Review Article

A review on blockchain operations in construction management

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ABSTRACT

This study investigates the important role that the blockchain plays to manage the information about who did what and when and hence provides a strong base for any legal potential conflicts. Blockchain technology permits you to distribute, encrypt, and secure the records of digital transactions. In addition, bitcoin and other cryptocurrencies are encompassed in it. Even though the construction industry has traditionally been a late user of innovative technology compared to other sectors of the economy, it faces various hurdles in terms of trust, accessibility, information sharing, and process automation. As a result, stakeholders, clients, subcontractors, contractors, and suppliers have been unable to work together effectively. Even if building information modeling is employed, which envisions a centralized building, the primary benefit of blockchain is the secure storage of sensitive sensor data.

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1. INTRODUCTION

The construction industry has a great impact on any country's economy. Recently, there have been new advancements in the technologies regarding construction management. One of these technologies is blockchain operations. The aim of this review is to provide information for the scientific studies which are focusing on the field of construction management and the effect on blockchain technology with respect to it. The structure of this article is as follows: introduction, body, result and conclusion.

A blockchain is considered to be a distributed ledger system. This means that it is a general agreement of shared and synchronized digital data. In addition, it is going to be distributed geographically among numerous sites,cities or institutions. To put it another way, there is no central administrator or data storage [1].

The main purpose is for the majority of the system's members to validate the content of each block. The information in a block cannot be removed or changed once
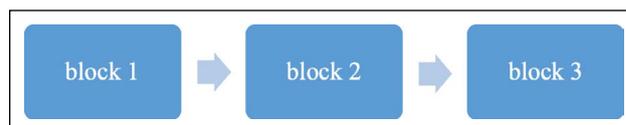

Figure 1. The formation of blocks [4].

it has been entered and confirmed. Each block could be thought of as a piece of encrypted data. Anyone in the system can theoretically add data to the chain of blocks and see the data at any moment, but no one can edit the data without proper authorization. As a result, all the "blocks" work together to create a comprehensive and immutable history of the network's operations, which is shared with all system participants. When a block is approved, it is added to a chronological chain of other blocks, acquiring the name "blockchain" (Fig. 1). As a result, the blockchain is a chain that holds verifiable records of all transactions, documents, and other actions ever performed in the system. By utilizing newly created technology, the demand of

the construction industry would be met. These requirements could be filled by blockchain technology, despite it being a relatively new technology [2].

This technology consists of a distributed database of records, digital events, or a public ledger containing many transactions that are completed and shared among retention of workers. Getting rid of a third party as a requirement in any transaction is the aim of the blockchain technology. Instead, the majority of the system's participants, or nodes,- verify each transaction in a public ledger. Mutual trust has been shown in previous research to assist in smoothing the construction process that allows flexibility in the face of uncertainty, boost efficiency and maintain long-term relationships [2].

The popular crypto currency Bitcoin innovated blockchain technology, which allows digital information to be circulated without being duplicated or edited. Data is maintained in a central database that can be accessed from multiple locations in the traditional construction sector. The biggest concern is the security issue, as the transaction data could be tampered with by a hacker The blockchain technology, on the other hand, can be thought of as a shared database across a peer-to-peer network .In a set amount of time, transactions are grouped together into blocks and then added to a permanent chain. Once added to the chain, these blocks cannot be changed, making the transaction chain publicly verifiable and totally unhackable [3].

The main element of blockchain technology is trust. Participants do not need to have an established trust connection if they trust the blockchain itself, or if the building business or activities are carried out on a blockchain system [3]. Furthermore, blockchain technology facilitates information interchange by designating each project member as the owner of all information flowing during the project lifespan [2].

