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Potential Applications of Blockchain and Crypto-Assets in Construction Industry & Management:- A Review

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***Abstract*:- The trusted exchange of data lies at the heart of many processes in the fourth industrial revolution. Blockchain technology (BCT) & Crypto Currencies (CC) promises to ensure that data is secure, decentralized, and immutable. As the Construction Industry is always a slow adopter of innovative technologies than other sectors of the economy, therefore facing many challenges in terms of Trust, transparency, information sharing, and process automation issues. Which has caused loose collaboration among stakeholders and clients sub-contractors, contractors, and suppliers. Also, the BCT & CC application lacks concrete and up to state-of-the-art applications in the Construction Industry. Therefore the primary intention of this paper is to scrutinize the potential applications of the BCT & CC in the Construction Industry (CI) & Construction Management (CM). BCT was found to be one of the disrupting technology that has attracted interest from the academic and industrials aspects by demonstrating the capabilities and fulfilling the facilities to overcome the challenges faced by the Construction Industry. This paper also deals with the 6 dimensions of the BCT & CC in CI & CM, which improves Confidence, Performance, Speed & Project Management and reduces Cost & Time.**

Keywords:- Blockchain Technology, Crypto Assets, Construction Industry, Industry 4.0, Construction Engineering Management, Distributed Ledger Technology (DLT), Real Estate Management.

1. INTRODUCTION

Globally, construction spending was projected to reach US$12.4 trillion by 2022. Construction has always been a collaborative process involving a larger or smaller group of participants. Throughout history, communication technology has had a significant impact on the relationships among those involved. In the construction industry, trust relations concern people from organizations such as clients, contractors, subcontractors, and suppliers.

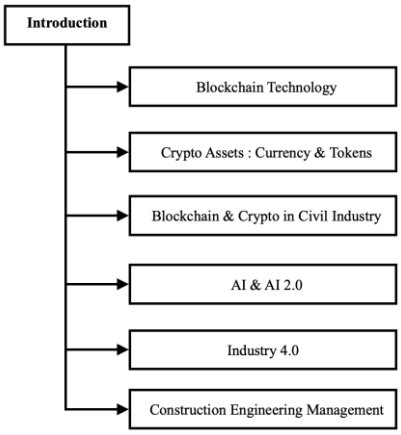

Fig.1 Introduction

But, the construction industry is often critiqued because of its inefficiency, low productivity, transparency, and some trust issue that is no longer acceptable. To rid the trust issues, it is necessary to introduce blockchain technology because Trust is the critical feature of blockchain technology.

1.1 Blockchain Technology

Blockchain technology has been described as the fourth industrial revolution to roll out in the construction industry. The construction industry is facing problems of lacking TrustTrust and transparency in the working relationship. This has caused loose collaboration among the project stakeholders and challenges in information sharing.
The decentralized feature of blockchain technology that promotes high transparency and TrustTrust has drawn significant interest from many industry sectors, including the construction industry. Therefore, there is a point to discover the potentials

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areas that Blockchain can be adopted in the construction industry and the current state of blockchain technology in the construction industry.

Types of Blockchain:-

1.1.1 Public Blockchain

The public Blockchain is also known as the permission-less Blockchain, and it is open to anyone who wishes to participate as a member of the network. All the network members can access and read any transactions on the Blockchain [1], as illustrated in Fig. 1.1.1.

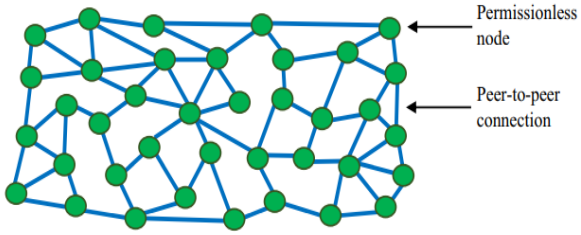

Fig. 1.1.1 Schematic Diagram

1.1.2 Private Blockchain

The private Blockchain is also known as the permissioned Blockchain, and only authorized participants can join the network [2]. In a permissioned blockchain, participants can be limited to those who are preapproved. Further, it is possible to restrict the participants regarding the different access levels to the information in the ledger. Fig. 1.1.2 [1] illustrates that it is a small node compared with public blockchain networks.

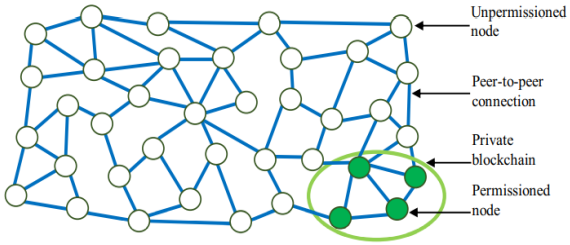

Fig.1.1.2 Schematic Diagram

1.1.3 Consortium Blockchain

A consortium blockchain is partly private without a single owner organization and is usually called a federated blockchain [1]. Consortium blockchain has privileged permissioned nodes across the network, as illustrated in Fig. 1.1.3. Consortium blockchain platforms have many of the same advantages such as privacy, efficiency, scalability, performance, and the like, which a private blockchain has but operates under the governance of a group [11, 17].

