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Advancing Timber for the Future Built Environment

NET-ZERO TIMBER BUILDING DESIGN TYPOLOGIES

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ABSTRACT: The conception of sustainable building design necessitates the implementation of data-driven decisions at the outset, which must encompass the integration of architectural vision, structural feasibility, and environmental impact. This paper presents the findings from a collaboration between the Bern University of Applied Sciences (BFH) and Digital Blue Foam (DBF), conducted through several workshops and knowledge exchanges. The subject of the paper is the development and application of recommendations for span and material systems for timber design of multi-storey buildings. BFH contributed technical expertise in timber engineering to establish a decision matrix that supports the plausibility of span dimensions and grid configurations during early-stage planning. In combination with DBF's AI-driven platform, this enables designers to dynamically compare structural options with respect to cost and embodied carbon. The platform has been developed to facilitate the visualisation of these interdependencies at the earliest stages of the design process, with the aim of enabling users to make well-informed decisions that favour timber construction and support the transition to sustainable, net-zero buildings.

KEYWORDS: timber engineering, sustainable design, AI in architecture, material systems evaluation, net-zero buildings

1 – INTRODUCTION

DBF is a global technology company founded by architects, specializing in developing AI-powered solutions from the buiding to the city scale. The focus is on improving project efficiency resulting in improved sustainability outcomes [1]. DBF has created an easy-to-use software platform for consultants, architects and city planners that offers geospatial data on every city, unparalleled user experience, a powerful design engine, and project analytics tools - all in one web-based platform. The software is being used by some of the world's leading AEC companies such as Jacobs, Aecom or Takenaka Corporation of Japan.

Alongside its enterprise software business, DBF regularly conducts and publishes research activities with a specific focus on innovative generative design methodologies and approaches to improve project sustainability outcomes.

Bern University of Applied Sciences (BFH), Department of Architecture, Wood and Civil Engineering (AHB), is internationally recognized for its excellence in timber engineering, timber construction systems, and applied digital technologies. BFH-AHB combines teaching and applied research, educating engineers and specialists at bachelor's and master's level while advancing structural applications, product innovation, and the digitalization of timber construction. The department works in close cooperation with leading companies in the wood industry, research institutions, and universities in Switzerland and abroad to foster a future-oriented and climate-conscious wood industry. Interdisciplinary courses and collaborative formats play a vital role in bridging architecture and structural design in the context of sustainable building.

DBF and BFH exchange knowledge, conduct joint R&D projects with specialised research units, and test structural solutions with students. The collaboration looks at developing accessible tools to fast-track the adoption of timber construction as a carbon friendly alternative to concrete and steel. The goals of the collaboration include:

- Creating algorithms for generative site-specific typologies for multi-storey timber buildings.
- Identifying timber construction use-cases at building, quarter and neighbourhood scale.
- Comparing embodied carbon of different structural solutions for a given building massing.
- Facilitating knowledge transfer about wood construction systems through user-friendly online tools.
- Exploring existing building typologies and develop a "best practice" matrix.

2 – BACKGROUND

2.1 DBF KEY EXPERTISE

DBF offers an intuitive, browser-based design environment powered by AI, enabling real-time

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generation and evaluation of building typologies. It integrates geospatial data, generative algorithms, structural logic, and sustainability metrics to facilitate informed decision-making "Fig. 1". A key innovation is its ability to quantify embodied carbon and cost in early-stage models.

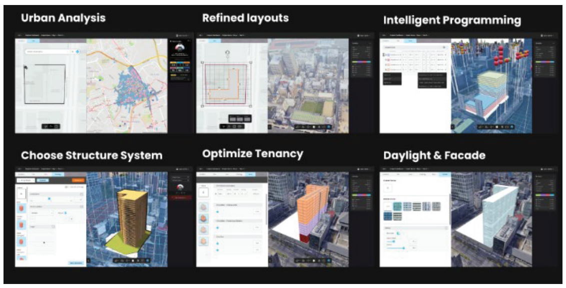

Figure 1. DBF platform

Collaborating with prominent real estate developers confronted with stringent deadlines and limited opportunities for design refinement, DBF identified a persistent challenge: the time-consuming nature of structural design frequently prompts teams to choose conventional, high-impact materials such as steel and concrete. To accelerate the adoption of low-carbon alternatives such as mass timber, it is essential to expedite structural decision-making processes during the early conceptual phase. DBF addresses this challenge through the provision of a user-friendly platform that integrates spatial design, structural system generation "Fig. 2", and performance-based evaluation.