2. MATERIAL AND METHODS

In the Material and methods section, it was a collection of knowledge with regards to the blockchain operations. Furthermore, this tracking has been done by using the following terminology such as smart contract in blockchain operation, blockchain operations advantages and disadvantages and the effect of blockchain operation in the construction industry. For this section, there are only secondary sources. In other words, no raw materials were obtained for this research report. Firstly, this study includes an introduction section, which includes information and explanation of the relevant topic. Most of the articles obtained are recent and published within 2008-2021. Moreover, google scholar and academia were the main sources for obtaining these information and findings. Only articles were used to gather all of the information related to blockchain operation in construction management. Nearly over fifteen articles were checked and used for this study.

In recent years, research on blockchain applications and development in the construction industry has attracted a great deal of interest. A large number of review papers have recently evaluated and assessed blockchain research from diverse angles .One example for this, Jennifer Li and David Greenwood. [4] carried out a study on the built environment and construction sector related to blockchain. The findings suggest that blockchain has the potential to help digitization in the construction sector. A use case analysis and a complete literature review are also used to examine the application possibilities of blockchain in the construction industry, which was done by Perera in 2020. According to this study, it seems that blockchain has great potential in the construction sector. Hunhevicz and Hall. [4] have suggested the technical elements of blockchain scenarios and a decision framework is given to assist users in determining whether they require blockchain technology and which form to utilize. From 2017–2020, around 100 papers were published. Furthermore, they were examined to study the incorporation of blockchain, which led to progress and expansion. The outcome indicates that the extension of the blockchain conceptual model has nearly reached a plateau and that existing concepts will mature as attention turns to testing and improving earlier ideas in the future [4].

Hileman and Rauchs [5] claim that blockchain is made up of five components, such as cryptography, peer-to-peer, network, consensus mechanism, ledger, and validity rules. Moreover, these components contribute to the uniqueness of blockchain's quality. For example, cryptographic techniques are used to assure data secrecy and integrity in the event of a challenger. Cryptographic one-way hash function, symmetric key cryptography, or public key cryptography are a few examples of the variety of usages that are involved in cryptography techniques.

The peer to peer network is a peer-to-peer network that permits data sharing and peer discovery. In the event that not all participants are telling the truth, the consensus process regulates the ordering of transactions (adversarial environment). A ledger is a collection of transactions that are arranged into 'blocks' that are cryptographically linked. The eligibility rules are a set of guidelines used by the network to determine if a transaction is valid. Blockchain can reduce the amount of confidence necessary prior to a transaction, but they do not eliminate it entirely. Validators and/or operators are similarly trusted; in a well-configured environment, participants independently examine the system state and validate transactions [5].

