

Potentials of Circular Construction for the Bauakademie Berlin

Potenziale des kreislaufgerechten Bauens für die Berliner Bauakademie

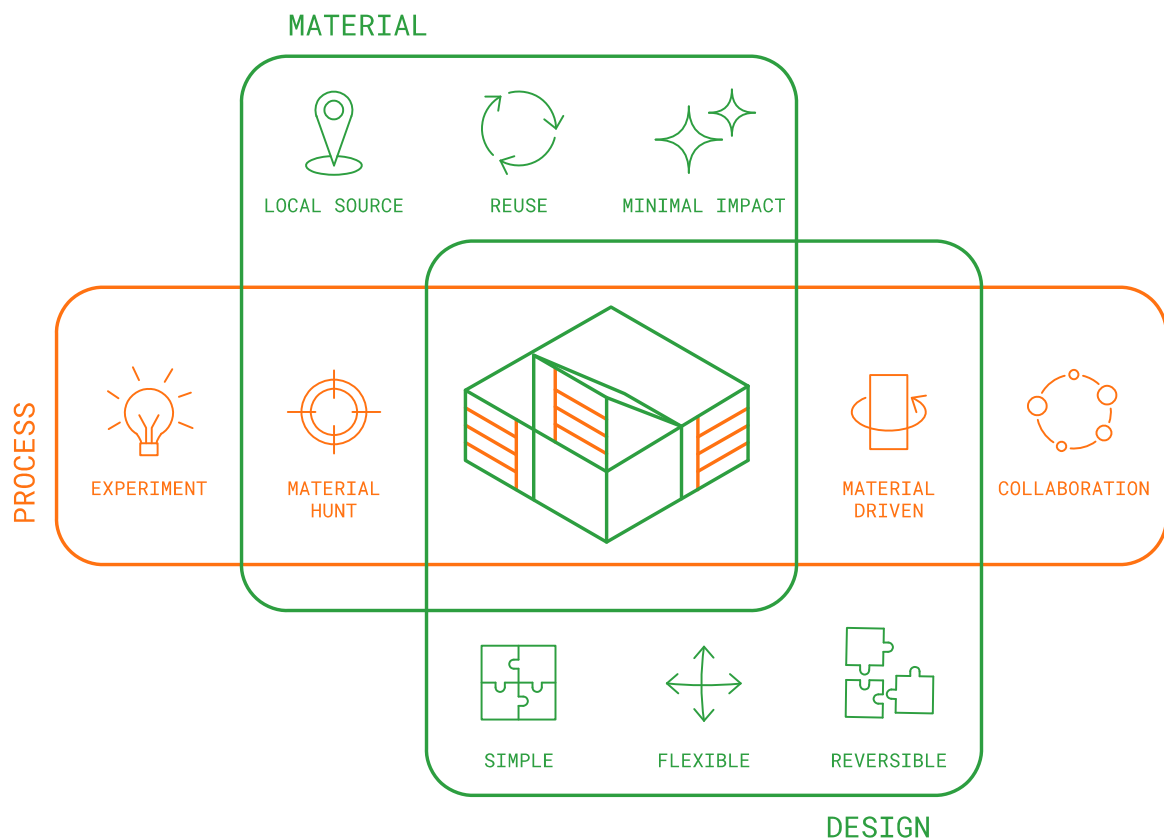




Figure 1: Collaborative team environment during construction, Ferme du Rail. Photo: Jeromine Derigny.

Executive Summary

English

This study presents insights about the state of the art of Circular Construction both on a theoretical and practical level to provide a development perspective for the reconstruction of the Bauakademie Building. The central conclusion is that this project could significantly contribute to transforming the construction sector towards more resource-consciousness. We argue that being a prestigious public building of international rank with representative functions for construction, a building process that is driven by circular practices could set an industry-wide example and advance the ecological, economic, and especially regulatory remits of regenerative buildings. The questions we addressed are: What are the implications of cycle-oriented thinking in construction and how can this be made useful for the Bauakademie Building in Berlin? This study shows that from a lifecycle perspective, Circular Construction has significant ecological and economic benefits. However, the legal perspective is currently rather geared towards the one-off use of a product. According to different authors, manifold learning processes, leadership by governments as well as extraordinary examples are necessary to harmonise arbitrary regulatory guidelines for contributing to a low-carbon building sector. Therefore, our recommendation is that in the light of the energy crisis and climate change, the much-discussed reconstruction of the Bauakademie Building should be characterised by a holistic approach connecting the single parts of supply chains from sourcing building materials to reusing them after their first end-of-life – something the literature review identified as missing. Finally, we present 22 Circular Construction practices from empirical case studies across Europe that might be a starting point for this process and serve as a useful toolbox for planning and design.

Deutsch

Diese Studie stellt den aktuellen Forschungsstand zu kreislaufgerechten Bauen sowohl auf theoretischer als auch auf praktischer Ebene vor, um eine Perspektive für die Wiedererrichtung des Gebäudes der Bundesstiftung Bauakademie zu entwickeln. Die zentrale Schlussfolgerung ist, dass dieses Projekt wesentlich dazu beitragen könnte, den Bausektor ressourcenbewusster zu gestalten. Als prestigeträchtiges öffentliches Gebäude von internationalem Rang hat der Wiedererrichtungsprozess repräsentative Funktionen für das Bauwesen. Daher könnte ein Bauprozess, der von zirkulären Praktiken geprägt ist, ein branchenweites Beispiel setzen und die ökologischen, ökonomischen und vor allem regulatorischen Aspekte regenerativer Gebäude weiterentwickeln. Die Fragen dieser Studie sind: Was sind die Implikationen eines kreislaufgerechten Ansatzes im Bauwesen und wie kann dies für das Bauakademie Gebäude in Berlin nutzbar gemacht werden? Das Ergebnis zeigt, dass kreislaufgerechtes Bauen, aus der Lebenszyklusperspektive betrachtet, erhebliche ökologische und ökonomische Vorteile bietet. Allerdings ist die rechtliche Perspektive derzeit auf die einmalige Nutzung von (Bau-)Produkten ausgerichtet. Nach Ansicht unterschiedlicher Autoren sind vielfältige Lernprozesse, Interventionen durch Regierungen sowie Beispiele mit Vorreiterrolle notwendig, um die komplexen regulatorische Richtlinien zu harmonisieren und diese auf einen kohlenstoffarmen Bausektor abzielen zu lassen. Unsere Empfehlung lautet daher, dass die viel diskutierte Wiedererrichtung des Bauakademie Gebäudes angesichts der Energiekrise und des Klimawandels durch einen ganzheitlichen Ansatz gekennzeichnet sein sollte. Was bei der Literaturrecherche als fehlend identifiziert wurde, sollte hier exemplarisch statuiert werden: einzelne Teile der Bauprozesse – von der Beschaffung der Materialien bis zu ihrer Wiederverwendung nach dem ersten Lebenszyklus – sollten integriert werden. Abschließend stellen wir 22 Praktiken für kreislaufgerechtes Bauen aus empirischen Fallstudien in ganz Europa vor, die einen Ausgangspunkt dafür darstellen können und als nützliche Toolbox für Planungs- und Entwurfsentscheidungen dienen.



Figure 2: Modular construction detail, EDGE Südkreuz. Photo: Ilya Ivanov.

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1. Introduction: Key Dimensions of Circular Construction

The construction, use, and demolition of buildings play a critical role in the context of **our responsibility towards the changing climate**. Conventional buildings consume massive amounts of energy, have a very high material intensity, and produce exorbitant levels of emissions during their entire lifecycle. Globally, construction is the single most energy and emission intensive sector responsible for at least 39% of all Greenhouse Gas (GHG) emissions.¹ Besides that, the construction industry creates vast amounts of waste. For example, in Germany, 52% of the total waste produced is caused by construction and demolition², and across the globe about 35% of waste from construction goes to landfill³. Thus, buildings cause **serious ecological externalities that manifest in emissions and waste**. To provide healthy and sustainable livelihoods in the future, approaches for architecture and construction are required that respect the planetary boundaries.

The relevance for the increased sustainability of buildings is underlined by the recent proposal of a New European Bauhaus, an initiative under the umbrella of the European Green Deal that is in pursuit of a paradigm change for living spaces based on beauty, sustainability, and inclusion. The New European Bauhaus defines not only an environmental or economic approach but suggests a cultural project with aesthetic ambitions to transition to alternative models of construction⁴. At the same time, at city or regional levels of governance, initiatives that support lower emissions and less waste in construction are observable. For example, the

adaptation of the building code in Berlin (Germany) to enable the increased use of timber in public buildings⁵ or the planned introduction of wide-spread digital material passports to transform the building stock into a material depot in the Netherlands.⁶

There is widespread agreement among practitioners and scientists that **the construction sector requires fundamental change** regarding its production of emissions and waste. The question is how, when, and with what pace this transition will take place. Contemporary answers reach from *make do*, an approach practised by Pritzker-Prize winners Anne Lacaton and Jean-Phillipe Vassal that suggests to never demolish existing structures but to add, transform, and reuse them; *re-materialising*, keeping products in the cycle through regenerative design proposed by the cradle-to-cradle inventors William McDonough and Michael Braungart; *dematerialisation*, an argument for reducing the amount of physical substance that goes into the built environment – supported, amongst others, by R. Buckminster Fuller; to a *global building moratorium*, initiated by Charlotte Malterre-Barthes and colleagues.⁷

Central to all the above-mentioned concepts is the **continuity of value of a building's materials**, regardless of whether existing or newly built. This is in line with the principal ideas of the Circular Economy (CE). Generally, an economy that operates in a circular way should not have negative effects on the environment; rather, the damage done in resource acquisition should be restored while as little waste as possible is generated.⁸

¹ Abergel, T., Dean, B., & Dulac, J. of. (2017). Towards a zero-emission, efficient, and resilient buildings and construction sector. In Global Status Report 2017.