Structural type	Floor type	LLRS
Composite steel concrete frame	Concrete slab with 150mm thickness	Steel bracing
Concrete frame	Concrete slab with 150mm thickness	Concrete shear wall
Timber frame	Timber 7-layer CLT slab with 240mm thickness	Timber shear wall
Composite steel timber frame	Timber 7-layer CLT slab with 240mm thickness	Steel bracing

Figure 2. Structural types, floors, and lateral load resisting systems

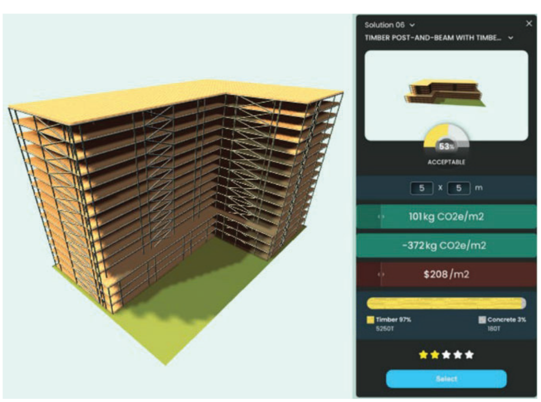

Figure 3. Example of generated structural system

The massings, developed through the interaction of design intent and algorithmic input, serve as the basis for structural layout. They define the volume, number of stories, floor area, setbacks, and heights. The platform generates corresponding structural systems, including beams, columns, slabs, cores, and lateral load-resisting systems, based on two orthogonal span directions (in a range between 3 and 10 meters) and the intended structural type "Fig. 3". Underlying scripts facilitate the dynamic generation of structural grids and the placement of key elements, which are subsequently assessed in terms of cost, embodied and sequestered carbon. The ability to compare design scenarios in real time empowers project teams to make faster, more sustainable choices aligned with commercial realities.

2.1 BFH KEY EXPERTISE

Digital transformation is not only changing business models, working methods and production and construction processes, but is also having an impact on automation-compatible designs and materials. The Institute for Digital Construction and Wood Industry (IDBH) is dedicated to the digital transformation of the built environment, with core activities spanning integrated planning processes, digital fabrication in construction, Building Information Modelling (BIM), parametric design methods, and market and business strategy for the construction and timber industries.

It is organized into specialist groups that mirror these competencies: a Digital Fabrication group advances automation, robotics and production-integrated design, leveraging Industry 4.0 concepts to integrate planning and manufacturing for automated construction processes ; a Business Management and Market Research group focuses on digital strategy, conducting market and industry analyses and developing business models to guide firms in the construction and wood sectors through digital transformation ; and an Integral Construction and Planning Processes group concentrates on BIM-driven information management and holistic process optimization across the building lifecycle

This structure enables an interdisciplinary collaboration - combining technological innovation, process methodology, and strategic industry insight - that underpins the institute's contribution to developing integrated digital design platforms in architecture and construction.

BFH engages in innovative scientific R&D in multi-storey timber and hybrid construction, focusing on typologies for grids, floor / wall / roof, and general construction systems.

The collaboration with DBF aims to create algorithms for generating site-specific typologies for multi-storey mass timber buildings and identify timber construction use cases at various scales. The DBF platform offers the possibility to integrate static concepts for vertical and horizontal load transfer and constructive solutions to specify suitable bracing systems for tall buildings, assign structural elements and floor systems to address structural design issues. Additionally, the project aims to specify the most suitable materials and combinations for fire safety, energy efficiency and sustainability at the predesign stage, thereby aiding decision-making processes.

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3 – PROJECT DESCRIPTION

In Spring 2022, DBF and BFH researchers collaborated on a high-rise timber study where first investigations and attempts to structure engineering and architecture needs were carried out. Since then, DBF and Karamba 3D (FEM) developed an application to predict embodied carbon energy [2] for various structures "Fig. 4" and "Fig. 5".

