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BLOCKCHAIN-BASED MATERIAL APPROVAL TRACKING USING BIM DATA

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ABSTRACT

The construction industry often faces challenges in material tracking and information management due to the use of traditional systems that rely on centralized databases such as Excel sheets and registers. These systems can lead to problems such as lack of transparency, data modification, delays, and trust issues among project stakeholders. To overcome these limitations, integrating Building Information Modeling (BIM) with blockchain technology has been proposed as a secure and transparent solution for managing construction data.

The aim of this study is to demonstrate a simple integration of BIM and blockchain for secure material tracking in construction projects. In this project, a building model is created using Autodesk Revit, and a material schedule is generated to extract details such as material ID, name, and quantity. The extracted material information is then stored on a blockchain ledger using a smart contract developed in Solidity and compiled using Remix IDE.

The results of the study show that the material data obtained from the BIM model can be successfully recorded and retrieved from the blockchain ledger. This ensures that the stored information is transparent, traceable, and resistant to unauthorized modification. Therefore, the project demonstrates that integrating BIM with blockchain can improve the security and reliability of material information in construction projects.

KEYWORDS: Building Information Modeling (BIM), Blockchain Technology, Smart Contract, Material Tracking, Construction Management, Transparency, Data Security, Solidity, Remix IDE, Decentralized Ledger.

INTRODUCTION

The construction industry has faced major challenges in managing material information and supply chain activities due to the use of traditional and centralized systems. These systems mainly depend on manual records, spreadsheets, and isolated databases, which often lead to data inconsistency, lack of transparency, and communication gaps. Such limitations reduce coordination among stakeholders and increase the risk of errors and delays. (Liupengfei Wang et al;2022). Effective material tracking plays a crucial role in ensuring that construction projects are completed on time and within the allocated budget. Proper monitoring of materials helps project managers control procurement, reduce wastage, and avoid shortages at construction sites. When material information is accurate and regularly updated, it supports smooth workflow and improves overall project performance (Xiao Li et al;2022).

Previous studies have reported that traditional construction systems rely on centralized databases such as spreadsheets, which are vulnerable to errors, data loss, and misuse, resulting in poor transparency, coordination problems, delays, and trust issues (Wang et al 2022; Xiao Li et al 2022; Tezel et al 2021). Integrating BIM with blockchain can enhance collaboration, data security, and resource traceability across the construction lifecycle. Blockchain provides a secure platform for storing BIM-related transactions and enables smart contracts to automate certain project processes, which can improve efficiency and reduce disputes among stakeholders (Yasin Celik et al;2023). A blockchain is a distributed ledger that uses cryptography and decentralized consensus mechanisms to securely record and verify transactions among participants in a shared system. It enables transactions to be stored in a transparent, secure, and traceable manner. The main advantages of blockchain include improved transparency, traceability, immutability of data, privacy protection, and automation of processes. In addition, decentralization supports more democratic decision-making by allowing multiple participants to contribute without relying on a central authority (Liupengfei Wu et al;2022). Integration of BIM and blockchain has strong potential to improve material tracking, supply chain management, and information transparency in construction projects.

Xiao Li (2022) built a Blockchain–BIM platform and tested it on a student housing project in Hong Kong, showing that data could be shared safely and tracked in real time. Hijazi and Perera (2023) created a BIM “Single Source of Truth” using Hyperledger Fabric and

Autodesk Revit, proving that project information could be stored in a tamper-proof and transparent way. Yixian Dong (2024) developed a BIM–Blockchain system for tracking materials and project delays, which helped reduce disputes and improve coordination between teams. Lingming Kong (2024) designed a smart system that only records small BIM updates on the blockchain, saving storage while keeping full traceability. Similarly, Muhammad Afzal (2022) focused on keeping BIM design data private and secure by using smart contracts to control who can access or edit it. Together, these experiments show that linking BIM with Blockchain can greatly improve trust, security, and collaboration in construction projects, even though large-scale testing is still needed before it becomes common in the industry.

The integration of Building Information Modeling (BIM) and blockchain technology to improve information management in construction projects. Xiao Li et al. (2022) developed a blockchain-enabled platform to improve supply chain management and track construction materials in modular construction. Their study demonstrated that blockchain can provide transparency, traceability, and secure storage of construction data among project stakeholders. Similarly, Liupengfei Wang et al. (2022) proposed a blockchain-based information-sharing system to improve communication and reduce errors in modular construction assembly.

Implementation of BIM and blockchain integration for material tracking using commonly available tools such as BIM models, schedules, and basic blockchain smart contracts. By creating a BIM model using Autodesk Revit, extracting material information into a schedule (Excel sheet), and recording the material data in a blockchain ledger using a smart contract. This approach demonstrates how blockchain can store material information securely and provide a transparent record of construction materials.

BIM model of a building is first created using Autodesk Revit. From the BIM model, a material schedule is generated to obtain details such as material ID, name, and quantity, which are exported to an Excel sheet. A blockchain environment is then set up, and a smart contract is written in Solidity to store the material information in a blockchain ledger. The smart contract is compiled and deployed using Remix IDE, and the material data obtained from the BIM schedule is manually entered into the blockchain. This process demonstrates how BIM data can be securely recorded and verified using blockchain technology for material tracking in construction projects.

