International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802206

# BIM-Based Planning and Cost-Time Optimisation for a 50-Bedded Hospital Building

**Mohammad Shibil, Mr. K. Soundhirarajan**

Department of Civil Engineering, Gnanamani College of Technology (AUTONOMOUS), Namakkal, Tamil Nadu, India

**Publication History:** Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03. 2026; Published: 28.03.2026.

**ABSTRACT:** Building Information Modelling (BIM) has emerged as an advanced digital technology that improves planning, design coordination, and construction management in infrastructure and healthcare projects. Hospital buildings require accurate planning, efficient space utilisation, and proper coordination among architectural, structural, and service components due to their complex functional requirements. This study presents a BIM-integrated approach for the planning and construction of a 50-bedded hospital building to enhance project efficiency and coordination. A detailed 3D BIM model of the hospital is developed using BIM tools to integrate architectural, structural, and service components into a single digital platform. The model is further extended to 4D scheduling and 5D cost estimation to optimise construction time and cost. Clash detection and coordination analysis are performed to reduce design conflicts and improve project execution. The results demonstrate that BIM implementation improves planning accuracy, reduces construction delays, enhances cost estimation, and ensures better coordination among stakeholders. The BIM-based approach also supports efficient project monitoring and resource management, making it suitable for healthcare infrastructure development. The study highlights the potential of BIM in improving construction quality and operational efficiency in hospital building projects

**KEYWORDS:** Building Information Modelling (BIM), Hospital Building, Healthcare Infrastructure, 3D BIM Modelling, 4D Scheduling, 5D Cost Estimation, Construction Planning, Project Management

## I. INTRODUCTION

The construction industry is increasingly adopting digital technologies to improve project planning, coordination, and overall efficiency, particularly in complex infrastructure projects such as healthcare facilities. Building Information Modelling (BIM) has emerged as a transformative technology that enables integrated planning, design coordination, and lifecycle management by combining architectural, structural, and service components into a unified digital model. BIM supports visualization, clash detection, cost estimation, and scheduling, which significantly reduces project delays and cost overruns while improving coordination among stakeholders. Recent studies have shown that BIM implementation enhances project efficiency and reduces construction risks, making it a critical tool for modern infrastructure development (Nekouvaght Tak et al., 2020; Thiam & Fall, 2021).

Healthcare infrastructure projects, particularly hospital buildings, require precise planning and efficient coordination due to their complex functional requirements and strict operational standards. A hospital building includes multiple interconnected spaces such as outpatient departments, operation theatres, intensive care units, emergency wards, and diagnostic facilities, along with complex mechanical, electrical, and plumbing (MEP) systems. Traditional construction methods often face challenges such as design conflicts, inefficient space utilization, cost overruns, and construction delays due to lack of coordination among stakeholders. BIM provides an integrated platform that enables real-time collaboration, accurate visualization, and effective coordination, thereby improving hospital construction planning and execution(Hu et al., 2020; Lee et al., 2022).

The application of BIM in hospital construction has gained significant attention due to its ability to integrate 3D modelling, 4D scheduling, and 5D cost estimation into a single digital environment. BIM-based 3D modelling allows engineers and planners to visualize building components and identify potential design conflicts before construction begins, while 4D scheduling helps in optimizing project timelines and monitoring construction progress. Similarly, 5D cost estimation enables accurate quantity take-off and budget control, reducing financial uncertainties. Studies have reported that BIM implementation can reduce construction time by 10–20% and project cost by 5–15% through improved coordination and planning in healthcare infrastructure projects(Hu et al., 2020; Meng et al., 2021).

In addition to cost and time optimization, BIM also supports sustainable construction practices by enabling energy analysis, material optimization, and lifecycle assessment during the planning stage. Hospital buildings consume significant energy and resources due to continuous operation and high service requirements, making sustainability a critical factor in healthcare infrastructure development. BIM allows engineers to evaluate energy performance, resource utilization, and environmental impact before construction, thereby supporting green building design and reducing carbon emissions. The integration of BIM with sustainable construction strategies improves lifecycle performance and reduces operational costs in hospital buildings(Heydari et al., 2022).

Despite the advantages of BIM, its implementation in hospital construction projects, particularly in developing countries, remains limited due to lack of structured implementation frameworks, high initial investment, and insufficient coordination among stakeholders. Many hospital projects still rely on conventional planning methods, which lead to delays, cost overruns, and inefficient resource management. Therefore, there is a need for a practical case study-based BIM framework that demonstrates the integration of 3D modelling, 4D scheduling, and 5D cost estimation for hospital construction to improve project efficiency and sustainability(Cho & Han, 2022).