Additionally, DBF and BFH worked with a group of 15 timber and architecture master students on a formally agreed and concerted case study on multi-storey (high rise) timber buildings. A literature survey on high rise timber buildings was undertaken to find out in what way vertical and horizontal load transfer was solved in practice in realized buildings. In the main study seven multi-storey to high rise timber buildings were developed for a given site. The findings from this study were compared to and combined with the experiences from practice and a design matrix was established to start elaborating "best practice".

In parallel another multi-storey project was developed for a specific site in Switzerland that finally led to a 2-storey full scale prototype that serves as a reference framework for low-carbon urban development that was shown to a larger public during one of the major construction fairs [Fig.4,5].

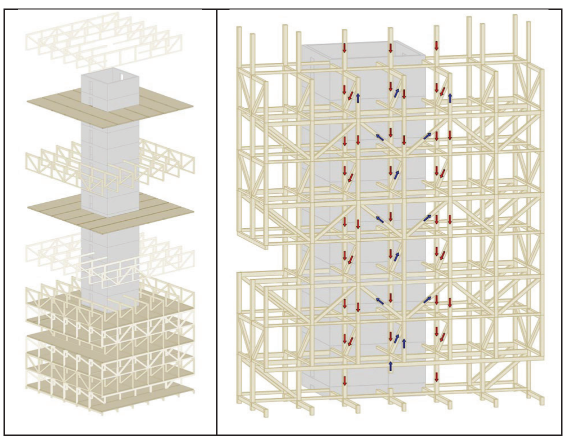

Figure 4. "Jenga" Tower, a 20 storey with room height truss structure and concrete core (left), robustness study when considering robustness in the case of column failure (center)

In 2024, a one-week workshop in Bali [3] DBF and BFH brought together international experts to consolidate initial findings and explore best practices in sustainable construction. The aim was to foster interdisciplinary collaboration and integrate insights into the DBF software, enhancing early-stage design processes through AI and computational tools. Emphasis was placed on merging structural and architectural strategies to refine low-carbon timber typologies. The workshop addressed key questions as:

- Why use timber, considering both its benefits and limitations?
- What are current best practices in sustainable construction?
- How to integrate vertical and horizontal load transfer in early design?
- Which bracing systems are suitable for tall timber buildings?
- How to assign structural and floor systems to meet SLS and ULS?
- Which material combinations best address fire safety, energy, and sustainability?
- How to deliver decision-relevant results at the predesign stage?

These discussions shaped the technical agenda, aiming to make structural design approaches more accessible and to advance DBF-integrated design typologies.

Figure 5. Executed 1:1 mock-up of construction principal

The core objective of the project is the development of a building typology for multi-storey timber buildings (5 to 15 stories). By integrating multidisciplinary knowledge, including expertise, data, and technology, the project aims to define ambitious yet applicable design strategies for climate-neutral construction in early design. Central guiding questions include:

- How can a high-impact, integrative solution for sustainable buildings be developed through early-stage collaboration across disciplines?
- What design principles, structural strategies, and material combinations are required to meet environmental, structural, and usability standards?

The project also establishes a collaboration with actors based in Singapore (see: https://www.greenplan.gov.sg/), who are engaged in advancing sustainable building practices. This collaboration enables the transfer of proven methods and insights into the Swiss construction context.

4 – SELECTED WORKSHOP RESULTS

4.1 FIRST KEY ISSUE: MATERIAL SELECTION, EMBODIED CO2

This part discusses principles for optimizing building design, particularly when using materials like timber, with a focus on structural and environmental considerations. It discusses the importance of integrating early-stage design decisions, effective material use, and optimization algorithms to create a more efficient and sustainable building design process. To improve the outcome on a predesign level initial design considerations should be followed.

Environmental and structural issues are treated together as these areas influence each other significantly. Tools like the Energy Performance Directive and EPIC (Early Phase Planning Tool) can aid designers and act as differentiators for projects. The applications offered by DBF can bring computational power to a wider audience, increasing speed in complex projects while ensuring sustainability. It helps provide a balance between cost reduction and carbon reduction, often aligning both goals.