² Müller, F., Lehmann, C., Kosmol, J., Keler, H., Bolland, T. (2017). Urban Mining. Ressourcenschonung im Anthropoz n. Umweltbundesamt. Bonn.

³ Solís-Guzmán, J., Marrero, M., Montes-Delgado, M. V., & Ramírez-de-Arellano, A. (2009). A Spanish model for quantification and management of construction waste. Waste Management, 29(9), 2542-2548.

⁴ https://europa.eu/new-european-bauhaus/about/about-initiative_en.

⁵ <https://www.parlament-berlin.de/ad0s/18/IIIPlen/vorgang/d18-2225.pdf>.

⁶ <https://paspoorten.platformcb23.nl/>.

⁷ Ruby, I., & Ruby, A. (2020). *The Materials Book*. Ruby Press. Berlin.

⁸ Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. Journal of Business Ethics, 140(3), 369–380. <https://doi.org/10.1007/s10551-015-2693-2>, p. 371.

CE enables thinking in cycles and aims at keeping the valuation of materials in **closed loops** instead of having an open-ended conception of value chains. When designing products, this makes it necessary to include the notions of input reduction, reuse, and recycling.⁹ In other words, virgin material or energy inputs to the system and waste as well as emission outputs from the system should be reduced.¹⁰ However, the CE discussion is highly fragmented regarding definition, objectives, and forms of implementation but there is an opportunity to use it as a tool for transformative change because it has become widely adopted in academic and non-academic sectors.¹¹ Yet, to make CE applicable for practitioners in construction, it

requires a **translation to the architectural vocabulary**.

The CE is primarily focused on products and their lifecycles. A building is a very specific ‘product’ since it provides services, is usually made from a complex set of materials, and includes layers with different lifecycles. The concept of Circular Construction is trying to link the CE with construction by **emphasizing recycled and renewable materials and by using design methods to make components reusable after a building’s end-of-life**¹². This changes the practices and dynamics of traditional building processes and requires innovation and openness for new methods (See Fig. 1).

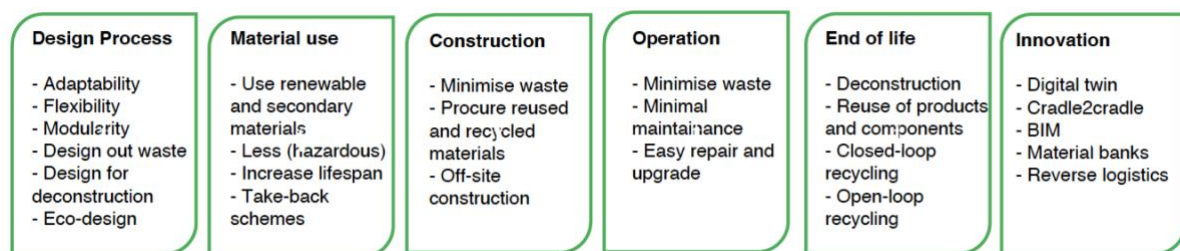


Figure 1. Key dimensions of a building’s life cycle in Circular Construction, adapted from Adams et al.¹³

The original building of the Bauakademie, designed by Karl Friedrich Schinkel and erected between 1832 and 1836, was a prime example of **innovation and openness for new methods**. Today, it is seen as one of the early examples of modernist architecture. Thus, the reconstruction of this building as an open learning environment is the opportunity

to again set an example for the entire construction sector. To tackle the challenges of our time, it is necessary to use sustainable materials and adaptive construction techniques. This study seeks to build a perspective for a regenerative reconstruction of the Bauakademie Building in Berlin.

⁹ Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 33(5), 308–320.

Homrich, A. S., Galvão, G., Abadia, L. G., & Carvalho, M. M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, 175, 525–543. <https://doi.org/10.1016/j.jclepro.2017.11.064>, p. 526.

Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews*, 68(October 2015), 825–833. <https://doi.org/10.1016/j.rser.2016.09.123>, p. 825.

¹⁰ Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544–552. <https://doi.org/10.1016/j.jclepro.2017.12.111>, p. 544.

¹¹ Calisto Friant, M., Vermeulen, W. J. V., & Salomone, R. (2020). A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. *Resources, Conservation and Recycling*, 161 (November 2019), 104917. p.15.

¹² Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, 143, 710–718. <https://doi.org/10.1016/j.jclepro.2016.12.055>.

¹³ Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017, February). Circular economy in construction: current awareness, challenges and enablers. In *Proceedings of the Institution of Civil Engineers-Waste and Resource Management* (Vol. 170, No. 1, pp. 15–24).



Figure 3: Wood wall panels with straw insulation, Bombasei. Photo: Unknown.



Figure 4: Cutting brick panels to reuse them as façade element, Resource Rows. Photo: Rasmus Hjortshøj.

2. Definition and Methodology

There is no widely accepted definition of Circular Construction. A very simple and useful one is provided by the architecture collective Material Cultures. In the opening of their new book, they state: **“We work with primarily plant-based materials, developing systems that integrate them into contemporary construction, designed for a post-waste economy where all components can be reused, recycled or composted.”**¹⁴

Angst, Brandi and Stricker focus their definition of Circular Construction on using building fabric in additional lifecycles. Three strategies are key:

Preservation. Further use of buildings and components.

Reuse. Using demounted building components again, no matter if their form is kept or modified, if their function is the same or different, and independent from their potential loss of quality between the original and new use.

Recycling. Transforming building fabric into new materials while losing their original form.¹⁵

A broader definition emphasizing both an anthropogenic dimension and non-material

aspects includes three criteria that are necessary preconditions for establishing circularity at the building scale:

Materials and their use. The use of biobased materials that store carbon on a long-term basis or reusing materials in their highest possible value as well as an emphasis on preserving already existing structures and the reuse of entire buildings through adaptation.

Design techniques and methods. Construction methods allowing for flexibility, disassembly, separability, and deconstruction as well as material-based design techniques, in which the materials define the design.

Systemic enablers. Organisational aspects focusing on keeping materials in the value chain. This includes planning parameters, digital enabling technologies, contracting and business models, and interfaces to stakeholders.¹⁶

To conclude, when defining Circular Construction, there is agreement about the use of bio-based materials and material (components) that are in any form and function preserved, reused, or recycled. At the same time, enabling strategies, methods, and tools are conditional as well as designing for disassembly and deconstruction.

¹⁴ Material Cultures (2022). Material Reform. Building for a Post-Carbon Future. MACK books.

¹⁵ Angst, M. et al. (2021) Vorwort. In: Bauteile wiederverwenden. Ein Kompendium zum zirkulären Bauen. Park Books.

¹⁶ Hubmann, G. & van Maaren, V. (2022). Circular Material Systems. In: IOP Conference Series: Earth and Environmental Science. Vol. 1078.

This study aims to **synthesize the most relevant aspects of Circular Construction** from academic literature and recent reports including ecological, economic, regulatory, and implementation perspectives. These might serve as a guideline and inspiration for the reconstruction of the Bauakademie Building in Berlin. The main question is: What are the implications of cycle-oriented thinking in construction and how can this be made useful for the Bauakademie Building in Berlin?

In the **first chapter**, we introduce the topic by stating its relevance in the contemporary context, mention some central existing approaches, and outline the key dimensions of Circular Construction.

In the **second chapter**, we firstly analyse three definitions of Circular Construction, and secondly explain the methodology of the study including a summary of the content.

The **third chapter** is about the overview of the current scientific literature and the identification of knowledge gaps. Therefore, we carried out a literature review to give a short overview of the existing literature for Circular Construction.

The **fourth chapter** summarises the ecological perspective via an in-depth quantitative case study that is attached to the study as an annex. Then, we review the

economic and regulatory perspectives via the analyses of recent reports.

The **fifth chapter** is based on another in-depth analysis of 25 buildings that are best-practice examples of the Circular Construction paradigm. We filtered the most important circular practices that might be relevant for the reconstruction process of the Bauakademie Building.

The idea behind selecting cases with outstanding performance regarding closed resource loops lies in the potential to get a good understanding how already realised projects incorporated circular thinking in construction processes. The in-depth analysis of the buildings was carried out by student groups and is based on interviews with architects or engineers and the analysis of the building's plans, thus included both quantitative and qualitative approaches. The following aspects were considered: a material inventory of the building, the carbon footprint using a Life Cycle Assessment (LCA), a mapping about the localisation of supply chains behind single materials or components, an analysis of the planning approach as well as describing the necessary processes (stories behind the system) that have contributed to establishing closed resource loops.

The study ends with a summary and conclusion in the **sixth chapter**.