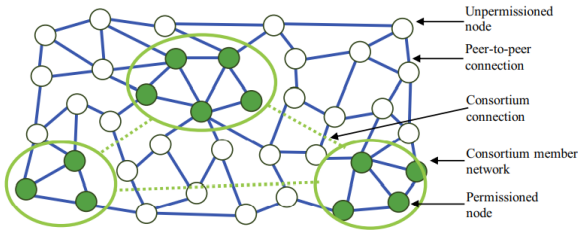

Fig. 1.1.3 Schematic Diagram

1.2 Crypto Assets

The term "crypto-asset" is used herein to refer to both crypto-currencies and crypto tokens. At their core, crypto assets provide a decentralized governance model for reaching a *shared notion of reality* in trust-less environments.

1.2.1 Cryptocurrencies

In 2009 a mystery character named Satoshi Nakamoto published a paper online called "Bitcoin: A Peer-to-Peer Electronic Cash System"[4]. The paper presented a solution to how to trade currency without an intermediary, a task previously thought could only be done by legitimizing trusted socio-cultural institutions to act as a watchdog – state-regulated banks in the case of currency. In the case of currencies, the third party's job is to make sure that each dollar is only be spent once in a transaction, a problem known as double-spending. Nakamoto's brilliant solution allows nodes in a network (i.e., computers running the same protocol) to agree on what transactions occur. To record the transaction, computers compete against each other, solving a mathematical puzzle. The first computer on the network present the solution gets to write a block on the ledger, which is proof the coin was spent and earns credit for the work. This system is called '**proof of work**.' The record thus created, verified, and remembered is called the 'blockchain.'

1.2.2 Crypto Tokens

Crypto tokens are one example of smart contracts. A crypto token agreement is executed on the Ethereum Virtual Machine (EVM). It manages its supply of tokens and their exchanges by updating a set of variables written to the underlying Ethereum blockchain. For smart contracts to transact with one another and for trading to occur, these tokens contracts and their functionalities needed to be Standardized.

This gave birth to the Ethereum Request for Comments (ERC) documents that describe a token standard. The two exceptional token standards are the ERC20 standard [11] and ERC721 standard [12], respectively used to represent *fungible* and *non-fungible* digital assets.

1.3. Blockchain & Cryptocurrencies in Construction Industry & Management

Dimensions of Blockchain & Cryptocurrencies in Construction Engineering Management are shown in Fig. 1.3.

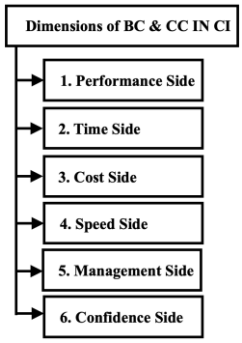

Fig.1.3 Dimensions

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- Blockchain Technology and Cryptocurrencies can help speed up the processing and Management of Construction Projects.
- Blockchain Technology and Cryptocurrencies contribute to a better project management process.
- Blockchain Technology and Cryptocurrencies can help lower Construction projects.
- Blockchain Technology and Cryptocurrencies are helping Shorten time, and the management of construction contracts is more accurate.
- Blockchain Technology and Cryptocurrencies help reduce errors.
- It helps to make construction projects more efficient.
- Overall, confidence in Blockchain Technology and Cryptocurrencies is used in construction projects.

1.4. Industry 4.0

The 4th industrial revolution (Industry 4.0) follows Industry 1.0 (water and steam power), Industry 2.0 (electricity), and Industry 3.0 (internet, electronic devices). It is characterized by the seamless integration of cyber-physical environments propelled by various technologies that enable the development of digital and automated industries and the digitization of the value chain [3–5]. Blockchain follows the egalitarian ideologies of the modern society where equality, direct dealing, openness, consensus, and mutual Trust play a vital role. A recent global report by McKinsey ranked the construction industry as the second-lowest sector to have adopted information technology during Industry 3.0 [7].
Hence, the problem lies in whether Blockchain will create just hype or real disruption in construction, similar to the digital revolution that is taking hold in other industries.

1.5. Artificial Intelligence

In recent years, technology is increasingly being used in various ways to make construction more efficient and innovative. Artificial Intelligence (A.I.) helps in the identification and analysis of clauses and other data.

