Enhancing Multidisciplinary Coordination and Construction Planning with Three-Dimensional Building Information Modelling: A Review

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ABSTRACT

Building Information Modelling (BIM) has become more commonly used in the planning and coordination processes of construction projects. It provides an opportunity to create and analyse multi-disciplinary information within one environment. The 3D model is key to this process. By integrating models from architectural, structural and building services, coordination problems can be identified before starting on site. This review discusses how 3D BIM is used in planning on construction projects, looking at integration of 3D models, identification and resolution of clashes, integration of schedules and 4D BIM. Applications, advantages, issues when implementing and recent trends have been assessed. An integrated model is always produced therefore improving visualisation and inter-disciplinary communication. Clash detection improves identifying spatial clashes and prioritising them ensures the most important clashes are resolved first. However, increased time is required to link the coordinated model to the construction schedule allowing the processes to be viewed in 4D. Several issues reduce the effectiveness of these processes. Interoperability issues, data inconsistency, user knowledge, poor inter-disciplinary coordination and the large number of clashes can all be an issue. Recent studies have moved away from simple clash detection to intelligent coordination and greater integration between models and schedules. Overall, this paper has developed a framework to link 3D BIM modelling, inter-disciplinary coordination, clash management, construction planning, 4D BIM and project performance. Areas which can be improved and further researched have been identified.

Keywords: Building Information Modelling (BIM), Clash Detection, Clash Resolution, Construction Planning, Four-Dimensional Building Information Modelling, Multidisciplinary Coordination, Three-Dimensional Building Information Modelling

1. INTRODUCTION

Collaboration is key in construction; multiple parties are involved including Architects, Structural Engineers, Building Services specialists, Contractors and Planners. If information is developed separately by each party, issues and clashes may not be noticed until the construction stage of the project which causes extra costs, delays and extra work [1]. Using BIM allows information to be stored in a single, coordinated digital model. This allows greater visibility for project

participants to understand the design [2]. The real benefit of using a 3D model is having all Architectural, Structural and Building Services components in the same place allowing checks to be made before any construction [3]. Clash detection has now become an everyday task during the design process using software such as Autodesk Revit and Navisworks. These tools have been developed to identify and manage clashes in the building systems [4]. Research has now moved onto prioritising clashes and resolving them. The 3D model can be linked into project timescales to aid in sequencing, resources and 4D BIM [8]. There are still obstacles to overcome with the use of BIM. Software compatibility, uniformity of data, lack of BIM knowledge, communication problems between disciplines and poor integration with scheduling systems [5].

2. CRITICAL LITERATURE REVIEW

The following critical literature review discusses recent research into Three-Dimensional Building Information Modelling, clash detection and Four-Dimensional planning. It also evaluates how much each study contributes to the topic.

Sampaio et al. (2022) investigated how an integrated BIM can facilitate collaboration between disciplines within building and improve construction planning. The 3D BIM model was created using Revit and Navisworks with architectural, structural, and water information. By combining multiple models from different disciplines, they were able to look at how different components interacted with other components and identify any possible clashes. Additionally, the BIM model was connected to construction processes so a 4D model could be made showing the expected sequence of works. This helped with planning processes such as material provision and resource management. Some practical challenges were found within the study including the transfer of information between the different software, training required for users, more complex workflows and extra equipment costs. This study has shown that an integrated 3D BIM process can bring together interdisciplinary collaboration, collision detection and planning however proper software integration and human competence is needed for success [1].

Solanki et al., (2025) researched using Autodesk Revit and Microsoft Project in conjunction for managing construction projects. Autodesk Revit was used as a 3D visualization tool and design collaboration tool. Microsoft Project was used for planning, analysis of timeframes and resource management. A workflow was developed by the researchers based on generating information within Revit models, transferring the information into Excel. This was then imported into Microsoft Project where it was used for planning and resource management. Using this tool within the case study helped to give more insight into the construction activities by linking the design information with the project schedule. Some issues were found when trying to implement such a tool into practice including lack of labour, materials and poor collaboration. Frequent changes to data had to be made between the software. Overall combining BIM with scheduling tools can improve the planning of construction projects but needs to be implemented correctly. Constant communication, quick updates to schedules and continuous involvement from those involved in the project will ensure this is achieved [2].

