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Preliminary Study: Blockchain and Its Challenge in the Construction Industry

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Abstract

Despite the growing complexity of construction projects, stemming from diverse disciplines, the risk of human error and delay continues to escalate. To gain a competitive advantage, Malaysia's construction industry needs to develop new organizational and efficiency tools. The Construction 4.0 Strategic Plan identifies 12 disruptive technologies, including blockchain, which is a key area for advancement. Blockchain is a decentralized ledger technology that secures, verifies, and maintains transactions on a peer-to-peer network. Despite blockchain's potential benefits for the construction industry and its status as a disruptive innovation, its adoption rate has not met market expectations. This is due to the lack of understanding and support for blockchain technology, as well as the absence of transparent laws and regulations, contribute to the slow adoption. In addition, the high investment costs and slow stakeholder receptivity also hinder the full adoption of blockchain in the construction industry. Therefore, the purpose of this study is to provide a preliminary understanding of blockchain technology and its challenges in adoption for the construction industry.

1. Introduction

The involvement of parties from various disciplines has led to a notable increase in the complexity of construction projects these days, and the projects themselves involve a lot of complex information. Most procedures in a construction project are done by hand, which raises the risk of human error and could result in faulty judgments and delays (Alaloul *et al.*,, 2020). Therefore, in line with the current construction revolution, it is time for the Malaysian construction industry to come up with new organisational and efficiency tools sooner or later to achieve a level of competitive advantage in markets, locally and globally. CIDB (2020) in the Construction 4.0 Strategic Plan highlights that the need for Malaysia's construction industry to develop new organisational and efficiency tools to gain a competitive advantage in local and global markets. This plan has identified 12 main technologies also known as “disruptive technologies” which will change the future of the construction landscape, such as Building Information Modelling (BIM), Prefabrication and Modular Construction, Autonomous Construction, Augmented Reality and virtualization, Cloud and Real Time, Collaboration, 3D Scanning and Photogrammetry, Big Data & Predictive Analysis, Internet of Things, 3D Printing and Additive Manufacturing, Advanced building materials, Blockchain and Artificial Intelligence. Blockchain is one of the 12 emerging technologies that are key areas to bring the construction industry forward. Blockchain is a decentralized ledger technology that secures, verifies, and transparently maintains all transactions done on the top of a peer-to-peer network (Bazel *et al.*,, 2023). Blockchain technology has been popularly discussed in recent years. It has been widely discussed as the second wave to change the world after the Internet. (Kamel *et al.*,, 2023). However, even though blockchain has many benefits for the construction industry and is recognized as a disruptive innovation technology that is changing the industry, its adoption rate has not met market expectations. (Li *et al.,*, 2022).

Research by the National Blockchain Roadmap 2021-2025 reveals that the construction industry has the lowest investment intention towards blockchain technology adoption, with only 3% of the total percentage achieved, indicating a slow adoption of blockchain decisions. In addition, According to a survey of construction industry experts, only 20% had used blockchain in their projects, and only 30% believed that blockchain technology would play a significant role in the building sector over the next 5-10 years (Hamledari & Fischer, 2021: Luo *et al.,*, 2019, as cited in Waqar *et al.,*, 2023) This is due to most construction firms are still cautious and take a wait-and-see strategy when it comes to implementing blockchain. Despite the effectiveness and efficiency of using software and structural equation models to rank the predictive indicators of technology adoption, no research has been done on how these techniques are applied in the construction sector. (Li *et al.,* 2022). Okangba *et al.,* (2021) and Zhou (2022) as cited in Waqar *et al.,* (2023) also highlighted that the lack of understanding and support for blockchain technology could hinder innovation and its potential use, potentially leading to a lack of support among stakeholders. Next, Hamledari & Fischer (2021): Wu *et al.,* (2022) contend that the absence of transparent laws and regulations is a significant impediment to the broad implementation of blockchains in construction. Bazel *et al.,* (2023): Waqar et (2023) also supported that the slow adoption of blockchain technology in the highly regulated construction industry is due to the lack of established frameworks and guidelines. Besides, the construction industry has not fully embraced blockchain due to high investment costs and slow stakeholder receptivity, posing financial burdens for smaller businesses, as noted by Yang *et al.,* (2020). Therefore, the purpose of this study is to provide a preliminary idea towards the understanding of the concept of blockchain technology and its challenges of adoption in the construction industry.

2. Literature Review

2.1 Construction 4.0

CIDB (2020) through the Construction Strategic Plan 2021-2025 has defined Construction 4.0 as the process of implementing modern technology to encourage the digitisation of the construction industry and its supply chain. It also defines the transformation of the construction industry towards the Fourth Industrial Revolution, from automated production to a greater level of digitalisation. Fauziah *et al.,* (2020) mentioned that the revolution of Malaysian Construction 4.0 has revolutionised the construction industry by introducing a digital transformation through the use of emerging technologies. In order to address upcoming digital challenges, it is necessary to adopt a computerised protocol that will help automate contract performance. Construction 4.0 brings new technologies such as Cloud Computing, Mobile Information, Data Analytics, Artificial Intelligence (AI), Augmented Reality (AR), Blockchain, and 3D printing, which will play a vital role in real-time communication, coordination, and cooperation between construction stakeholders. The concept of Construction 4.0 is mainly to enhance current and future technologies for the construction industry to achieve higher productivity and better safety and towards a more sustainable approach incorporating whole life cycle analysis. CIDB 2020 through is Construction Strategy Plan 4.0 has also determined 12 main technologies also known as "disruptive technologies" which will change the future of the construction landscape and potentially shape Malaysian construction companies to become more technology competent. as per Fig1.