Integrating BIM with blockchain can improve the transparency and security of material information in construction projects. A building model created in Autodesk Revit was used to extract material details such as material ID, name, and quantity through a schedule. This information was then recorded in a blockchain ledger using a smart contract developed in Solidity and executed through Remix IDE. The stored material records were successfully retrieved from the smart contract, showing that the data was securely stored and could be verified. The blockchain can be used to maintain a transparent and tamper-resistant record of construction materials obtained from BIM models.

OBJECTIVES OF THE WORK:

The main objective of this work is to develop a secure and transparent system for tracking construction materials by integrating Building Information Modeling (BIM) with blockchain technology.

- To take material data from BIM (Revit model):
  The project begins by creating a building model in Autodesk Revit, from which a material schedule is generated. This schedule contains important details such as material ID, name, and quantity, which are essential for construction management.
- To store it securely on blockchain using smart contracts:
  The extracted material data is then transferred to a blockchain platform and stored using a smart contract written in Solidity. This ensures that the data is stored in a decentralized and secure manner.
- To prevent data tampering (no modification once the data is stored):
  Once the material information is recorded on the blockchain, it cannot be altered or deleted. This immutability feature helps in maintaining data integrity and prevents unauthorized changes.
- To allow easy verification of material details anytime:
  The stored data can be accessed and verified at any time using smart contract functions. This allows stakeholders such as contractors and engineers to check material status, quantity, and other details, ensuring transparency and trust.

LITERATURE REVIEW

Xiao Li, et_al (2022) The paper presents a system that connects IoT devices, BIM models, and blockchain to manage modular construction supply chains more efficiently. Modular construction projects need accurate, real-time tracking of materials and work progress, but current systems often lack transparency, trust, and secure data sharing. The authors design a Blockchain-Enabled IoT-BIM Platform (BIBP) and test it in a real student housing project in Hong Kong to show how it improves traceability, security, and storage efficiency. The platform can make modular construction supply chains more transparent and trustworthy, but it's still a prototype and needs further testing before large-scale use [1].

Liupengfei W, et_al (2022) The paper talks about using blockchain technology to make information sharing in modular construction assembly more reliable and transparent.In modular projects, mistakes and delays often happen because of poor communication and inaccurate information sharing. Blockchain is explored because it can create a trustworthy, tamper-proof record for all stakeholders. The researchers built a blockchain-based information sharing model and tested it with a prototype system. It stored key construction data in a decentralized way, so every team member could see accurate updates in real time. The study shows that blockchain can reduce errors, improve collaboration, and increase efficiency in onsite modular assembly. However, it also notes challenges like technical complexity and integration with current practices [2].

Sadri, Yitmen et_al (2023). It is a systematic review that investigates the role of Blockchain and Digital Twins in the built environment and how they can be combined with disruptive technologies such as IoT, AI, cloud computing, and big data. The paper was written because the construction industry faces ongoing problems of inefficiency, fragmentation, and lack of trust, and there is a strong need to explore digital solutions. The authors collected and analyzed 86 papers published between 2017 and 2022 using PRISMA guidelines and bibliometric mapping with VOS viewer. Their findings show that Blockchain–DT integration is still in the early stages and is mostly limited to conceptual studies and prototypes, but it holds strong potential for improving data transparency, collaboration, and lifecycle management in smart construction. The study concludes that more real-world projects, standardization, and interoperability frameworks are required to make this integration practical. It also suggests future research on combining Blockchain–DT systems with AI, IoT, and big data to create efficient and sustainable smart cities.

METHODOLOGY

Step 1: Development of BIM Model

Firstly create a Building Information Model by using Autodesk Revit. In this step, a digital representation of a building is developed (see fig.1), which includes structural components such as walls, slab, doors, windows and floors. Each element in the BIM model is embedded with detailed information like material type, material ID, quantity and properties. BIM acts as a centralized data source where all construction-related information is stored in a structured format. This enables efficient planning, visualization, and management of the construction project.

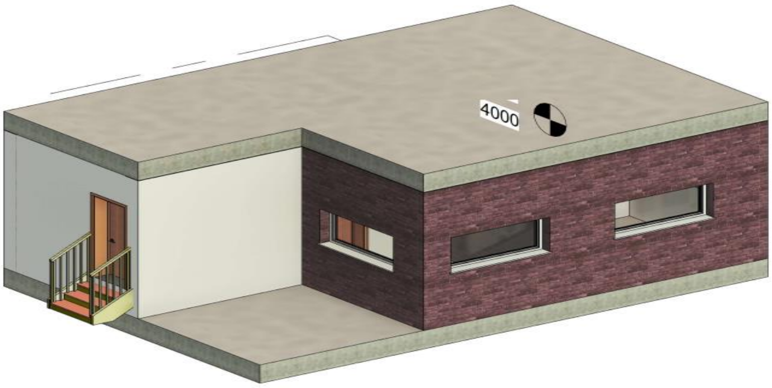

Fig. 1: 3D Revit Model.