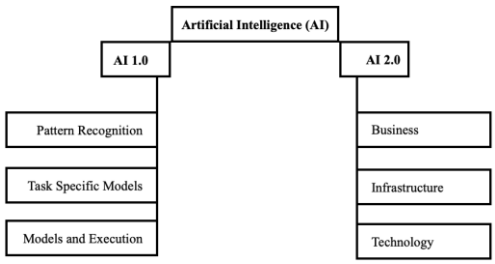

Fig.1.5 Artificial Intelligence

1.5.1 AI

Artificial intelligence was coined in 1956, but A.I. has become more popular today thanks to increased data volumes, advanced algorithms, and computing power and storage improvements. Early AI research in the 1950s explored topics like problem-solving and symbolic methods. In the 1960s, the U.S. Department of Defense took an interest in this type of work and began training computers to mimic basic human reasoning.

1.5.2 AI 2.0

In terms of concepts and infrastructures, the focus is on developing scalable and production-ready A.I. applications. Platforms and templates are used to implement data and A.I. products. To transfer them into production in an agile way, MLOps processes come into play. But alongside, the implementation of the necessary organizational structures and techniques in the company is crucial.

1.6. Construction Engineering Management

Construction Engineering Management is essential. Digital technology is used in management, as each Construction project contains large and diverse data, primarily in contract documents [6]. To help manage engineering works of Construction projects continuously. Considering the project Cost reduction, speed, management time to achieve results, Legal implications, confidence in the technology used Minimize wasted resources, and the most cost-effective management of the construction project industry.

1.6.1 Major Issues faced by the Construction Engineering Management

The first challenge faced by the construction corporations is the trust issue. Traditional construction engineering management involves trust issues in almost every aspect of daily activities. This has caused loose collaboration among the project stakeholders and challenges in information sharing, reducing efficiency and transparency among the various people.
Supply chain issue is the second main challenge. Many studies in the construction engineering management discipline have focused on improving supply chain management performance between manufacturers, distributors, contractors, and customers [5]. According to [7], the ultimate goal of supply chain management is to achieve a seamless and agile supply chain to meet customers' needs at the lowest cost. However, because of the conflicting interest of various participants in the supply chain, this ultimate goal is challenging to achieve.
The third one is related to asset management, which is critical in construction engineering management, especially for sectors where much attention is directed toward operation and maintenance [8]. As such, many studies have focused on asset management in construction engineering management. [9]

2. LITERATURE REVIEW

Most Blockchain Technology is known as the underlying technology of the Bitcoin virtual currency, invented in 2008 by a person known as Satoshi Nakamoto. Cryptocurrencies are technologies in digital form, and the term "Digitalization" is associated with the intensive development of information and communication technology. It has become a role in various industries, and it is helpful in the construction project industry for Construction Engineering Management. The Blockchain solves many current problems in Construction Engineering/Data Management [3].

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6 Dimensions, we have seen as a benefit of the Blockchain and Crypto Assets which improves:- **Performance side, Cost Side, Time Side, Speed Side, Confidence Side, Management side.**

The main *objective of this paper* is to study the feasibility of the application of Blockchain Technology and Cryptocurrencies for Engineering Management in Construction Projects and to study the relationship of stakeholders, clients, subcontractors, contractors, and suppliers by using this technology.

3. RESEARCH METHODOLOGY

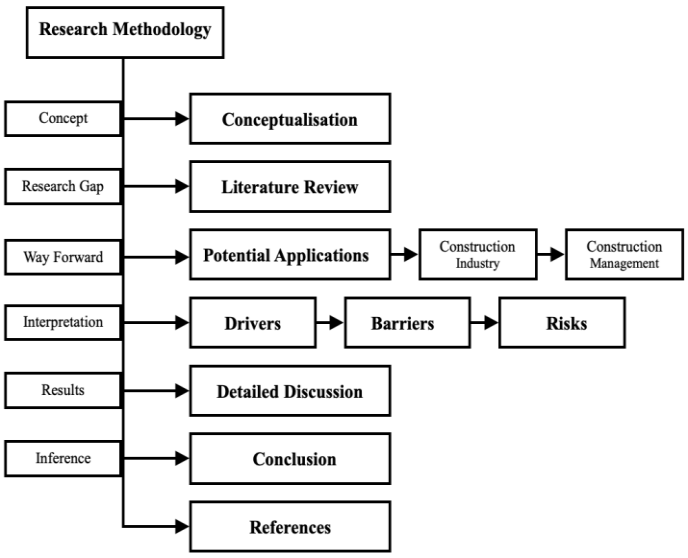

Fig.3 Research Methodology

The research methodology of the study comprises six steps, as illustrated in Fig. 3. After following the systematic literature review, the searching for the papers related to Blockchain Technology and Cryptocurrencies in the field of CI & CM. The literature review was carried out on 14 Journal Papers, 3 Conference Papers, 1 Book, and 3 Reports that give a detailed description of the use of Blockchain Technology and Cryptocurrencies in CI & CM.
The conceptualization process took place where literature was classified into different categories. Afterward, the Research gap was identified, leading to the Potential Applications and interpreting features, drivers, barriers, and risks. Finally, they extracted the Result, Inferences and reached the Conclusion.