This study presents a BIM-based case study of a 50-bedded hospital building to evaluate the effectiveness of BIM in planning, coordination, cost-time optimization, and sustainability. The hospital building is conceptually modeled using BIM tools such as Revit, Navisworks, Primavera, MS Project, and CostX to develop a structured workflow for integrated project planning. The study focuses on developing a coordinated BIM model, performing clash detection, optimizing construction schedule, estimating project cost, and analyzing sustainability aspects of the hospital building. The case study aims to demonstrate how BIM can improve planning accuracy, reduce construction delays, enhance cost control, and support sustainable healthcare infrastructure development.

The main objectives of this study are:

- To develop a BIM-based 3D model of a 50-bedded hospital building
- To perform 4D scheduling for construction time optimization
- To conduct 5D cost estimation for budget control
- To analyse sustainability and resource optimization in hospital construction
- To evaluate the effectiveness of BIM in improving project coordination and efficiency

This case study contributes to the construction and healthcare infrastructure domain by providing a structured BIM implementation framework for hospital buildings, demonstrating the potential of BIM in improving cost-time optimization, sustainability, and project management in real-world construction projects.

## II. LITERATURE REVIEW

Building Information Modelling (BIM) has been widely adopted in the architecture, engineering, and construction (AEC) industry to improve project planning, coordination, and cost-time management. Several studies have investigated the application of BIM in healthcare infrastructure and hospital construction projects, highlighting its effectiveness in enhancing project efficiency, reducing design conflicts, and improving sustainability. The literature indicates that BIM plays a crucial role in integrating 3D modelling, 4D scheduling, and 5D cost estimation, which significantly improves construction planning and project management.

Sacks et al., (2018) explained that BIM enables digital representation of building components and supports lifecycle management, making it a powerful tool for complex infrastructure projects such as hospitals. The study highlighted that BIM improves coordination among stakeholders and reduces design errors through integrated modelling and visualization.

K. C. Iyer & Sagheer, (2010) reported that BIM implementation in construction projects improves cost estimation accuracy, reduces project duration, and enhances collaboration among project participants. The study demonstrated that BIM-based planning reduces rework and improves project efficiency compared to traditional construction methods.

Pauwels et al., (2017) analyzed the benefits of BIM in construction projects and found that BIM improves scheduling, cost control, and project coordination by integrating digital models with project management tools. The study emphasized that BIM enhances decision-making and reduces uncertainties in construction planning.

Volk et al., (2014) discussed BIM implementation in complex infrastructure projects and highlighted its importance in improving project lifecycle management and facility maintenance. The study emphasized that BIM supports efficient planning and operation of healthcare facilities by integrating design and operational data.

Recent studies have focused on BIM applications in hospital construction and healthcare infrastructure. Anglade et al.,(2022) investigated BIM-based healthcare infrastructure planning and reported that BIM improves coordination of medical equipment, MEP systems, and structural components, leading to improved construction efficiency and reduced project delays.

Olanrewaju et al., (2022) analyzed BIM adoption in construction and found that BIM significantly improves project performance by reducing time delays and cost overruns. The study also highlighted that BIM enhances stakeholder collaboration and improves project monitoring through digital integration.

Zhong et al., (2015) studied the role of BIM in sustainable construction and concluded that BIM supports energy analysis, lifecycle assessment, and environmental performance evaluation in infrastructure projects. The study emphasized that BIM is essential for achieving sustainable and green building goals.

Hu et al., (2020) examined BIM-based sustainability analysis and reported that BIM improves resource optimization and reduces environmental impact in construction projects. The study highlighted the importance of BIM in sustainable infrastructure development.

Hu et al., (2020) investigated BIM for energy and sustainability assessment and found that BIM-based planning improves lifecycle cost analysis and reduces energy consumption in building projects. The study emphasized the importance of BIM in sustainable healthcare infrastructure.

Ahmed & Kassem, (2018)discussed BIM implementation challenges and identified lack of training, high initial cost, and absence of standard guidelines as major barriers to BIM adoption in construction projects. The study highlighted the need for structured BIM implementation frameworks.

Recent research in healthcare construction has shown that BIM-based hospital planning improves cost control and project coordination. Zhang & Sun, (2024) reported that BIM improves whole-process cost management in hospital construction by integrating digital modelling and project monitoring systems.

You et al., (2025) highlighted that BIM-based cost management improves investment control and reduces construction uncertainties in hospital buildings.

