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Advancing Timber for the Future Built Environment

BIMwood – optimized timber construction planning process

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ABSTRACT: One of the challenges facing the construction industry is the ongoing digital transformation of planning and construction processes. Building Information Modeling (BIM) is a key driver of this progress. However, the application of BIM in prefabricated timber construction still faces significant obstacles, particularly due to non-standardized data exchange and limited integration of timber-specific requirements. BIMwood addresses these bottlenecks in BIM-supported planning solutions for prefabricated timber constructions, specifically focusing on the lack of standardized data exchange between planners and timber manufacturers. To overcome this, BIMwood develops timber-specific standardized procedures including a BIM Execution Plan (BEP) for collaboration management and a BIMwood reference process that defines specific information requirements throughout the planning and production workflow. By reducing the complexity of the 3D CAD model, BIMwood supports a timber construction planning process that is both, efficient, reliable and scalable. Bridging the gap between digitalization and prefabricated timber construction, BIMwood enables standardized workflows, improves collaboration, minimizes data loss, and increases overall process efficiency.

KEYWORDS: BIM, digital transformation, timber construction, BPMN, DfMA, planning, prefabrication, collaboration

1 – DIGITAL TRANSFORMATION IN TIMBER CONSTRUCTION DESIGN

The digital transformation is a challenge for the construction industry. Architecture, engineering and construction (AEC) are among the slowest sectors adapting to digital driven innovations and processes [1]. Digital tools and methods have already changed processes, structures, ways of thinking and seeing, as well as collaboration in companies and in the construction value chain. Building Information Modeling (BIM) is an important driver of digitalisation in the construction industry. The international development is led by buildingSMART [2]. Guidelines and technical standards for the implementation of the BIM method have been introduced to the construction sector. They usually refer to standardized planning procedures like VDI in Germany [3].

The research project BIMwood [4] focuses on the development of BIM-based solutions for project-related cooperation for the design of prefabricated timber structures. It has developed strategies and recommendations on the background of common planning environments based on the cooperation of planning disciplines bringing together strategies of digitalisation of the construction industry and the industrialisation of construction processes. These ideas have been partially implemented in the production of prefabricated timber buildings, but not yet universally in a digital process chain. Timber construction is characterised by a high degree of off-site manufacturing. One of the main obstacles in the planning process of timber construction is the lack of standardized data exchange between planners, engineers, and manufacturers resulting in a high loss of information and additional work. Prefabricated timber construction elements have a highly complex, multi-layered component structure, resulting in an increased level of construction complexity compared to mineral-based building methods. The planning methodology (reference process, 3D modelling suitable for timber construction, etc.) shows how the existing bottleneck in projects can be overcome. Planning processes are advanced by standardisation of data exchange between the planners involved. The exchange of data with the timber construction company can proceed without loss of information and additional work. BIMwood has developed standardized workflows to streamline collaboration and reduce errors in the digital timber planning process. To address these challenges, BIMwood establishes a structured framework, including a standardized BIM Execution Plan (BEP) and a tailored reference process for timber construction [5].

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2 – BACKGROUND

The timber construction industry has been engaged with digital production processes since the late 1980s, when the first automated cutting machines revolutionized the fabrication of timber components. In work preparation, customised CAD CAM models are usually developed from scratch based on architects' and engineers' plans delivered in Portable Document Format (PDF). The absence of a unified data structure complicates the collaboration between planners and manufacturers, reinforcing inefficiencies throughout the project workflow.

Design for manufacture and assembly (DfMA) [6] and the principles of off-site prefabrication are common inherent characteristics of timber construction. Today further digitalisation of working methods becomes a game changer in collaboration of project teams. Building Information Modeling (BIM) describes a cooperative working method in Architecture, Engineering and Construction (AEC) with which, based on digital models of a building, the information and data relevant to its life cycle are consistently recorded, managed and exchanged in a transparent communication between the parties involved or transferred for further processing.

Specific requirements of prefabricated timber construction (e.g. building codes, structural fire safety, panel dimensions, wood-based material specification) and the high complexity caused by multi-layered component structures are not yet considered in standardised BIM workflows. A research analysis of BIM manuals revealed that common BIM objectives and use cases that were analysed are not specific to timber construction and that solutions for timber construction-specific problems are missing [4].