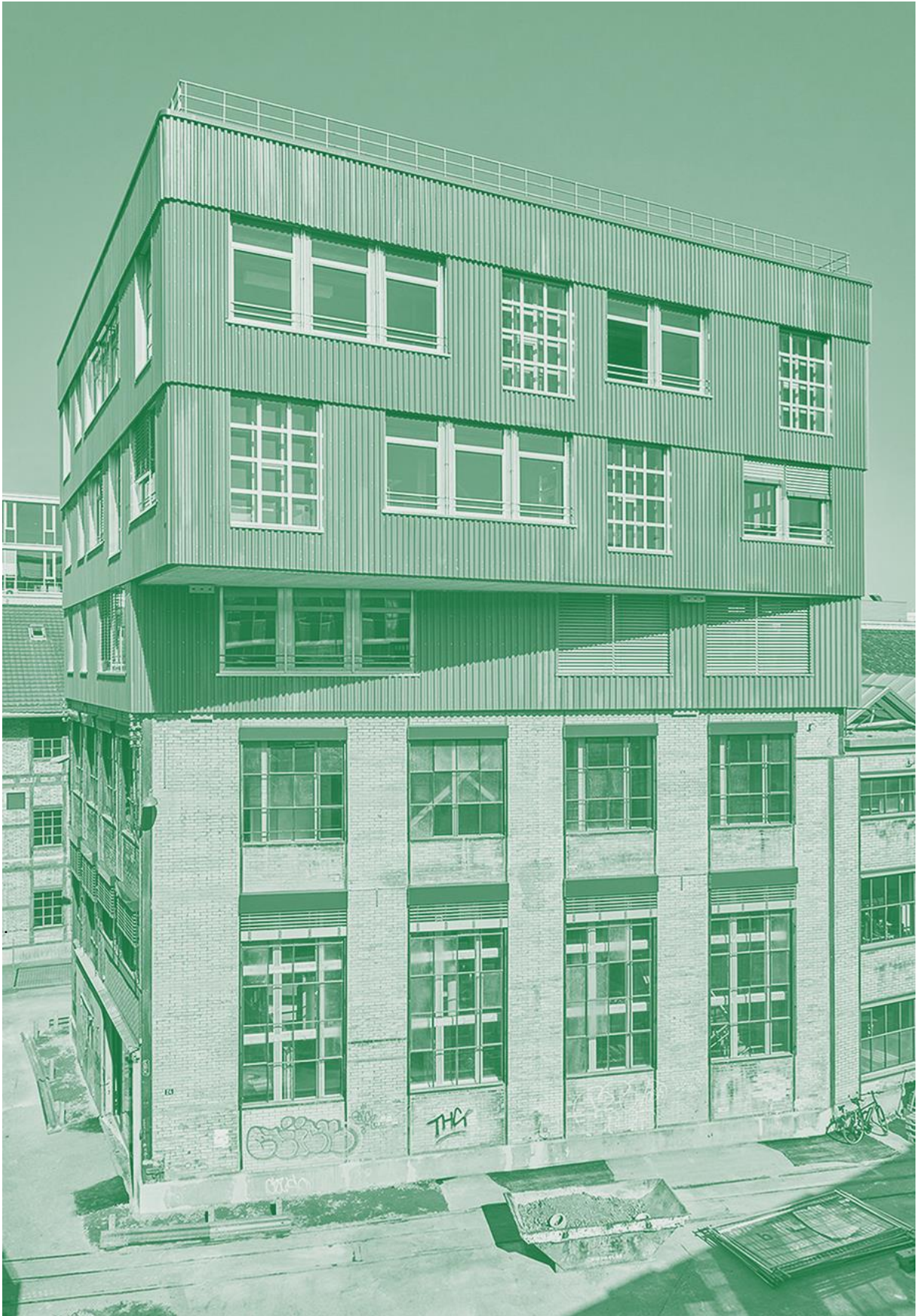


Figure 5: Form follows availability, K118. Photo: Martin Zeller



Figure 6: Flexible interior, Ausbauhaus Südkreuz. Photo: Lindsay Webb.

3. Literature Review and State of Research

The Circular Economy (CE) has started to enter architectural design as a promising concept for resource-conscious construction practices but the research about Circular Construction remains in its infancy¹⁷. There is increasing awareness about **the usefulness of the CE for construction, especially regarding closing the biological cycle**. For example, the use of bio-based materials in construction replacing steel and concrete is seen as a solution to extensively store carbon in buildings and to answer the challenge of urgent climate action¹⁸.

For future construction, it is necessary to not only produce less emissions during the production of building materials but also to **sequester carbon in them** to mitigate climate change¹⁹.

However, the current framing and definition of Circular Construction implies **only certain aspects within the scope of the building sector**, which leads to a rather fragmented application of strategies in practice²⁰. For example, extensive studies have focused on resource use and waste management while neglecting whole life cycle costing and building designs²¹.

Currently, a systems perspective including how new business models might enable materials to retain high residual values is missing²². Another level of analysis that is lacking is the building as an entity per se²³. Yet, there is an urge to find frameworks and methods to **“foreground material stocks and flows in order to further the objectives [...] of truly sustainable construction”**.²⁴

Table 1. Results of the literature review.

Materials and Supply Chains	Design and Construction	Operation and Use	Deconstruction and Repurposing
Amiri et al. (2020)	Eberhardt et al. (2020)	Stephan & Athanassiadis (2018)	Furlan et al. (2020)
Churkina et al. (2020)	Hildebrand et al. (2017)		Ginga et al. (2020)
Nasir et al. (2017)			Lederer et al. (2020)
Zabek et al. (2017)			Osobajo et al. (2020)
Geldermans (2016)			Siew (2019)

¹⁷ Osobajo, O. A., Oke, A., Omotayo, T., & Obi, L. I. (2020). A systematic review of circular economy research in the construction industry. *Smart and Sustainable Built Environment*. <https://doi.org/10.1108/SASBE-04-2020-0034>.

¹⁸ Churkina, G., Organschi, A., Reyer, C. P. O., Ruff, A., Vinke, K., Liu, Z., Reck, B. K., Graedel, T. E., & Schellnhuber, H. J. (2020). Buildings as a global carbon sink. *Nature Sustainability*, 3(4), 269–276. <https://doi.org/10.1038/s41893-019-0462-4>.

¹⁹ Amiri, A., Ottelin, J., Sorvari, J., & Junnila, S. (2020). Cities as carbon sinks - Classification of wooden buildings. *Environmental Research Letters*, 15(9). <https://doi.org/10.1088/1748-9326/aba134>.

²⁰ Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544–552. <https://doi.org/10.1016/j.jclepro.2017.12.111>, p. 544.

²¹ Churkina, G., Organschi, A., Reyer, C. P. O., Ruff, A., Vinke, K., Liu, Z., Reck, B. K., Graedel, T. E., & Schellnhuber, H. J. (2020). Buildings as a global carbon sink. *Nature Sustainability*, 3(4), 269–276. <https://doi.org/10.1038/s41893-019-0462-4>.

²² Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017, February). Circular economy in construction: current awareness, challenges and enablers. In *Proceedings of the Institution of Civil Engineers-Waste and Resource Management* (Vol. 170, No. 1, pp. 15-24).

²³ Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, 143, 710–718. <https://doi.org/10.1016/j.jclepro.2016.12.055>.

²⁴ Angélil & Siress (2020). The Matter of Construction: Systemic Overhaul or Tweaking the Status Quo?. In: *The Materials Book*, Ruby Press, p.12.

Methodologically, we used a Google Scholar search with the key words ‘Circular Construction’ and filtered peer-reviewed articles published in scientific journals. Our interest was to take into consideration a holistic idea of the construction process that includes all lifecycle stages of a building’s materials. Therefore, we defined the following four categories that cover the processes from sourcing a material to reusing it. The categories under which we categorised the papers are: ‘Materials & Supply Chains’, ‘Design and Construction’, ‘Operation and Use’, and ‘Deconstruction and Repurposing’. Altogether, we identified 21 relevant papers that are related to or include a definition or a conceptual framework for Circular Construction. In a next step, we dismissed 8 papers because of a lack of applicability or a misleading focus, and eventually included 13 papers to create a classification (See Table 1).

The analysis of the most relevant literature in the field of Circular Construction confirms a high fragmentation. We found that the concept of Circular Construction is currently limited to the type of materials used and to the recycling of waste after the end-of-life of a building – the two opposite poles of a building’s lifecycle. Thus, in the existing literature we identified a **misbalanced interest on the direct in- and outputs of material value chains**.

Out of the 13 papers analysed, 5 had a strong emphasis on the use of materials and 5 on the recycling of construction and demolition waste. Surprisingly, **the roles of designers, architects, engineers, and builders** who potentially have significant responsibilities regarding the choice of construction materials and their recycling as well as aspects of operation and use of a building **are only marginally represented** in the literature.

Another result is a **lack of systemic perspective across the different stages of a building’s lifecycle**. This suggests that the links between different stages (e.g., links between material choice, design of the building, and options for reuse after the end-of-life of a building) are not sufficiently addressed.

To conclude, the identified gap is a **lack of whole system thinking across the entire lifecycle of a building as well as a missing focus on the integration of design and construction processes**.

Taking into consideration the lack of systemic perspective, the remainder of this study is targeted at potentials of Circular Construction for the Bauakademie Building as well as on the question of how to implement holistic thinking into construction processes.



Figure 7: Flexible floor plans and healthy interior design, Venlo City Hall. Photo: Ronald Tilleman.



Figure 8: Reuse of a metal staircase by Rotor architects, Zinneke. Photo: Delphine Mathy.