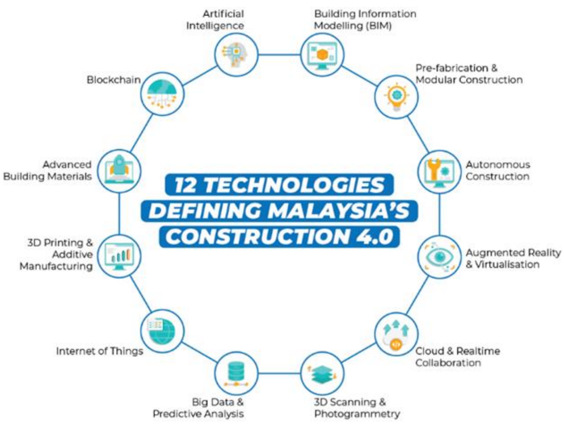

Fig.1 *12 Emergence Technology (CIDB, 2020)*

2.2 Definition of Blockchain

Ministry of Science and Technology (MOSTI) through the National Blockchain Roadmap 2012-2025 has defined the blockchain in technological terms as a well-established cryptographic technique, and somewhat less well-understood econometric game theory, which enables the operation of distributed computing systems that dispense with the need for an implicit trust in any server or operator thereof, as is required for existing ICT services. Penzes (2018) also explained that the Blockchain is a distributed ledger that possesses unique properties and a fundamental database. It is distributed, which means that the database is shared and spread over several locations. As a result, it is somewhat like other online shared stores or standard cloud systems. Li *et al.,* (2022) describe blockchain technology as a distributed ledger that is open, secure, and immutable. It enables transactions without the involvement of a third party, removing the need for third-party trust. It is a decentralised network built on top of Internet protocols that use distributed consensus algorithms and cryptography to record transactions among a dispersed group of users in an unchangeable way.

According to National Blockchain Roadmap 2021-2025, the technological terms of "blockchains" are defined as well-established cryptographic techniques, that enable the operation of distributed computing systems that dispense with the need for implicit trust in any server or operator thereof, as is required for existing ICT services. Feng *et al.,* (2019) as cited in Choy *et al.,* (2020) also explained that the term Blockchain is a peer-to-peer (P2P) network's open, decentralised ledger for data sharing. By using the consensus mechanism, all nodes in the P2P network can access and share the transactions, which are kept under constant observation and management by all nodes but are not under the authority of any single party.The benefit of Blockchain technology is that it allows two parties to conduct safe transactions via the Internet without the intervention of a third party. Hence, removing the third party, can provide lower transaction costs and strengthen transaction efficiency and security (Bazel *et al.,*, 2023).
Therefore, it can be concluded that blockchain technology is an open, secure, and immutable distributed ledger that enables transactions that eliminate the need for third-party trust and involvement. The blockchain concept employs a decentralised network that runs on top of Internet protocols and records transactions in an immutable manner among a distributed set of users via cryptography and distributed consensus algorithms.

2.3 Evolution of Blockchain

Four distinct stages can be identified in the development of blockchain technology: Transactions, Contracts, Application, and Integration in Industry.

(a) Phase 1: Transactions (Blockchain 1.0 and Bitcoin):

The Blockchain 1.0 phase, from 2008 to 2013, focused on peer-to-peer transactions. The first phase introduced Bitcoin, a virtual currency, that allows users to conduct financial transactions (Ullah *et al.,* 2019: Nakamoto.S, 2008 as cited in Srivastava *et al.,* 2018). Each coin has an electronic signature, with private and public keys for signing and verifying transactions.

(b) Phase 2: Smart Contracts (Blockchain 2.0 and Ethereum):

Between 2013 and 2015, contracts transitioned from peer-to-peer communication to distributed use of smart contracts. Ethereum, introduced in 2013 addressed the limitations in Bitcoin Scripting which paved the way for Smart Contracts (small computer programs that live and execute on the blockchain) (Ullah *et al.,* 2019: V.Buterin, 2013 as cited in Srivastava *et al.,*, 2018)This phase of Blockchain 2.0 evolved into one of the largest applications of blockchain technology.

(c) Phase 3: Applications (Blockchain 3.0):

With phase 3, the Blockchain history extends beyond Bitcoin and Ethereum, integrating applications and biometric complementation since 2018. IoT platforms and applications are also incorporating blockchain in their daily operations. (Ullah *et al.,* 2019).