In 2023, the research project "BIMwood - Development of Building Information Modeling-based solutions for project-related cooperation in the value chain of prefabricated timber buildings" at the Technical University of Munich closed the gap. The project aims to advance the implementation of BIM methodology in timber construction, optimizing processes to support planning that aligns with the principles of prefabricated timber building as described in Figure 1. Various projects worldwide showcase that the current challenges for the development of a BIM methodology for timber construction face common issues [6] [7]. BIMwood has developed a reliable solution considering national requirements and regulations.

The project focuses on improving BIM methodology by defining a reference process for timber construction planning, establishing standardized data structures for smoother collaboration,

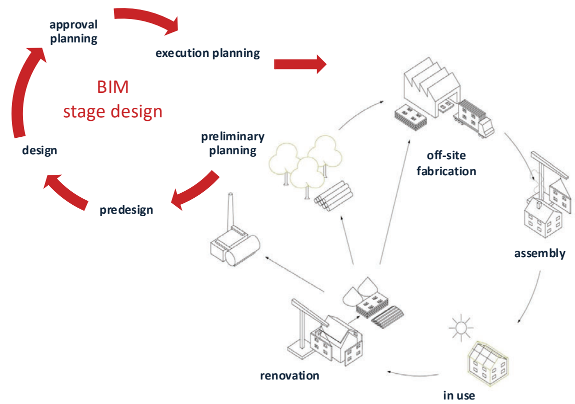

Figure 1. BIM workflow in timber construction; Source Lattke

and ensuring that critical timber-specific considerations are incorporated early in the design process. Through these advancements, BIMwood aims to bridge the gap between digital modeling and real-world prefabrication, enabling a more efficient, reliable, and industrialized approach to timber construction.

2.1 – RESEARCH METHODOLOGY

The BIMwood research project followed a three-step methodology to develop a timber-specific BIM framework. First, a requirements analysis was conducted through literature reviews and stakeholder interviews to identify gaps in current BIM workflows for prefabricated timber construction. Second, a reference process was developed using Business Process Model and Notation (BPMN 2.0), defining data exchange workflows, roles, and responsibilities across the planning and production phases. Third, the framework was validated through mock-up simulations of multi-storey timber buildings and reviewed in expert panels. The outcome includes a standardized BIM Execution Plan (BEP), role-based planning strategies, and simplified 3D modelling techniques adapted for prefabricated timber construction.

3 – PROJECT DESCRIPTION

The BIMwood project addresses the unique challenges of integrating BIM into prefabricated timber construction by applying a standardized process model based on Business Process Model and Notation (BPMN) and role-based planning concepts. This structured approach defines clear data exchange standards and responsibilities throughout the planning and production phases. Unlike traditional construction methods, timber structures require precise digital planning due to their multi-layered nature, off-site prefabrication constraints, and specialised assembly techniques. Recognizing these complexities, BIMwood establishes a structured reference process to enhance collaboration, data exchange, and process automation throughout the design-to-production workflow.

One of the primary advantages of BIM in prefabricated timber construction is its ability to enhance communication and interface coordination. Traditional 2D-based workflows often result in data fragmentation, making it difficult to synchronize design and fabrication processes. By contrast, a fully integrated BIM workflow enables real-time data sharing, improving efficiency, quality control, and project visualization.

The BIMwood reference process aligns with standard planning phases using Business Process Model and Notation (BPMN 2.0). It includes two complementary observation levels: the descriptive level, defining structured multidisciplinary data sets, and the procedural level, detailing data exchange processes, role allocations, and responsibilities. This dual structure ensures transparency and accountability in data handling across all project stages.

Furthermore, the basics for the creation of 3D models are devised regarding geometric specifications. The demands on the models are clarified concerning the necessary component data. The proposed solutions provide the basis for developing an implementation strategy to improve data exchange between planners and contractors to complete the process chain from planning to production. BIMwood has developed an implementation strategy for BIM-based planning and data management processes for prefabricated timber construction. The reference process defines relevant multidisciplinary data sets and regulates data exchange, considering role concepts and responsibilities. The necessary information requirements for geometric characteristics and relevant data along the planning stages were defined for the individual specialist models. At the procedural level, BIMwood defines role-based responsibilities for various stakeholders involved in the digital planning, engineering, and fabrication processes. This ensures that data flows seamlessly from architects and engineers to manufacturers and on-site assembly teams, minimizing the risk of errors, redundancies, and miscommunication.

The reference process was validated through expert panels and mock-up simulations.