4. Ecological, economic, and regulatory Perspectives of Circular Construction

4.1. Ecological Perspective

A building's carbon footprint is directly linked to its construction, lifespan, and material recycling and reuse qualities. The *Carbon Atlas*, a study provided in the annex, gives an overview of the **greenhouse potential of 58 commonly used building components**, including renewable and non-renewable materials. The aim of this quantitative study was to compare materials and components from a lifecycle perspective and to provide a tangible decision-making base for practitioners based on the **ecological perspective of Circular Construction**. Therefore, elements with different lifespans were analysed in the categories structure, envelope, space, and fittings. The assessment criteria include the effectiveness of a component by identifying its functions, methods of assembly, and four different types of recyclability including renewable material content, material recycling content, material-loop-potential, and material end of life.

The results show that **the use of bio-based materials leads to a low or negative carbon footprint and high recycling and reuse potential**. For most of the functions analysed, **renewable materials can act as low-carbon alternatives**, e.g., for thermal insulation, fire, or weather protection. It also shows that **mechanically joined components have a high level of reversibility, increasing their chance of being reused**, while chemically bonded components are often complex and non-recyclable.

To summarise, it might not come as a surprise, but the *Carbon Atlas* confirms it with a great level of detail: from an ecological point of view, **using bio-based materials in the built environment in combination with simple building systems that refrain from unnecessary technification is ideal for a post-waste and low-emission construction economy**.

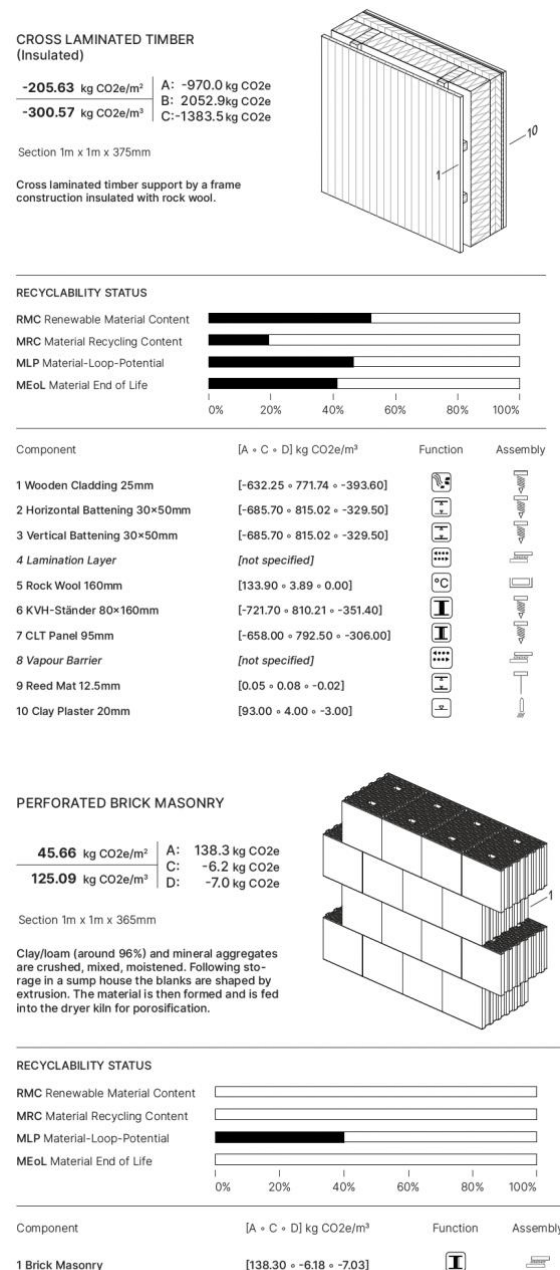


Figure 9: Lifecycle perspectives of a typical wall element and brick masonry. Krauss & Jerosch-Herold (2022).

4.2. Economic Perspective

We could only find one study that explicitly outlines the **economic perspective of Circular Construction**. Accordingly, significant economic savings are possible when using circular practices of construction (See Fig. 9.) But this only holds true when buildings are evaluated with a life-cycle perspective that also takes into consideration the maintenance of the building and its deconstruction at the end-of life. The initial costs of circular buildings are indeed higher but by using high-value materials and adaptive construction techniques, **the costs for maintenance are lower compared to conventional buildings**. Furthermore, since building components can ideally be reused or maybe even sold at the end of a building's lifecycle, **the costs for deconstruction are significantly lower**. Thus, for example, circular office buildings are possibly almost one third more cost-effective.²⁵

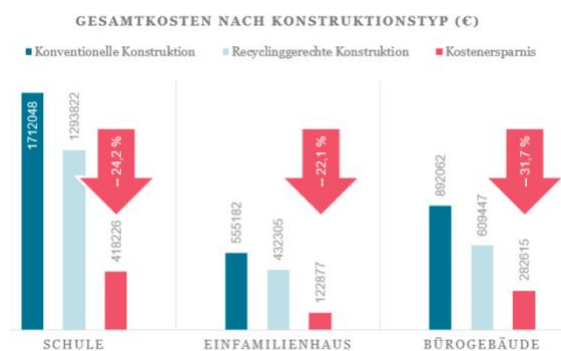


Figure 10: Cost-savings per type of building, © WWF Deutschland, 2022.

Other articles point to product service systems (PSS), where manufacturing companies only rent products for buildings

(e.g., elevators, roof tiles) with the objective of reducing resource consumption while remaining profitable. However, due to their operationalisation challenges such models have been the exception as of now.²⁶

To summarise: from an economic point of view, Circular Construction starts to be attractive **when pricing in the entire lifecycle costs**. Circular business models, for example the leasing of components, are still in an early phase of development.

4.3. Regulatory Perspective

The **regulatory perspective of Circular Construction** is a complex topic because multiple levels of governance as well as different types of laws (e.g., building codes, product law, public procurement law, tax law, circular economy law) apply for the building sector while there are many different stakeholders involved.

Generally, the legal system altogether and many current regulations are rather geared towards the one-off use of a product or at least favour this.²⁷ However, at European and national level, there are regulatory regimes in place that enhance a circular economy in construction. The most important ones are the European Climate Law, EU Construction Products Regulation, Eco-Design Guideline, Waste Guideline, European Green Deal, Circular Economy Action Plan (EU level), Bundesklimaschutzgesetz, Kreislaufwirtschaftsgesetz, Baugesetzbuch, Bauordnungen (national and sub-national level).²⁸

²⁵ Küstner, Tauer, Breer (2022). [Zirkuläre Maßnahmen im Bestand und Neubau zum Schutz von Klima- und Ökosystemen ergreifen. WWF Deutschland.](#)

²⁶ Dräger, P., & Letmathe, P. (2023). Who Drives Circularity? The Role of Construction Company Employees in Achieving High Circular Economy Efficiency. *Sustainability*, 15(9), 7110.

²⁷ Halstenberg & Franßen (2022). Regelwerke des Normungs- und technischen Zulassungswesens anhand des Themenkomplexes Recyclingverfahren und Weiter-/Wiederverwendung von Bauprodukten und Baustoffen.

²⁸ Braun, Fecke, Sebis (2022). [Die Etablierung eines geeigneten Rahmens für zirkuläre Ansätze im Bausektor. GWD-Positionspapier.](#)

From a legal perspective, it is necessary to address the **standardisation of Circular Construction projects and the increased use of regenerative construction materials**. Key challenges are the warranty question in case of reusing building components, the installation of a circular material trading scheme, the prolongation of life cycles, and incentives for renovation.

Also problematic is that inadequate regulations in waste legislation mean that manufacturers cannot obtain clean construction or demolition waste at all or only with great difficulty, technical standards have been proven to block the use of recycled materials, there are hardly any digital information on buildings, which makes necessary measures for high-quality material reuse extremely difficult, procurement criteria can be easily circumvented as there is no obligation to justify non-compliance, and primary materials are currently usually cheaper than secondary materials, as the environmental impact costs are not priced in.²⁹

Many of these challenges can only be addressed through political leadership and top-down regulatory measures. Three necessary actions include: 1) The promotion of the **recovery of recyclable materials** from demolition and a revision of waste legislation.

2) **Minimum requirements for manufacturers** and adaptation of technical standards. 3) **Resource-conserving and cycle-friendly requirements** for refurbishment and new construction, especially in the public sector.³⁰

For example, solutions that need to be integrated into existing laws include: **an extended producer responsibility** for building components to facilitate the reuse of components because these need to meet the same standards as new products; **a high-value recycling should be prioritised while downcycling should be avoided**; the building codes of local governments, which in some cases work against other laws at the moment, should accept secondary materials as construction materials. Another important challenge stressed by various authors is to establish **a basis of data**, upon which regulatory measures could be finetuned. The key message is that **all these measures are feasible on the short- or medium-term**.³¹

To summarise: **there are very good arguments to make use of Circular Construction practices from both ecological and economic perspectives**. The legal perspective requires a **standardisation of Circular Construction projects**, in which the Bauakademie Building could play a significant role.



Figure 11: Fully wooden connections allow for disassembly, Collegium Academicum. Photo: Thilo Ross.

²⁹ Miruchna, Viktor (2022). DUH Fachgespräch am 18.11.2022: Mehr Recycling von Baustoffen ermöglichen. Notwendige Maßnahmen zur Verbesserung der Kreislaufwirtschaft am Bau.