(d) Phase 4: Industry (Seamless Integration with Industry 4.0):

Blockchain 4.0 aims to make blockchain technology usable for business and industry needs, with significant investment from businesses, governments, and organizations. According to Mukherjee & Pradhan (2021), It decentralizes Blockchain 3.0, making it a platform for application development and influencing other technologies like artificial intelligence, making it a mainstream technology.

2.3 Component of Blockchain

2.3.1 Blocks

According to Abeyratne *et al.,* (2016) as cited in Hultgren and Pajala (2018 The rise of the name of blockchain comes from the fact that this distributed ledger has a chronological chain of "blocks," each of which contains a record of valid network activity, documents, or transactions. The use of blocks in blockchain technology will act as a decentralised node that is equipped with databases and contains digital data. Nofer *et al.,* (2017) as cited in Hultgren and Pajala (2018) mentioned that whenever a block has been verified this block is added to a chain of other blocks chronologically and therefore, it is called the blockchain. Then, blocks are linked together containing the hash value of the previous block into the current block (Singh and Kumar (2021). As a result, All of the "blocks" creates an entire, unchangeable history of the network's operations, which is accessible to all system users. (Fig 2)

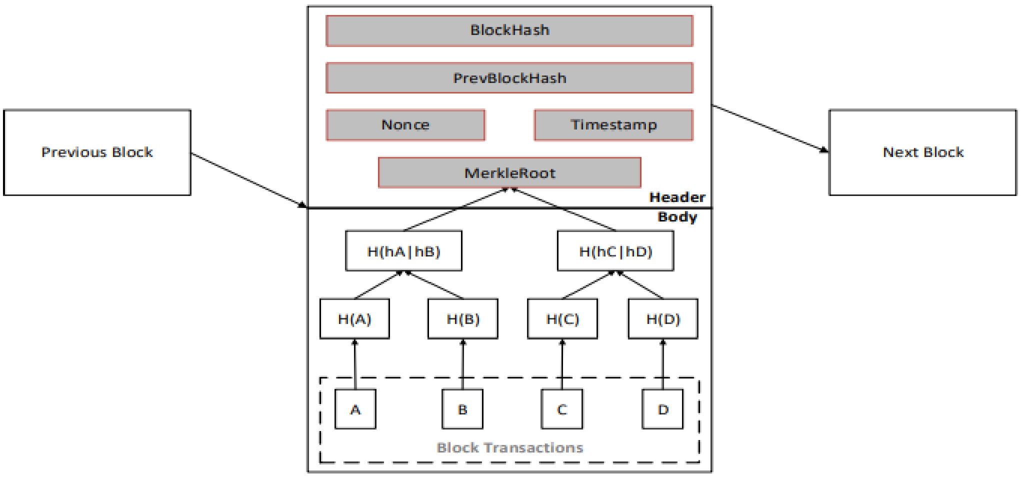

Fig.2 *Diagram of Block (Singh & Kumar, 2021)*

2.3.2 Hash Function

The information or the blocks containing the information are cryptographically "hashed" prior to being recorded by blockchain technology. Hashed refers to the process of using blocks as input to an algorithm that creates a fixed-length alphanumeric string known as a hash value (Lemieux, 2015 as cited in Hultgren and Pajala. 2018). As per the statement, the hash function is a mathematical function that can accept any number as an input and transform it into an output within a predetermined range of numbers. Blockchain utilises a lot of secure hash functions to guarantee that transactions are unchangeable once they are recorded in the ledger. Hashes play a vital role in the blockchain operation since it works as a main guarantee for blockchain security. This technique makes blockchain technology one of the most secure options in the industry nowadays Karame and Capkun (2018) as cited in Mukta (2023) (Fig3).

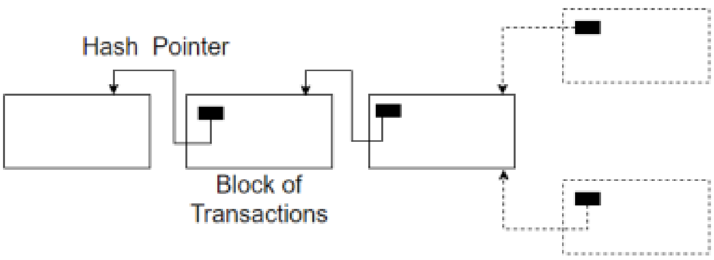

Fig.3 *The process of hash within block (Sarode et al.,., 2021)*

2.3.3 Nodes

According to a book by Poston (2019), the purpose of the existence of the node in blockchain is to implement and operate the system. Hence, nodes are an essential component of the blockchain ecosystem because they perform all tasks of work within the system. The next block creator is chosen by a node using a blockchain consensus algorithm. They are responsible for generating the subsequent block and initiating its dissemination.. Singh (2019) as cited in Sarode *et al.,* (2021) stated that the nodes are the system running the blockchain software. These nodes will copy the entire blockchain initially from the start of time and adding a new transaction to the topmost block. Hence, a full copy of the distributed ledger can be completed (Fig 4).