Step 2: Extraction of Material Information (Schedule Generation)

After completing the BIM model, the next step is to generate a material schedule or quantity take-off (see figures 2, 3, 4, 5). This is done within the BIM software itself. The schedule provides a detailed list of all materials used in the building along with their quantities. The extracted data typically includes: Material name (e.g., cement, steel, bricks), Quantity required, Type of structural element, etc.. This step is very important because it ensures that the data used in the blockchain is accurate and directly derived from the BIM model. It reduces manual errors and improves reliability.

<Wall Schedule>

A	B	C	D	E	F
Family and Type	Count	Area	Volume	Width	Length
Basic Wall: Wall-E	1	10 m²	3.25 m³	310	3000
Basic Wall: Wall-E	1	27 m²	8.51 m³	310	9000
Basic Wall: Wall-E	1	18 m²	5.54 m³	310	6000
Basic Wall: Wall-E	1	8 m²	2.43 m³	310	3000
Basic Wall: Wall-E	1	9 m²	2.72 m³	310	3000
Basic Wall: Wall-E	1	6 m²	1.80 m³	310	1800
Basic Wall: Wall-E	1	3 m²	0.94 m³	310	700
Basic Wall: Wall-E	1	6 m²	1.99 m³	310	1800
Basic Wall: Wall-E	1	8 m²	2.41 m³	310	3000
Basic Wall: Wall-E	1	4 m²	0.83 m³	215	1200
Basic Wall: Wall-E	1	10 m²	3.11 m³	310	3155
Basic Wall: Wall-E	1	23 m²	6.98 m³	310	7160
Basic Wall: Wall-E	1	12 m²	3.47 m³	290	2845
Basic Wall: Wall-E	1	7 m²	1.97 m³	290	1840
	14	151 m²	45.96 m³	4205	47500

Fig. 2: Wall schedule.

<Window Schedule>

A	B	C	D	E
Family and Type	Count	Width	Height	Area
Windows_Sgl_Plain	1	910	910	0.8281
Windows_Sgl_Plain	1	910	910	0.8281
Windows_Sgl_Plain	1	1810	910	1.6471
Windows_Sgl_Plain	1	1810	910	1.6471
Windows_Sgl_Plain	1	1810	910	1.6471
Windows_Sgl_Plain	1	1810	910	1.6471
Windows_Sgl_Plain	1	1810	910	1.6471
Grand total: 7	7	10870	6370	9.8917

Fig. 3: Window schedule.

<Door Schedule>

A	B	C	D	E	F	G
Family and Type	Count	Width	Thickness	Door Panel Height	Area	Volume
Doors_IntSgl: 810x	1	810	38	2060	1.6686	3437.316
Doors_IntSgl: 810x	1	810	38	2060	1.6686	3437.316
Doors_IntSgl: 810x	1	810	38	2060	1.6686	3437.316
Doors_IntSgl: 810x	1	810	38	2060	1.6686	3437.316
Doors_IntSgl: 810x	1	810	38	2060	1.6686	3437.316
Doors_IntSgl: 810x	1	810	38	2060	1.6686	3437.316
Grand total: 6	6	4860	228	12360	10.0116	20623.896

Fig. 4: Doors schedule.

<Floor Schedule>

A	B	C	D
Family and Type	Count	Volume	Area
Floor: Floor-Grnd-S	1	27.61 m³	59 m²
Floor: Floor-Grnd-S	1	23.38 m³	50 m²
Grand total: 2	2	50.99 m³	108 m²

Fig. 5: Floor schedule.

Step 3: Exporting the Data in Excel

The material schedule generated from BIM is exported to Microsoft Excel as fig.6 for further processing. Excel acts as an intermediate layer between BIM and blockchain. In Excel, the data is organized into a simple tabular format with fields such as Material ID, Material Name, Quantity, Status (e.g., Pending/Approved). At this stage, additional fields like "status" are added manually, as they are not typically available in BIM schedules.

ELEMENT NAME	MATERIAL ID	MATERIAL NAME	QUANTITY	UNITS	STATUS
walls	1	cement	60	bags	approved
walls	2	brick	22660	no	approved
walls	3	sand	12	m^3	approved
floor	4	concrete	50.99	m^3	approved
windows	5	glass	7	no	pending
doors	6	wood	6	no	pending

Fig. 6: Exporting the Data in Excel.

Step 4: Design and Development of Smart Contract

Open Remix IDE, see figure 7.

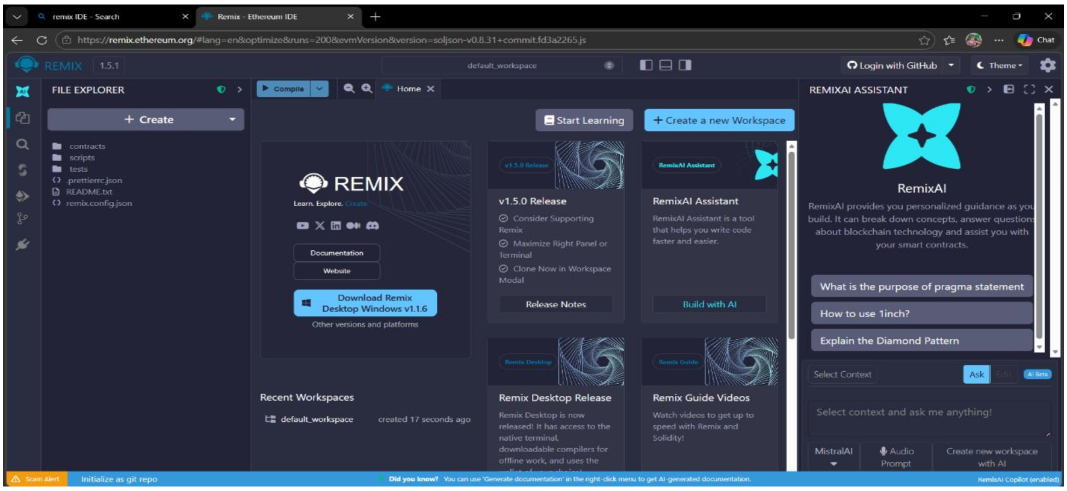

Fig. 7: Remix IDE web page.