³⁰ ibd.

³¹ IKEM (2022): *Rechtliche Prüfung von Maßnahmen im Bereich Gebäude und Kreislaufwirtschaft*. Juristische Kurzstudie im Auftrag des WWF Deutschland.



Figure 12: Bio-based interior finishes, Haus Rauch. Photo: Martin Rauch

5. Implementation: Circular Practices In Construction

The following section is part of an ongoing research project entitled ‘[Circular Material Systems](#)’ that started in 2021. The aim of the project is to empirically analyse 25 buildings that successfully implemented principles of circularity. The following 22 practices and their descriptions are particularly relevant for the reconstruction process of the Bauakademie Building.

Table 2. List of analysed buildings

#	Name of the building	Location	Completed
1	Ausbauhaus Südkreuz	Berlin	2022
2	Blue City	Rotterdam	2017
3	Bombasei	Nanikon	2020
4	CIRCL Pavilion	Amsterdam	2017
5	Collegium Academicum	Heidelberg	2022
6	CRCLR Haus	Berlin	2022
7	EDGE Südkreuz	Berlin	2022
8	Ferme du Rail	Paris	2019
9	Feuerwehrhaus Straubenhardt	Straubenhardt	2022
10	Green House	Utrecht	2018
11	Haus Rauch	Schlins	2008
12	K118	Winterthur	2021
13	Mjostarnet	Brumunddal	2019
14	OBK 27	Paris	2017
15	Plattenpalast	Berlin	2019
16	R128	Stuttgart	2000
17	Recycling Haus	Hannover	2019
18	Resilience	Stains	2020
19	Resource Rows	Copenhagen	2019
20	Sara Kulturhaus	Skelleftea	2021
21	Strohuis	Braunschweig	2016
22	TECLA	Massa Lombarda	2021
23	Venlo City Hall	Venlo	2017
24	Villa Welpeloo	Enschede	2010
25	Zinneke	Brussels	2021

#1: Dynamic Design and Planning.

Reusing materials comes with uncertainties including their availability, quality, and suitability. This forces architects to adopt a flexible and solution-oriented design process based on available materials rather than on exact plans. Working with non-conventional materials makes it necessary to anticipate the construction process, develop creative alternatives to reinforce the quality of a project, and leave room for serendipity.

Example applications in existing buildings: 2,4,6,8,10,12,15,17,24,25

#2: Harvesting Materials. The process of looking for recyclable or reusable building components and cataloguing them for a new use typically includes different types of waste streams such as demolition sites, production waste or dead stock. Wherever possible, the components are sourced locally to ensure a low ecological footprint for transportation. Material Harvesting has the potential to create new jobs and businesses.

Example applications in existing buildings: 2,4,5,6,9,10,12,15,17,19,24,25

#3: Material-Based Design. This strategy is about selecting and using materials in a thoughtful and intentional way to achieve specific goals. In reuse projects, form follows availability, e.g., available building components in their 2nd or 3rd life are integrated into the design by taking into consideration their specific properties and measurements. For example, the shape of a building is defined by the available secondary materials.

Example applications in existing buildings: 2,10,12,15,17,18,19,21,24,25

#4: Low Tech Design. The premise of this practice is to create simple designs and avoid unnecessary technification. For example, only three-layered walls make the assembly efficient while contributing to a high potential of recycling at the end of its life. The reduction of layers and materials also makes maintenance easier.

Example applications in existing buildings: 3,5,9,10,15,17

#5: Design for Modularity. Particularly when constructing with timber, modular design approaches are applied. Modules are usually prefabricated and standardised, which saves time during the production process and the assembly of the building. Mostly, dry connections are used for joining parts that allow for modifications over time.

Example applications in existing buildings: 1,3,5,7,8,10,13,16,18,20

#6: Design for Longevity. Building techniques for longevity are characterised by massive envelopes out of wood or stone. One more option is a structure made from reinforced concrete with easily adaptable inner layers. Other examples that go into the opposite direction are flexible systems that can be dismantled and re-built again and again for different needs in different locations.

Example applications in existing buildings: 1,3,5,10,13,14,20

#7: Design for Disassembly. This is one of the most used practices. It requires a construction system that makes it possible to deconstruct the entire building again. After the building's first end-of-life, components and materials can be ideally reused or recycled. Prefabrication and a modular

approach are connected to this as well as a digital material bank that documents the components and their properties.

Example applications in existing buildings: 1,4,5,6,7,8,9,10,12,13,14,15,16,18,20,23

#8: Creating Flexible Layouts. Designing buildings in a way that their floor plans and inner layers are adaptable for different future uses contributes to the preservation of resources. For example, this can be achieved through flexible partition walls, a sequence of equal spaces at each floor that allows for various configurations or using a solid structure with interchangeable materials on the inner layers of the building.

Example applications in existing buildings: 1,5,6,10

#9: Knowing your Supply Chains. The sourcing of raw materials can create significant environmental damage. A circular building strategy should also focus on the effects of supply chains. For example, a sustainable forest management is a prerequisite when building with wood. Additionally, new innovative processes or the avoidance of waste becomes possible.

Example applications in existing buildings: 3,5,17,21,25

#10: Transport and Storage. For secondary materials to be reused, significant logistical processes are required. In some cases, a storage space to collect, sort, and if necessary, process materials and components is a condition for success. In other cases, the just-in-time transportation of bulky components to dense inner-city districts is challenging and requires exact planning.

Example applications in existing buildings:
2,6,7,10,12,15,17,25

#11: Preventing Emissions and Waste. When realising a building, as many emissions and waste as possible should be prevented. Green steel or recycled concrete are examples for modified traditional formulas, which reduce emissions during the production of components. Waste avoidance strategies address the construction process on site with the goal to not produce waste at all.

Example applications in existing buildings:
1,3,5,6,10,13,17,22,23

#12: Using Local Materials. The use of locally available materials keeps emissions for transportation low, activates the local ecosystem of knowledge, and strengthens the local economy. Supply chains are usually established and there is accordance regarding the local building code. Additionally, the proximity of construction site and available materials has logistical advantages.

Example applications in existing buildings:
5,7,8,9,10,11,12,13,15,17,18,19,20,21,22,24

#13: Using Bio-based and Renewable Materials. The central advantage of using plant-based materials in construction is their long-term storage of biogenic carbon. Additionally, in combination with simple and reversible construction systems, they have a high recycling and reuse potential after the first end-of-life of a building. Especially the use of wood for high-rise structures in a modular construction system is a powerful combination that not only addresses carbon storage qualities, but also the creation of large quantities of housing.

Example applications in existing buildings:
1,3,4,5,6,7,8,10,11,12,13,17,18,20,21,22

#14: Using Reused and Recycled Materials. Giving existing materials or components a new life is a key strategy of Circular Construction. Ideally, the original building fabric is preserved, or components are reused for the same purpose as in their original use but also the use in different functions and forms is common as well as the recycling of materials. This approach requires a flexible design process, and, in many cases, form follows availability.

Example applications in existing buildings:
1,4,5,6,8,10,12,15,17,18,19,20,24,25

#15: Using Materials of Endless Value and Reuse. Building with solid stone is an economic investment that promises durability and reusability. Stones have a very long lifecycle with a high level of integrity that makes it a material of endless value and endless reuse. Selecting building materials holistically by focusing on their specific material qualities, role in the building system, and long-term value enables circularity at different scales: material, maintenance, and reuse.

Example applications in existing buildings:
1,14,22

#16: Using Residual Waste Flows. Identifying and making use of large residual waste flows for construction is beneficial for keeping materials in the value chain. For example, straw or rice husk are agricultural waste products that have good qualities of insulation and thermal inertia. Another curious example are old jeans that can be recycled into fibres, which then can be utilised as insulation or for acoustic wall panels.

Example applications in existing buildings:
3,4,17,19,21,22

#17: Integrating Local Craftsmanship.

The combination of local materials and local skills is essential for many projects. Integrating local networks of companies and suppliers in projects creates regional socioeconomic effects, supports the local economy, and helps collaboratively to build new skillsets.

Example applications in existing buildings:
11,12,13,17,20,21

#18: Digitalising the Material Stock.

Material databases or passports are created to record and evaluate building materials. This predominantly applies for new buildings. The resulting inventory is not only useful during the design and construction phase, but especially in the post-use phase of a building, which requires a long-term data management. This might facilitate the reuse and recycling of existing building fabric. At the same time, a dynamic system of reuse might evolve by connecting material inventories of many buildings, which can be the start of using the city as material bank.

Example applications in existing buildings:
1,6,7,9,25

#19: Open-Source Architecture.

Deliberately giving access to processes, construction details, and insights into the planning of a project in the form of publications or online handbooks allows for the transfer of knowledge and ideas. This possibly contributes to a wider use of circular and regenerative approaches in architecture.

Example applications in existing buildings:
4,5,10,12

#20: Gaining Knowledge. New techniques or radical approaches that are documented in accompanying research result in a knowledge gain for the entire Circular Construction community. At a regional scale, there is a bidirectional learning process between locally practiced construction techniques and innovative circular projects that ideally lead to an improved value proposition.

Example applications in existing buildings:
4,5,10,11,12,13,15,16,20,23,25

#21: Collaborating with all Stakeholders.