A person can have their own bitcoin once its unique hash on the bitcoin has been signed. This can only be done after it has been sent to you by another peer. After the sending process, all the past signatures on your part can be checked. In order for all bitcoin's participants to resume the chain. Moreover, the ownership of the funds must be verified by the peers using the blockchain. Once the transaction has been inserted into the blockchain, it becomes irreversible. It's a shared transaction log ('ledger') that also functions as a timestamp server. The old-time stamp is included in any new timestamp, resulting in a perfectly trustworthy chain of events. The paper also introduces the proof of work system, which employs an algorithm to validate any operation and create a new blockchain [6].
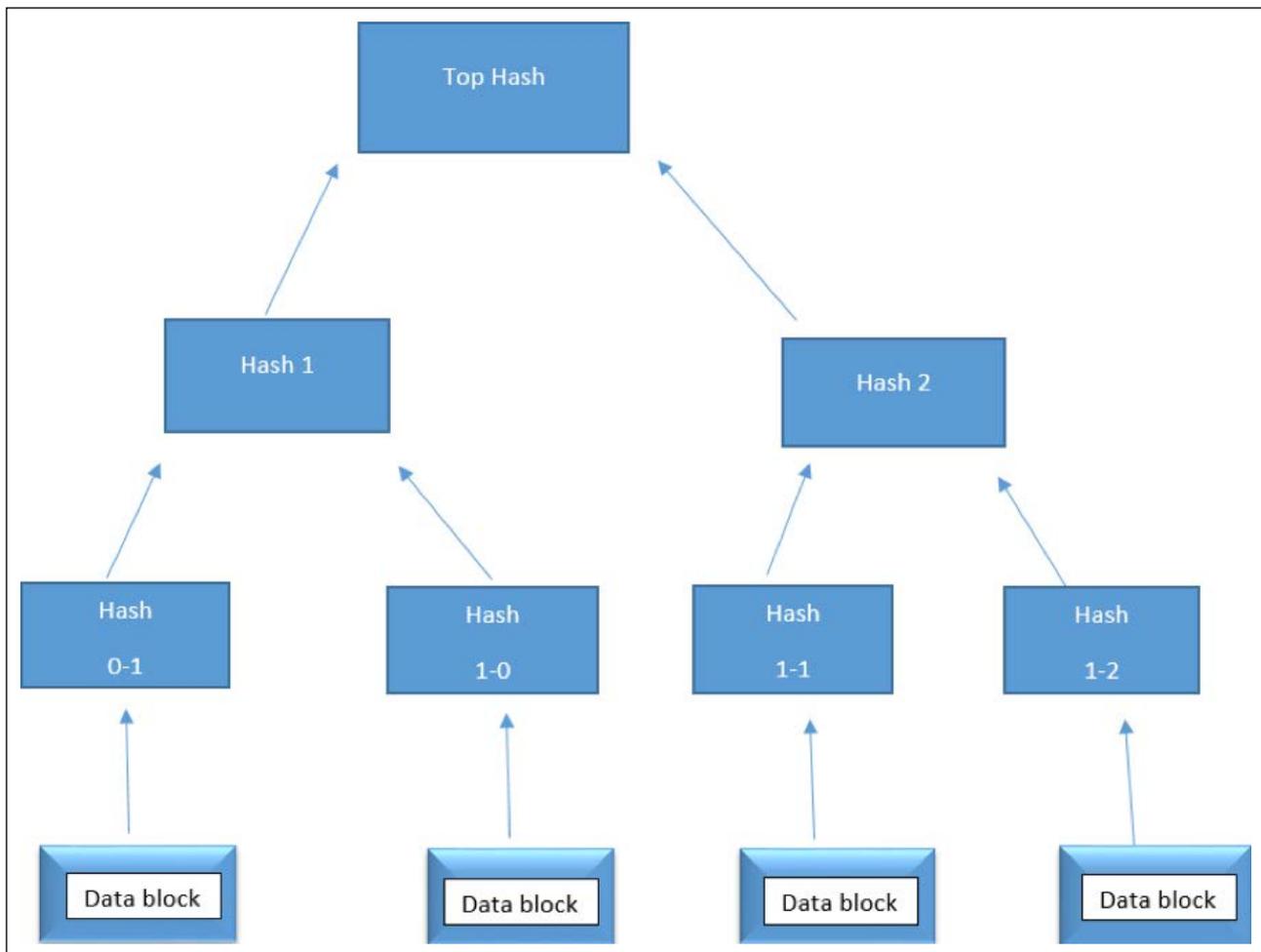
Figure 2. Merkle tree [7].

2.1. Hash Algorithm

This section is going to illustrate the significance of the hash algorithm operations.Peers must use a large amount of computing energy to obtain a similar hash when representing a block (as a SHA-256 hash). Then it's recorded in the ledger. For verification and continuity, nodes (i.e., people or computers) interact, especially when signing a block into the chain. In other words, the nodes must agree on the new block in the transaction. Even so, the POW (proof of work) is required to reach this agreement and to create and verify blocks. As a result, hacking Bitcoin is extremely costly due to the massive computing resources required by most block chains [6].

According to Shackelford and Myers. [6], it was suggested that there is a great consumption of the amount of energy used by the current blockchain designs to power up the algorithms (around 215 kWh with every transaction). In particular for validating and securing transactions, blockchain requires a great amount of processing power. It is considered that the bitcoin blockchain consumes more processing power (between 10 and 100 times) than combining all of Google's service farms.