Next, create new file named as MaterialTracking.sol., see figure 8.

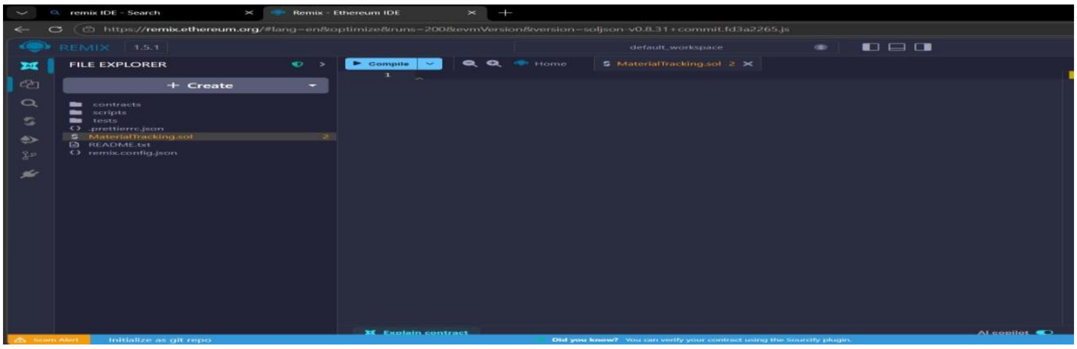

Fig. 8: Creation of smart contract file in remix IDE.

A smart contract is developed using the Solidity programming language in Remix IDE as shown in figure 9. The smart contract acts as a digital system to store and manage material data securely. The contract includes structure (struct) to define material properties and a mapping or array to store multiple materials. And Functions such as addMaterial() to store data, getMaterial() to retrieve data. Each material record contains ID,Name, Quantity, Status, Timestamp. This step ensures that the system is capable of securely storing BIM data on the blockchain.

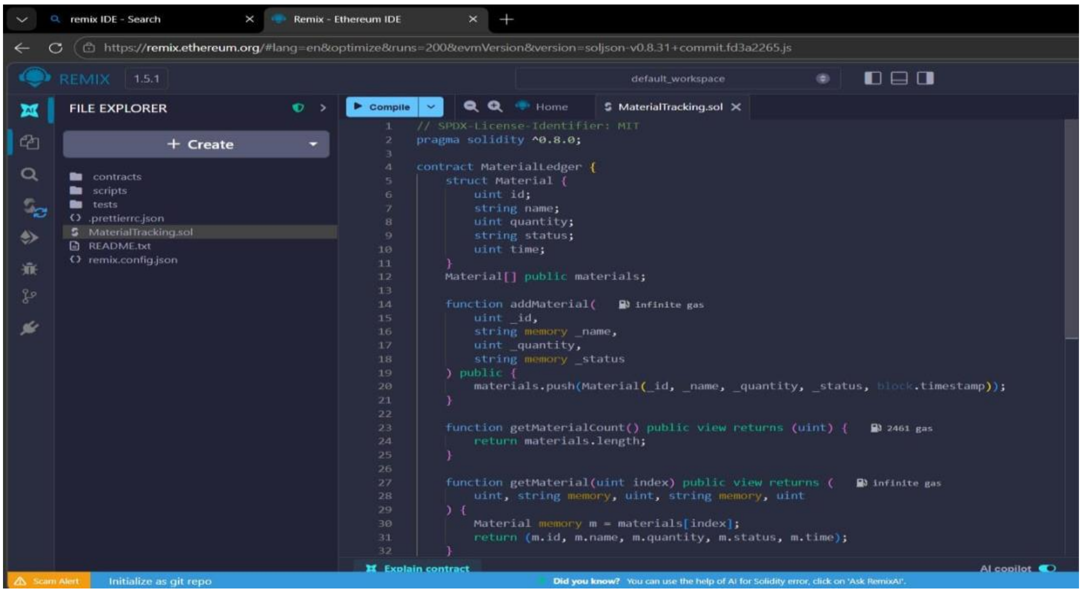

Fig. 9: Writing a smart contract in remix IDE.

Step 5: Compilation of Smart Contract

The written smart contract is compiled using the Solidity compiler available in Remix IDE as shown in figure 10. Compilation is necessary to check for errors and convert the human-readable code into machine-readable bytecode. If there are syntax errors, they are identified and corrected at this stage. Successful compilation ensures that the contract is ready for deployment.