Rigorous and integrated planning methods such as LEAN allow to manage projects in a collective way. All the actors of the project regularly participate in meetings to explain in detail their work to each other. Through a built-in time buffer, each involved actor does not only fulfil the own expectations, but also the ones from everyone else.

Example applications in existing buildings:
5,8,16,20,25

#22: Making Maintenance Simple. The Circular Construction paradigm ideally results in low and simple maintenance of buildings over time. A holistic plan, low-tech construction techniques, and adaptable strategies in combination with flexible bio-based or reused materials should make it possible that buildings can be easily repaired and renovated. This might also lead to a prolonged use of materials.

Example applications in existing buildings:
1,5,11,14,16



Figure 13: IKEA-like assembly of a highrise building, Mjøstarnet. Photo: Jens Haugen.

6. Summary and Conclusion

The current construction practices are far away from being sustainable. Buildings are responsible for the single largest share of global Greenhouse Gas emissions and produce enormous amounts of waste. Therefore, strategies to reduce the environmental impact of the construction industry are urgently needed. Unlike in other sectors, the global COVID-19 pandemic did not at all induce change. The questions addressed in this study were: What are the implications of holistic thinking in construction and how can this be made useful for the Bauakademie Building in Berlin? Firstly, we introduced the topic and presented three recent definitions of Circular Construction to outline conceptual consistencies. We then presented an overview of the literature and discussed the ecological, economic, and regulatory perspectives of this new paradigm. Finally, we selected 22 relevant circular practices, which are derived from our own empirical study of circular buildings across Europe to inform the reconstruction process of the Bauakademie Building. These might serve as a toolbox for planning and design decisions.

Circular Construction is a promising new paradigm in architecture that is characterised by using regenerative materials and collaborative design strategies that allow adaptability and disassembly. Its overall aim is the reduction of environmental impact. This is in radical contrast to modernist architecture that is focused on concrete, steel, and glass without considering the end-of-life perspective of buildings. Research about Circular Construction is in its infancy but there is a growing number of examples to learn from. This study summarised the current knowledge and discussions of this paradigm by outlining the state of research, identifying barriers, and providing an implementation perspective for the Bauakademie Building in Berlin.

We argue that the reconstruction of the historic Bauakademie Building could be an important steppingstone and a lighthouse example for the German construction industry to transform towards more resource-conscious modes of operation. With reference to Schinkel's openness for innovation in the original building and considering the planned programme of the future building, Bauakademie Building has the potential to set new standards for sustainability in construction. There are very good arguments to make use of Circular Construction practices from both ecological and economic perspectives. The legal perspective – identified as a barrier – requires a standardisation of Circular Construction projects, in which the Bauakademie Building could play a significant role. The use of circular practices during the planning, design, and construction processes as well as in the use-phase could substantiate necessary debates about regulatory questions of regenerative buildings. The results also suggest that a radical shift is needed in the way we think, design, and use our built environment.

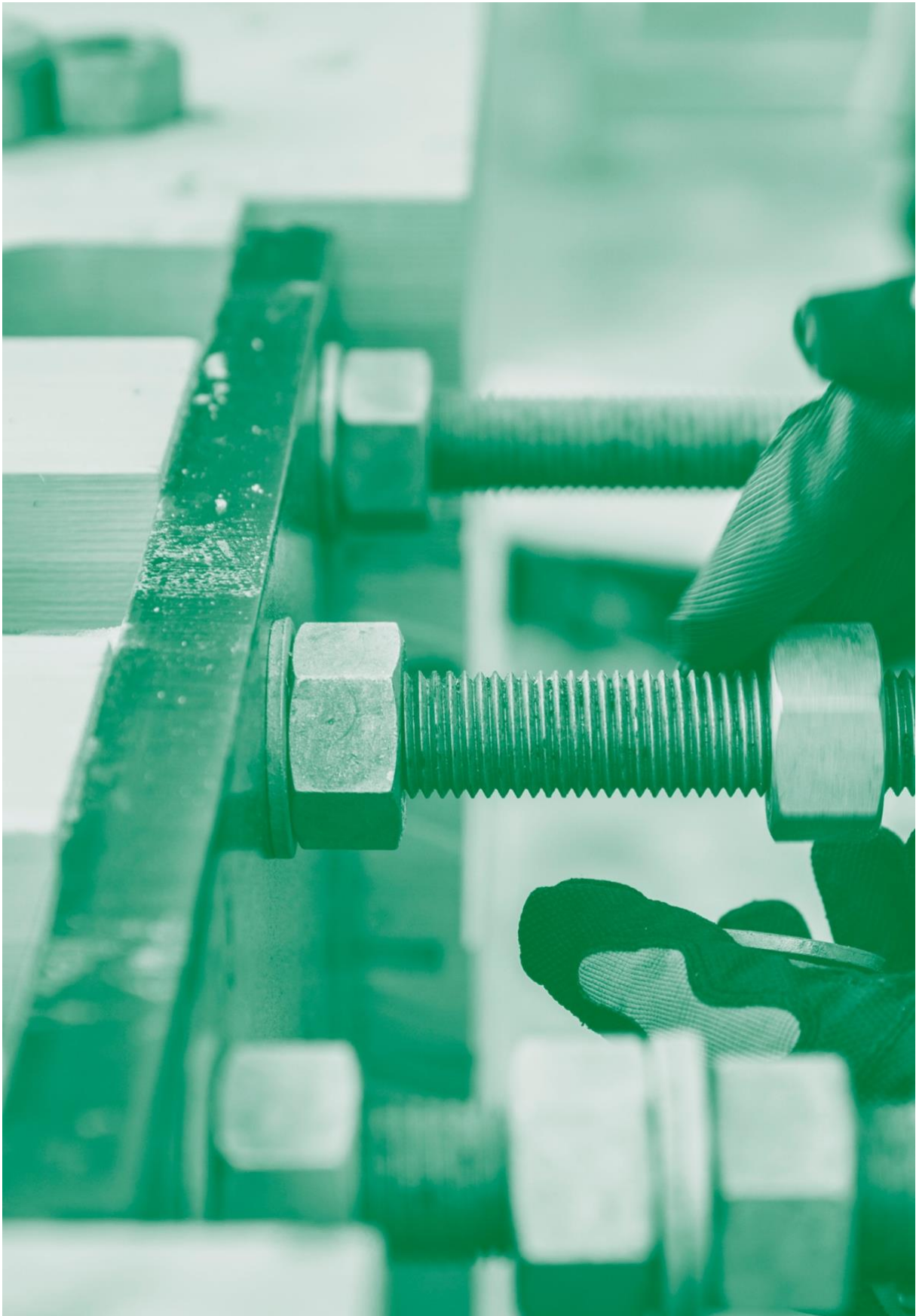
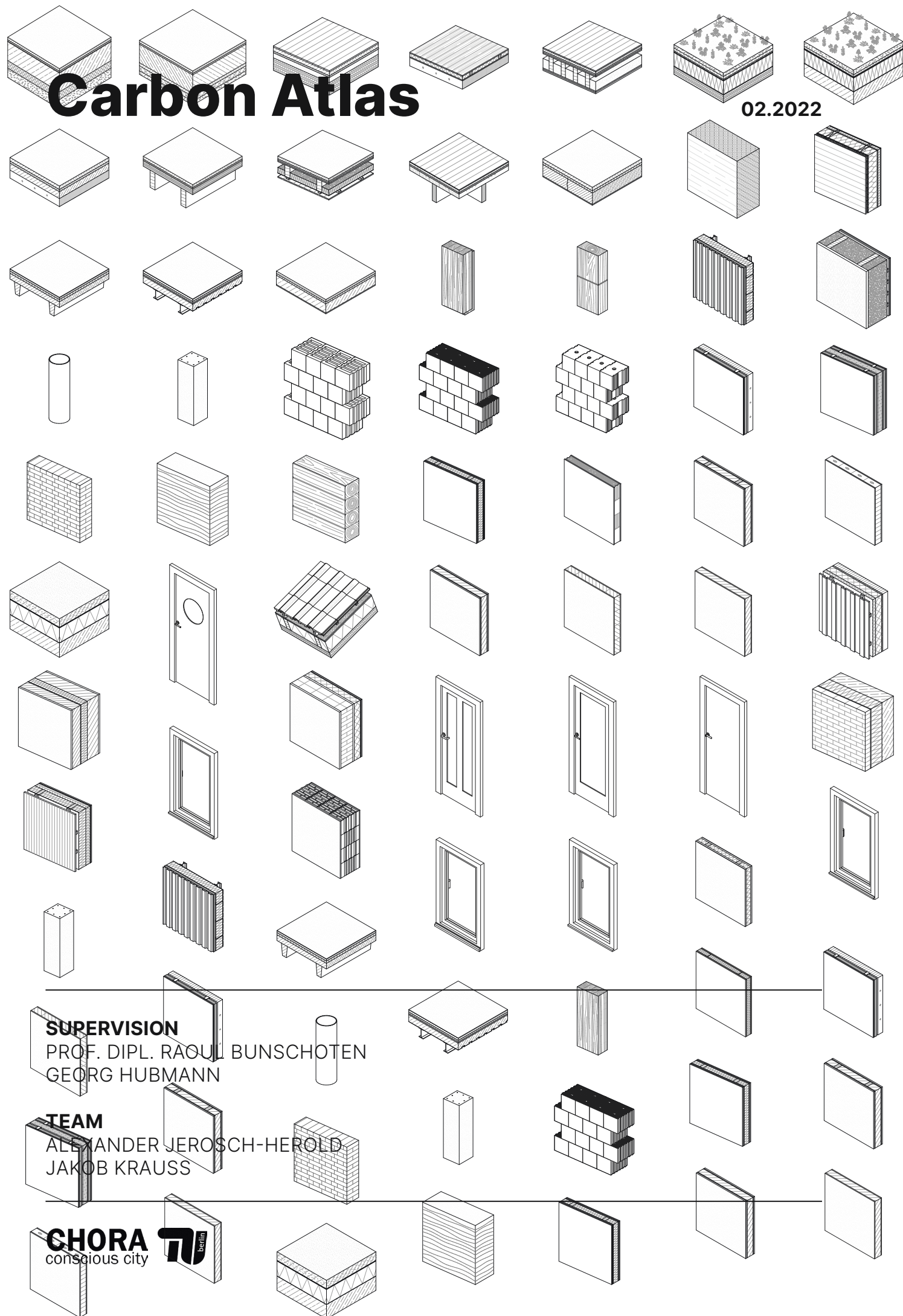


Figure 14: Bolted connection in a wooden highrise building, Sara Kulturhus. Photo: Jonas Westling.