Structural optimization and early design decisions:

It is crucial that areas of the building attributed to specific use and their influence on the structural concept, a clear structure of the building presenting symmetry if possible, oriented floor concepts and the general structural stability form a sound design basis. Structural components like columns and beams should be sized and arranged to fit within the larger building scheme. The key here is an optimization algorithm, which can be easily implemented for structural design, to ensure everything fits together efficiently. The floor system and its components should be discussed early, as decisions at this stage can significantly impact the design of the overall structure. Furthermore, connections between timber slabs and vertical members need to be defined early on to ensure stability and to be linked to the general bracing concept.

Developing a rich information model with layers of materials integrated into the massing model before being exported to BIM has been set up. It's important to use a detailed and informed building model that integrates structural considerations, allowing for real-time calculations of material usage and other factors. Like layer-based floor structures, the facades (and walls) could also be treated as layer-based items in a flexible approach. The tool should allow users to explore different floor, facade and wall configurations, refining from general to specific parameters, fed by databases, with easy clickable options and rich insights between the options on material usage, carbon emission, areas and more.

Material selection:

Sustainability requires thoughtful material choices, sometimes questioning "neutral" indicators. Using the right material in the right place is essential. Concrete, despite its environmental concerns, may be necessary for specific contexts due to its problem-solving capabilities.

Emphasis on timber, assigning properties to materials and integrating them into the model early on, lead to better calculations and can have a large impact on the building's efficiency and sustainability. As fire protection considerations have a large impact on feasible solutions they should be included at an early stage when designing timber buildings.

DBF tool requirements:

The tool should enable the ability to quantify everything in the early phases. A combination of urban analytics and building-level analysis in the DBF tool is a critical function for efficient decision-making and is essential for optimizing design. This should include flexible systems for evaluating materials for facades, walls, allowing the user to customize parameters based on available databases.

Working backwards (optimization approach):

The idea is to design an optimization algorithm that determines material quantities and carbon intensities required to achieve a zero-carbon building. This approach could help in understanding what is needed in structural design to reach the target of zero carbon emissions.

Working forwards (assembly-based design):

Another approach is assembly-based design, where designers choose specific assemblies for different parts of the building. This can be useful if combined with an API that incorporates material data for these assemblies.

However, caution is needed as this method may overlook some building elements (like cores and structural transfers) that aren't initially captured in pre-defined assemblies. Despite the risk of "truncation error," it offers a promising design starting point.

Data structuring for API:

To make the algorithm functional, it is important to ensure data is correctly structured and transmitted to the API. Collaboration with engineers might be necessary to ensure proper integration.

Cost/carbon synergies:

There is potential to optimize both cost and carbon emissions together, with building form or geometries being a major factor. More efficient building shapes often lead to lower costs and reduced carbon footprints. Additionally, changing the building form can shift the importance of envelope vs. structure, providing an opportunity for parametric optimization to address both factors simultaneously.

Overall, the main goal is to explore optimization approaches that balance material, carbon, and cost considerations, while leveraging assembly-based design and API integrations to streamline the process.

4.2 SECOND KEY ISSUE: SPANS AND SYSTEMS

Preferred timing for integrating sustainability:

The most effective time to optimise structural design is during the schematic phase, where the greatest potential for optimization can be achieved. Once the grid and column layout are finalized - key contributors to multiple topics - opportunities for significant impact diminish. This can be achieved by suggesting a system-selection tool that starts broad and later refines details like floor systems combined with general bracing requirements. From a structural engineering perspective, the need for developers

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to have detailed data on beams, reinforcements, and other elements is of main importance. Providing a minimum of 10 to 12 viable options ensure well-informed decisions based on supply and local market conditions. The discussion also explored how altering grid sizes influence a building's overall performance. The optimal grid span - whether 8 x8 m or 8 x12 m - remains an open question. While grid span may not be crucial for all building types, it still affects carbon emissions. It was noted that participatory design models are gaining traction in Europe. A tool that supports this collaborative process can empower users to make informed sustainability decisions.