4 – BIMWOOD DESIGN PROCESS

BIM has been widely implemented across various sectors of the construction industry, demonstrating its reliability in enhancing planning processes. BIMwood has identified specific requirements that need to be considered in the design stages of a timber construction project. Role-based collaboration models and standardized 3D modelling techniques ensure a seamless transition from digital design to fabrication and assembly. The BIMwood design process implements off-site fabrication principles, with an emphasis on early integration of timber expertise and simplified digital modelling techniques.

4.1 PROJECT MANAGEMENT

Successful BIM-supported projects require structured planning processes, beginning with clearly defined objectives, stakeholder roles, and data requirements. The application of the BIM method must be planned at the start of a project using structured guidelines for each planning phase.

The **Employer's Information Requirements** (EIR), as defined in VDI 2552-10 [3], serve as the contractual foundation of BIM-based planning, outlining the client's expectations for data exchange, model deliverables, and decision-making milestones across all project phases. This foundational document ensures that all project participants align their work with the agreed-upon BIM methodology, minimizing miscommunication, data inconsistencies, and planning errors. Since early integration of timber construction expertise is essential in timber construction planning, the Employer's Information Requirements (EIR) should place a special focus on BIM objectives, use cases, role definitions, modelling guidelines, and required levels of information detail [4].

A key tool in improving project coordination is the **BIM Execution Plan** (BEP). It provides a project-specific summary of all BIM-related activities, defines roles and responsibilities, and ensures transparency workflows. The BEP translates the client's Employer's Information Requirements (EIR) into actionable guidelines for planners, contractors, and manufacturers. By establishing clear BIM objectives, data exchange standards, and quality assurance measures, the BEP facilitates seamless collaboration, reduces design conflicts, and minimizes rework efforts.

Necessary Specifications for a BIM Execution Plan (BEP) include [8]:

- Implementation of BIM objectives
- BIM use cases in the individual project phases
- Tasks and responsibilities (roles)
- Quality assurance measures
- Coordination and communication (model structure and content)
- Technologies (data environment, software tools, data exchange, and handover)

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- Project structures (organization)
- Processes and requirements for collaboration (collaboration strategy)
- Digital deliverables and delivery timelines

Project management stakeholders should possess at least a basic understanding of the principles and requirements of prefabrication, including element sizing across the planning, fabrication and assembly phases. It is advisable to hold one or more **BIM workshops** after commissioning the project planning and the other specialist planners. These workshops, led by the overall BIM coordinator, they are used to define how the client's EIR will be implemented. The outcome of these workshops are documented in the initial BEP. To support digital collaboration, planning standards and naming conventions and clear definitions for interfaces between the design, fabrication and construction phases must be established early in the process.

4.2 TIMBER CONSTRUCTION EXPERTISE IN BIM WOOD PROCESS

Unlike steel or concrete, timber construction is highly dependent on prefabrication principles, requiring precise modelling techniques that account for component tolerances, moisture behaviour, fabrication and assembly logistics. Timber-compatible design considers prefabrication constraints as for example suitable dimensions of panel elements or space modules to be manufacturable in production while considering size, weight, and complexity and ensuring economic transportability. Connections are designed to be easily assembled, ensuring that airtightness can be implemented and that fastenings remain accessible for screwing. They are planned to guarantee weather protection during the construction phase as well as all necessary measures for moisture protection, e.g. drainage systems, sealings and possible monitoring strategies are considered.

A planning team must thus have the skills of design, timber materials, structural behaviours and prefabrication requirements to successfully plan a timber construction project. Defining specialized roles in the BIM planning environment minimizes design conflicts, reduces late-stage modifications or re-design, and optimizes material efficiency. These individual roles and responsibilities for actors in a BIM planning process are defined, as for example in VDI [3]. BIMwood identifies five main roles of actors. The roles are not limited to individual companies, planning disciplines or persons in a project. A company or person can take on several roles. The assignment and distribution of BIM roles is project specific. The responsibilities of the actors involved describe their tasks and duties, including areas of responsibility for specific details and information in the overall model, such as geometry and other relevant data.