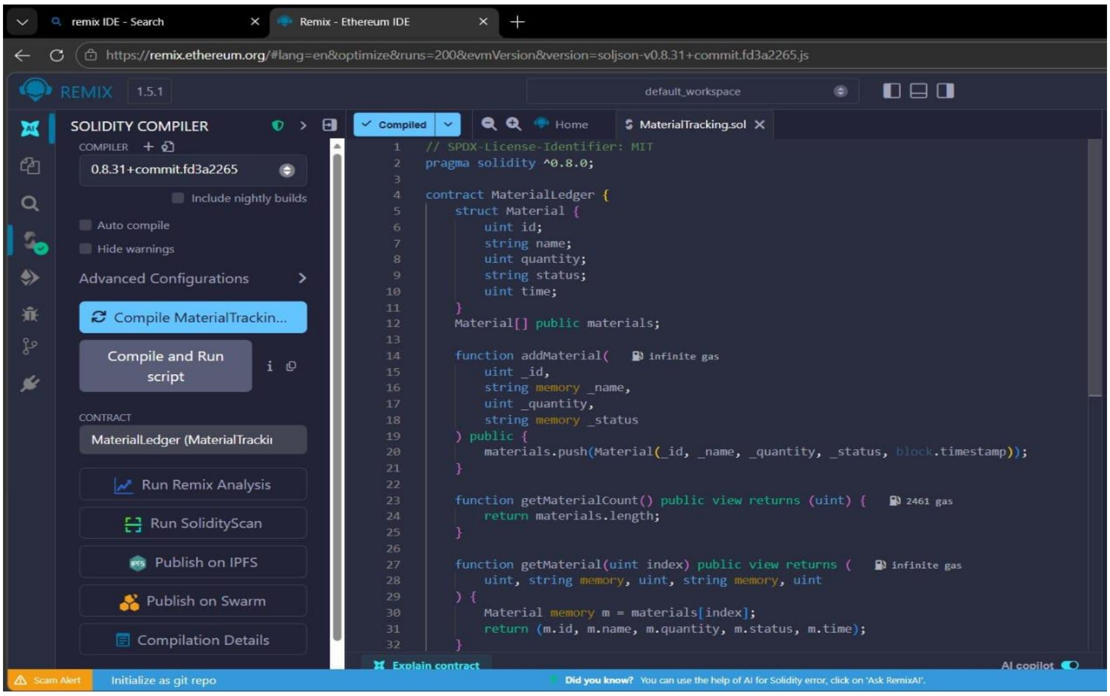

Fig. 10: Solidity compilation.

Step 6: Deployment on Blockchain (Remix VM)

After compilation, the smart contract is deployed on the Remix Virtual Machine (VM) environment. This VM simulates a blockchain network and allows testing without using real cryptocurrency or wallets. Once deployed, the contract becomes active and ready to interact with (see figure 11). It appears under the Deployed Contracts section in Remix IDE. This step establishes a working blockchain environment.