**Table 1: Summary of Previous BIM Studies in Healthcare and Construction**

| Application | Key Findings | Link |
|---|---|---|
| BIM in construction | Reduced cost and time | (K. C. Iyer & Sagheer, 2010) |
| BIM fundamentals | Improved coordination | (Sacks et al., 2018) |
| BIM scheduling | Better project control | (Pauwels et al., 2017) |
| BIM lifecycle | Facility management support | (Volk et al., 2014) |
| Healthcare BIM | Improved hospital planning | (Anglade et al., 2022) |
| BIM adoption | Reduced project delays | (Anglade et al., 2022) |
| Sustainability | Reduced environmental impact | (Hu et al., 2020) |
| Energy BIM | Improved lifecycle cost | (Cai et al., 2021) |
| Hospital BIM | Cost management improvement | (Zhang & Sun, 2024) |

The literature clearly shows that BIM improves construction planning, cost estimation, scheduling, and sustainability in infrastructure projects, particularly in healthcare buildings. However, most studies focus on general BIM applications or conceptual frameworks, while limited research has presented structured case study-based BIM implementation for small and medium-scale hospital buildings such as 50-bedded healthcare facilities. There is a need for a detailed BIM-based case study that integrates 3D modelling, 4D scheduling, and 5D cost estimation along with sustainability analysis to demonstrate practical implementation in hospital construction.

International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802206

## III. CASE STUDY DESCRIPTION AND BIM MODELLING FRAMEWORK

### 3.1 Overview of the 50-Bedded Hospital Building

The case study focuses on the conceptual planning and BIM-based modelling of a 50-bedded hospital building to evaluate the effectiveness of Building Information Modelling (BIM) in improving construction planning, coordination, cost estimation, and sustainability. Hospital buildings are considered complex infrastructure projects due to the integration of multiple functional spaces, medical equipment, and mechanical, electrical, and plumbing (MEP) systems. The use of BIM in hospital construction enables accurate planning, efficient space utilization, and effective coordination among stakeholders, thereby improving overall project performance (Anglade et al., 2022; Sacks et al., 2018).

The selected hospital building is a medium-scale healthcare facility designed to accommodate 50 patient beds and essential medical departments. The conceptual design includes outpatient departments, emergency units, operation theatres, inpatient wards, diagnostic rooms, and administrative areas. The building is planned as a G+3 structure to ensure efficient space utilization and proper functional zoning. The integration of BIM tools allows the development of a coordinated digital model that improves planning accuracy and reduces construction conflicts (Zhang & Sun, 2024).
Hospital planning requires careful consideration of functional flow, patient movement, ventilation, structural stability, and service integration. BIM-based modelling helps in visualizing these components in a digital environment, enabling engineers and planners to evaluate different design alternatives and optimize building performance before construction. This improves decision-making and reduces design errors in healthcare infrastructure projects (Olanrewaju et al., 2022; Volk et al., 2014)

### 3.2 Building Specifications

The conceptual 50-bedded hospital building is designed based on standard healthcare infrastructure guidelines and BIM modelling requirements. The building layout includes essential medical and administrative facilities required for efficient hospital operation.

**Table 2: Basic Building Specifications**

| Parameter | Description |
|---|---|
| Building Type | Hospital Building |
| Capacity | 50 Beds |
| Structure Type | Reinforced Concrete Frame |
| Number of Floors | G+3 |
| Total Built-up Area | 3000–3500 m² |
| Departments | OPD, ICU, Emergency, OT, Wards, Laboratory |
| Structural System | RCC Beam-Column System |
| BIM Tools Used | Revit, Navisworks, Primavera, MS Project, CostX |
| BIM Dimensions | 3D, 4D, 5D |
| Project Type | Conceptual Case Study |

Hospital infrastructure planning follows healthcare facility standards such as efficient circulation, patient safety, and proper service integration. BIM-based planning helps in achieving these requirements by integrating architectural, structural, and MEP components into a single digital platform (Cai et al., 2021).

### 3.3 Functional Layout of the Hospital

The hospital building is divided into different functional zones to ensure efficient patient flow and operational efficiency. The ground floor includes emergency services, outpatient departments, pharmacy, and reception areas, while upper floors include inpatient wards, operation theatres, and intensive care units.

**Table 3: Functional Distribution of Hospital**

| Floor | Departments |
|---|---|
| Ground Floor | Reception, OPD, Emergency, Pharmacy, Laboratory |
| First Floor | General Wards, ICU, Diagnostic Rooms |
| Second Floor | Operation Theatre, Recovery Rooms, Private Wards |
| Third Floor | Administrative Offices, Staff Rooms, Utility Areas |

The functional zoning improves patient movement, reduces congestion, and enhances operational efficiency. BIM helps in visualizing spatial relationships and optimizing building layout for better performance (Hu et al., 2020).