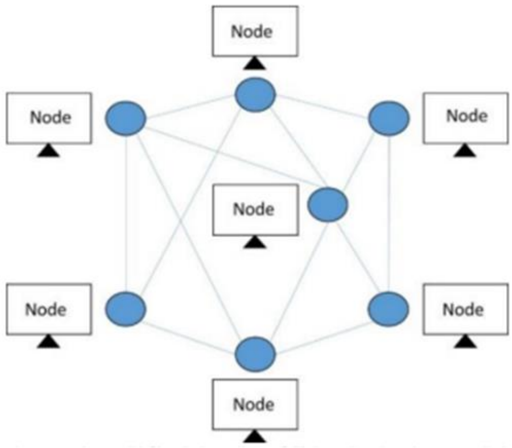

Fig.4 *Nodes in Blockchain Architecture (Sarode et al.,., 2021)*

2.3.4 Peer-to-Peer Network

According to Dhillon *et al.,* (2017), as cited in Choy *et al.,* (2020), switching away the central trusted authority in a massively distributed network is the fundamental shift that blockchain technology offers. By relating the terms of "switching away central trusted authority" and "reducing reliance on the third parties" technique, the system of blockchain uses the peer-to-peer network as a platform of sharing and transferring the data without any trusted authorization or reliance to the third parties. Moreover, the main implication of the peer-to-peer model for blockchain networking is to transfer the information and nodes. According to Huang *et al.,* 2017, as cited in Sarode *et al.,* (2021), each node in the network speaks with every other node directly through a peer-to-peer network. Then, P2P facilitates direct communication between various nodes, and each member maintains a record of transactions via P2P transaction verification. The author also mentioned that the commit stage is the point at which a coordinator sends a request to a subordinate, and if the subordinate votes in favour of the request, the coordinator sends a commit to the subordinate, and the subordinate replies with an ack, marking the completion of the transaction (Fig 5).

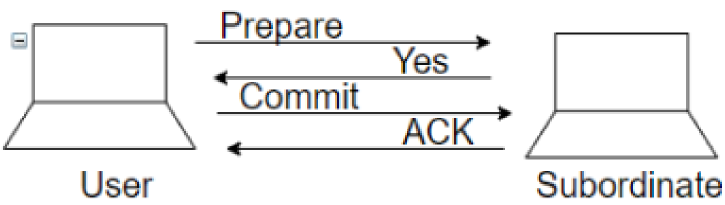

Fig.5 *Commit Stage of P2P Network* (Sarode *et al.,* 2021)

2.3.5 Consensus

Blockchain network maintains a shared, decentralised ledger with each node in the network maintaining a copy and updating it as each new block is created. However, the challenge that occurs with this process is to ensure that all nodes make the same updates to their copies of the ledger with each block. Since the network lacks consistent authority to create the official version of the ledger, each block is created and shared by a temporary authority. The mechanism to achieve this is called the blockchain consensus algorithm. By referring to Zhang *et al.,* (2020);

Xu *et al.,* (2023) as cited in Zhu (2023), it is stated that consensus is described as an essential concept in blockchain technology that ensures network participants' agreement and consistency regarding the state of the distributed ledger. Muzammal *et al.,* (2019) as cited in Choy *et al.,* (2020) also highlighted that an algorithm known as a consensus mechanism consists of a set of agreements and rules intended to establish fairness in a distributed network. It allows access to several nodes in a decentralised network to agree on what transactions are legitimate and what order they should be added to the blockchain. Proof-of-Work is one of the most widely used consensus algorithms (PoW). By requiring significant processing power and network consensus, Proof of Work (PoW) maintains the security of the blockchain. (Zhang *et al.,* 2020; Cao *et al.,* 2019 as cited in Zhu, 2023). Figure 1.4 illustrates the working of the PoW mechanism in the blockchain. Each miner using this method must first specify and construct a PoW puzzle on the blockchain. Every other node involved in the system will be able to see and interact with the puzzle that has been created. On the other hand, the node that has solved the proof-of-work problem can store, access, and alter blockchain data (Singh and Kumar, 2021) (Figure 6).