A study by Doukari et al. (2022) looked at how 4D BIM could be applied to planning in construction projects. It compared traditional methods with automated methods. The study focused on how activities within construction can be linked to objects in the 3D BIM model. Two case studies were carried out on the processes involved in setting up the BIM model, creating a construction plan and linking the elements. Using 4D BIM can improve the knowledge within the construction sequence. Having a construction plan can be useful for communication throughout the project, planning the construction site, tracking progress and co-ordination. However, this study showed that there will always be some manual input needed. Having accurate data within the model, an efficient schedule and good collaboration between stakeholders will still be required. They suggested that artificial intelligence, IoT and ontological techniques could be promising technologies for automating 4D BIM processes in the future [3].

Sanjaya et al. (2025) looked at the use of BIM based clash detection to improve coordination between architectural, structural and mechanical plumbing disciplines on an RSIA hospital project. Discipline models were designed using Autodesk Revit and clashes identified using Navisworks. The amount of disputes found were analysed to see what affect they may have had on the quantity of materials, rework, cost of the project and construction time. 964 disputes were identified and there was a high number of disputes relating to architecture and mechanical plumbing. This analysis showed that resolving these issues in the design phase could reduce the rework and therefore save costs and time on the project. An estimated 4.63% of cost savings and approximately 41.7 days of construction time savings were found. This

is equivalent to 7.79% of the overall project time. This shows the practical benefits of using 3D BIM modelling with clash detection using Navisworks to identify coordination issues. However, this analysis was limited to one hospital project so the results should be considered in this context and cannot be directly applied to all construction projects [4].

Pambudi et al. (2025) reviewed the role of BIM in improving project constructability within the Integrated Project Delivery (IPD) approach through a systematic literature review. The study examined how BIM can bring different project participants into a shared working environment and support the coordination of design information, particularly through clash detection and clash avoidance. The review found that BIM can facilitate information sharing across different project stages and help stakeholders identify and address coordination issues at an early stage. The integration of BIM with IPD was also associated with reduced design-related problems, improved project efficiency, shorter implementation periods, and better control of construction costs. Clash detection refers to the identification of clashes between elements from different disciplines, whereas clash avoidance refers to avoiding clashes in the design process. Effectiveness of BIM-IPD integration can be affected by the quality of information in the BIM environment, communication between disciplines and capabilities of clash prediction technologies. The study therefore emphasizes that the benefits of BIM for constructability depend not only on the development of a 3D model but also on effective information sharing, multidisciplinary coordination, and early decision-making throughout the project [5].

Wu et al. (2022) reviewed the development of BIM-based coordination research by examining published studies and identifying the major research themes in the field. The researchers analysed 656 journal articles published between 2006 and 2020 and applied bibliometric analysis with VOS viewer to examine the development and relationships among different research areas. The analysis showed that BIM coordination research has expanded into areas such as project management, stakeholder coordination, sustainable development, and construction-related innovation. These issues are particularly relevant to working across disciplines as BIM models can include information from a range of different disciplines. Effective use of this information will depend on the accurate transfer and co-ordination between a variety of systems. The authors emphasised the importance of increased interoperability, more efficient information management, and greater incorporation of emerging digital technologies into future BIM workflows. In terms of construction coordination, the study emphasises that BIM efficiency is determined not only by 3D modelling and collision detection, but also by how project information is distributed, maintained, and coordinated among project participants [6].