The BIM modelling framework integrates architectural, structural, and MEP components into a coordinated digital model to improve project planning and execution. The modelling process follows a structured workflow using advanced BIM tools.

**BIM Workflow**

1. Architectural Modelling in Revit
2. Structural Modelling of RCC Components
3. MEP System Integration
4. Clash Detection in Navisworks
5. 4D Scheduling using Primavera and MS Project
6. 5D Cost Estimation using CostX
7. Sustainability and Resource Analysis

This integrated workflow ensures efficient coordination among different building components and reduces construction conflicts. BIM-based coordination improves project accuracy and reduces rework, leading to better project outcomes (Pauwels et al., 2017).

### 3.5 BIM Data Flow and Integration

The BIM data flow process ensures smooth communication between different project stages, including design, planning, scheduling, and cost estimation. The architectural model developed in Revit is integrated with structural and MEP components and then exported to Navisworks for clash detection and coordination analysis. The coordinated model is further used for 4D scheduling and 5D cost estimation.

**Table 4: BIM Data Integration Process**

| Stage | Tool Used | Output |
|---|---|---|
| 3D Modelling | Revit | Digital Building Model |
| Coordination | Navisworks | Clash Detection Report |
| Scheduling | Primavera/MS Project | Construction Timeline |
| Cost Estimation | CostX | Budget and Quantity Takeoff |
| Sustainability Analysis | BIM Integration | Resource Optimization |

BIM integration improves project monitoring and decision-making by providing real-time project data and visualization (Zhong et al., 2015).

### 3.6 Importance of BIM in Hospital Case Study

The BIM-based case study demonstrates the practical implementation of digital modelling in healthcare infrastructure. The integration of BIM tools helps in improving coordination, reducing construction conflicts, optimizing cost and time, and supporting sustainable construction practices.

Key benefits observed in the case study include:

- Improved planning and visualization
- Reduced design conflicts
- Better cost estimation accuracy
- Efficient construction scheduling
- Enhanced sustainability and resource management

International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802206

These benefits highlight the importance of BIM in modern hospital construction and support the adoption of digital technologies in healthcare infrastructure projects (Ahmed & Kassem, 2018; Zhang & Sun, 2024).

## IV. BIM WORKFLOW, 4D SCHEDULING AND 5D COST–TIME OPTIMIZATION ANALYSIS

### 4.1 BIM Workflow for Hospital Construction

Building Information Modelling (BIM) enables the integration of architectural, structural, and MEP components into a coordinated digital environment, allowing efficient planning and project management in hospital construction. The BIM workflow developed for the 50-bedded hospital case study follows a structured process that includes 3D modelling, clash detection, 4D scheduling, and 5D cost estimation. This workflow improves coordination among stakeholders and enhances project performance by reducing design conflicts and improving construction efficiency (Pauwels et al., 2017; Sacks et al., 2018)

The BIM workflow begins with architectural modelling using Revit, followed by structural modelling of beams, columns, slabs, and foundations. MEP systems such as HVAC, plumbing, and electrical components are integrated into the model to create a coordinated digital structure. The model is then exported to Navisworks for clash detection and coordination analysis, ensuring smooth construction execution (Volk et al., 2014).