Building spans, loading, and regulations:

The tool must account for building spans and load capacities tailored to the building's function to ensure safety and usability. Different regulations apply to various building types as for instance different deflection limits, fire safety requirements or acoustic or thermal insulation requirements that also depend on increased complexity the larger the building gets. Such requirements could be simplified into three categories - high, average, and low - ensuring accurate (carbon) calculations while maintaining broad consistency across countries. Similarly, the tool could offer different carbon scenarios (e.g., conservative, moderate, zero). A flexible, case-by-case approach would enhance project-specific decision-making. Simplifying the calculation methodology would also improve the tool's usability and efficiency.

Modular approach:

The meeting highlighted the potential benefits of a modular approach, allowing designers to experiment with different structural systems, including floor systems, columns, and lateral supports. This method enhances design flexibility and sustainability outcomes. A modular, assembly-based approach - constructing buildings from prefabricated parts - can accelerate construction and minimize waste. However, timber construction lacks standardization, with solutions varying by country due to localized fabrication processes. Pure timber solutions are often impractical. The effectiveness of timber-concrete hybrid structures depends mainly on the spacing between supports, arrangement of cores and the diaphragm's ability to manage lateral stress.

While these factors present structural challenges, project goals can influence decisions, encouraging socially responsible solutions even within budget constraints. The tool should assist in selecting cost-effective solutions that still align with sustainability targets. Given that material costs fluctuate by location, integrating this variable into the tool is crucial. A systems breakdown approach could enhance the efficiency of managing distinct building components during design and construction. This methodology would improve precision and control over each element.

A robust dataset and regression analysis could improve the tool's effectiveness. Much of the relevant data exists in Revit models but making it difficult to use directly. AI could potentially clean and organize this data for better usability. Data from past projects also serve as an internal dataset.

In conclusion the discussion underscored the importance of early-stage decision-making in structural design to optimize structures in all respects. A well-designed tool should:

- Offer adaptable precision levels for system selection.
- Facilitate collaboration between engineers and architects.
- Integrate participatory design models.
- Simplify compliance with building regulations
- Support modular and assembly-based construction methods.
- Utilize AI to refine and analyse data effectively.

By addressing these key factors, the tool can enhance decision-making in structural sustainability and carbon reduction, paving the way for more responsible and efficient building practices.

4.3 THIRD KEY ISSUE: REALIZING MULTI-STOREY BUILDINGS IN TIMBER

The discussion focuses on the Swiss reference project zWatt H1 [4] currently being built. It will be one of the highest timber buildings in Switzerland "Fig. 6".

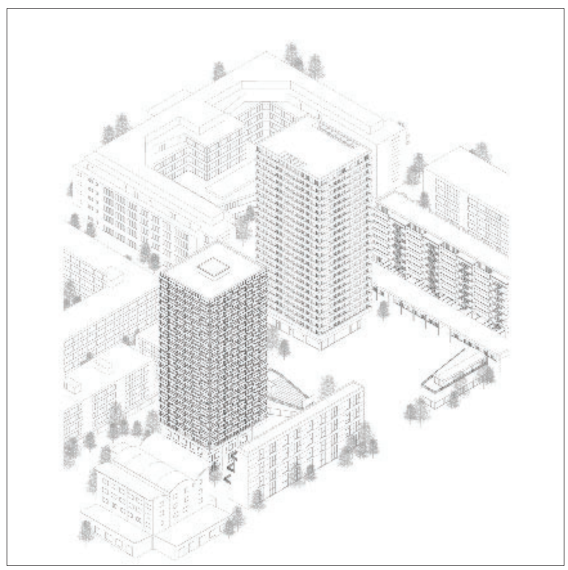

Figure 6. Overview of multi-storey zWatt H1building [4] currently in construction

A standard floor comprises six or eight compactly organised apartments, circulation area and the core for vertical access. The apartments are arranged modularly and match with the grid of the wooden structure. They allow a large flexibility in the horizontal and vertical

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organisation of the flats. Spatially a plurality of typologies was developed which can serve a wide variety of needs.