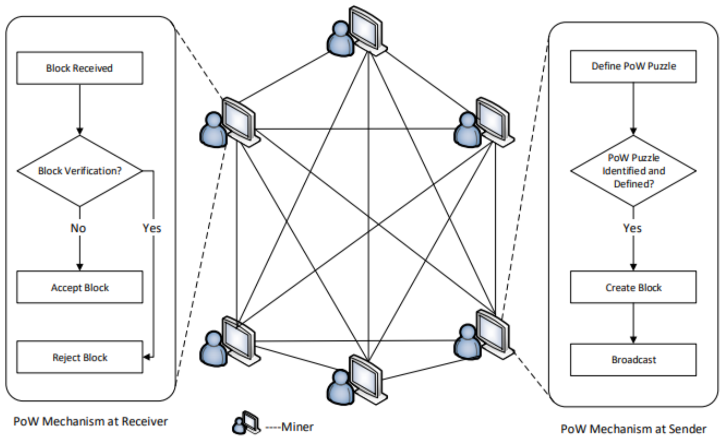

Fig.6 *Working of Consensus Mechanism in Blockchain (Singh & Kumar, 2021)*

2.4 Concept of Blockchain

2.4.1 Distributed Ledger

According to D. Shrier *et al.,* (2016) as cited in Al-Jaroodi and Mohamed (2019), one of the key success factors of blockchain is its ability to protect the data and transactions recorded in the shared ledger using a compartmentalised and distributed approach. In blockchain, it is called the feature of a distributed ledger. Distributed ledgers use independent computers usually referred to as nodes to record, share or synchronise transactions in their respective electronic ledgers (Sarode *et al.,* 2021). A ledger, which is an entire dataset, is kept up to date by each member node. Thus, these features will provide a set of unique and enhanced features that increase the trust, usage, and applicability of information systems in many sectors.

2.4.2 Smart Contract

A smart contract is one of the concepts in the application of blockchain technology. Smart contracts built on blockchain technology have the potential to advance numerous industrial sectors in various ways. According to Al-Jaroodi and Mohamed (2019). The concept of smart contracts eliminates the need for a third-party facilitator. It also has rules for exchange and transfer that cannot be changed during execution. This contract is trackable, secure, and unalterable. Therefore, smart contracts hold the key to implementing the blockchain technology system in a smart and structured way, as it solves any trust-related issues and provides an easy solution for any conflicts that may arise.

2.4.3 Decentralised system

Decentralisation is a key concept in blockchain applications that makes it a centralised technology that is different from the current traditional centralised database systems or servers widely used today. Decentralisation simply means that no middleman or central authority is needed, such as a bank transferring money or a lawyer to confirm the conditions of a contract (San *et al.,* 2019). In detail, the concept of decentralisation in blockchain eliminates the need for centralised authority by eliminating the need for the trust management middleman role; in other words, there is no single database, company, or party on which the data or information is solely controlled. Ullah *et al.,* (2019) also stated that the decentralisation in blockchain allows transactions to be made directly from person to person without the help of any third party. This increases financial efficiency and reduces people's reliance on banks and other financial institutions.

2.4.4 Autonomous

Another concept of blockchain technology is autonomous. Autonomous means that after the blockchain application is launched and run, a contract and its initiating agent need not be in further contact. Automation includes the deployment of algorithms and rules that can automatically trigger self-execution, self-enforcement, self-verification, and self-containment of the performance of smart contracts (San *et al.,* 2019). Therefore, the use of the autonomous nature of the blockchain digital ledger can trigger transactions between nodes without the need for human interaction because information or monetary transactions are tied to calculation logic and rules that are programmed automatically. In addition, Gaikwad (2020) also stated that anonymity is one of the important aspects of security in blockchain. The actual identity of the user who is doing the transaction is not known. Users will be linked to a public address, but no one will get to know the actual name or address.

2.4.5 Fraud Detection

Kameel *et al.,* (2023) addressed that with the adoption of this technology, documents are stored in the blockchain with their history of addition, updating, or deletion visible to all the nodes, which makes the authentication easier, faster, and more efficient, and prevents any fraudulent transaction. Applications in this category are appropriate for maintaining records of quality management. For instance, information on material quality, recurring construction site progress reports, and data on the amount of concrete, steel, and equipment used during a project's construction.

2.4.6. Peer to peer relationship

T. Aste *et al.,* (2017) as site in San *et al.,* (2019) state that another main concept in blockchain technology is the peer-to-peer systems known as P2P which encourage the operation of information or monetary transactions from one wallet to another wallet without the intermediary of trusted third party or central authorities. In detail, the peer-to-peer platform is based on the concept of decentralisation, which allows the participants to conduct transactions without needing a central server. Furthermore, the researcher also expresses that the application of blockchain makes use of peer-to-peer network technology to create a decentralised ledger for one or more digital assets. All nodes or computers in this decentralised P2P network are linked to one another in some way. Each node keeps a complete copy of the ledger and compares it to other nodes to ensure data accuracy.

2.4.7 Immutable Record

Next, another concept related to the application of blockchain is it can provide an immutable record in the system. The blockchain ledger is a collection of blocks that are connected by a chain of blocks. Every block has the previous block's hash. Thus, transactions through blockchain are immutable (Nathan *et al.,* 2019) as cited in (Sarode *et al.,*, 2023). Taylor (2017): Swam (2015) as cited in Choy *et al.,* (2020) further highlighted that the blocks in blockchain cannot be altered once they are added to the chain, which makes the chain of transactions publicly verifiable and immutable. Once the blocks are connected within a chain, they become immutable. Ramage (2018) acknowledged that the blockchain maintains an immutable record of transactions on the ledger system, making it incapable of being falsified after the event as the information is not kept in one place, but is encrypted and split across everyone in the network.