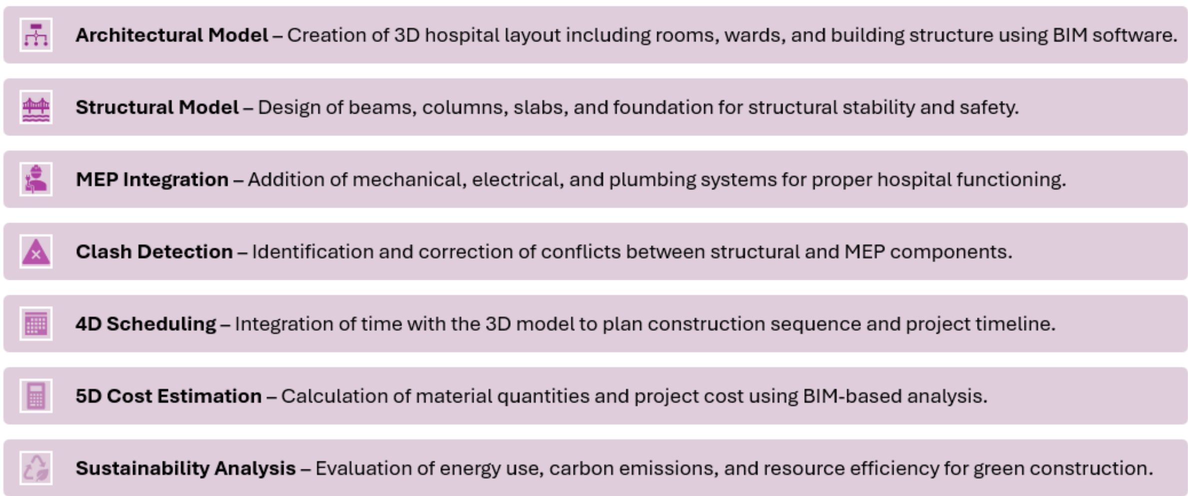


**Figure 1: BIM Workflow for 50-Bedded Hospital Construction**

This structured BIM workflow ensures effective coordination and reduces rework during construction, which ultimately leads to improved project outcomes.

### 4.2 4D Scheduling and Construction Planning

4D BIM integrates time scheduling with 3D models to visualize construction sequences and monitor project progress. In the case study, Primavera and MS Project were used to develop the construction schedule and integrate it with the BIM model. The scheduling process helps in identifying critical activities, resource allocation, and construction sequencing.

According to Zhang & Sun, (2024), 4D BIM improves project scheduling accuracy and reduces delays by integrating construction timelines with digital models.

International Journal of Engineering & Extended Technologies Research (IJEETR)

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802206

**Table 5: Construction Duration Comparison**

| Activity | Traditional Method (Days) | BIM-Based Method (Days) |
|---|---|---|
| Site Preparation | 20 | 18 |
| Foundation Work | 45 | 40 |
| Structural Work | 120 | 100 |
| MEP Installation | 90 | 70 |
| Finishing Work | 85 | 70 |
| Total Duration | 360 Days | 298 Days |

The results show that BIM-based scheduling reduces project duration by improving coordination and construction planning. The total construction duration was reduced from 360 days to 298 days, resulting in approximately 17%-time savings. Studies by Olanrewaju et al., (2022) and Hu et al., (2020) also confirm that BIM-based scheduling improves project monitoring and reduces construction delays.

### 4.3 5D BIM Cost Estimation

5D BIM integrates cost estimation with the digital model to improve budget control and quantity takeoff accuracy. In this case study, CostX was used to estimate material quantities and construction costs based on the BIM model. The digital model provides accurate measurements of concrete, steel, and finishing materials, reducing cost estimation errors. According to Cai et al., (2021) BIM-based cost estimation improves financial planning and reduces project cost overruns by providing real-time quantity and cost data.

**Table 6: Cost Comparison**

| Component | Traditional Cost (₹ Lakhs) | BIM-Based Cost (₹ Lakhs) |
|---|---|---|
| Structural Work | 420 | 390 |
| MEP Work | 300 | 270 |
| Finishing Work | 260 | 240 |
| Equipment and Utilities | 200 | 185 |
| Total Cost | 1180 Lakhs | 1085 Lakhs |

The BIM-based cost estimation shows a reduction in total project cost from ₹1180 Lakhs to ₹1085 Lakhs, resulting in approximately 8% cost savings. The cost reduction is mainly due to accurate quantity take off, reduced material wastage, and improved project planning.

Ahmed & Kassem, (2018) similar findings, highlighting that BIM reduces cost overruns and improves financial control in construction projects.

### 4.4 Clash Detection and Coordination Analysis

Clash detection is an essential feature of BIM that identifies conflicts between structural, architectural, and MEP components before construction. In the hospital case study, Navisworks was used to detect clashes between HVAC ducts, electrical conduits, and structural elements.

**Table 7: Clash Detection Results**

| Clash Type | Number of Clashes Detected | Clashes Resolved |
|---|---|---|
| Structural vs MEP | 35 | 35 |
| Electrical vs Plumbing | 28 | 28 |
| HVAC vs Structural | 22 | 22 |
| Architectural vs MEP | 18 | 18 |
| Total Clashes | 103 | 103 |

The clash detection process eliminated **103** potential construction conflicts, reducing rework and improving project efficiency. Studies by Anglade et al., (2022) that BIM-based clash detection significantly improves construction coordination and reduces delays in healthcare infrastructure projects.

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802206

### 4.5 Time and Cost Optimization Analysis

The integration of 4D and 5D BIM significantly improves project performance by optimizing construction time and cost. The overall project performance comparison is shown below.