2.2. Merkle Tree

Merkle Tree is demonstrated in the Figure 2 below. Based on Satoshi research. [6], all the transactions in Bitcoin and blockchain technology are summarized and used in the data structure. In addition, it is made up of many hashes, but it condenses them all into one while still being able to verify the data of each individual hash. It summarizes all transactions in a block, but each transaction in a block can still be checked. Because of this layout, the blockchain is smaller, requiring less CPU power to process and validate blocks. As a result, even the most basic devices can run a tiny blockchain and connect to it as blockchain nodes. In other words, rather than having every hash to join a Merkle Tree branch. The nodes (i.e devices) can do it. Moreover, Satoshi also explains how Bitcoin can enable data privacy to its users. Banks, for example, have the ability to reduce the number of transactions while being the only party with access to users' identities. However, while Bitcoin displays each transaction in actual time, users use a public key to identify one another in the network and a private key to access coins given to them. Their identity and transactions are thus secured.

2.3. Digital Signature

The digital signatures show the private key consists of randomly selected numbers that must be done in secret. For example, if one user wants to send something to another user, they need to use the private key to sign. Furthermore, across the blockchain, the message is sent and distributed.

The nodes then examine the memo to check that the transaction is legitimate. After the confirmation of the transaction, it is sent in a block that cannot be amended later The two key system is considered a fundamental and vital process [7].

Nonetheless, Nakamoto [6] emphasizes Bitcoin's (almost) non-hackable nature. For instance creating a chain to resemble an actual blockchain is useless because it is highly unlikely to form Bitcoin out of thin air. Therefore, the nodes will reject the misleading action automatically. Furthermore, the system incorporates secure channels, notably encrypted public channels.With the blockchain concept, the goal is to reduce broken trust digitally. When the need arises, blockchain may always refer to the unaltered data stored in public space. This procedure improves digital trust. Fraud and deception become more difficult as a result of this exposure. It is a hybrid of old technologies that have been around for a while. Cryptography and payment, for example, are forms of cryptocurrency. It represents values (for example, payment via a token) that, when combined, establish a totally new principle of cryptocurrencies [7].

Cryptocurrency combines the concept of money, the ability to send and receive money online, and the ability to trade safely using a token. For example, Bitcoin was created to disseminate the Bitcoin cryptocurrency, but it now clearly has a much greater capability [8].

Matter of fact, blockchain technology is the secret weapon driving cryptocurrency's sharp increase. Bitcoin demonstrated to the world what blockchain technology is capable of. It stirred up a monetary revolution, discussing the merits of cryptocurrency. As a result, the fundamental technology (blockchain) that powers bitcoin separates from the currency and is used for a variety of other purposes. In the last decade, this innovation has opened the way for numerous block-chain-based solutions Smart contracts are an example of a blockchain-based solution that integrates applications to the blockchain [9].

2.4. Main Components of a Block

As it is indicated in Figure 3, each block is made up of coded hashes that group together time-stamped transactions. Since the order is fundamental, the transaction must be entered in the order in which it occurs. The hash is determined by the current transaction and the hash of the previous transaction [10].

2.5. Nodes

The hashes are inspected by the nodes to ensure that a transaction has not been altered. A node-approved transaction is composed into a block. Each block makes reference to (and holds the information from) the preceding block, allowing the blocks to take part in the Blockchain [10].