In response, BIMwood introduces a role-based framework to define the expertise in timber construction required at different project stages. The primary roles include:

- **BIM Information Management** – Strategy: This role focuses on the objectives defined by the client. It creates the Employer's Information Requirements (EIR), specifying the required data, information, and BIM use cases (BIM-AwF). Additionally, it monitors compliance with the EIR and the implementation of the BIM Execution Plan (BEP) throughout the project lifecycle.
- **Overall BIM Coordination**: This role works closely with specialist planners and develops the BIM Execution Plan (BEP) in response to the Employer's Information Requirements (EIR). It integrates the specialist models into a comprehensive BIM model, submits it to BIM Management, documents the results, and communicates them to all project stakeholders. This role is preferably carried out by object planning (architectural design) to ensure not only the technical feasibility of BIM processes but also to integrate the design aspects of the construction project.
- **BIM Author Object Planning** – Building Architecture: This role is responsible for ensuring that architectural models align with timber-specific design constraints and regulatory requirements and coordinates the specialist planning disciplines as well as communication within the planning team in close collaboration with Overall BIM Coordination.
- **BIM Author for Timber Construction Planning**: This role describes the timber construction-specific competences with focus on the structural detailing of timber components, ensuring that all design elements are optimized for fabrication and assembly. If the planning team is missing expertise in timber construction, it can be supplemented for the overall project. This can be achieved either by bringing in a timber construction engineer as an independent consultant. Another option is the early integration of the timber construction company into the planning process by awarding contracts in the early planning phase (performance description with functional tendering) or by applying collaborative team models such as those described in leanWOOD [9].
- **BIM author structural design**. This role is responsible for the design and dimensioning of the building's supporting structure. The planning and modelling of the supporting structure is carried out in close collaboration with the members of the planning team, who have specific timber construction expertise.

4.3 BIM WOOD REFERENCE PROCESS

A BIM Reference Process provides a comprehensive framework for structuring digital workflows for an efficient collaboration of planning teams. This methodology not only defines information requirements for different project phases but also determines the appropriate Level of Development (LOD) [8] for planned contents. One of the key aspects of the reference process is the definition of information density and collaboration across different planning stages, ensuring that only relevant and actionable data is included at each step. The BIM Reference Process serves to illustrate an ideal-typical BIM project process, which is often developed along a specific construction project and serves as the basis for further decisions. Reference processes form the basis for fast and effective modelling. The BIM Reference Process is typically structured around the standard project phases:

- Pre-Design Phase
- Conceptual Design
- Detailed Planning
- Engineering & Coordination
- Construction & Assembly
- Facility Management & Lifecycle Optimization

In general, it can be said that a standard BIM reference process procedure can be applied for timber construction projects. The reference process maps the tasks of the individual actors over the planning stages and the content of different model types, i.e. Architectural Model, Structural Model, MEP (Mechanical, Electrical and Plumbing Model). In addition, the specific topics of timber construction along the phases and the actor 'BIM author for timber construction planning' are key elements in the BIMwood reference process. Following aspects of timber construction, prefabrication and production must be considered during planning and must be mapped in the BIM models.

Conceptual Design phase in LOD 100

- Definition of structural elements, e.g. walls, columns, roof, ceilings with reference to suitable element sizes
- Definition of horizontal and vertical timber construction elements
- Initial concept of element dimension and partition hierarchy

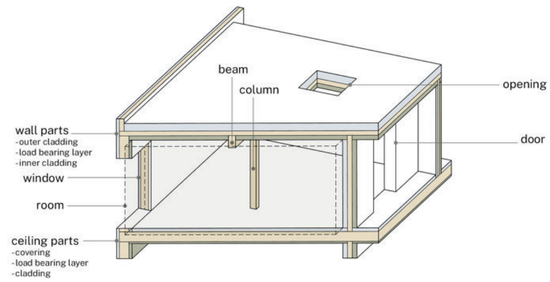

Figure 2. Architectural model with components drawn in 3 layers, Source: BIMwood 2023

Detailed Planning phase in LOD 200 / LOD 300

- Clarification of the essential details in the timber construction (plinth, ceiling support, parapet)
- Detailed planning of element dimensions and connections
- Detailed planning of structural elements (e.g. studs, frame, rafters) Detailed planning of openings in timber elements
- Assembly and weather protection concept
- Material, building physics and fire safety properties

Timber construction imposes specific requirements on the geometry, assembly, and design of building elements, ensuring structural integrity, efficient fabrication, and seamless on-site installation. An example of this layered representation is shown in Figure 2, which illustrates an architectural model with components structured in three layers.

Geometric & Structural Considerations

- Element geometry: Timber elements must be designed in height and length for efficient prefabrication.
- Manufacturability: Components must be optimized for production, considering size, weight, and complexity.
- Transportability: Modular or prefabricated elements should be designed for economic transportation.
- Structural integrity: Load-bearing elements must meet mechanical performance criteria for wind, seismic, and dynamic loads.

Connection Design & Assembly Efficiency

- Modular joints and connections should allow for fast on-site assembly and disassembly.
- Screw connections must remain accessible to facilitate future maintenance and modifications.