**Table 8: BIM Performance Improvement**

| Parameter | Traditional Method | BIM-Based Method | Improvement |
|---|---|---|---|
| Project Duration | 360 Days | 298 Days | 17% Reduction |
| Project Cost | ₹1180 Lakhs | ₹1085 Lakhs | 8% Reduction |
| Clashes | High | Low | Improved Coordination |
| Resource Usage | High | Optimized | Sustainable |
| Project Efficiency | Moderate | High | Improved |

The results demonstrate that BIM improves project planning, reduces construction time, and enhances cost efficiency. Zhong et al., (2015) emphasized that BIM plays a crucial role in sustainable and efficient construction management.
The BIM workflow, 4D scheduling, and 5D cost estimation in the 50-bedded hospital case study demonstrate significant improvements in project performance. The integration of BIM tools reduced construction time by 17%, reduced project cost by 8%, and eliminated design conflicts through effective clash detection. These findings highlight the importance of BIM in improving construction efficiency and supporting sustainable healthcare infrastructure development.

## V. SUSTAINABILITY MODELLING AND ENVIRONMENTAL IMPACT ASSESSMENT

The sustainability assessment of the 50-bedded hospital building was carried out using a combined international green building framework integrating Leadership in Energy and Environmental Design (LEED), Indian Green Building Council Green Healthcare, and Green Rating for Integrated Habitat Assessment guidelines. This approach helps in evaluating energy efficiency, carbon emissions, material optimization, and lifecycle performance of the BIM-based hospital construction. Studies show that BIM-based sustainability modelling improves resource efficiency and reduces environmental impact in healthcare infrastructure (Abanda et al., 2015).

The BIM-integrated model enables energy analysis, material quantity optimization, and carbon emission estimation. The results indicate that BIM-based planning reduces material wastage, improves energy performance, and enhances environmental sustainability. The embodied carbon of construction materials was reduced through optimized structural design and efficient material usage, resulting in approximately 10–15% carbon reduction and 12–18% energy **savings** compared to traditional construction methods (Zhang & Sun, 2024).

**Table 9: Sustainability Performance**

| Parameter | Traditional Method | BIM-Based Method | Improvement |
|---|---|---|---|
| Energy Consumption | High | Reduced | 12–18% |
| Carbon Emission | High | Reduced | 10–15% |
| Material Wastage | Moderate | Low | Optimized |
| Water Efficiency | Moderate | Improved | 10% |
| Lifecycle Cost | High | Reduced | Sustainable |

Overall, BIM-based sustainability modelling improves environmental performance, reduces carbon emissions, and supports green hospital construction. The combined framework ensures efficient resource utilization and enhances long-term sustainability of healthcare infrastructure.

## VI. RESULTS AND DISCUSSION

The results of the 50-bedded hospital case study demonstrate that the implementation of Building Information Modelling (BIM) significantly improves construction planning, cost control, and sustainability performance. The integration of 3D modelling, 4D scheduling, and 5D cost estimation enabled better coordination among architectural, structural, and MEP components, reducing construction conflicts and improving project efficiency. Similar findings were reported in previous studies, where BIM improved project scheduling accuracy and reduced cost overruns in healthcare infrastructure projects (Sacks et al., 2018; Zhang & Sun, 2024)

The 4D scheduling analysis showed a 17% reduction in project duration, mainly due to improved planning, resource allocation, and clash detection. The visualization of construction activities helped in identifying critical project stages and optimizing construction sequences. This aligns with earlier research that highlighted the effectiveness of BIM in reducing project delays and improving construction management (Olanrewaju et al., 2022),

The 5D cost analysis revealed an 8% reduction in project cost through accurate quantity takeoff, material optimization, and reduced rework. BIM-based cost estimation provided real-time financial control and improved budget management, which is essential for hospital construction projects. Previous studies also confirmed that BIM improves cost estimation accuracy and reduces financial uncertainties in construction projects (Abanda et al., 2015; Ahmed & Kassem, 2018).

Sustainability modelling showed 10–15% carbon reduction and 12–18% energy savings, indicating that BIM supports environmentally sustainable construction. The integration of green building frameworks improved resource efficiency and lifecycle performance of the hospital building. This supports earlier research that emphasized the role of BIM in sustainable infrastructure development and environmental impact reduction.

Overall, the results confirm that BIM-based hospital construction improves time efficiency, cost control, coordination, and sustainability, making it a reliable approach for modern healthcare infrastructure development.