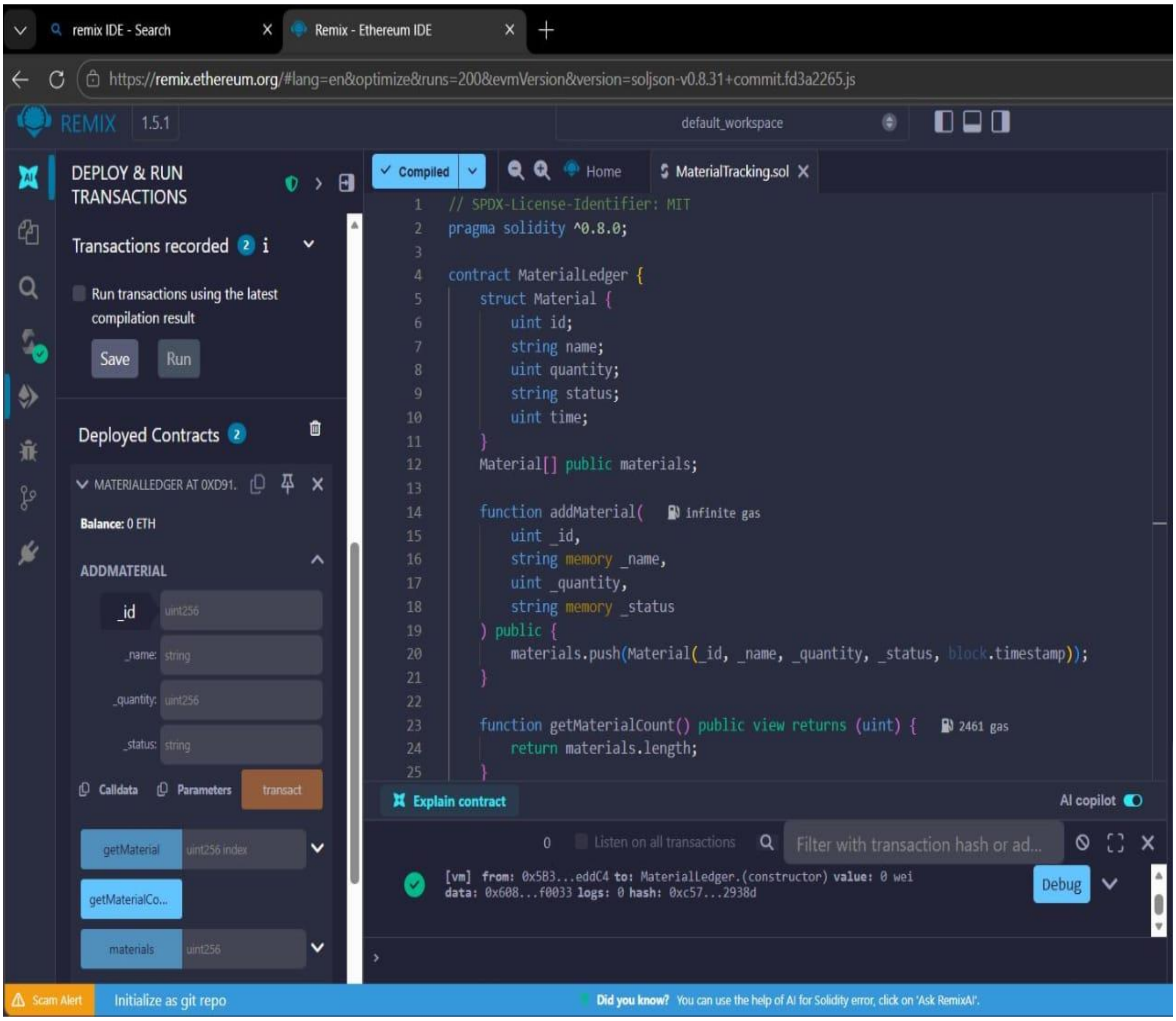

Fig. 11: Deployment of smart contract.

Step 7: Data Entry from Excel to Blockchain

The verified material data from Excel is manually entered into the smart contract using the add Material function. Each record is entered one by one by providing inputs such as Material ID, Name, Quantity, Status. When the function is executed, the data is stored permanently in the blockchain ledger. Each entry is recorded as a transaction and is assigned a timestamp.

Step 8: Retrieval of Stored Data

The stored data can be accessed using functions like get Material or by calling the materials mapping in the contract.

By providing an index or ID, the system displays Material details, Quantity, Status, Time of entry as given figure 12.

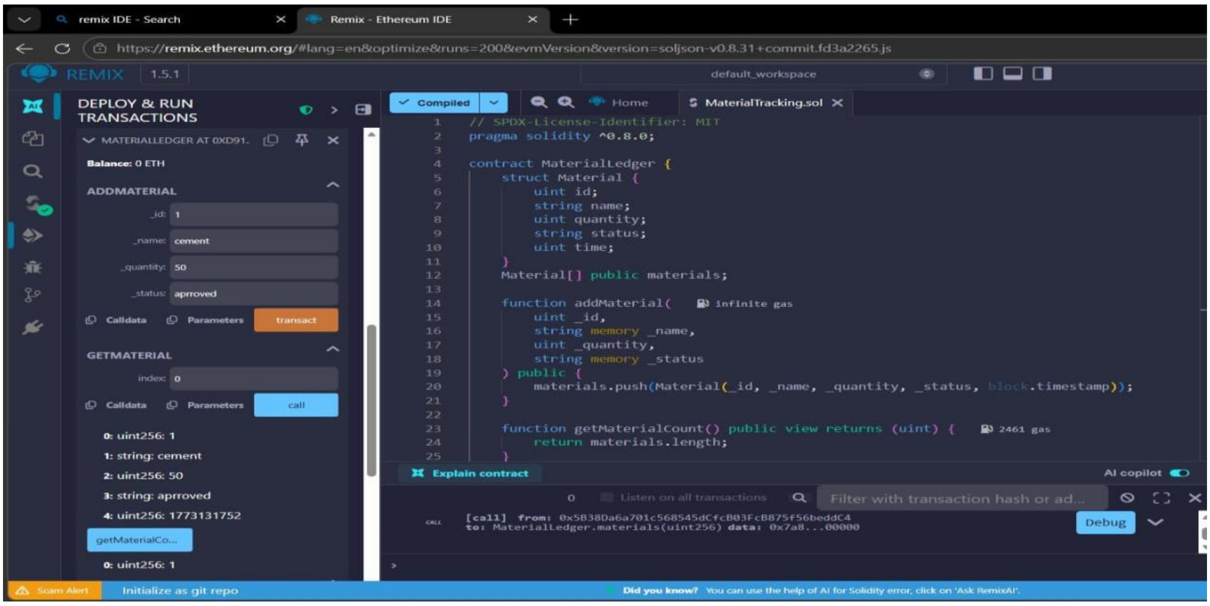

Fig. 12: Adding material data to block chain using smart contract.

This allows users such as contractors, engineers, and clients to verify material information at any time.

One of the key advantages of blockchain is that once data is stored, it cannot be altered or deleted. This ensures immutability of records. Transparency is achieved because all participants can access the same data. Traceability is ensured through timestamps and sequential data storage, allowing users to track the history of material records. For example, if the status of a material changes from “Pending” to “Approved,” a new record is added instead of modifying the old one. This maintains a complete history.

Chapter 5

RESULTS

The integration of BIM and blockchain can effectively improve the management of construction material data. A building model developed using Autodesk Revit was used to generate a material schedule containing details such as material name, quantity (in terms of volume, area, or count). This information was successfully extracted and utilized as input for the blockchain system.