Sampaio et al. (2024) used conflict analysis and 4D simulation to study how BIM may be used to coordinate multiple design disciplines and support construction planning. The researchers combined architectural, structural, and water-supply data into a single 3D BIM environment and used conflict analysis to identify anomalies between the discipline-specific models. A 4D BIM model was then created by integrating the building model to the anticipated construction operations, resulting in a visual depiction of the construction sequence. The study discovered that using an integrated strategy can assist project teams in identifying coordination issues during the design stage and reviewing construction sequences prior to execution. The authors also emphasised that conflict analysis should be approached as an iterative coordination process, with identified problems assessed and models revised until an acceptable level of coordination is achieved. However, using separate software platforms might provide practical challenges such as increased workflow complexity, processing time, and the chance of data loss or errors during model exchange. The study highlights the need of merging interdisciplinary collaboration, conflict analysis, and 4D construction visualisation, while also noting that successful implementation requires a good technological workflow and sufficient user expertise [10].

Chahrour et al. (2021) assessed the financial advantages of utilising BIM to identify and settle design conflicts before construction. Using BIM-based collision detection, the researchers developed a workable method for calculating potential cost savings and tested it on a significant infrastructure project. The method involved identifying and classifying conflicts according to their characteristics and the required corrective actions, then predicting the potential costs if the conflicts were discovered after construction had started. The case study illustrated how BIM-based coordination could identify problems that would be challenging to identify in conventional 2D designs and offer a chance to fix them before they resulted in additional procurement, demolition, redesign, rework, or construction disruption. About 20% of the USD 75 million project value examined in the case study, or USD 15.2 million, might be saved, according to the analysis. The primary contribution of the work is its attempt to quantify the economic worth of BIM-based collision detection, providing a financial basis for evaluating its benefits rather than only presenting them qualitatively. The authors acknowledged that few experts were involved in developing the assessment approach, and they suggested conducting additional study on projects of all sizes and levels of design complexity. Consequently, the

study provides useful evidence for connecting measurable project cost benefits with BIM-based collision resolution; nevertheless, it also recommends that the anticipated benefits be examined in a wider range of project scenarios [13].

Akponeware et al. (2017) investigated coordination problems associated with the use of 3D BIM, with particular attention to the difference between clash detection and clash avoidance**.** Rather than viewing BIM only as a method for finding conflicts after they appear in a model, the study considered whether coordination should be addressed earlier while the design is being developed. The authors discussed how coordination difficulties can occur when information from different building disciplines is developed without sufficient consideration of how the individual components will interact. The study highlights a shift from merely identifying conflicts that already exist to preventing coordination problems using more robust multidisciplinary design techniques. Because the advantages of modelling extend beyond visualisation to include early coordination of architectural, structural, and building-service information, this perspective is particularly crucial to 3D BIM-based construction workflows [16].

By increasing the effectiveness of conflict identification and management, Hasannejad et al. (2023) sought to improve BIM-based clash detection. The approach addresses a flaw in conventional clash detection: BIM models can produce many conflicts that are found, requiring project teams to spend a lot of time looking at each one separately. To enhance clash information processing and enable the methodical identification of important disputes, the researchers investigated an automated approach. Because automated processing can reduce repetitious human verification and help project teams manage large amounts of clash information more efficiently, this technique is particularly advantageous for multidisciplinary BIM collaboration. There is insufficient information in the supplied source material to provide detailed numerical results or performance enhancements. Therefore, rather than attributing unsupported numerical conclusions to the research, the study's contribution is best defined by its emphasis on automating and improving BIM-based collision detection [17].

With a focus on managing the many conflicts that may arise during BIM-based coordination, Koo et al. (2026) examined BIM coordination and clash resolution from the perspectives of risk and relevance. Because observed disagreements may differ significantly in significance and potential impact on project delivery, the study is particularly relevant to interdisciplinary collaboration. This technique can help coordination teams organise the review process and concentrate their efforts on conflicts that could have more significant effects on construction activities, design changes, or project performance. The study supports a more organised BIM coordination method where collision data is assessed according to its importance rather than as a uniform list of disagreements. This perspective emphasises that efficient coordination in 3D BIM-based construction planning needs not only identifying disputes, but also analysing their relevance, evaluating potential hazards, and prioritising relevant resolution steps [18].