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- Prefabrication-friendly detailing to ensure factory-controlled quality and minimal on-site adjustments.
- Tolerances and joint behaviour must be integrated into BIM modeling to avoid assembly conflicts.

Airtightness & Moisture Protection

- Weather protection during construction should be planned into the BIM model, ensuring that prefabricated elements are not exposed to excessive moisture.
- Integration of airtightness strategies into wall, roof, and floor assemblies to meet energy efficiency requirements.
- Waterproofing and drainage considerations for wet areas, balconies, and loggias must be modelled in BIM.

Fire Safety & Regulatory Compliance

- Fire-resistant design of timber components must comply with local building codes and fire regulations.
- Compartmentation strategies (e.g., fire barriers, smoke control) should be defined in early planning stages.
- Use of BIM simulation tools for fire performance analysis and evacuation modelling.

4.4 MODELLING TIMBER CONSTRUCTION

BIMwood emphasizes timber construction-specific modelling strategies, ensuring that digital representations of timber elements accurately reflect real-world production requirements. A critical distinction between traditional BIM processes and BIMwood's methodology is the way, multi-layered timber elements are digitally modelled. Instead of overloading BIM environments with excessive detail, BIMwood employs a structured, process-oriented approach that balances data accuracy with computational efficiency. This methodology allows for rapid iteration of design solutions, improves model interoperability between disciplines, and ensures seamless data exchange between designers and manufacturers.

BIMwood has developed a standard procedure to represent complex, multi-layered components in a 3-layer model. This reduced representation is illustrated in Figure 3. The system applies to all structurally relevant components. An external wall is thus represented by the description of an inner and outer cladding and a load-bearing layer. Ceilings, are represented by an upper and lower cladding, resulting in a lean geometric model that meets the requirements of collaboration in the planning team

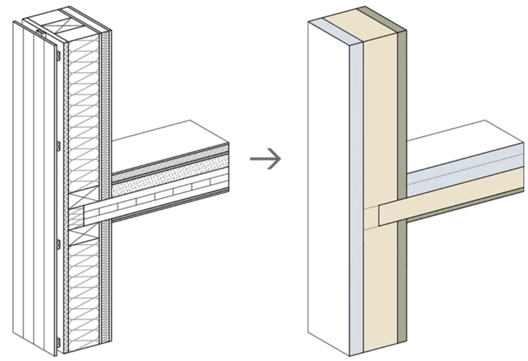

Figure 3. Reduce complexity in timber construction design; Source: BIMwood, 2023

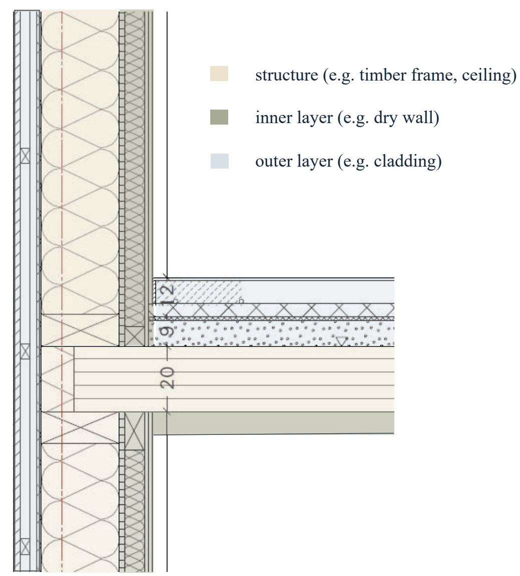

Figure 4. 3-layer model for exterior walls and ceilings; Source: Lattke

and simplifies the complex construction method of timber construction. This approach is visualized in Figure 3, highlighting the reduced complexity in timber construction design. Detailed semantic information can be assigned to the geometric model using linked data records, for example via a component catalogue.

Who does what? In the BIMwood Reference Process, the design of the discipline-specific digital model for structural design and architectural planning is developed in a multi-layered approach. The architect models the load-bearing core layer in the centre of the timber frame component as a distinct layer, ensuring alignment between the architectural and structural model. This multi-layered modelling strategy is depicted in Figure 4, showing a 3-layer model for exterior walls and a simplified 3-layer model for ceilings. At the load-bearing layer level, the

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structural engineers model the relevant components of the load-bearing timber construction, including top plate, bottom plate, studs, beams, and shear zones.

The use of the load-bearing layer provides the structural design team with a dedicated space for modelling structurally relevant construction elements. This approach also enables the generation of the structural analysis model within the BIM environment.