A smart contract was developed using Solidity and deployed through Remix IDE, through which the material data was recorded in a blockchain ledger. The stored data was retrieved using smart contract functions, confirming that the material records were securely stored and could be verified without any data loss.

It indicates that the blockchain system ensures transparency, traceability, and data integrity, as once the material information is recorded, it cannot be easily altered. This reduces the chances of data manipulation and improves trust among project stakeholders.

By integrating BIM and blockchain, providing a reliable solution to overcome issues such as lack of transparency, delays, and trust problems in traditional construction material management systems.

ELEMENT NAME	MATERIAL ID	MATERIAL NAME	QUANTITY	UNITS	STATUS
walls	1	cement	60	bags	approved
walls	2	brick	22660	no	approved
walls	3	sand	12	m³	approved
floor	4	concrete	50.99	m³	approved
windows	5	glass	7	no	pending
doors	6	wood	6	no	pending

Fig. 13: BIM Material Data.

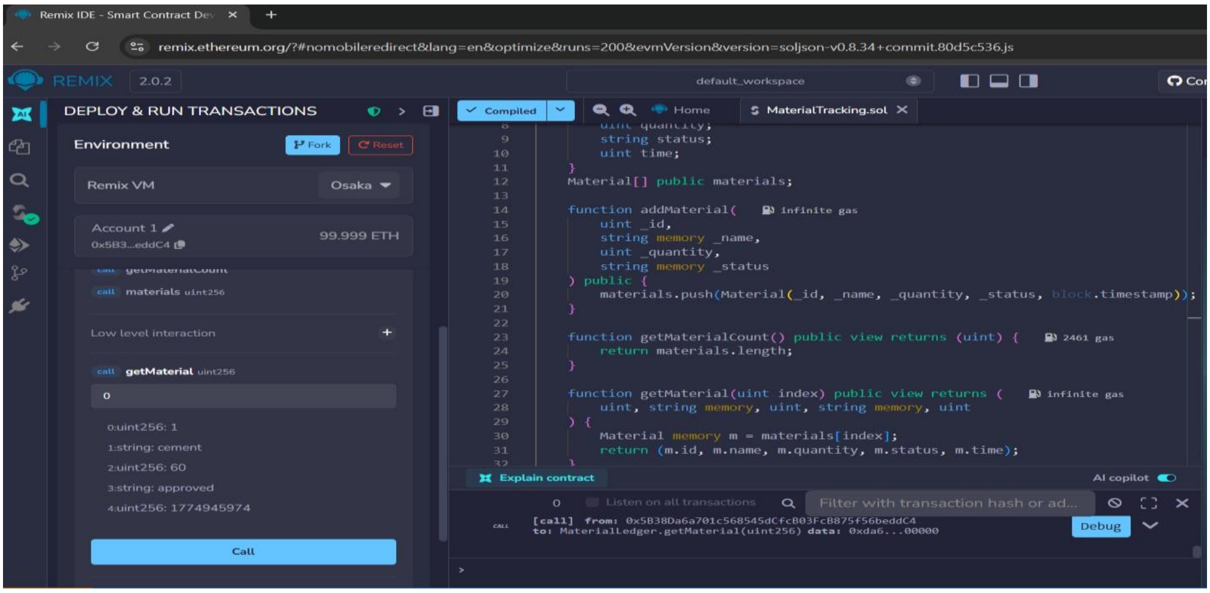

Fig. 14: Blockchain stored data.