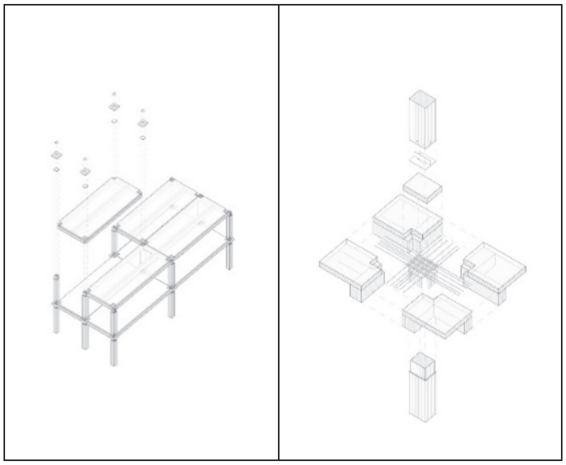

Figure 7. Floor system and column to floor detail of zWatt H1 building [4]

An extensive analysis of the floor system was carried out beforehand to find the most suitable floor system “Fig. 7”. A decision matrix was created to evaluate how different spans in flooring systems impact key requirements like fire safety, noise insulation and comfort, aiding in better-informed design choices. Although the specific parameters may vary by country, the fundamental factors considered in building design remain consistent worldwide. The importance of using repetitive structural elements was highlighted and specific grid dimensions (3.4m by 7.4m) improve efficiency, while smaller spans (e.g., 2.5m) enhance safety and the logistical benefits, particularly under Swiss regulations, while also noting the importance of adhering to maximum slab size restrictions for structural integrity.

Like in other expert discussions, it was highlighted that the structural system is often considered too late in the design process, which complicates construction specially for wood-based designs. Early integration of structural systems is critical to prevent cumbersome and costly redesigns, especially when shifting to timber late in the design process.

Again, a key statement was that ideally the tool should be designed to help test and compare different strategies early in the design process, enhancing decision-making and planning efficiency also by connecting it to extensive databases and combining systems. Monitoring and comparing CO_2 impacts, costs, and ensuring aesthetic quality are essential for sustainable and economically viable building designs. The feedback underscores the need for the tool to support early feasibility testing and strategy comparison, particularly focusing on environmental and cost impacts to optimize design decisions from the outset.

4.4 FORTH KEY ISSUE: BUILDING FOR THE FUTURE

Need for high-rise buildings:

The rise of population in urban areas and the shortage of available land have led to the increasing demand for high-rise buildings. As land prices soar, vertical expansion becomes a viable solution for maximizing space efficiency. Additionally, high-rise structures contribute to a city’s identity and appeal, enhancing its skyline and attracting investors and tourists alike.

Material costs and challenges:

Timber, while considered a sustainable option, is considerably more expensive than concrete. It also presents challenges such as floor vibrations and acoustic issues due to its lightweight nature. The consequence could be that timber floors have to be replaced by other solutions to meet acoustic standards. A balance is needed between building light to reduce underground structural requirements and ensuring sufficient mass for acoustic performance. Despite the environmental appeal of timber, its sustainability is increasingly being questioned, as its actual carbon footprint reduction is unclear.

While steel is another lightweight material commonly used in high-rise buildings, it requires additional covering when considering fire issues. Concrete remains dominant, comprising most of building materials due to its cost-effectiveness, but it has a significant negative environmental impact.

Regulatory and design constraints:

Urban municipal regulations impose restrictions on building heights and require safety measures, such as dual fire stairs for larger floor areas. For instance, a ground floor exceeding 900m² mandates the inclusion of two fire stairs in Switzerland. Fire safety and structural regulations also influence grid size limitations and the overall stiffness of high-rise buildings. Optimal grid size for residential and office buildings is 3.6m (which makes good floorplans difficult), while grids larger than 4.5m x 4.5m may lack sufficient stiffness for high-rise applications.

Efficiency of supercomputers:

In building design advanced computational tools, such as supercomputers, are being utilized to analyze and optimize building designs. This is particularly interesting when for instance studying the contribution to stiffness of secondary structural elements and their “soft” connections. However, their efficiency is still developing as millions of design options must be run which still takes a long time today. By selectively computing only the most relevant parameters and eliminating unnecessary ones, the process could be shortened.

Marketability and aesthetic considerations:

High-rise buildings serve not only a functional purpose but also play a crucial role in urban aesthetics and marketability. The bay length of a building significantly impacts its design appeal. With updated CO2 and pricing data, more informed decisions can be made to enhance

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sustainability and cost-effectiveness in high-rise construction. Current CO2 calculators require revision to reflect accurate pricing and environmental impact.