In the construction planning phase the common model represents components or group of components in LOD 300 as object with definition of size, dimension, form, position and orientation [10]. Additional information can be supplemented by detailed drawings and detailed information e.g. fire safety report).

BIMwood has proven the concept of a joint model-based collaboration in a simulation of the planning of a multi-storey timber building. The process was based on a BIM Execution Plan involving the different actors with specific tasks working on their models. During the process, key points were identified where experience in timber construction played a crucial role in problem-solving. These are above all the specifications for multi-layered timber components (terminology definition and component structures) and the responsibilities of structural engineers in the model (interaction between architecture and structural design in timber construction). For planning teams with little or no BIM experience, as well as for new design groups, it is essential to allocate sufficient time for collaboration coordination and to allow for a generous testing phase. Use a simplified model during the test phase, representing the key building components of the project (similar to a mock-up model). During the mock-up modelling process, the following timber construction-specific modelling rules were identified, which should be agreed upon in advance among all participants:

- Coordination of "layers" (e.g., definition of the load-bearing layer with or without cladding).
- Agreement on model content (attribute list).
- Definition of the modelling approach for component connections.

To facilitate collaboration between architects, structural engineers, and specialist planners with limited experience in timber element design, a tool like the leanWOOD Matrix [11] can serve as a valuable tool for guidance and support. It is a detailed description of the component hierarchy and the component structures, with a checklist to clarify 'who does what' in the process from design to workshop planning.

4.5 INFORMATION MANAGEMENT AND TIMBER SPECIFIC ATTRIBUTES

In addition to the three-dimensional geometric model, in the BIM method semantic information is systematically captured within the model. This includes component and material properties as well as usage characteristics of rooms, all of which are recorded in the digital building model. Modern CAD systems are equipped with input interfaces and data exchange features, enabling a seamless integration and utilization of information in collaborative planning processes. In the IFC standard, the characteristics and naming conventions for attributes are defined [12]. Modelling guidelines for standardized building data models define the conventions for attribute structuring and naming [13].

In addition to the existing standards, BIMwood has analysed specific attributes for timber construction, which must be defined in the modelling workflow. The BIMwood Information Exchange Requirements define the information needs for planning in multi-story timber construction. Attribute lists specify the extent and timing of the required information within the respective specialist models [4] p. 79. They establish who provides which information, at what stage, and at what level of detail, as well as who receives it. The development of these attribute lists was carried out within the BIMwood research project under the principle of "as little as possible – as much as necessary," with a focus on timber construction-specific information requirements for the architectural model and structural model. The lists define the minimum requirements for these specialist models.

The attribute lists are an integral part of the BIM Execution Plan (BEP). Figure 5 illustrates the attribute list for foundations, slabs, walls, and columns, defining both the required information and the responsibilities of the involved stakeholders for data provision and management. They are adapted to project-specific needs and updated throughout the planning process. It is crucial to consider the client's information depth requirements for building components from the very beginning of the modelling process. The BIMwood attribute lists are structured as follows.

In the first column, "Source" it is indicated whether the attributes are embedded in the 3D specialist models or if the information is integrated into the Component Catalogue (CC) or within the specialist planning concepts. The catalogue provides a detailed, tabular description of components, listing all elements and properties. The information density in the geometric model is enhanced by the referenced attributes (properties) from the same source.