Annex

Krauss, J. & Jerosch-Herold, A (2022). Carbon Atlas. TU Berlin. 1-79.



Carbon Atlas

02.2022

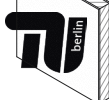
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1. CARBON ATLAS

Alexander Jerosch-Herold
Jakob Krauss

Life Cycle Analysis	4
Calculation Method	5
Element Categories	6

2. COMPONENT CATALOGUE

Layout and Legends	10
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Structure	15
Column	
Wall	
Floor Plate	

Envelope	40
Exterior Wall	
Roof	

Space	56
Interior Wall	
Acoustic Ceiling	

Fittings	70
Door	
Window	
Sanitary Installation	

Glossary	82
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LIFE-CYCLE-ANALYSIS

As the effects of global climate change intensify, research into more comprehensive methods of measuring global warming the impact of buildings on the environment are being developed. Despite a diverse catalog of environmental certifications that have been created over the past decades, few have seen widespread use within the construction industry. The perceived complexities of the subject have led to a slow integration of carbon-neutral building design into the construction sector. As a result, documented examples of these design tools, such as life-cycle analysis (LCA), have seen little application in analyzing a building's carbon impact. An LCA analysis includes the balance of carbon dioxide emissions or grey energy contained within the components of a building due to its production, construction, and eventual deconstruction. This carbon balance can be measured at 17 different points (DIN EN 15978) within a component or building's life cycle (fig. 1.1). As these points are aggregated over a time span, the LCA provides an optimal way to plan a building's potential impact. It thus serves as an indelible tool in unbiased comparison of different building designs.

Production	A1: Raw Material Supply A2: Transport A3: Manufacturing A4: Transport A5: Construction Process
Use	B1: Use B2: Maintenance B3: Repair B4: Refurbishment B5: Replacement B6: Operational Energy Use B7: Operational Water Use
End of Life	C1: De-construction C2: Transport C3: Waste Processing C4: Disposal
Benefits	D: Reuse Potential D: Recovery Potential D: Recycling Potential

1.1 Life Cycle Stages

CALCULATION METHOD

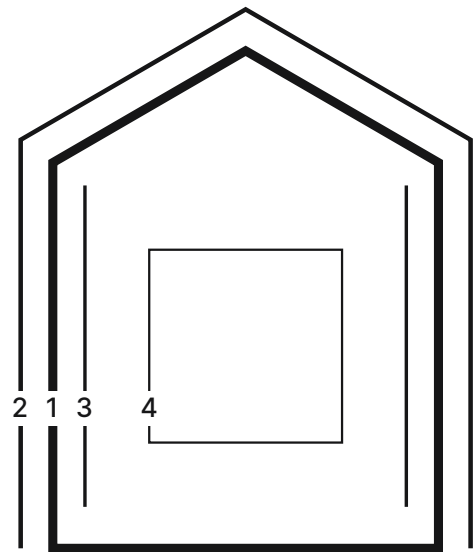
The Carbon Atlas provides an overview of the greenhouse potential of renewable and non-renewable building materials. The decisive characteristic values are declared employing the life cycle phases A (production), C (deconstruction), and D (potential credit). In the case of negative characteristic values, the material binds more carbon dioxide during production than it releases during the manufacturing process. The life cycle assessment database ÖKOBAUDAT of the Ministerium des Innern und für Heimat, Germany (BMI) serves as the data basis.

-34.15 kg CO2e/m ⁽²⁾	CO ² balance cradle-to-life (A-C) plus potential credit (D) in kg CO2e/m ⁽²⁾ of a specific building component
	Section 0m x 0m x 0mm
A: -639.5 C: 749.5 D: -394.7	CO ² balance separately for phases A, C, D in kg CO2e/m ³ summed up for all layers of a building component
-284.70 kg CO2e/m ³	CO ² balance cradle-to-life (A-C) plus potential credit (D) in kg CO2e/m ³ of a building component

1.2 Exemplary Calculation

ELEMENT CATEGORIES

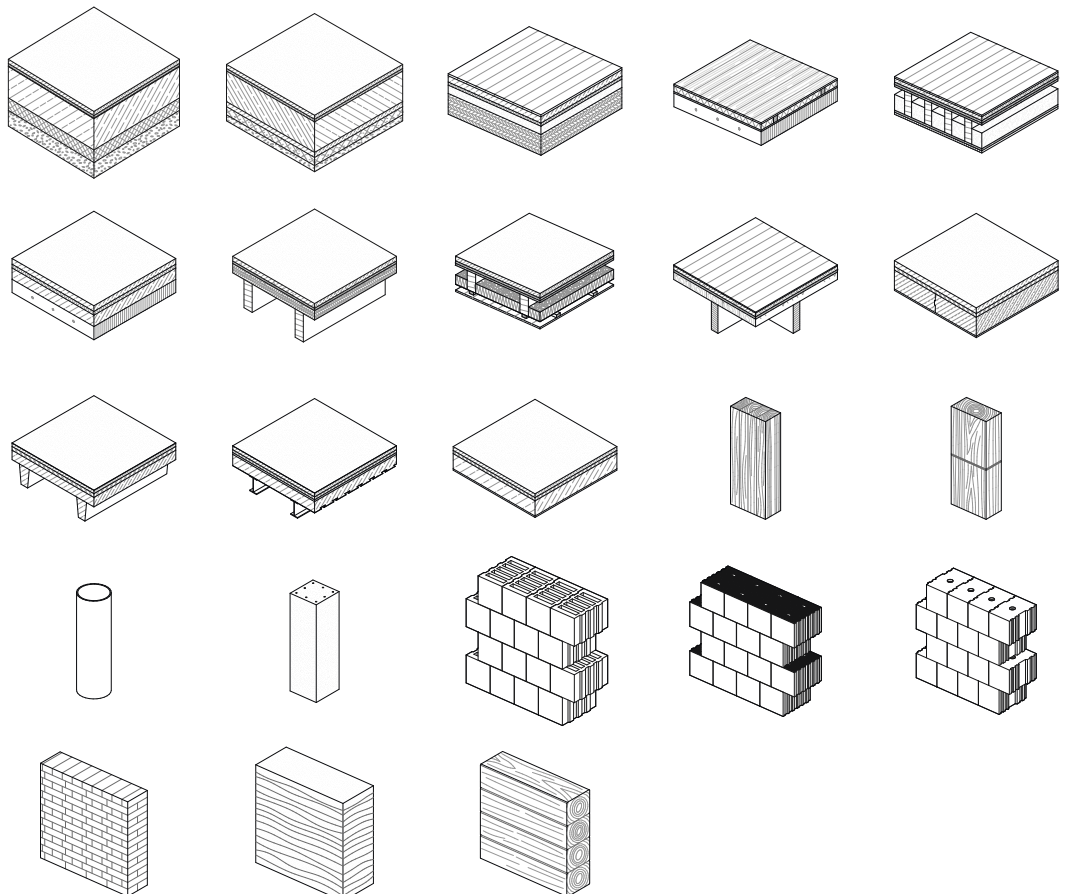
A building's carbon footprint is directly linked to its construction and lifespan. The durability of the elements which make it up is crucial in ensuring that the building's embodied carbon is reduced over its lifespan. Materials such as timber ensure that buildings embodied carbon is negative and can also compensate for carbon positive components such as a concrete foundation. Each element is subject to either more or less intensive modes and scales during its lifespan. These lifespan categories can be separated into four classes: structure, envelope, space, fittings. Analyzing a building design based on these categories makes it possible to consider economic and environmental factors based on these lifespan categories. Thus, ensuring that the embodied carbon can be balanced and compensate for changes within and even around the building.