4. POTENTIAL APPLICATIONS OF BLOCKCHAIN AND CRYPTOCURRENCY IN CONSTRUCTION INDUSTRY & MANAGEMENT

The applications of Blockchain Technology and Crypto Currencies in the Construction Industry & management are bifurcated into two parts,
1. Construction Industry
2. Construction Management

The brief overview is shown in Fig.4.

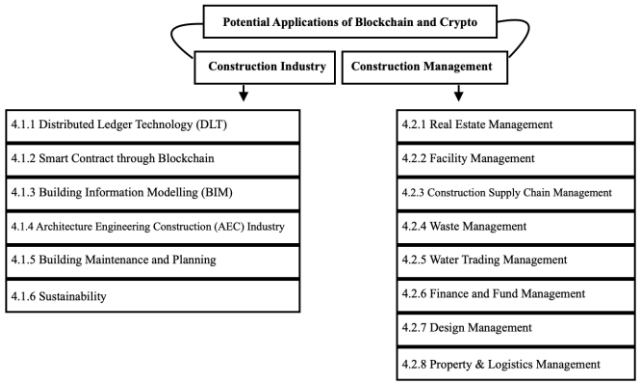

Fig.4 Potential Applications

4.1 Construction Industry

A brief description of Potential Applications in the Construction Industry are as follows:-

4.1.1 DLT- Distributed Ledger Technology

While various industries have already developed different DLT prototypes and applications, the construction sector is only at the beginning of DLT implementation as a tool. However, the application of DLT in construction might be especially promising [9,10].This provides a concise summary of the emerging applications of DLT in the built environment.

Smart Energy: Until recently, major Power Producers (MPPs) have traded energy, leading the market and setting prices; they still make up 94% of the electricity production market [4,2]. However, due to the falling cost of renewable technologies and the increase in consumer behavior [4], this market is opening up to offer more opportunities to individual, residential producers of electricity, primarily those who use solar photovoltaic panels on their homes and who produce an excess to that which they need to run their home, to sell it to the grid or their neighbors.

Smart cities: A smart city integrates resources where human and social capital interact using technological solutions [9]. The concept responds to projected increases in urban migration [7], putting immense pressure on the built environment to manage this increase. Advances in information and communication technology (ICT) and the IoT have made the sharing economy much easier and more accessible [2,6], allowing people to see real-time data about the availability of resources to make better-informed choices.
Smart homes.: Smart homes, while covered only briefly in the literature, are likely to become archetypal for new builds and existing homes as devices and appliances are replaced with intelligent versions and conversions are made to existing homes. [19] Blockchain is used to monitor and reduce energy consumption. Blockchain provides increased privacy and security in the smart home, and despite increases in overhead due to the use of low-resource IoT devices, the benefits are deemed

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worthwhile [21]. Digital signatures can be used to identify suspicious activity while, at the same time, giving each smart home device its own identity.

Intelligent transport. DLT broadens possible applications within intelligent transport through integration with other applications such as smart energy and better use of resources [15]. Smart vehicles now have on-board storage for private data, which, via the Blockchain, owners can choose whether to grant access to third parties giving them more control over their data. Blockchain reduces security and privacy issues through encryption and authentication. Various applications are offered: remote software updates during manufacturing and vehicle maintenance; flexible insurance based on driver behavior (i.e., speed, braking habits, etc.); smart vehicle charging which integrates with smart home, calendars, individual behaviors, etc.

4.1.2 Smart Contract

A smart contract has been defined as a computerized transaction protocol that executes the terms of a contract [12]. Smart contracts can express triggers, conditions, and business logic to enable more complex programmable transactions [14] while strengthening the mutual trust mechanism among users, becoming the core technology of Blockchain 2.0 [18]. Smart contracts allow digitization and automation of executing business workflows, i.e., self-executing contracts, which enforce the execution by the consensus mechanism [2, 12]. Smart contracts are written as computer codes and are deployed to and executed in blockchains such as Ethereum, EOS, etc.

4.1.3 BIM (Building information modeling)

BIMCHAIN is one of the recent blockchain applications in the construction industry which combined BIM concept with Blockchain tends to improve the current limitation of BIM in terms of design ownerships, traceability of design changes, and accountability [17] However, BIMCHAIN is still in its early adoption and require some time for maturity. In short, Blockchain will solve the trust issue and change the way of collaboration among the construction stakeholders in the BIM system shortly.

4.1.4 Architecture Engineering and Construction (AEC) Industry

AEC industry reports available by mid-2017 don't mention the Blockchain as a technology to watch out for. This study thus looked at articles on industry blogs instead. No direct mention of blockchain technology is found in AEC industry reports at the time of writing. A mandatory precondition for blockchain application is a high degree of digitalization, digital processes, and reliable digital infrastructure.