2.5 Blockchain in Construction Industry

2.5.1 Blockchain-based Smart Contract

Altay & Motawa (2020) stated that Smart contracts are defined as computer code that is derived from the concept of a blockchain platform that executes contracts automatically, contributing to stakeholder agreements such as QS, contractor and client, and payment realisation. The author also explained that the smart contacts are replicated and archived at nodes which cannot be changed, indicating that project activity has taken place by initiating transactions by the project stakeholder and will require consensus. Wu *et al.,* 2022, have provided some ideas for the framework of blockchain-based smart contracts (BBSC). The BBSC was developed by combining the method of smart contract lifecycle in blockchain with the real-life scenarios of progress payment in construction. As shown in figure 7, the framework is composed of three parts, namely initialization and configuration, payment freezing, and disbursement. Firstly, the conditions of payment should be agreed upon by all parties involved, including the contractor, manufacturer, QS, architect, inspector, client, and bank.

Next, the terms of the agreement are formulated as computer protocols via smart contracts that are established within the blockchain network. At the beginning of each payment cycle, the recipient of payments is required to submit a request for a payment guarantee in the second section. The project's expected cash flow can also be used to determine the estimated progress payment amount for the project's subsequent progress payment period. Then, the conditions for payment freezing will be automatically verified by the smart contract. The bank will guarantee the payer's amount if the predetermined criteria are satisfied. The payee is then required to finish each payment cycle with a disbursement application. In a similar vein, the disbursement applications' conditions will be automatically verified by the smart contract. Finally, after the terms of the condition are fulfilled, the banking institution will release the money to the recipient of payment. Through its distributed ledger and decentralised consensus network, the blockchain will validate and record the operation transactions generated during the payment freezing and disbursement application.

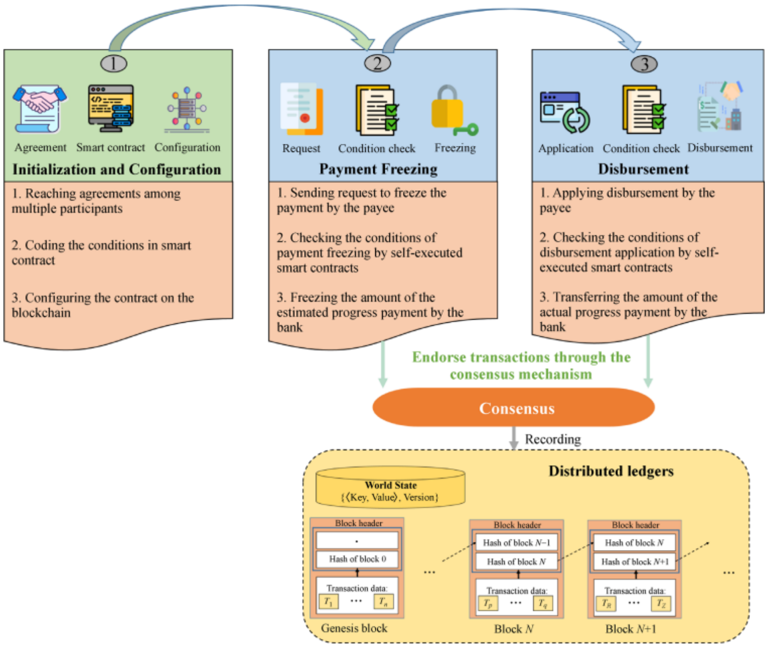

Fig.7 *Blockchain-Based Smart Contract Framework (Wu et al., 2022)*

2.5.2 Payment Settlement

Late payments and cash flow issues are two of the most common issues encountered in most construction projects. The construction industry has a chained payment settlement culture, and default settlement durations are much higher than the other industries (Ramachandra and Rotimi, 2011 as cited in Perera *et al.,* 2020). To overcome the issues, Al – Smadi (2023) highlighted that the Blockchain can facilitate the automatic execution of smart contracts, allowing for automatic payment disbursements and other transactions based on predetermined conditions. In addition, the implementation of a smart contract-enabled blockchain payment application provides more trust in the transaction as automation allows greater enforceability of the contract (San *et al.,* 2019)

2.5.3 Immutable Record Keeping

According to Ramage (2018), Blockchain's use in the construction sector enables each participant to view the timeline of both financial and non-financial transactions such as transfers of land or drawings). The authors also clarified that every participant involved in the transaction, whether it be financial or data exchange, can see each other thanks to the blockchain. Furthermore, Wang *et al.,* (2017) also specified that blockchain technology's decentralised feature permits users to have identical information across all applications, and that information cannot be erased. The sender and recipient will both have access to more information than others. As a result, the system's traceable and unchangeable record gave users transparency. As a result, it can be said that as blockchain technology is applied to construction-related businesses or activities, participants do not necessarily need to establish trusting relationships because the concept of immutable record will help to create transparency and build trust toward the user.

2.5.4 Tracking

One potential application of blockchain is in supply chain management, where the blockchain can help track the movement of materials and reduce the risk of fraud and errors (Kouhizadeh and Sarkis, 2018 as cited in Al-Smadi, 2023). It can also enable real-time tracking of inventory levels and facilitate more efficient procurement processes. Furthermore, the researchers also addressed this concept of tracking can be used to track the asset of the life cycle in construction. According to Wang *et al.,* (2017), Blockchain-based, construction asset management systems would allow tracking and access to all the necessary data throughout the asset life cycle. It could provide a better asset life cycle while minimising challenges and providing better maintenance performance.