3. DEVELOPMENT OF 3D BIM MODELS

The first step towards the generation of an integrated digital representation of the construction project is the creation of a 3D BIM model. In this work, the authors combined three construction areas (architectural, structural and water supply) into one BIM model [10]. Autodesk Revit was used to create each of the discipline specific models. After that, they performed a conflict analysis to understand how well they worked together. This study then progressed to create a 4D model to simulate their construction. This shows how a well organised 3D model can be used to plan and coordinate activities in the future [10].

1. Establishment of the Modelling Environment: The first step was to create an environment for the project. Elements were created at varying levels of detail, with different plan grids and units of measure [Sampaio et al. 2022]. This can then be used as a guide to place elements within the model. The use of exact co-ordinates was highlighted to ensure the architect, structural and water supply models could be combined correctly. This is important when working with multiple disciplines as incorrect placement of elements from another discipline can affect how they interact with elements from your discipline. Starting with creating the modelling environment allows for a consistent foundation to be created for the overall BIM model [10].

2. Architectural 3D Modelling: Parametric BIM objects were used to create the architectural elements to develop the project. Architectural families were taken from the Revit library and then adapted to suit the requirements of the case study. This gave the model geometric characteristics and material properties. An advantage of using BIM is that you can view the entire model from multiple perspectives and internal views. Elements can also be changed by editing the settings or deleting objects meaning different design ideas can be tried [10].

3. Structural 3D Modelling: Once the architectural model has been constructed, the structural elements have been modelled. A separate structural project was created by Sampaio et al. to link to the architectural model. This meant that the structural elements could be placed into the architectural layout but still have their own discipline data. Structural elements are the main components of the model; columns, beams, slabs and foundations. The order in which they were modelled was columns then beams, slabs and finally foundations. Structural families were selected from the Revit library and adjusted to fit the project requirements. The architectural model was used to place the structural elements with high accuracy [10].

4. Modelling of the Water-Supply System: The third major component of the project was the water supply system [10]. This was created using the references from the project to ensure the service components are consistent with the architectural and structural models. The size, type, family and features of piping needed was determined. The piping layout was designed using the correct views in the model to give an indication of the layout. Both the cold water and hot water systems were considered. During the modelling process, consideration was given to how the service components would be laid out and relate to each other and the rest of the building [10].

5. Integration of the Discipline Models: The architectural, structural and services models may then be combined into a single 3D BIM model. This allows all the different disciplines to be viewed within a common digital environment [10]. Figure 1. Architectural, structural and services models combined into a coordinated 3D BIM environment to allow clash detection from different disciplines and 4D planning.