The mood generally oscillates between positive and hopeful, with a grain of skepticism. Most commentators admit that as much as they like the idea of transforming the AEC industry into a peer-to-peer system profiting from the distributed ledger technology of the Blockchain, they don't consider the AEC industry ready for blockchain technology regulating collaboration and exchange of information anytime soon. They point to the slow speed at which the AEC industry sets up standards for digital cooperation and the necessary scaling effect [16].

4.1.5 Building Maintenance

Preventive maintenance and planned maintenance play a key role in safety aspects and occupant satisfaction during the operational phase. An automated blockchain-enabled system can assist in monitoring the maintenance procedures of a building. Maintenance requests, procurement process, delivery of products, payments, and the like can be quickly and accurately managed through smart contracts. The occupant and all other parties are aware of the status of the maintenance request from the beginning to the completion of the work due to the transparency provided through Blockchain. It enables maintenance managers to identify who supplied and installed any building component at what cost at any time [18, 20].

4.1.6 Sustainability

Sustainability is one of the highest priorities in the built environment today due to the external demand from governments, customers, and the general public. Blockchain technology can correctly calculate embodied and operation carbon in the construction industry and optimize carbon management or even carbon trading. Furthermore, blockchain technology can be used for proper energy management in the built environment. The construction industry produces a significant portion of waste worldwide, and a blockchain could be utilized for appropriate waste management, including waste trading and circular economy. A blockchain network can also help energy management on a grand scale to achieve a smart grid. First, both energy consumption and production should be tracked using a blockchain. Then, this could provide a basis for better supply and demand control and ultimately accurate dynamic pricing for energy.

4.2 Construction Management

A brief description of Potential Applications in Construction Management are as follows:-

4.2.1 Real Estate Management

Blockchain is a robust shared global infrastructure that can represent property ownership and move value around via smart contract that encodes property as smart property in Blockchain. The current land title registry system uses a centralized database system, laying to the risk of data security and causing mistrust towards the non-transparent system. There is also the possibility of paper-based error resulting in transactional risk. The title searching using the existing land registration system is time-consuming and labor-intensive, resulting in elevated property transaction costs [16] due to the non-interoperable centralized system. Conversely, Blockchain improves efficiency, security and reduces risks by registering all the public property title records into the decentralized system. Blockchain offers an immutable and decentralized ledger allowing all present and past real estate transactions to be meticulously stored in the permissions database [16] and thus further eliminate fraud and paper-based error in property title transfer. In essence, a smart contract allows the asset to be registered in Blockchain, allowing the management and record of registry, purchase, and transfer of the property to be more transparent and cost-effective.

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4.2.2 Facility Management

Integrating Blockchain and BIM or Building Maintenance System (BMS) would provide a reliable integrated system that can give the project's complete history and trace every building detail to its source [13]. Furthermore, this integration can stretch to the future and use smart contracts when maintenance is needed to automatically place a work order and release the payment to the contractor upon the verification of completeness. The concept of Decentralized Autonomous Organization (DAO) is introduced as an organization governed via multiple smart contracts is an example of a similar picture from a different industry.

4.2.3 Construction Supply chain Management

The construction industry makes a significant impact on the global economy and global construction industry output. In contrast, in 2017, it was worth more than USD 10 trillion [16, 17], and it is approximately 13% of the global gross domestic product [15]. The construction industry produces complex and most significant objects, and it has arduous, lengthy supply chains with a large number of internal and external suppliers [14, 15]. Therefore, it is more challenging to implement an information and communication technology solution in project-based industries than in process-based sectors [18]. Although Information Technology (I.T.) applications can improve the efficiency of information flow, they cannot eliminate uncertainty in construction supply chains [19]. Blockchain-based supply chain management can enhance the authenticity and compliance of products, and ultimately it would lead to greater quality assurance of the final product [19]. In this manner, throughout the project's entire life cycle, an immutable record of data can be stored and maintained. Further, such data stored can even be retrieved during the post-construction stage [14].

Blockchain-based supply chain management provides greater payment security, ensures product compliance and authenticity, efficient payment handling and reduces the cost of finance, induces TrustTrust between suppliers and clients, and provides transparency for auditing purposes [16].

4.2.4 Waste Management

Waste generated by the construction industry is recognized as a global issue, directly adversely impacting the environment [17,18]. Therefore, proper waste management has become critical. In contrast, an accurate estimating of construction and demolition waste is one of the essential factors for implementing a successful waste management system [19]. Construction and demolition waste currently is treated as a necessary evil, but in essence, it is a by-product of the construction process. As such, waste can often be traded and recycled. A uniform waste management system that treats waste as a resource may be developed using blockchain technology to provide solutions for construction waste management.

