad or not. I do not think all the practices are bad, but yes in general it leans towards a poor side to it. Not all is bad. There are some systems that does work.

Interviewer: Would you say that people execute the contract properly and also do you think they always understand how to execute the contract?

Interviewee: No, that is what I am getting too. So not all is bad, but sometimes the people don't understand how the contract management practices should be applied and therefore you get to a point where you can't implement practices the way you should. People are generally concerned to get to the job at hand at more than often neglect the contract. It is a very administrative process. It is in the nature of people to give attention to familiar territories and contract management may not be one of them. Also, the contract is the roadmap and it needs to be utilized in order to increase the outputs of projects. Automation of these contracts may assist everyone to comply better with the obligations.

Interviewer: And have you experience any payment disputes while you have been a principal agent on a contract? Do you have any knowledge or examples you can give on that front?

Interviewee: I think everybody experience payment disputes during sometime of their professional career. The reasons are more than often problems with the measurement of the work performed or tasks completed or not

completed. Variation orders that has been brought on during the construction phase and unclear scope of work. Also, what sometimes leads to disputes is construction time that was allowed, and no extension of time may also then cause payment disputes in the end.

Interviewer: And that obviously has a direct impact on the contractors cashflow. So, for me, I would just like to get your input on how sensitive are contractors on the something like cash flow?

Interviewee: Yes indeed. The contractors normally work on a cash flow chart or likea forecast which they basically compile when they get awarded the contract. They forecast all their payments. The way the cashflow will work is on that forecast and if there is a problem and they don't get paid or full payment there is a problem. More than often, this can hamper their performance. Making the contract late or possibly there is a workmanship and quality issues.

Interviewer: Mmm, that is true.

Interviewer: And then also what is their remedy in terms of contractual leverage. The contract does make provision for certain avenues they can go to actually enforce payment, but in your opinion how strong is that leverage to enforce payment from a contractor's side?

Interviewee: The only leverage they have legally in the contract that normally gets used, NEC or JBCC is the Builders Lien. That is the only leverage they have. More than often the Builders Lien is there to protect them but once the banks are involved the Builders Lien is the first item that gets struck out of that contract because they don't accept a Builders Lien to be held against the project. So, I would say form a contractor's side they have got only that avenue and if that is taken away, they actually have got no other method to get payment out of the contract except going the legal route. If the construction company does not have strong

resources and cash flow, long winding legal action can mean the end of business for them.

Interviewer: Then you need to go to litigation, and you need to leave it in the handsof the courts to actually resolve the matter. Firstly, how do you feel about litigation and then secondly do you think an alternative system like the BIM-Blockchain, and Smart contracts framework would be more beneficial to actually resolve a dispute. Having a so-called papertrail before it goes to court?

Interviewee: Yes of course, I mean any litigation is costly, it is time consuming and have a negative connotation to the whole system on how it works. And at the end nobody really wins. Normally the project gets stopped or delayed. The operation of the project does not get to a point where the facility can be used. So, there is a big loss there as well in my opinion. Nobody wins through litigation. And if you can have some other way or method to avoid this by having a paper trail like you put it. Then definitely it can assist and perhaps avoid litigation.

Interviewer: All that we are talking about also affect relationships in terms of trust. How important would you view trust between parties?

Interviewee: It's like anything else. If you get to a place where you can't trust your professional team or your client, then you have got a problem. I think the whole project would get hampered by it. So, trust is everything in my opinion between all parties. It the triangular type of thing. You have the professionals the client and the contractor. They all need to work together. If there is a breakdown in trust in that triangle, it will cause some problems somewhere.

Interviewer: Definitely. So, the current system or the implementation of the current system is still very much a traditional paper-based system. How can this process become more seamless in terms of automation?

Interviewee: Off course there is advantage in an electronic process. I don't think paper-based systems will disappear in the near future. Everybody is still set in their ways in that regards. However, where you share information electronically that will definitely contribute to a more effective out roll of communications from professionals to the contractor back and forth and it will also assist in not receiving old information to site. So, the information that you will receive, you will know that is always the latest information on hand. And I think that is a big advantage.

Interviewer: Then again, there is less confusion and more clarity which leads to less disputes.

Interviewee: Yes, definitely.

Interviewer: The final two questions I would like to get your input on, is, would you view transparency as an important aspect when it comes to projects.

Interviewee: I think we have dealt with that earlier on. Transparency is everything in a contract or a project. I mean if the contractor is going to know that there is a payment issue and he gets notified in advance he can work around it as well as … if the professional team need to update drawings and it is going to take two or three weeks and say with trust this is where we are, surely you can then work around it. So, transparency needs to be basis of the whole construction industry I would say.

Interviewer: For me lastly, I would just like to find out. You know the history of thetopic and you understand the rationale of the theoretical framework. What are the key benefits that you can identify by having a framework such as the BIM-Blockchain and Smart contract framework?

Interviewee: I think at the end of the day the trust issue that we just spoke about. If the system runs as it should everyone will have the same information therefore it will increase the trust and transparency that way. Performance can increase if the system is electronic based and flawless

then construction performance will go up. Less disputes less litigation that basically limit that type of route to be taken by a contractor because everything is measured to date and available and cannot be disputed. And so, can the payment for that not be questioned if I can put it like that. He (the contractor) will get paid for the work done automatically after receiving approval. And for time spent to do it. At the end I think it is a big advantage to have all of that together so that gives you your BIM aspect your Blockchain aspect. Your contracts are the underpinning arrangement between all parties that binds everything together.

Interviewer: Ok that is great. Is there anything from your side that you would like to add?

Interviewee: Hopefully, we will get there someday, that this type of process can be available. From an engineering side, I think I am not just speaking for myself. But the contracts we have is sometimes very legally challenging for us and if there is a process that actually help any engineering and or contracts manager on that basis to put it in the right context then industry will benefit from that. A semi-automated process will be welcomed to alleviate most of these tedious processes.

Interviewer: Yes, that is a very good point. Okay, thank you so much for valuable input. I'm just going to stop this recording…