2.5.5 Enhancing Security

In the current construction industry for payment, data security is an issue that we should not overlook, especially when large construction projects are heavily funded with a huge amount of money. is practising storing the construction data in a centralised database and platform. Kshetri (2017) as cited in Mohammed *et al.,* (2021) stated that the uniqueness of blockchain technology lies with it ensures data security when the decentralised and consensus-oriented nature of blockchain technology ensures that each partner is accountable for their specific role in the transaction as a whole, thereby avoiding conflict even in networks that are expanding exponentially. Furthermore, Col & Alcazar (2017) also supported that the decentralised nature of blockchain technology ensures that all participants in the construction industry own identical information throughout the system. Since blockchain data is replicated throughout a peer-to-peer network, it is incredibly difficult to corrupt or destroy. In addition, the author also added that the system's verified and unchangeable record also protects the construction data from being altered or removed by users or hackers. As a result, this will ensure participant safety and data security. Therefore, it can be concluded that blockchain technology enhances data security and helps reduce the risk of hacking and ransom requests, ensuring data owners can retrieve their data.

2.6 Barrier of Blockchain Adoption in the Construction Industry.

2.6.1 People Challenge

Due to low investment, a lack of industry experience, and the requirement to implement blockchain technology rather than on an individual basis, the industry is not yet ready. (Kosala *et al.,* 2021) These obstacles could create challenging situations to justify allocating funds for the application of blockchain and to secure the permission and support of relevant parties. Next, an inadequate understanding of the technology, its potential applications, and its benefits will become one of the barriers to increasing the adoption of blockchain in the industry. (Mohammed & Salem, 2022) The reason that leads to the lack of understanding occurs when there is a misunderstanding regarding the recognition of blockchain platforms in the construction industry and the technology of blockchain in Bitcoin. Blockchain should be understood as a technology rather than a subfield of cryptocurrencies, and its benefits should be obvious in that they are not limited to those associated with cryptocurrencies.

Furthermore, the lack of industry exposure to the use of blockchain technology also contributes to the challenges of blockchain application in the construction industry. The Ministry of Science and Technology in National Blockchain Roadmap 2021-2025 highlighted the lack of industry-related exposure will cause the fragmented development of talent and low industry awareness towards these technologies. Hence, it will create a low level of interest in the exploration of blockchain. Lastly, insufficient educated, skilled, and certified employees are also one of the challenges that need to be emphasized against the use of this blockchain system. This is because businesses cannot fully benefit from blockchain technology without the contribution of sufficiently skilled and qualified workers (El Koshiry *et al.,*, 2023). These are the people who will explore and ensure the smooth use of this system in a business or company. Therefore, educating and training individuals on the use of blockchain technology is essential for its successful implementation by providing the development of training programs and educational materials that can be used by all people.

2.6.2 Technology Challenge

The technology limitation is one of the biggest barriers faced in adoption of this blockchain technology. Due to these standards being widespread across the construction industry, the industry's biggest challenges are the technological limitations that many construction companies have. Blockchain requires a simple IT infrastructure and servers, but many construction companies are still transitioning to computer systems, making it difficult to transition to advanced technology (Graham, 2019). Due to the complexity of blockchain, its adoption will cause a technology risk in terms of in-depth systems. The reason for this risk is because of the development of a complex system of blockchain that requires and installation of extended software and the use of a lot of computerised protocols. The concept of a blockchain that uses a protocol system will always update which can cause multiple delays due to incompatibilities within individual data blocks, which can disrupt the entire system (Deng *et al.,* 2022; Srinivas Aditya *et al.,*., 2021 as cited in Singh *et al.,* 2023).

Blockchain technology has also been described as too risky to engage the masses. This is since blockchain technology is still new for most people that will create a hesitation among stakeholders towards its adoption. Therefore, this will lead to the lack of an understanding of blockchain technology that will become the reason for difficulty in cultural adaptation to it and has hindered the spread of the technology (Niranjanamurthy, 2019 as cited in Suliman, 2022). Hence, this scenario indicates a higher level of complexity than any other centrally directed economic tool in the case of blockchain implementation. As blockchain is a relatively innovative technology, there is a need for widespread adoption. However, Adamska *et al.,* (2021) the lack of maturity to prove the level of effectiveness of its use in the construction industry will hinder its process of adoption. This is due to some disputes about the deficiency of terminology among the construction players and the vision of what can be its purpose towards its adoption. The Ministry of Science and Technology in the National Blockchain Roadmap 2021-2025 also highlighted that the technology of blockchain is still unproven.