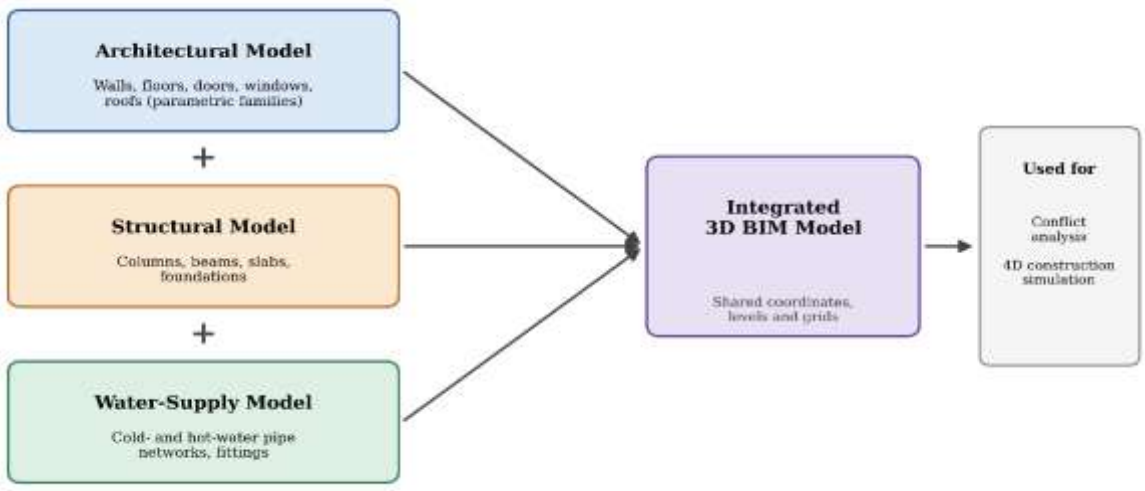


Fig. 1. Framework for Integrating Discipline Models in 3D BIM-Based Coordination

Integration is a key stage because coordination problems often stay hidden while each discipline is examined on its own. Once the models are combined, the interactions between building components are much easier to see [4]. Sampaio et al. treat the integrated BIM model as the basis for the conflict analysis and construction simulation that follow [4].

BIM software is becoming increasingly important in current construction practice. From creating models, to design coordination, analysis, data management and planning. Different platforms can be used to help create 3D building models, coordinate information across different disciplines, identify clashes, analyse building performance and help team collaboration. When these tools are properly used, they can help to organise project information and boost coordination throughout the construction process. The selection of appropriate BIM tools is thus a crucial factor in building an effective digital workflow for construction projects. Table 1 lists the most important BIM software and tools addressed in the literature, along with their developers, principal users, essential features, and application domains [11].

Table 1 BIM software/tool discussion and its details

Tool name	Developer Primary use	Primary use	Key features	Application domains
Autodesk Revit	Autodesk	BIM-based 3D modelling and building information management	Parametric modelling, multidisciplinary modelling, visualization, documentation, model coordination	Architecture, structural engineering, MEP, building construction [2].
Autodesk Navisworks	Autodesk	Model review and multidisciplinary coordination	Model integration, clash detection, coordination review, construction simulation	Construction coordination, clash detection, project planning [3].
Green Building Studio (GBS)	Autodesk	Building energy and performance analysis	Energy analysis, performance evaluation, sustainable design assessment	Building design, energy analysis, sustainable construction [2].
Autodesk Construction Cloud / BIM 360	Autodesk	Construction information management and collaboration	Information sharing, issue management, model coordination, cloud-based collaboration	Construction management, coordination, field operations.
AutoCAD	Autodesk	Computer-aided drafting and design	2D drafting, technical drawings, design documentation	Architecture, engineering, construction documentation [2].
Bentley Systems	Bentley Systems	BIM-based engineering and infrastructure modelling	Multidisciplinary design and engineering information management	Infrastructure and civil engineering projects [2].

4. PLANNING, COORDINATION, CLASH DETECTION & 4D BIM

BIM has evolved from a means for developing three-dimensional digital models to a more comprehensive approach to construction planning and multidisciplinary cooperation. Once the various discipline models have been established, they can be merged and tested to uncover coordination issues before building begins. The coordinated model can then be linked to building activities to introduce the temporal dimension using 4D BIM. This evolution establishes a link between model development, planning, coordination, clash management, and construction simulation, resulting in a more comprehensive approach to construction project management [3].

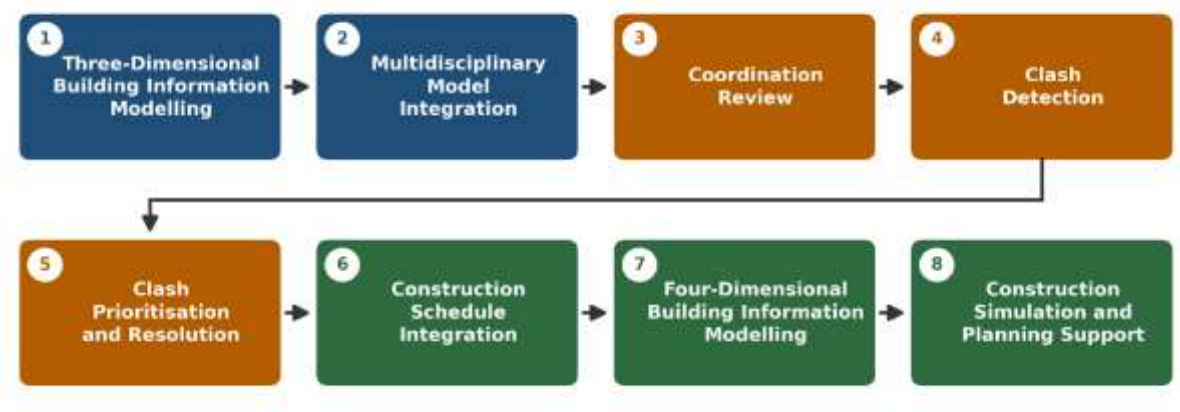


Fig. 2. Integrated BIM Workflow for Construction Planning, Coordination, Clash Detection, and 4D BIM