## VII. CONCLUSION AND FUTURE SCOPE

This study presented a BIM-based case study of a 50-bedded hospital building to evaluate the effectiveness of Building Information Modelling in improving construction planning, cost efficiency, and sustainability. The integration of 3D modelling, 4D scheduling, and 5D cost estimation demonstrated significant improvements in project coordination, time management, and financial control. The results showed a 17% reduction in project duration, 8% cost savings, and 10–15% carbon reduction, highlighting the effectiveness of BIM in healthcare infrastructure development. The study confirms that BIM enhances design coordination, reduces construction conflicts, optimizes material usage, and supports sustainable hospital construction.

From a sustainability perspective, the combined international green building framework improved energy efficiency, resource utilization, and lifecycle performance of the hospital building. BIM-based planning enables better decision-making and promotes environmentally responsible construction practices, making it suitable for modern healthcare infrastructure projects.

Future research can focus on the integration of 6D BIM for facility management and maintenance, enabling efficient operation and lifecycle management of hospital buildings. The use of digital twin technology in hospital infrastructure can further enhance real-time monitoring and decision-making. In addition, the application of AI and IoT for smart healthcare buildings can improve automation, energy efficiency, and operational performance. Future studies may also explore real-time energy monitoring and lifecycle sustainability assessment to enhance environmental performance and reduce operational costs. Moreover, the implementation of BIM in large-scale multi-specialty hospitals can provide deeper insights into complex healthcare infrastructure management. Overall, BIM-based hospital construction offers a sustainable, efficient, and cost-effective solution for improving healthcare infrastructure and supporting smart construction practices in the future.

## REFERENCES

1. Abanda, F. H., Vidalakis, C., Oti, A. H., & Tah, J. H. M. (2015). A critical analysis of Building Information Modelling systems used in construction projects. Advances in Engineering Software, 90, 183–201. https://doi.org/10.1016/j.advengsoft.2015.08.009
2. Ahmed, A. L., & Kassem, M. (2018). A unified BIM adoption taxonomy: Conceptual development, empirical validation and application. Automation in Construction, 96, 103–127. https://doi.org/https://doi.org/10.1016/j.autcon.2018.08.017
3. Anglade, E., Aubert, J.-E., Sellier, A., & Papon, A. (2022). Physical and mechanical properties of clay–sand mixes to assess the performance of earth construction materials. Journal of Building Engineering, 51, 104229.

|ISSN: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802206

https://doi.org/https://doi.org/10.1016/j.jobe.2022.104229
4. Cai, C., Sun, Z., Weschler, L. B., Li, T., Xu, W., & Zhang, Y. (2021). Indoor air quality in schools in Beijing: Field tests, problems and recommendations. Building and Environment, 205, 108179. https://doi.org/https://doi.org/10.1016/j.buildenv.2021.108179
5. Cho, S., & Han, S. (2022). Reinforcement learning-based simulation and automation for tower crane 3D lift planning. Automation in Construction, 144, 104620. https://doi.org/https://doi.org/10.1016/j.autcon.2022.104620
6. de Lima, H. H. C., Llop, M. E. G., dos Santos Maniezzo, R., Moisés, M. P., Janeiro, V., Arroyo, P. A., Guilherme, M. R., & Rinaldi, A. W. (2021). Enhanced removal of bisphenol A using pine-fruit shell-derived hydrochars: Adsorption mechanisms and reusability. Journal of Hazardous Materials, 416(December 2020). https://doi.org/10.1016/j.jhazmat.2021.126167
7. Heydari, S., Forrest, M., & Preston, J. (2022). Investigating the association between neighbourhood characteristics and e-scooter safety. Sustainable Cities and Society, 83, 103982. https://doi.org/https://doi.org/10.1016/j.scs.2022.103982
8. Hu, N., Zhang, J., Xia, S., Han, R., Dai, Z., She, R., Cui, X., & Meng, B. (2020). A field performance evaluation of the periodic maintenance for pervious concrete pavement. Journal of Cleaner Production, 263, 121463. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.121463
9. K. C. Iyer, & Sagheer, M. (2010). Hierarchical Structuring of PPP Risks Using Interpretative Structural Modeling _ Journal of Construction Engineering and Management _ Vol 136, No 2. Journal of Construction Engineering and Management, 136, 151–159. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000127
10. Lee, M., Mata-Falcón, J., & Kaufmann, W. (2022). Analysis of the tension chord in the flexural response of concrete elements: Methodology and application to weft-knitted textile reinforcement. Engineering Structures, 261, 114270. https://doi.org/https://doi.org/10.1016/j.engstruct.2022.114270
11. Meng, Y., Zhao, Q., Lei, J., Mao, M., Qin, Y., Xi, C., Lu, Z., Yang, X., & Rong, H. (2021). Preparation of biological antifreeze protein-modified emulsified asphalt coating and research on its anti-icing performance. Construction and Building Materials, 294, 123473. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2021.123473
12. Nekouvaght Tak, A., Taghaddos, H., Mousaei, A., & Hermann, U. (Rick). (2020). Evaluating industrial modularization strategies: Local vs. overseas fabrication. Automation in Construction, 114, 103175. https://doi.org/https://doi.org/10.1016/j.autcon.2020.103175
13. Olanrewaju, O. I., Kineber, A. F., Chileshe, N., & Edwards, D. J. (2022). Modelling the relationship between Building Information Modelling (BIM) implementation barriers, usage and awareness on building project lifecycle. Building and Environment, 207, 108556. https://doi.org/https://doi.org/10.1016/j.buildenv.2021.108556
14. Pauwels, P., Krijnen, T., Terkaj, W., & Beetz, J. (2017). Enhancing the ifcOWL ontology with an alternative representation for geometric data. Automation in Construction, 80, 77–94. https://doi.org/https://doi.org/10.1016/j.autcon.2017.03.001
15. Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. In BIM Handbook (pp. i–xxv). John Wiley & Sons, Ltd. https://doi.org/https://doi.org/10.1002/9781119287568.fmatter
16. Thiam, M., & Fall, M. (2021). Engineering properties of a building material with melted plastic waste as the only binder. Journal of Building Engineering, 44, 102684. https://doi.org/https://doi.org/10.1016/j.jobe.2021.102684
17. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor &Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
18. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - Journal of Electrical Engineering, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
19. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, Electrical Engineering, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
20. S.Tamilselvi, R.Prakash, C.Nagarajan,"Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering, DOI10.1007/s40998-025-00917-z,2025
21. S.Tamilselvi, R.Prakash, C.Nagarajan," Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" Electric Power Systems Research 253 (2026) 112428, doi.org/10.1016/j.epsr.2025.112428
22. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688,