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						Wall components				
Source	Type	Name	Pit	Foundation	Floor slab	Cladding 1	Load bearing	Cladding 2	Framing	Column
Component specification	Basics	**Name**	ARC	ARC	ARC	ARC	ARC	ARC	ENG	ARC
		Component ID	ARC	ARC	ARC	ARC	ARC	ARC	ENG	ARC
		Level	ARC	ARC	ARC	ARC			ENG	ARC
		Quantities (length,width,...)	ARC	ARC	ARC	ARC	ARC	ARC	ENG	ARC
		Element number	–	–	BPW	BPW			ENG	BPW
	Construction / Qualities	Exterior component	–	ARC	ARC	ARC	ARC	ARC	ENG	ARC
		Load Bearing element	ENG	ENG	ENG	ENG	ENG	ENG	ENG	ENG
		Structural orientation	–	–	–	–	ENG	–	ENG	ENG
		Prefabricated element	–	ARC	ARC	HLZ	HLZ	HLZ	HLZ	HLZ
		Trade	–	ARC	ARC	ARC	ARC	ARC	ENG	ARC
		Material	–	ARC	ARC	ARC	ARC	ARC	ENG	ENG
		Strength class	–	ENG	ENG	ENG	ENG	ENG	ENG	ENG
		Utilization class	–	–	–	–	ENG	–	ENG	ENG
		Surface quality	–	–	ARC	ARC	ARC	ARC	–	ARC
	Requirements	Construction type	–	–	–	BRS			–	–
		Fire resistance	–	BRS	BRS	BRS			–	BRS
		Encapsulation criterion	–	–	–	BRS			BRS	BRS
		Sound insulation requirements	–	–	–	BPS			–	–
		Energy parameters	–	–	–	BPW			–	–
Component catalogue	Heat insul.	Temperature correction factor	–	–	–	BPW			–	–
		Thermal conductivity	–	–	–	BPW			–	–
		Building material Vapour diffusion	–	–	–	BPW			–	–
	Sound insulation	Sound absorption coefficient	–	–	–	BPS	–	BPS	–	–
		Airborne sound reduction index	–	–	–	BPS			–	–
		Building material Specifications	–	–	–	BPS			–	–
		Building material Bulk density	–	–	–	BPS			–	–
		Material impact sound insulation	–	–	–	BPS			–	–
		Material fibre insulation	–	–	–	BPS			–	–

Figure 5. BIM attribute list for foundation, slabs, walls and columns (ARC-Architect; ENG-Engineer; HLZ-timber manufacturer; BPS-building physics sound; BPW-thermal building physics); Source: BIMwood, 2023

The "Attributes in Components – 3D Specialist Model(s)" section lists the attributes that are the responsibility of designated specialist planners and are incorporated into a specialist model. The Component Catalogue can be linked to components via the "CC Number" property. The Component Catalogue is created during the preliminary design phase and is gradually expanded and refined throughout the planning process.

The precise assignment of information must be further defined during the BIM Execution Plan (BEP) development, depending on the construction project, to ensure that all project participants can easily locate the necessary information at any time.

The attributes are categorized in the "Type" column based on:

- Basic Properties
- Construction/Quality Attributes
- Requirements
- Fire Protection
- Thermal Insulation
- Acoustic Insulation

This categorization helps structure the attribute lists, and additional attributes may be required depending on the project type.

Basic Attributes include fundamental properties of the components, such as geometry. The "Construction and Quality" section lists specific features and properties that are integrated into the 3D specialist models.

The "Requirements" section outlines the essential criteria that components must meet at a minimum.

5 – RESULTS

What is the added value of establishing a timber construction-oriented BIM planning culture across a seamless planning and process chain?

Effective planning of timber buildings demands integrated expertise in material properties, production and logistics, and the principles of prefabricated component composition and connections. BIMwood enhances this by providing a structured, model-based planning process that minimizes redundancies, reduces late-stage design conflicts, and ensures a seamless transition from digital models to manufacturing and assembly [14]. In current planning practice, process steps are often based on the sequential fulfillment of self-contained planning phases from conceptual design, design development, construction documentation, detailing, off-site fabrication and on-site assembly [6]. Each step is completed and documented independently, without integrating aspects of later phases. A forward-thinking planning approach, which anticipates execution planning details already during design development, is generally not foreseen.

However, for timber construction design, a high level of planning discipline and early-stage detailing are fundamental prerequisites for achieving creative, structurally sound, and economically viable solutions. The BIM methodology can support this approach by enabling a structured process for model-based planning and ensuring the handling of digital data at an early project stage. Additionally, it is essential to coordinate the representation of building elements, component structures, and the definition of assigned attributes. The design process and the interfaces between spatial, structural, and building services systems become visibly three-dimensional at an earlier stage through model-based planning, allowing the project team to address potential issues collaboratively. BIM modelling fosters closer cooperation among stakeholders, enabling more comprehensive, digitally supported planning steps and transparent documentation.

In this collaborative environment, the expertise of each discipline is directly integrated into the process. Design approaches and planning concepts can be evaluated using model-based methods early in the planning phases. However, achieving this requires a willingness among all stakeholders to engage in interdisciplinary, transparent, and cooperative communication, as well as an open error culture.