1. Three-Dimensional Building Information Modelling: The first step is to create a 3D BIM model that represents the main physical elements of the construction project. This model will be used to coordinate, analyse and plan [10].

2. Multidisciplinary Model Integration: Architectural, structural and building services models will be combined within the BIM. Models can be analysed to determine the relationship between these disciplines and identify any potential issues of coordination at an early stage [10].

3. Coordination Review: This provides systematic review of the integrated model to identify any differences in the interaction between various elements from each discipline. This will help improve co-ordination between those involved in the project [6].

4. Clash Detection**:** The integrated model is analysed to look for spatial conflicts between building elements. This gives the opportunity to fix any design problems at an early stage which can reduce the amount of rework and delays from coordination [12].

5. Clash Prioritization and Resolution: The identified clashes are assessed according to their relevance and potential effect on the project. Higher-priority conflicts are addressed first and resolved before the coordinated model is used for subsequent planning activities. Recent studies have also explored automated approaches for improving clash identification and management [18].

6. Construction Schedule Integration: Once the key coordination concerns are resolved, the BIM model is linked to the construction timetable. This links specific model elements to their related actions and the planned order of execution [3].

7. Four - Dimensional Building Information Modelling: A 4D BIM model is created by combining the 3D model and schedule information. The addition of the time dimension allows project teams to comprehend how individual construction operations should move and how the project sequence evolves over time [3].

8. Construction Simulation and Planning Support: The finished 4D model can be used to visualise and analyse the intended construction sequence. This assists with construction planning, communication, coordination, and evaluation of the suggested execution strategy [14].

The following table sets out the main differences between conventional and Building Information Modelling based construction planning.

Table 2. Comparative Analysis of Conventional and BIM-Based Construction Planning Approaches

Element	Conventional Planning Approach	BIM-Based Planning Approach
Project Representation	Relies mainly on 2D drawings and separate project documents.	Uses an integrated 3D model to represent project components and related information [6], [10].
Planning Process	Activities are organized using schedules, drawings, and manual coordination.	Project activities can relate to corresponding elements of the BIM model [3], [10].
Multidisciplinary Coordination	Coordination largely depends on meetings, drawing reviews, and manual checking.	Models from different disciplines can be combined and reviewed within a shared BIM environment [6], [10].
Clash Detection	Conflicts are generally identified through drawing comparison and coordination during design or construction.	Model-based analysis can identify spatial conflicts between components at an earlier stage [12], [16].
Clash Resolution	Resolving conflicts may involve repeated communication, revisions, and drawing updates.	Detected clashes can be assessed, prioritized, and addressed before construction [17].
Schedule Visualization	Schedule information is mainly communicated through charts, tables, and activity lists.	4D BIM connects schedule activities with model elements to provide a visual representation of planned work [10].
Construction Sequence	The complete construction sequence can be difficult to understand from separate schedules and drawings.	Construction activities can be visually simulated according to their planned sequence [3], [10], [14].
Communication	Information is exchanged through drawings, reports, meetings, and schedules.	The shared BIM model provides a common visual reference for project communication and coordination [6], [14].
Error and Rework Control	Some design and coordination problems may become evident only during later project stages.	Early identification of model conflicts can help reduce coordination problems and potential rework [12], [14].
Planning Support	Primarily focuses on activities, schedules, drawings, and related documents.	Brings together spatial, coordination, and time-related project information within a connected workflow [3], [10].
Main Limitation	Limited 3D visualization and greater dependence on manual coordination.	Effective implementation requires reliable models, suitable software interoperability, trained users, and

		appropriate coordination procedures [3], [6].