4.2.5 Water Trading Management

Water trading allows users to buy and sell the water resources de- pending on the supply and demand, generally governed and managed by government agencies who have set its processes and rules, creating transparency issues [13]. Introducing blockchain technology to water trading will eliminate these issues while eliminating intermediaries, providing a transparent platform, connecting the water sources and the buyers, and providing smart contract-enabled transactions. Origin Clear, a US-based water treatment technology provider, is developing the blueprint for a Water Chain blockchain protocol to create transparency and efficiency in water treatment using smart contracts and cryptocurrency [17].

4.2.6 Finance Services and Fund Management

The construction industry has a chained payment settlement culture, and default settlement durations are much higher than other industries.

The primary concern on the traditional financial structure is the middlemen, which delay and add additional costs to transactions. Bitcoin was the first cryptocurrency aimed to address this by allowing users to do transactions directly without an intermediary or bank. Traditional financial business processes have another drawback where it is hard to transfer value without currencies. Blockchain can define its digital assets (or digitalized versions of assets) called Tokens. Tokens could be used by any business application to determine its digital assets to perform transactions. Most financial sector blockchain solutions could be integrated with many information and economic systems in other sectors, including the construction industry, to overcome their financial challenges, reduce costs, and add agility.

4.2.7 Design Management

In the construction industry, many contractors and consultants come together to design and deliver a one-off project. This can often cause a fragmented approach to developing as a different group of contractors and consultants. Usually, each construction discipline is kept separately during the design phase of the project. In recent years, the design management phase has been advanced by BIM to ensure that the design of the building meets the client's expectations. Blockchain could be utilized to truly enhance BIM benefits by allowing all architects and engineers to design on the same BIM model with their respective components with clear ownership. Moreover, continuous recording on design and construction decisions could be helpful in future case analyses, e.g., finding out who is at fault for designing or building a collapsed bridge.

4.2.8 Property and Logistic Management

The property sector is one of the most significant sectors in the built environment that can create global economic impact. Blockchain can be used as an immutable distributed ledger where transactions are timestamped into a block, enabling asset tracking, ownership transfer certification, and maintaining accurate, immutable history records [2]. Similarly, blockchain technology is considered ideal for maintaining a land registry on a blockchain as there are many occasions reported regarding tampering of data in land ownership-related aspects. The platform will be developed as a permissioned blockchain tied to the Bitcoin blockchain providing transparency and reducing fraud.

In 2017, two states in India, Telangana and Andhra Pradesh, announced using Blockchain for the land registry, and Telangana has already started a pilot project.

5. Drivers

Several drivers lead to the adoption of Blockchain in business computing applications in different industries. Some of the drivers identified and discussed and in this section are security,

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anonymity, no single point of Trust, fraud resistance, non-physicality, and financial incentives.

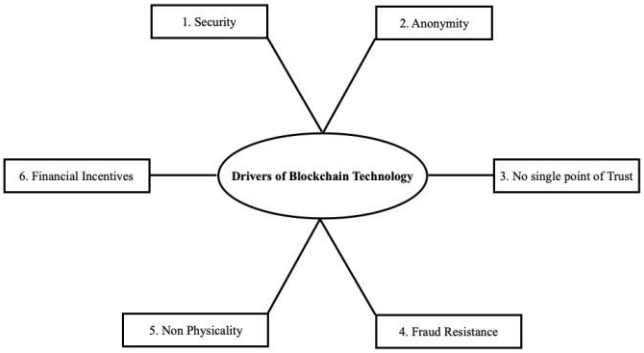

Fig.5 Drivers

A detailed description of drivers is as follow:-

1. Security:- For a transaction to occur, the sender needs to use their private key to access their cryptocurrency or tokens [12]. To make a transaction to any receiver, the sender needs to use the receiver's public key. In such a scenario, one can argue that public-key cryptography-based Blockchain is more applicable to the construction sector.

2. Anonymity:- To create an account on a blockchain, personal details are generally not required. Only the private and public keys need to be generated. One can use their public key as the account number for all transactions without exposing the information re- related to identity [13]. In the construction industry, anonymity will be advantageous on many occasions. For example, in a construction e-tendering process, the bids can be submitted anonymously until it is necessary to disclose the bidder.

3.No single point of TrustTrust:- Blockchain consists of a decentralized distributed ledger technology where issues due to centralization have been avoided [12]. Therefore, no single authority controls the Blockchain, and it is a collective effort to validate transactions and create blocks.

4. Fraud resistance:- Blockchain transactions are non-reversible and immutable [10]. Therefore, once a trade is recorded in a block and attached to the Blockchain, it is complicated for an attacker to change the data in a blockchain.

5. Non Physicality:- In blockchain transactions, a digital currency or tokens are exchanged between parties. Therefore, it does not require any physical instrument such as bank bills and bank vaults to store cash, reducing the cost of printing bills and the cost of providing security [11].