From construction practice, we know that many errors arise from missing planning documents and a lack of coordination between work steps, often resulting in subsequent trades damaging already completed components. One of the biggest sources of errors in timber construction is the integration of building services. If the installation of cables, cable trays, shafts, and fire protection systems is unplanned and executed without consideration for timber-specific construction requirements, it often leads to incorrectly installed components and construction defects. To ensure an integrated planning approach in the project, it is crucial to consider both the BIM expertise and the timber construction expertise of the planners when selecting and commissioning them. A frictionless data transfer from the coordinated overall model of the planners to the planning system of the timber construction company may contribute to a more efficient workflow. Recommendations for a timber construction compatible BIM Process:

- Integration of BIMwood-specific timber construction expertise into the planning process.
- Establishment and optimization of structured workflows for better coordination and avoidance of information loss and rework during model exchanges.
- Early clarification of compatible planning tools, data exchange formats, and storage formats.
- Use of openBIM formats (e.g., IFC, BCF) to facilitate collaboration across different software platforms.
- Use of platforms to consolidate data (e.g., BIMplus).
- Comprehensive commissioning of service steps to enhance the continuity and completeness of model-based planning.
- Solution-oriented conceptual approach in the early planning phase, involving all specialist planners and ensuring early input on technical and timber-specific solutions (e.g., shaft/tray/opening coordination).
- Shifting basic services to earlier project phases (see timber-compatible service profiles).
- Implementation of a Design Freeze to stabilize planning decisions.
- Early clarification and agreement on timber-specific BIM information.
- Early proof of compatibility between BIM and CAM/CNC systems to ensure seamless transition from design to manufacturing.
- Accurate representation of building components [9].

6 – CONCLUSION

From construction practice, we know that most errors arise from missing planning documents and a lack of coordination between the actors in the different stages. When buildings are designed with little understanding of timber construction, this often results in poor execution and construction defects. In a consistently BIM-planned project, these issues can be resolved during the planning phase. The high degree of prefabrication of timber panel elements for the building envelope, combined with third-party quality control, already ensures a high level of execution quality. For correctly installed building services, specialist planners play a crucial role in defining the placement and installation methods for cables, pipes, and components during the planning phase. Only then can errors, such as overcrowded fire protection penetrations or inadequate cable routing, be identified and prevented early on.

The BIM process requires a shift in mindset from “we’ll solve it on-site” to “let’s solve it together in the model”. Here, the architect takes on the role of coordinator, integrating the contributions of specialist planners as a core responsibility. During the solution development process, it is essential to consider the specific requirements of timber construction. A structured planning process, with clearly defined objectives documented in the Employer’s Information Requirements (EIR) and reference processes, establishes a clear framework for successful implementation.

Based on Building Information Modeling (BIM) as a key technology in Architecture, Engineering and Construction (AEC), a timber construction-specific BIM methodology for prefabricated timber construction was developed to improve smooth planning and data management processes. These solutions can now be integrated into planning practice. The BIMwood recommendation for action is intended to serve as a guideline. Although the proposed reference process is currently tailored to the German market for prefabricated timber constructions, future work should examine the transferability to other countries. Furthermore, a look into international research reveals common challenges, that confirm the BIMwood results. Projects around the globe [6] come to similar conclusions showing that the BIM method has been developed in principle, but is not yet readily transferable to the specific requirements of prefabricated timber construction.

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A necessary step for use in practice is to apply and evaluate the developed reference process and the specifications for creating the 3D specialist models as part of pilot projects. During the project, deficiencies in currently available BIM-compatible software applications and Common Data Environments (CDEs) were identified. Based on these findings, requirements for the functionality of software applications, BIM-compatible component catalogues, and cloud-based collaboration platforms could be developed. Additionally, these requirements could be expanded to incorporate lifecycle considerations for buildings, aligning with the concepts of the "Digital Twin" and circular economy. While BIMwood presents a comprehensive framework for digital planning in prefabricated timber construction, current limitations include the dependency on software interoperability and the absence of universally accepted openBIM standards tailored to timber construction. During the collaboration of the practice partners in the mock-up process, it was found that the functions of the software used did not meet the expectations of the users. This was confirmed in the expert interviews. Data exchange problems were repeatedly mentioned ending in so-called workarounds to be able to carry out the desired or necessary data exchange for planning. Future development should focus on the interoperability of software tools and enhancing IFC-to-CAM compatibility to streamline data exchange between digital planning and prefabrication workflows.

Further validation through real-world pilot projects is required to assess the scalability of the proposed reference processes and thus support the acceptance of the BIM method in timber construction. Despite these challenges, the results are promising as they prove the functionality of the concept to increase workflow efficiency. Additionally, integrating AI-driven BIM automation and digital twin technologies will support lifecycle management and foster circular economy approaches in timber construction. The validated BIMwood framework provides a solid basis for standardized digital planning processes, enabling efficiency and scalability in prefabricated timber construction.

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