Blockchain is extremely valuable because, as it expands across multiple computers, each computer (node) can have its own copy of the blockchain .Furthermore, because peers communicate directly with one another, any blockchain-related information is kept and passed on. Therefore, data is transmitted rapidly via the network. Besides, blockchain upgrades itself each 10 minutes, it is a very safe system. The blockchain is transformed into a database, with every node
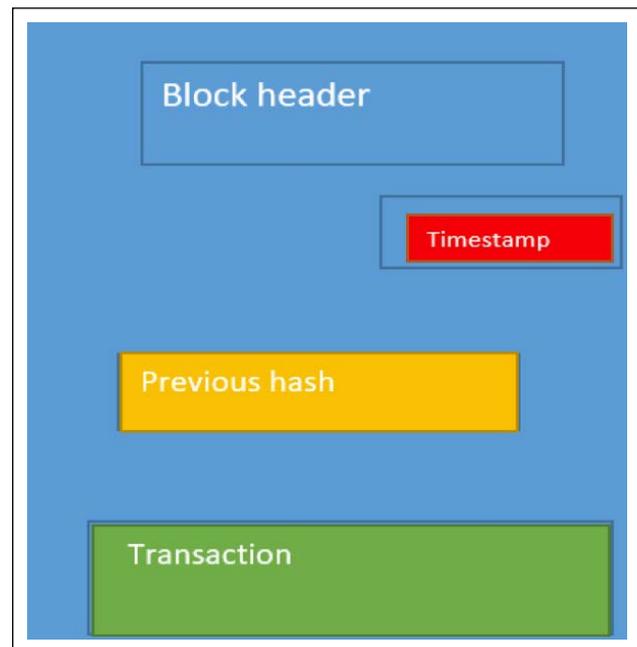

Figure 3. Main components of a block [11].

having access to the chain. As a result, it is practically impossible to forge a block because it must be validated by other nodes. Because it is encrypted and decentralized, blockchain security is unquestioned. Even though there are thousands of these nodes scattered around the world, trying to grab (or imitate) the system requires enormous computer power [4].

In general, Blockchain is a transaction ledger that instantly affirms itself. A single node (or computer) does not have any authority over the data. However, they can confirm the ledger without the use of intermediaries to regulate or try to control it [12].

There is a lot of debate concerning public versus private blockchain. Public blockchains, on the one hand, entail cryptocurrencies (such as Bitcoin) that allow Peer to Peer operations. Moreover, tokens are required in it and in the peer to peer network, it has its own set of rules. With the usage of private cloud infrastructure, blockchain based application can be used by private blockchains that functions and operates on it [13].

2.6. Smart Contract

In the construction industry, there has been an issue with the method of payment. For example, payment delays and the cost included to resolve all the issues. Therefore a solution to these problems that the construction industry faces is smart contracts. With the usage of smart contracts, the element of trust will be triggered in the process of exchange of money, any transactions and assets or anything valuable that will happen between stakeholders. As a result, smart contracts became a game-changer for the construction sector. Since it has transformed from document procedures into data procedures. Smart contracts are built on a set of rules; therefore, if all parties agree on these rules then it will enforce these rules for the completion of the contract. Moreover, the implementation of a smart contract in blockchain provides trust in the transaction. Since, the enforce-

ment of the contract is automated. For instance, clients can buy products or services directly from providers by paying a deposit at the time of ordering. The remainder of the payment can be sent to the suppliers in an automated process after the products are delivered to the site. Therefore, smart contracts manage and initiate all of this [2].

2.7. BIM

Construction projects can be replicated in a multi-dimensional digital model, which offers various advantages from the start of the project through its completion. Building Information Modeling (BIM) is the term for this technique. The building supply chain treats BIM differently, which has an impact on the quality of the finished product. By integrating BIM with the construction supply chain, the activities of the construction process, as well as data for facilities management, may be improved during the design, operation, and post-construction stages [14].

3. DISCUSSION

This section seems that most of the researchers have agreed upon the fact that blockchain will enhance trustworthiness among workers and immensely reduce fraud and corruption because of the transparency which blockchain technology provides. In addition many researchers stated that this transparency is viewed as a disadvantage regarding blockchain operation. Some articles provided profound details regarding the components of the blockchain technology while other articles briefly explained them. Later on in the result section, which was conducted in a construction company, the statistics support the researchers' findings.

The construction sector has been blamed for its slow adaptation to any new changes. However, this disadvantage has not prevented the construction industry from finding other methods (internet and IT) from improving its management process. Similarly, these improvements have increased the level of competitiveness. There will be new construction material, better qualification for the employees and access to the international market [11].