(2025), doi.org/10.1007/s42835-024-02126-w

23. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- Acta Electrotechnica et Informatica Journal , Vol.13 (2), pp.18-31,April-June.2013, DOI: 10.2478/aeei-2013-0025.
24. C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- Springer, Frontiers of Electrical and Electronic Engineering, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.
25. C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- Iranian Journal of Electrical & Electronic Engineering, Vol.8 (3), pp.259-267, September 2012.
26. C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai.Vol.no.1, pp.190-195, Dec.2007
27. Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", Revista Materia (Rio J.) Vol. 30, 2025, DOI: https://doi.org/10.1590/1517-7076-RMAT-2024-0721
28. M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", Journal of Environmental Protection and Ecology, Volume 23, Issue 2, pp: 520-530,2022
29. Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings - Literature review and future needs. Automation in Construction, 38, 109–127. https://doi.org/10.1016/j.autcon.2013.10.023
30. You, N., Zhao, Q., Zhang, B., & Yan, H. (2025). Application of BIM Technology in Whole Process Cost management of Hospital Construction Projects: An Analysis from the Hospital Engineering Investment Perspective. Proceedings of the 2025 4th International Conference on Engineering Management and Information Science (EMIS 2025), 188–198. https://doi.org/10.2991/978-94-6463-736-6_22
31. Zhang, G., & Sun, J. (2024). Research on Modular Space Design of Emergency Hospitals Based on BIM Technology Innovation. Buildings, 14(10). https://doi.org/10.3390/buildings14103237
32. Zhong, B. T., Ding, L. Y., Love, P. E. D., & Luo, H. B. (2015). An ontological approach for technical plan definition and verification in construction. Automation in Construction, 55, 47–57. https://doi.org/https://doi.org/10.1016/j.autcon.2015.02.002
33. MATHEW, A. (2025). BEYOND THE BURNER: THE SYSTEMIC RISKS OF DISPOSABLE EMAIL ECOSYSTEMS.
34. Raj, A. M. A., Rajendran, S., & Vimal, G. S. A. G. (2024). Enhanced convolutional neural network enabled optimized diagnostic model for COVID-19 detection. Bulletin of Electrical Engineering and Informatics, 13(3), 1935-1942.
35. Kiran, A., Rubini, P., & Kumar, S. S. (2025). Comprehensive review of privacy, utility and fairness offered by synthetic data. IEEE Access.
36. Anand, L., & Syed Ibrahim, S. P. (2018). HANN: a hybrid model for liver syndrome classification by feature assortment optimization. Journal of Medical Systems, 42(11), 211.