6. Financial Incentives:- Bitcoin has been designed to financially re- ward users that validate transactions by mining [12]. At the same time, miners also get to collect optional transaction fees for their effort in mining [13]. Due to these financial incentives, people are interested in mining to earn bitcoins while generating blocks.

6. Barriers

Barriers to adopting Blockchain create a negative impact in initiating and implementing Blockchain in industries. A few barriers such as data privacy, data storage, limitations in scalability, and the need for high computation power have been discussed in this section.

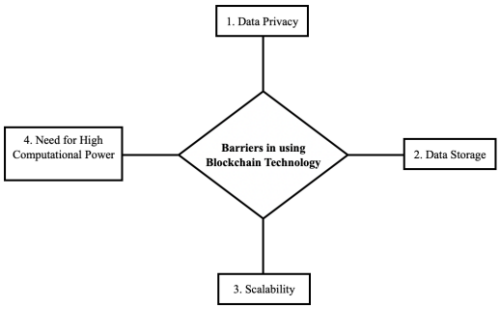

Fig.6Barriers

1. Data Privacy:- Public blockchains lack data privacy [9, 10]. As there are no privileged users, every node in the Blockchain can access all the information, and anyone can join and participate in the public blockchain network without any permission. Therefore, data privacy is a significant issue in public blockchains. Such users who are concerned about data privacy would prefer private blockchains. Private Blockchain, data encryptions, membership management, channels, and many other solutions have been proposed and implemented to solve data privacy issues in public blockchains. On the other hand, even in a public blockchain, sensitive or confidential information can be stored off-chain to ensure that all nodes do not have access to those [15], which will be beneficial for the construction industry as confidential information can be stored off-chain to avoid issues of data privacy.

2. Data Storage:- According to [1, 5], Blockchain is not suitable for storing Big Data due to the large volumes of data and low velocity of data taken for processing. Public blockchains have limits on the amount of data stored on a blockchain [14]. On the other hand, for a transaction to be recorded, it has to be validated and accepted by the majority of the nodes. When a large amount of data is stored, it will also delay the mining/block-producing process. As a solution to this issue, only the most essential data, which need to be on the Blockchain, will be on-chain. All other data will remain off-chain. A construction project comprises a massive amount of data. However, only the required data to be processed on the Blockchain can be stored in the blockchain ledger.

3. Scalability:- Public blockchains limit transaction processing rate and data transmission latency [17]. For a transaction to be recorded in a blockchain, the block should be validated by more than 50% of the nodes, which takes considerable time. As a result, a public blockchain will currently handle on average 3–20 transactions per second [15], whereas mainstream payment services like VISA handle 24,000 transactions per second [16]. Compared to the finance sector, the construction industry has a minimal number of transactions.

4. Need for high Computation Power:- The mining work related to PoW requires much computational power that uses a tremendous amount of electricity, which is a waste of energy [18] and unsustainable. Therefore, other consensus mechanisms such as PoS,

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DPoS, and many others have been introduced to address this issue, and these require computation power, which is significantly lower than PoW networks.

7. RISKS IN BLOCKCHAIN TECHNOLOGY

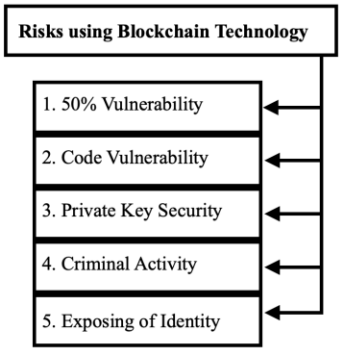

Fig.7 Risks in Blockchain Technology

Though Blockchain consists of many salient features that promote adopting Blockchain in various industries, there exist several risks inherent with blockchain technology. This section discusses a few risks such as vulnerability, fundamental private security, criminal activity, exposing identity, and the like.

1. 50% Vulnerability:- If a single miner gains more than 50% of the total hashing power of the entire Blockchain, then the 51% attack may be launched [18]. Hashing power means the attempts or guessing made per second by miners for creating a new block [14]. Similarly, 51% of attacks may occur if a single block producer or a colluding group of miners has more than 50% of the total stakes owned by the Blockchain.

The following possible attacks that could occur as a result of 51% vulnerability:-
1. Reverse transactions and initiate a double-spending attack.
2. Hamper normal mining operations of other miners.
3. Exclude and modify the ordering of transactions.
4. Impede the confirmation operation of regular transactions.

2. Code vulnerability:- Anyone can write a distributed application and run it in a smart contract enabled public Blockchain. In such a situation, the consequences of code vulnerability are significant [11, 18].

3. Private Key Security:- In the Blockchain, the user's private key is considered the identity and security credential. Suppose the private key is stolen by a criminal, as a single authority does not control the Blockchain. In that case, it is difficult to track its behaviors and recover the modified blockchain information [19].

