

# Development of a Digital Twin of a Building Using Building Information Modelling for Construction Analysis

S. K. Pawar<sup>1</sup>, N. R. Borase<sup>2</sup>, M. N. Ahirrao<sup>3</sup>, Sonawane Chetan D<sup>4</sup>, Sonawane Kavita S<sup>5</sup>  
Suryanwanshi Dhanshri Y<sup>6</sup>, Thakare Chetan B<sup>7</sup>

<sup>1,3</sup>Assistant Professor, Civil Engineering Department, NESS'S Gangamai College of Engineering, Nagaon

<sup>2</sup>Professor and Head, Civil Engineering Department, NESS'S Gangamai College of Engineering, Nagaon

<sup>4,5,6,7</sup>UG Student, Civil Engineering Department, NESS'S Gangamai College of Engineering, Nagaon

**Abstract**—The construction industry is undergoing a significant digital transformation driven by the adoption of advanced technologies such as Building Information Modelling (BIM) and Digital Twin systems. A digital twin represents a virtual replica of a physical asset, enabling real-time monitoring, simulation, and performance analysis throughout the lifecycle of a building. This paper presents the development of a digital twin of a building using BIM to enhance construction efficiency, coordination, and decision-making. The proposed approach integrates 3D modeling, 4D scheduling, and 5D cost estimation within a unified BIM environment. The digital twin enables improved visualization, clash detection, construction planning, and lifecycle management. The study highlights the methodology adopted for digital twin creation, system components, expected outcomes, advantages, and limitations. The results demonstrate that BIM-based digital twins significantly improve construction management and support sustainable and data-driven decision-making across the building lifecycle.

**Index Terms**—Digital Twin, Building Information Modeling (BIM), Construction Management, 4D Scheduling, 5D Cost Analysis, Smart Buildings.

## I. INTRODUCTION

The construction sector has traditionally faced challenges such as design conflicts, cost overruns, schedule delays, and inefficient coordination among stakeholders. With increasing project complexity, there is a growing demand for digital solutions that enhance planning, visualization, and lifecycle

management. Building Information Modeling (BIM) has emerged as a powerful tool that enables the creation of intelligent 3D models embedded with geometric and non-geometric information.

A digital twin extends the concept of BIM by creating a dynamic and continuously updated virtual representation of a physical building. By integrating real-time data, scheduling, and cost information, digital twins enable performance monitoring, predictive analysis, and informed decision-making. This research focuses on developing a digital twin of a building using BIM to support construction analysis and lifecycle optimization.

## II. DIGITAL TWIN AND BIM OVERVIEW

A digital twin is a digital replica of a physical asset that mirrors its structure, behavior, and performance throughout its lifecycle. In the construction domain, digital twins utilize BIM models as the foundational data source. BIM provides accurate 3D geometry, material properties, and construction details, which are essential for creating a reliable digital twin.

The integration of BIM and digital twin technology allows stakeholders to simulate construction activities, analyze project performance, detect clashes, and evaluate design alternatives before physical execution. This synergy improves collaboration, reduces rework, and enhances project predictability.

### III. OBJECTIVES

The specific objectives of the project include:

1. Developing an accurate 3D BIM model of the building
2. Visualizing construction phases using 4D scheduling
3. Performing cost estimation and analysis through 5D BIM
4. Identifying and minimizing design conflicts and construction risks
5. Enhancing coordination and decision-making using digital visualization
6. Supporting lifecycle management and future smart building applications

### IV. SYSTEM OVERVIEW AND COMPONENTS

The proposed system integrates multiple dimensions of BIM within a unified digital environment. The system architecture consists of the following components:

#### A. Input Data

Input data includes architectural drawings, structural layouts, material specifications, and project schedules. These data sources form the basis for BIM model development.

#### B. Processing Module

1. The processing stage involves:
2. Creation of a detailed 3D BIM model
3. Linking construction activities to model elements for 4D scheduling
4. Integrating cost data for 5D estimation
5. Preparing the model for future real-time data integration

#### C. Output

The final output is a functional digital twin model that enables visualization, construction analysis, cost monitoring, and lifecycle assessment.

#### C. Proposed System

The system enables real-time visualization and analysis of the building construction process. It improves coordination, reduces rework, and ensures better decision-making by providing a single, accurate source of project information.

The proposed system introduces a Building Information Modeling (BIM)-based Digital Twin framework that enables efficient construction management and performance analysis of a building project. The system focuses on creating a virtual replica of the physical structure that can simulate, monitor, and analyze different aspects of the construction process in real-time.

In the proposed approach, the digital twin is developed using Autodesk Revit or similar BIM software. The system integrates 3D modeling, 4D scheduling (time), and 5D cost estimation into a unified digital environment. This helps project teams visualize the entire construction lifecycle before execution, minimizing risks, errors, and delays.