4.1 CASE STUDY: BIM-based design coordination and four-dimensional construction simulation

Sampaio et al. [2022] proposed a feasible BIM-based workflow to improve design collaboration and construction planning. The study's demonstration project was a two-story residential building with a basement. Architectural, structural, and water-supply data were created individually and then combined to investigate coordination between the various disciplines.

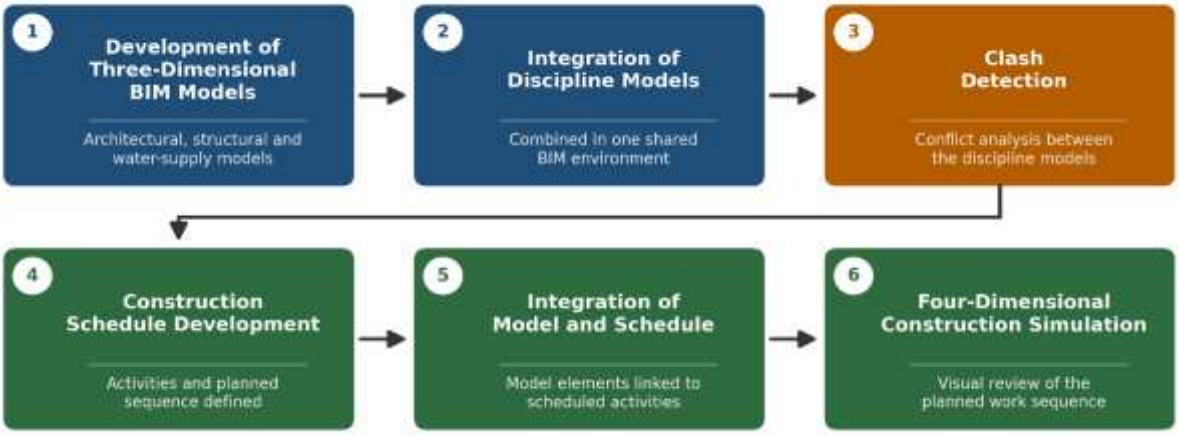


Fig. 3. BIM- Based Workflow for Clash Detection, Schedule Integration, and 4D Construction Simulation

The study focuses on how BIM may connect design coordination and construction planning via a continuous digital workflow. The 3D model serves as the foundation for multidisciplinary coordination and clash detection, and the addition of schedule data transforms the coordinated model into a 4D planning tool. As a result, the study shows that BIM adds more value when the model is linked to construction information rather than being utilised solely for three-dimensional visualisation.

5. Conclusions

The following findings are derived from the reviewed literature and the case study:

1. A 3D BIM model provides structure to the data and elements within a project.
2. By incorporating architectural, structural and building service models collaboration between disciplines can be improved. This enables clarification of how elements interact with each other.
3. Using BIM clash detection can identify any coordination issues at an early stage. This allows the project team to deal with any clashes without causing any issues at the construction stage.
4. Linking the BIM model to the construction programme will help with planning. Using 4D BIM will make it easier to understand what order and when elements are to be constructed.
5. As demonstrated within the case study, using modelling, integration, clash detection, scheduling and 4D simulation will produce an integrated BIM workflow. This can therefore help with planning the construction.
6. The successful use of BIM requires more than software tools alone accurate models, effective coordination, suitable interoperability, trained users, and appropriate implementation practices are also important for achieving its intended benefits.

Acknowledgement

The authors sincerely acknowledge Prof. (Dr.) Vinay Patel**,** Principal, Birla Vishvakarma Mahavidyalaya (BVM) Engineering College**,** and Prof. (Dr.) Reshma L. Patel, Head of Civil Engineering Department, for their continuous encouragement and valuable institutional support in facilitating this research. Er. Solanki Divyesh, PSP Projects Limited, Ahmedabad, for his valuable support and practical insights during this work.

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