2.6.3 Governance Challenge

The main purpose of achieving the environment of blockchain in the construction industry may fail if there is a lack of universal standards in the industry. This is because the lack of universal standards will raise questions on how to ensure quality controls and procedures are performed on the desired level. (Cousin, 2018 as cited in Adamska *et al.,* 2021). It will cause a difference of ideas between the parties involved towards the adoption of blockchain. Therefore, it is crucial to clarify the scope of blockchain adaptation and ensure that all parties will have the same expectations regarding this technology. beforehand and ensure that all the parties have the same expectations. Blockchain is known for its autonomy which uses the concept of no authority or third party to operate the system. Hence, this will cause difficulties for the government to control the system. (Suliman *et al.,* 2022). Therefore, the lack of proper government control will become a significant threat as this can increase corruption and money laundering to finance criminal activities in the construction industry.

Privacy-sensitive data leakage is one of the challenges to the successful use of digital twin technology. Blockchain is intended to provide all users with transparent visibility of transactions while also ensuring the suitability and immutability of transaction records. However, because of this feature, many potential users may reject it (Perera *et al.,* 2020). Some legacy institutions, such as governments, must protect access to sensitive data for a variety of reasons. The transparency features of blockchain technology stand in contrast to this requirement and this may not meet the requirements of some governments and financial institutions. Finally, Lack of regulatory clarity is also one of the points that will hinder the successful use of blockchain technology. National Blockchain Roadmap 2021-2025 has justified that the fragmented and different regulatory framework between industries will discourage the use of blockchain and stifle its innovation.

2.6.4 Economic Challenge

The initial cost for investing in blockchain technology adoption is quite high. Kouhizadeh (2021) as cited in Mohammed & Salem (2022) address that the reason of the high initial investment cost is due to the need of new hardware and software such as the computation-intensive nature of the technology used for the information gathering, which is costly for organisations and network partners Hence, this will be necessitating construction businesses and stakeholders to strategically coordinate their infrastructure investments to utilise its benefits. Another obstacle to blockchain integration is the cost of implementing and maintaining the technology. El Koshiry (2023) found that the maintenance costs of hardware, software, and personnel, as well as the costs of training and educating people about blockchain, will be become the barriers to the adoption of this technology. Another barrier is the cost of implementation and the need for a skilled person. Hughes *et al.,* (2019), as cited in Adamska *et al.,* (2021), explained that to fully grasp the benefits of blockchain-based business, there must be changes in the organisational structures and culture. Therefore, it will add an extra financial requirement to provide a skilled workforce that can handle the blockchain system. Lastly, the complexity feature that requires customization also poses significant challenges to the adoption of blockchain in terms of cost. Haleem *et al.,* (2022), specify the reason customization technology as an issue is due to the lack of common interfaces, and the requirement of custom keys, owing to the integration of blockchain technology with legacy systems or within the blockchain ecosystem that will raise the high costs associated towards its implementation.

3. Research Methodology

This study will use the mixed methods approach to accomplish its stated objectives and collect the data needed for the analysis. A mixed method is a method that integrates quantitative and qualitative approaches in a single study (Techno, 2016). The planning of the study will use the integration of questionnaire survey for quantitative data collection and semi-structured interviews for qualitative data collection. The questionnaire will have three parts. The first part is the demographic questions which is the background of the respondents. The second part is to gauge the level of understanding of the concept of blockchain in the construction industry. The third part is to identify the challenge in implementing blockchain in the construction industry. The planning scale is Likert's scale 5 points, which is composed of strongly disagree, disagree, neutral, agree, and strongly agree (Table 1). Besides, this research also will be conducting a semi-structured interview session that involve an open-end question to get more detail and information towards the research.

Table 1 *5 points Likert's Scale*

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

For this research, the target population will be the construction experts such Contractor registered under CIDB, Quantity Surveyor Firm registered under BQSM, and Developer. The research is focused on identifying their level of understanding of the concept of blockchain technology and its challenges of adoption in construction industry. Lastly, for research data analysis, the questionnaire survey will be analysed through the Statistical Package for Social Sciences (SPSS) using the method of descriptive analysis. According to Taherdoost (2020), descriptive analysis is acknowledged as the original form of data analysis and the least difficult method. It can be used to handle massive amounts of data such as a multiple set of questionnaires. As for the interview, the method of analysis is qualitative content analysis which is commonly used for analysing qualitative data. Azizan *et al.,* (2018) describe content analysis as a research method that offers a methodical and objective way to describe and quantify phenomena by drawing valid conclusions from written, visual, or spoken data.

4. Conclusion

In conclusion, the purpose of this paper is to provide preliminary study towards the understanding of the concept of blockchain and its challenge of adoption among the construction industry . Blockchain technology supplies the best platform for the construction industry as it is an open, secure, and immutable distributed ledger that enables transactions that eliminate the need for third-party trust and involvement. Understanding the concept of Blockchain Technology (BT) is essential to assist stakeholders in the construction industry. Thus, implementation of these new technologies is also crucial, to improve the quality of the project.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design****: Muhammad Ariff Najmie, Roziha Che Haron;* ***data collection****: Muhammad Ariff Najmie;* ***analysis and interpretation of results****: Muhammad Ariff Najmie, Roziha Che Haron;* ***draft manuscript preparation****: Muhammad Ariff Najmie. All authors reviewed the results and approved the final version of the manuscript.*

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