4. Criminal Activity:- The exchange of cryptocurrencies or tokens occurs pseudonymously. Therefore, cryptocurrencies or tokens can be used for any illegal activities, and no one would know the parties involved in it. It is difficult to track user behaviors as well. Examples for criminal activities related to the cryptocurrency, bitcoin, as (1) generating ransomware, i.e., CTB-Locker, where an attacker sends an email comprising of the virus, which will run in the user's system encrypting files and recover the files the user has to pay the attacker in bitcoins within a limited time, [19]; (2) using in an underground market; and (3) money laundering. Cryptocurrencies-based criminal activities are less relevant to enterprise blockchain solutions.

5. Exposing of Identity:- Though Blockchain is identified as a technology that maintains anonymity, the attackers could trace the I.P. addresses used in the transactions and the transaction processor [12]. Afterward, the user's location can be traced, which can ultimately expose the user's identity. Similarly, suppose one buys a product online and pays for it using cryptocurrencies to receive the effect. In that case, one has to enter a location's physical address, ultimately exposes the location and user's identity. Therefore, though the Blockchain has preserved anonymity, it can be disclosed in certain ways and according to different circumstances.

8. RESULT AND DISCUSSION

Compared to the other conventional methodologies of performing Supply Chain Management (SCM), Chain Management (CM), and equipment leasing, the three proposed Blockchain-enabled applications can significantly avoid disputes and litigations due to immutable data records. Also, there are still lots of challenges when implementing it in real-life construction projects. The three main challenges faced are:-
1. Technical challenges
2. Construction business-related challenges
3. Human related challenges

Despite all these, there are numerous benefits to out weight these challenges to its adoption. A key benefit is using smart contracts in BCT to improve construction efficiency and manage contract risk.

The use of BlockChain Technology (BCT) will enable stakeholders, clients, sub-contractors, contractors, and suppliers in construction projects to operate an interest loss environment that promotes transparency and accountability. There is also a significant concern to adopt the Blockchain in the Building Information Modelling (BIM) environment.
This shall end up more coordination work for the validation works for any design changes. Another line of thought is Blockchain in Building Information Modelling (BIM) might be more suitable for setting projects such as mega township projects.

From the analysis by 15 persons with expertise in both public and private sectors, consisting of 5 public sector persons and ten private sector individuals, collected the data from the field and found the effectiveness of the 6 Dimensions of Block-Chain and Crypto Currencies in Construction Industry & Man-

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agement(Performance, Cost, Time, Speed, Management, Confidence side) The results of the analysis done by the experts of both public and private sectors, in terms of efficiency are:-
The Blockchain Technology and Crypto Currencies in Construction Industry and Management show the Confidence Side as the more efficient factor/dimension than the rest five sides (Performance, Cost, Speed, Management and Time). So, we can infer that Blockchain Technology and Crypto Currencies in this industry will show some fruitful and commendable results shortly. Future engineers should focus on accepting this technology in their core fields.

9. CONCLUSION

The potential of Blockchain in construction is significant. The forces of globalization, industrialization, and digitalization are inevitable as industries move deeper into Industry 4.0, where the integration of cyber-physical environments is coming to fruition. The evidence that Blockchain is not just hype but very real as the next disruptive technology that will propel the construction sector right into the middle of the 4th Industrial Revolution is mounting high. The existing knowledge in the literature on blockchain technology and its applications to find out possibilities to create and enable a successful platform to conceptualize and implement blockchain applications in the construction industry to mitigate the existing issues in the current construction systems. The study identified six potential areas of blockchain technology in the construction industry to be driven for future blockchain research, namely: Supply chain management, BIM, Construction management, electronic document management, real estate management, and funding management. Certain aspects identified are currently under the blossoming stage, such as BIMCHAIN for Blockchain in BIM and Sitesense for Blockchain in SCM. The biggest challenges causing slow technological adoption in the construction industry have been identified as lack of collaboration and information sharing, poor levels of Trust between parties, low productivity, late payments, lack of enforcement of regulations, and issues surrounding ownership and intellectual property rights.

Benefits of Innovative Blockchain Technology is a rapidly evolving and responsive technology applied in different industries to benefit the business. This is why it is used to assist in reliable management and financial transactions in Cryptocurrencies and help the Construction Engineering Industry from the start of the project. Management should begin the process before construction begins. It was found that contributing to the processing and management of the construction project faster, contributing to reducing the construction project management process, contributing to the cost reduction of the Construction project, contributing to shortening the time and the Construction contract management is accurate, contributing to reducing errors. Helping Construction projects more efficient, confidence in Blockchain Technology and Cryptocurrency to be used in construction projects.

Therefore, future research may concentrate on developing simulation models, conducting case studies on real-life blockchain applications in construction projects, and analyzing the capability of blockchain applications on the existing systems currently in use in the construction industry.

Confidence > Performance > Cost > Speed > Management > Time

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