According to Tekreeti [12], there are many procedures and processes that have control over the construction field and the management field, which includes third entities and intermediaries. However, this will be an obstacle for any changes because of this dependence. For instance, a project which entails a construction of a new bridge between two different cities. Firstly, a contract should be prepared and it will be announced that the project is looking for contractors. The construction company that is interested and has the capability of the job would demonstrate the essential documentation (involves other parties). Then the bids will be evaluated and signing of the contract is needed. The execution of the work cannot be completed without certain documents such as descriptive report, budget and work plan. All this documentation is presented during the bidding process. After that, everything that was mentioned on paper should be executed on site. Therefore, the work is carried out. Finally, the bridge construction is completed and delivered to the government or any other client with specific documentation. This example of the bridge shows the long process of any construction project procedure. In addition, it involves a great number of intermediaries like the government, subcontracts and so on. As a result, blockchain operations are looking forward to making these kinds of processes less tedious.

According to PMBOK (stands for project management body of knowledge), it defines the application and tools needed to connect the beginning and the end parts of the project. This includes the scope of the project, required work, how to manage the stages and check over the work. Moreover, this is applicable in nearly all construction management projects [13].

In construction management, the following phases are applied such as planning, design and construction etc. However, every stage is carried out by itself. For instance, some design sketches need to be changed because of an error but there is a misunderstanding in the communication between the designers and contractors. Therefore, the architect cannot make any effective changes in the design. There are some delays that occur at the construction site; for instance, the constructors need to wait until the architect completes the sketch so they can carry out their tasks [14]. Therefore, LCM (Life cycle management) combines all the phases of management together and the concerned parties can be involved. In that way, time and cost can be used effectively. In addition, it makes sure all communications are open and shared. This is where blockchain plays an important role and creates great changes to construction management [15].

Since blockchain communication is transparent, it is a decentralized system (many points of entry). In other words, all the parties are involved in full transparency. Even though the communication is transparent, it does not mean that everyone can be included. The communication is permitted to assigned employees. Therefore, the entire communication is considered secure. Not only is the communication secured, but also the data transfer because it is quite impossible for any external influence to hack into the management process. The reason behind this is the cloud storage systems which are secured; it reduces the risks because of the project manager interference. Project managers can ensure everything is on the right path by using this blockchain technology. Blockchain operations limit discussions to project issues and transmit them; therefore, it keeps the project focused, efficient and reduces mistakes. Project manager has great control over all the information. Since he or she can access this information and make any necessary changes. All the transactions can be handled efficiently by the blockchain. For example, Briq is a construction fintech company that works on one modern platform that connects all transactions and operations on a construction data cloud. In that way, all involved parties can easily use this system, which is provided by Briq. Moreover, many databases contain a ledger. Each ledger is a sealed copy and cannot be modified in any way. It was found that in the construction sector a lot of data is lost due to handovers that occur in the industry which is 95% of all this lost data. However, with the new sophisticated technology which is

blockchain, we can see great horizons between blockchain's impact on the construction sector and management. Firstly, both the time of the transactions and number of intermediaries will significantly decrease. In other words, hiring any service or product directly from the company regardless of its location. The data can be used to find the best firm for various projects and the use of smart contracts would make the transaction easier. Furthermore, 'own payment method' could be a specialized payment procedure for certain sectors. To put it in another way, cryptocurrencies could be implemented as a method of payment for transportation, energy, insurance and other transactions [16].

Smart contracts enable computerization of legal binding forms and printed material; as a result, it decreases the cost and speeds up the delivery. Moreover, smart contracts are activated once the pre-set tasks are finished. Therefore, it grants permission for monitoring the stages and identifies responsibilities to the necessary parties. In addition, it demonstrates all the occurring events in the process (Like construction of a building) [14].

A reputation ledger, for instance, might track subcontractors deliverables and serve as a point of reference during the hiring process, thus blockchain can assist in this. This functionality makes it simpler to oversee the building process and find trustworthy subcontractors for a project [16].