4.5 SUMMARY AND MAIN WORKSHOP OUTCOMES

Focus areas include climate action strategies, key success factors, industry trends over the next 3-5 years, and notable successes in climate change efforts and tool applications. To optimize design decisions for high rise (timber) buildings considerations regarding location, overall height of structure, spans, regulation, environmental and cost impacts must be structured. It is suggested to perform a grid system analysis and to establish benchmarks for various materials to adapt grid sizing to material types and layout requirements "Fig. 8".

The discussions with experts indicate small sub-grids of about 1.2m x 1.2m to match with standard panel sizes, to yield good floorplans, sufficient core dimensions and positions as well as corridor width for high-rise buildings. The maximum main grid size as a multiple of the sub-grid very much depends on materials (steel, concrete, timber) and potentially hybrid construction systems. Timber solutions seem to be most efficient for average grid dimensions of 6m to maximum 7.2m if robustness considerations are fulfilled at the same time.

measures in case of column failure	number of storeys	≤ 5	≤ 10	≤ 20
standard ULS Load case, follows grid	all grid	X	X	X
extra structural space	small grids	X	-	-
	average grid	X	(X)	-
extra room high structure	small grid	-	(X)	X
	average grid	(X)	X	X
transfer slab	small grid	-	-	X
	average grid	-	X	X

small grid: e ≈ 4.8 m average grid: e ≈ 6.0 m large grid: e ≈ 8.4 m
unsuitable solution: -
possible timber solution

Figure 8. Definition of grid size and vertical load transfer when considering robustness in the case of column failure.

It was found that the tool should consider building physics and acoustic needs, to include cost databases and to integrate circular material considerations. Multiple sustainability targets should be integrated into the design process, addressing factors like earthquake resistance, structural integrity, general floor area, and parking provisions. The ideal tool provides initial building physics assessments, customizes data inputs, integrates EPDs, and calculates environmental impacts to specify materials and evaluate their impact on the building's lifespan as well. The EPIC tool should be used to evaluate materials' impact on building lifespan and detail carbon emissions for each material and construction phase "Fig. 9".

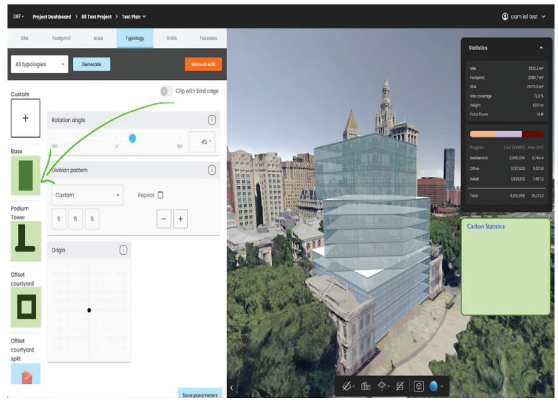

Figure 9. Screenshot of DBF platform including carbon statistics.

The workshop focused on expert discussion with invited specialists from all over the world also to represent different concepts and ways of approaching solutions. Specific results to point out key issues on topics tackled as grid arrangement, floor systems, material selection, general static and in particular robustness considerations have been developed. Other points of discussion aimed at city planning, energy questions, sustainability considerations as well as embodied CO2 in view of net-zero-buildings.

5 – CONCLUSIONS

Other sources seem to confirm the above findings. AI-powered design exploration [5] is one of the most exciting advancements in engineering and architecture. The advantages of AI-enhanced design are immense, primarily because humans have a limited capacity to process multiple variables simultaneously. While targeted goals with a few options are excelled at, handling multiple goals across a vast number of design permutations is a challenge. However, AI allows us to push beyond these limitations by enabling rapid, data-driven design exploration, leading to refined and optimized outcomes.

This is valid for instance, if the stability system of a building is considered. By clearly defining layout zones, stability locations, and setting design goals such as minimizing carbon footprint while meeting deflection requirements, AI can analyze multiple structural models against these criteria. By specifying allowable bracing styles and section types, AI systematically evaluates the options, presents the results in an understandable format, and allows engineers to make informed decisions based on insights they may not have otherwise considered. This results in a more iterative, explorative approach to engineering design, leading to higher efficiency and innovation.