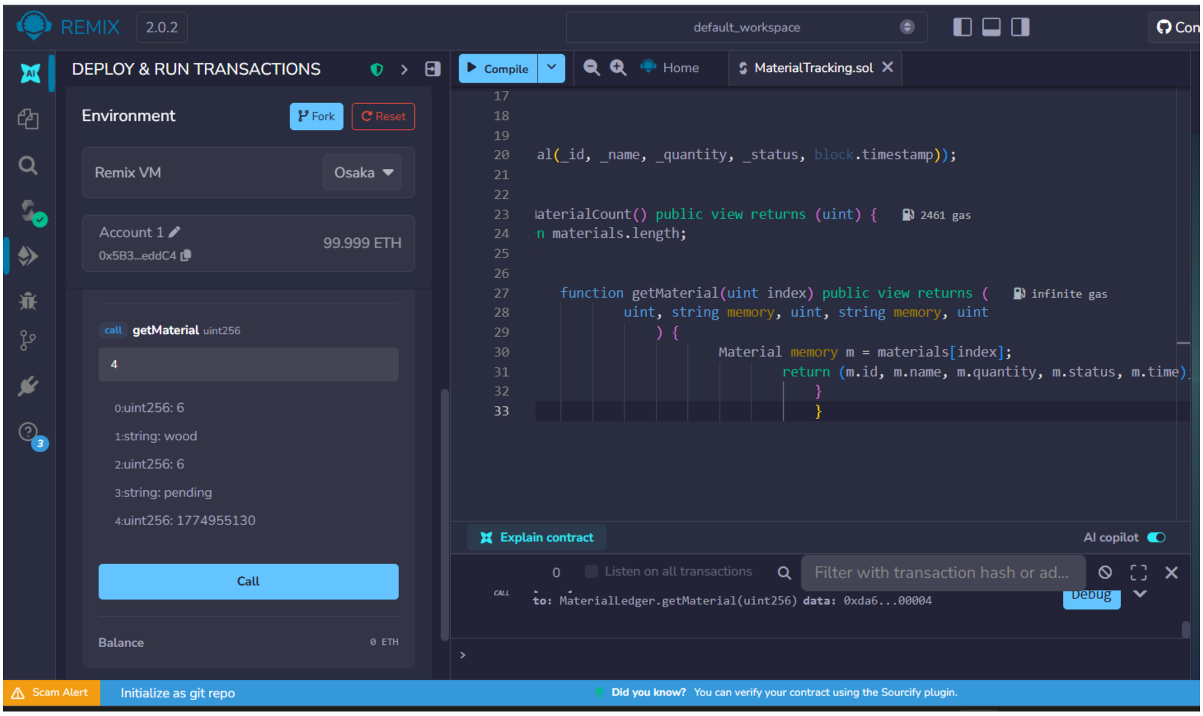

Fig. 15: Blockchain stored data verification.

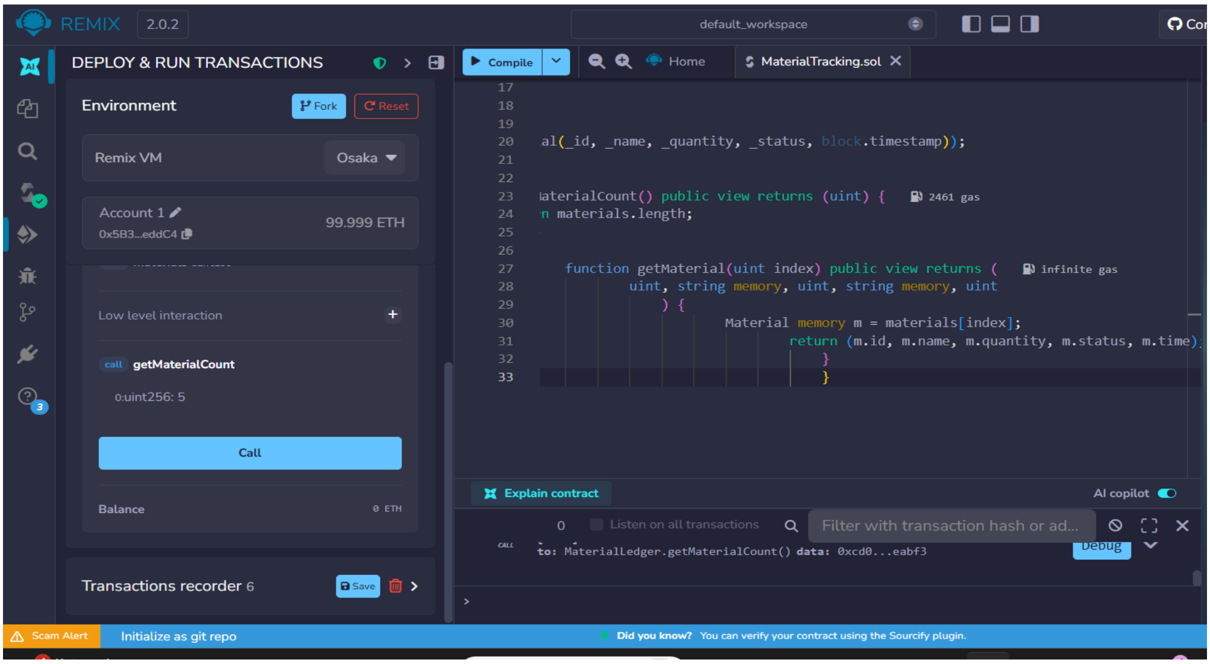

Fig. 15: Blockchain stored data count.

CONCLUSION

The integration of Building Information Modeling (BIM) and blockchain technology to develop a secure, transparent, and reliable system for construction material tracking. The BIM model created using Autodesk Revit enabled the extraction of accurate material information, including material ID, name, and quantity. This ensured that the data used in the system was consistent with the actual building design and minimized the chances of manual errors.

The extracted material data was organized and verified using Microsoft Excel, which acted as an intermediate platform for data preparation. This step helped in simplifying and structuring the BIM data into a format suitable for blockchain storage. A smart contract was then designed and implemented using Solidity in Remix IDE, which enabled the secure storage and management of material information on a blockchain-based system.

The implementation of blockchain technology ensured that once the material data was recorded, it could not be altered or deleted, thereby maintaining data immutability and integrity. The system also provided transparency, as all stored information could be accessed and verified by stakeholders at any time using smart contract functions. Additionally, the inclusion of timestamps for each transaction enabled traceability, allowing users to track the history of material records and status updates.

Integration of Building Information Modeling (BIM) and blockchain technology also demonstrated that even a simplified integration approach where BIM data is manually transferred to the blockchain can effectively showcase the benefits of combining these technologies. It highlights how blockchain can address common challenges in the construction industry, such as lack of trust, data manipulation, and inefficient record management.

The integration of BIM and blockchain presents a promising solution for improving construction data management by enhancing security, transparency, and reliability. This project provides a strong foundation for future developments, where automated data transfer, real-time updates, and data implementation can be achieved to further improve efficiency in construction projects.

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