This will be beneficial to manage projects afterwards, in regards to redesigning and following the rules. Corruption and fraud can be totally prevented in the construction process because the project material can be followed on the blockchain. Moreover, communication and findings of the information can be extremely effective with certain firms and people with the assistance of the record. Furthermore, payments are made quickly and the transactions would appear anywhere [16].

Smart contracts get rid of intermediaries and provide great improvement for the technology. Therefore, by diminishing the number of intermediaries, blockchain can provide better transparency. Since the status and the history of the transactions would be visible to anyone. However, the information stored in the blockchain can never be tampered with so it will be obvious which employees are hired, reason behind hiring them, date of hiring and how many were hired. Moreover, blockchain operations can tremendously affect the management process positively. Since it allows tracking the data, it decreases the time of delay for receiving and sending documents and increases the effectiveness of the decision-making procedures [12].

4. RESULTS

In this section, it will show some of the outcomes made in the United Arab Emirates regarding the application of the blockchain in the construction company. A construction company in the United Arab Emirates has applied the blockchain operations. Based on the answers obtained from the questionnaire of the methodology section, the following results were found. This questionnaire targeted upper management, executive-level managers, owners and board members [12].

Based on the questionnaire (regarding the decision making done for the blockchain operations), the following outcome was obtained
- It turns out that the IT staff have the highest percentage which is 47%
- Top managers in this construction company make up the second highest percentage which is 30%
- Comparing with the other sectors, the second highest is the top management
- In addition, finance has a low percentage which is 8%

Regarding the investment made to have blockchain operations in the company

A relatively high percentage responded that the investment in the blockchain technology in their company made above 5 million dollars.
- Only 1% stated that there is no investment
- In general, most of the respondents suggest that blockchain operations have great investment strategy and it is crucial for the organization

In regards, whether blockchain operations are relevant and important to the construction management. These are the following outcomes
- More than half of the respondents (53%) suggest that blockchain has some degree of relevance in their project.
- Majority of the respondents seem to find the blockchain technology a relevant component for their organization

5. CONCLUSION

Blockchain operations seems to be a very interesting topic and quite recent technology. Based on all the articles that were reviewed, the most liked idea was its non-hackable feature. Since the hash function in the blockchain is very similar to one's fingerprints and it's also related to the previous hash. In addition, the block that carries the information cannot be changed unless the majority of the people approve. Moreover, the system of how the blockchain works is fascinating and it can be implemented in other technologies such as BIM and smart contracts.

One of the main advantages of this blockchain technology in the construction sector would be collaboration. Since blockchain is implemented in BIM, many architects, contractors and other engineers can have an easy way of communication with each other. Many articles have mentioned these aspects will help in the reduction of the cost and mistakes.

In addition, cost is also another major factor in civil engineering. Based on these articles, blockchain technology would be of great assistance to reduce cost. Since, the third parties are eliminated in the blockchain operations and there are few administrative contracts. Therefore, the cost would significantly decrease.

In the project phase, the blockchain combines all the project stages together and the communication is open. It seems that this is crucial in management in order to avoid any delays or mistakes in the construction industry. The concept behind smart contracts seems intriguing that it is a digital form of contracts and the best part is that it reduces the paperwork. It seems that these kinds of paperwork will become obsolete in the near future. Technology

has been evolving each day and it's changing many aspects in our world including the construction industry. It is surprising to know that technologies such as blockchain could be incorporated in the construction sector. As many people believe that civil engineering has ordinary procedures that will not change. For example, construction of houses or bridges has certain traditional steps to be followed. However, this blockchain operation can change the perception of the construction sector and innovate it. Many buildings, theaters, bridges and so on have been constructed for thousands of years even before blockchain operations. However,construction companies should implement this technology because we can use these technological benefits to our advantage and change the perspective that the construction industry is always behind in technology.

ETHICS

There are no ethical issues with the publication of this manuscript.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FINANCIAL DISCLOSURE

The authors declared that this study has received no financial support.

PEER-REVIEW

Externally peer-reviewed.

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