The speed of AI is a crucial advantage. Where a human might take weeks to manually evaluate different configurations, AI can complete the process in minutes or less, analyzing vast amounts of data and recognizing complex patterns that inform better design decisions. AI's

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ability to assess multiple models and refine designs based on performance criteria provides a significant leap forward in optimization. However, despite these advantages, AI is not infallible. It can make mistakes, and its outputs must always be reviewed by a qualified professional. The consequences of an unchecked AI error in structural design could be catastrophic, leading to safety risks and potential structural failures.

Therefore, while AI does not replace engineering expertise and best practices, it serves as a powerful tool for expanding design possibilities, accelerating workflows, and ultimately producing more efficient, sustainable, and cost-effective structures. The challenge now lies in integrating AI more seamlessly into everyday engineering workflows while ensuring that human oversight remains central to the decision-making process.

Partial solutions to specific topics discussed above can be found on the market already. The Fast + Epp Bay Design Tool 2.0 for instance is a web-based tool [6] designed to assist in the preliminary structural design of a typical building bay. It helps compare structural sizes and embodied carbon for different materials, provides approximate member sizes for preliminary design, and encourages material efficiency to reduce cost and carbon footprint “Fig. 10”.

The tool analyzes a single interior bay at the bottom of a building, assuming floor spans between two beams and that the beams are laterally braced against buckling. It requires primary beams to be as deep as secondary beams if they frame into each other. Some parameters as loads, spans in two directions and the building material can be adjusted to compare options for structural grids.

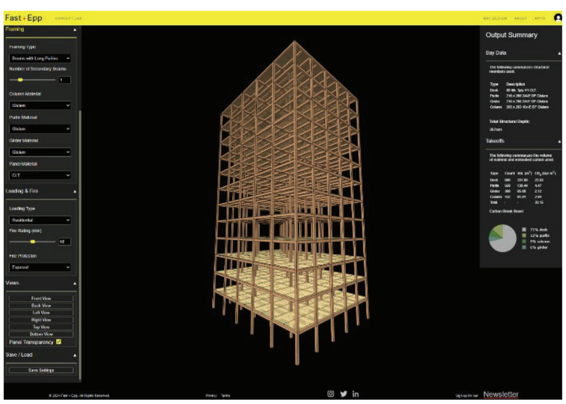

Figure 10. Multi-storey structure generated by Fast & Epp tool [6]

Regarding embodied carbon, values are based on Environmental Product Declarations (EPD) and include cradle-to-gate stages such as raw material supply, transport, and manufacturing. For mass timber, the tool uses Douglas Fir for columns, girders, and purlins, while Spruce-Pine-Fir is used for CLT panels. It assumes two-span continuous floor panels and notes that large spans (6.5m+) may require special manufacturing. For steel, it utilizes AISC’s database for W and HSS sections. Only unpropped composite decks are considered, and fire resistance is not included in the design. For concrete, span-to-depth ratios, assuming precast concrete when combined with other materials and a monolithic pour for full concrete structures are considered.

The tool provides several functionalities, including the “Bay Design Tool” for determining structural sizes, the “Embodied Carbon Calculator” for estimating carbon footprints, the “Member Calculator” for selecting beams, spans, and loading types, and the “Material Gallery” for exploring material options. Vibration calculations are preliminary and should be investigated on a case-by-case basis.

The DBF tool will be developed further to incorporate sch such features to make it an easy-to-use software for architects, city planners and structural engineers. The next steps will focus on simplified data presentation for accessible, user-friendly interfaces and start with basic sustainability features, adding complexity gradually. The early selection of structural elements and various materials to optimize carbon footprint and performance will be prioritised allowing instand design adjustments to be made dynamically as well as override input data that calculation embodied carbon energy. The impact of decisions on sustainability will be clearly presented, allowing later addition of detailed engineering aspects. Integration with secondary platforms for deeper exploration and recognition of feasibility limits of sustainable options are planned. Ultimately, the goal outcome of this work is to democratize awareness, knowledge and expertise around sustainable timber building design and make a sustainable design part of the early-stage decision making.

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