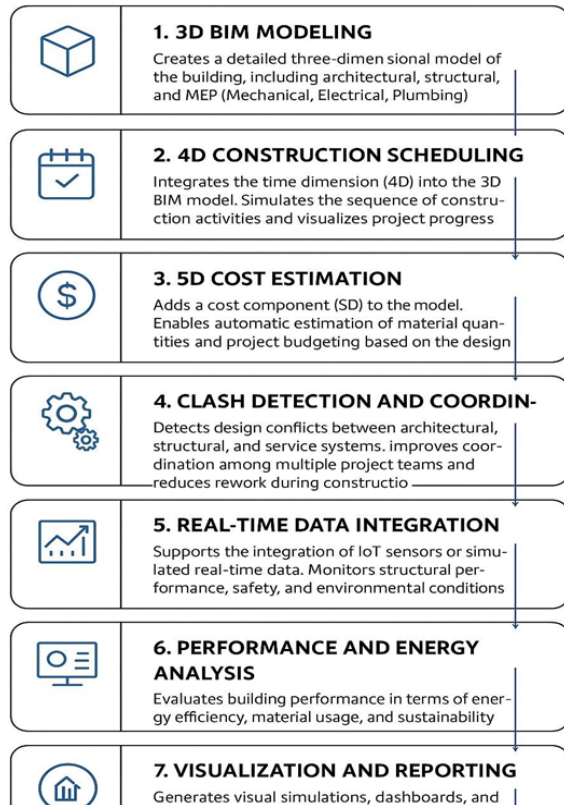
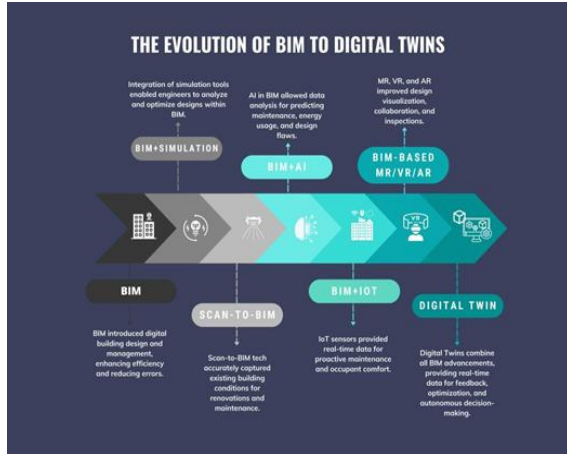
The proposed system also supports clash detection, allowing engineers to identify conflicts between architectural, structural, and MEP components during the design stage itself. Additionally, the model can be connected to real-time data sources (such as sensors or IoT inputs) to monitor construction progress and building performance dynamically.



#### Key Features of the Proposed System

1. 3D Digital Model Creation: Generate a detailed and accurate BIM model of the building.
2. Integration with Project Schedule (4D): Link construction activities with time-based progress tracking.
3. Cost Analysis (5D BIM): Integrate cost data to estimate and control project budgets.
4. Clash Detection: Identify and resolve design conflicts among different building systems.

5. Performance Monitoring: Simulate and analyze building performance metrics like energy efficiency or material usage.
6. Visualization and Reporting: Provide real-time visualizations and analytical reports for effective decision-making.



## V. METHODOLOGY

The methodology adopted for developing the digital twin consists of the following sequential steps:

1. Data Collection: Gathering architectural plans, structural details, and project requirements
  2. 3D BIM Modeling: Creating a detailed three-dimensional model representing the physical building
  3. 4D Scheduling: Integrating construction schedules to visualize project timelines and sequencing
  4. 5D Cost Analysis: Associating cost data with building components for accurate estimation
  5. Performance Analysis: Evaluating construction efficiency, coordination, and potential conflicts
  6. Digital Twin Integration: Preparing the model for real-time data and lifecycle monitoring
- Each stage ensures that the digital twin accurately represents the physical building and supports effective project management.

## VI. EXPECTED OUTCOMES AND ADVANTAGES

The implementation of a BIM-based digital twin offers several benefits:

1. Enhanced visualization of construction activities
2. Improved coordination among project stakeholders
3. Accurate cost estimation and budget control
4. Reduction in design conflicts and construction errors
5. Improved decision-making through data-driven insights
6. Support for sustainable construction and lifecycle optimization

The digital twin acts as a decision-support tool that improves efficiency and reduces project risks.

## VII. DISADVANTAGES AND LIMITATIONS

Despite its advantages, the adoption of digital twin technology faces several challenges:

1. High initial costs of BIM software and hardware infrastructure
2. Complexity in model development and data integration
3. Requirement for skilled professionals and training
4. Time-consuming setup and implementation
5. Challenges in managing large volumes of data

These limitations may restrict adoption, particularly in small-scale construction projects.

## VIII. PROJECT SCOPE AND FUTURE APPLICATION

The scope of the project includes design modeling, construction planning, cost estimation, and lifecycle management. Beyond construction, the digital twin can be extended to support:

1. Smart building systems
2. Predictive maintenance
3. Energy performance analysis
4. Facility and asset management

The approach aligns with future trends in smart infrastructure and sustainable development.

## IX. CONCLUSION

This study demonstrates the successful development of a digital twin of a building using BIM for construction analysis. The integration of 3D modeling, 4D scheduling, and 5D cost estimation enhances project visualization, coordination, and decision-making. BIM-based digital twins represent a significant step toward the digital transformation of the construction industry. By improving efficiency, reducing risks, and supporting sustainability, digital twins offer a promising solution for modern construction and long-term asset management.

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