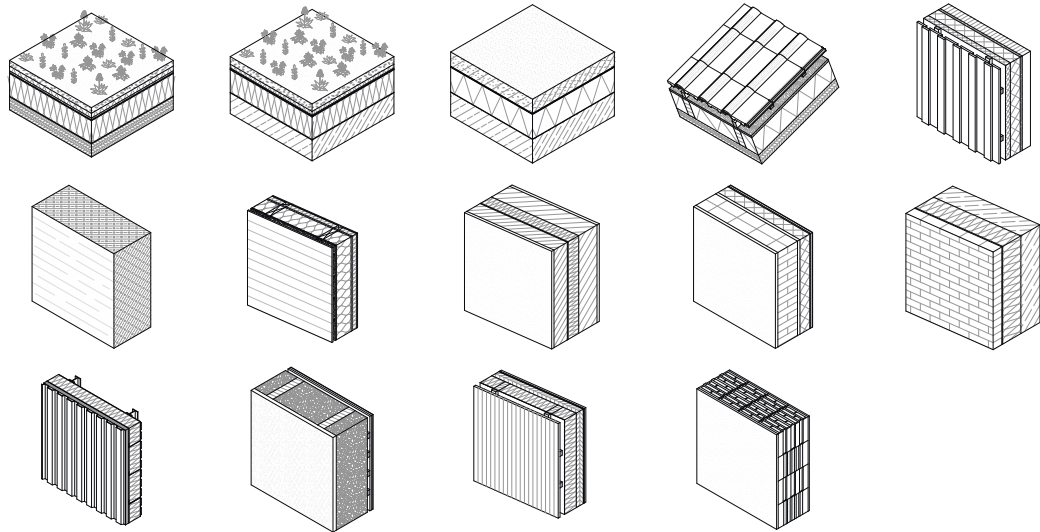
1 Structure, 2 Envelope, 3 Space, 4 Fittings

1.3 Elements of a Building

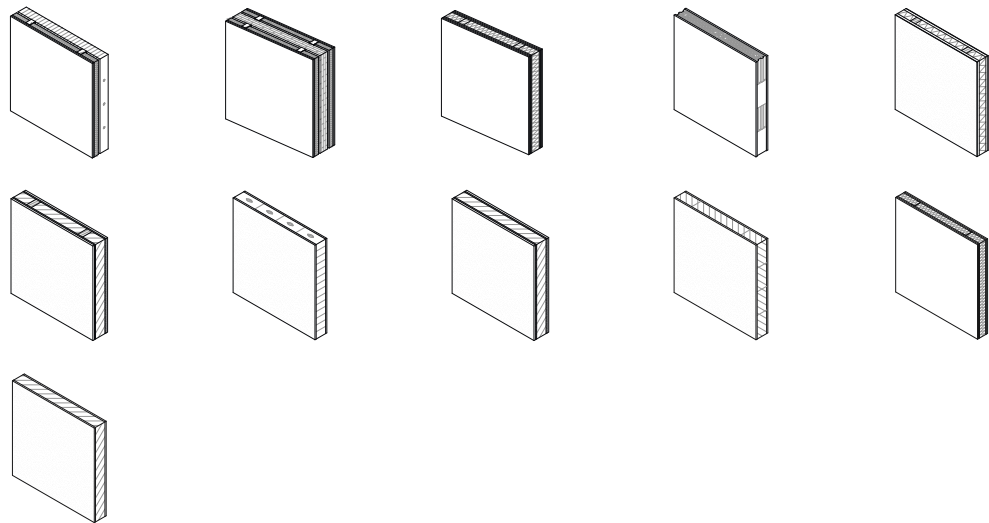
Structure



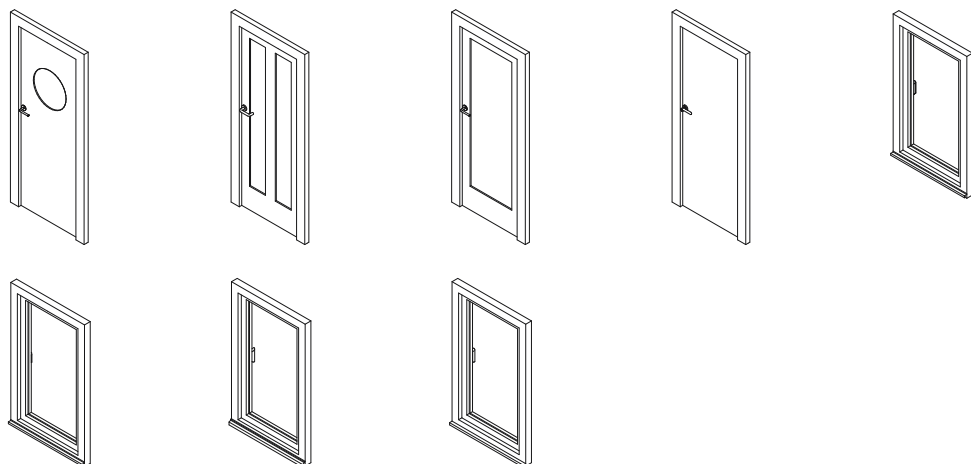
Envelope



Space



Fittings



Component Catalogue

LAYOUT

Building Component, Name

Life-Cycle-Analysis

Dimensions, Discription,
Axonometric Drawing

Recyclability Index

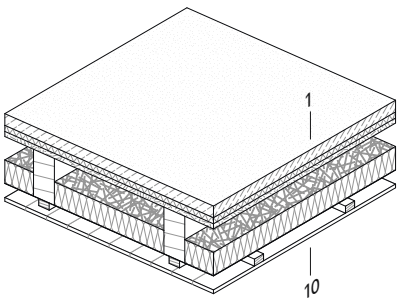
Component Layers, Function,
Assembly

TIMBER FRAME

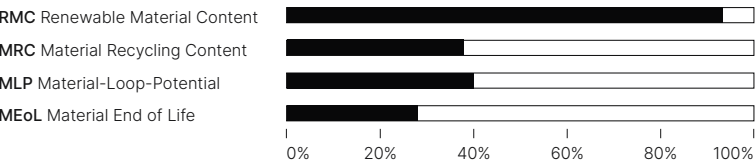
-15.72 kg CO2e/m²	A: -161.0 kg CO2e
-42.14 kg CO2e/m³	C: 238.2kg CO2e
	D: -119.4 kg CO2e

Section 1m x 1m x 375mm

Timber frame floor plate using C24 class timber. Insulation is provided by wood fiber board and timber cladding seals the underside of the floor plate.



RECYCLABILITY STATUS



1 Cement screed 50mm	[0.18 ◦ 0.03 ◦ 0.00]
2 PE Foil	[not specified]
3 Wood Fiber Insulation Board 25mm	[-198.00 ◦ 270.00 ◦ -184.00]
4 OSB/3 Wood Particle Board 22mm	[-753.00 ◦ 967.00 ◦ -1.03]
5 Timber Beam 200×100mm	[-721.70 ◦ 810.21 ◦ -351.40]
6 Rock Wool 100mm	[133.90 ◦ 3.89 ◦ 0.00]
7 Vapour Barrier	[not specified]
8 Vertical Battening 30mm	[-685.70 ◦ 815.02 ◦ -329.50]
9 Horizontal Battening 30mm	[-685.70 ◦ 815.02 ◦ -329.50]
10 Cladding 16mm	[-632.25 ◦ 771.74 ◦ -393.60]



CATEGORIES OF FUNCTION

The complex layering of modern building components places high demands on the functionality and lifespan of the layers. As the number of layers increases, so does the complexity of the connections required to produce them. In many component categories, efforts have been taken to reduce the variety of possible solutions through standardization to achieve more reliable results. This phenomenon is most visible in the development of prefabricated timber components, which use highly standardized details to ensure their longevity; by identifying the function of each layer, the carbon atlas evaluates a layer's effectiveness within a component.



Weather Protection



Weater Absorption, Distribution



Load Bearing Structure



Substructure, Supporting Construction



Surface, Finish



Separating Layer, Airtight Layer



Condensation Protection



Thermal Insulation



Fire Protection



Acoustic Insulation



Room Acoustics

1.5 Categories of Function

METHODS OF ASSEMBLY

Joining techniques are the basis on which building components are constructed. These techniques are defined in DIN 8580 and DIN 8593. Techniques such as assembly, filling, gluing, and screwing in can determine the lifespan of a component and its longevity and recyclability. Mechanically joined components have a high level of reversibility, which increases their chance of being reused, while chemically bonded components are often difficult or even non-recyclable. Because traditional building techniques often were developed in resource-efficient environments, they tend to be more recyclable than their modern counterparts. By identifying the methods of assembly the recyclability and effort required to separate components is more effectively evaluated.



Layup, Layering, Stacking



Insertion



Telescope



Bolting, Screwing



Clamping



Clinging



Press Fitting



Nailing, Pinning, Hammering



Filling



Filling In / Up



Forming Wire-shaped Elements



Forming Metal Sheets, Tubes, Parts



Adherence, Gluing



Application, Coating, Painting

1.6 Methods of Assembly

RECYCLABILITY

A materials recycling and reuse qualities can significantly affect its embodied carbon. In order to evaluate a component's recycling status, it is essential to identify its status using four categories.

The **RMC** status examines the amount of renewable material including the percentage of which the component is manufactured with.

RMC Renewable Material Content

The **MRC** status examines the recycling content including the proportion of recycled materials with which a material or product is currently manufactured.

MRC Material Recycling Content

The **MLP** examines how high the proportion of recycled materials can be if the production of the component were to be ideally optimized to the maximum possible extent

MLP Material-Loop-Potential

The **MeoL** examines what is currently the state of the building material at the end of the life cycle. Black represents the proportion of materials that can be recycled without loss.

MEoL Material End of Life

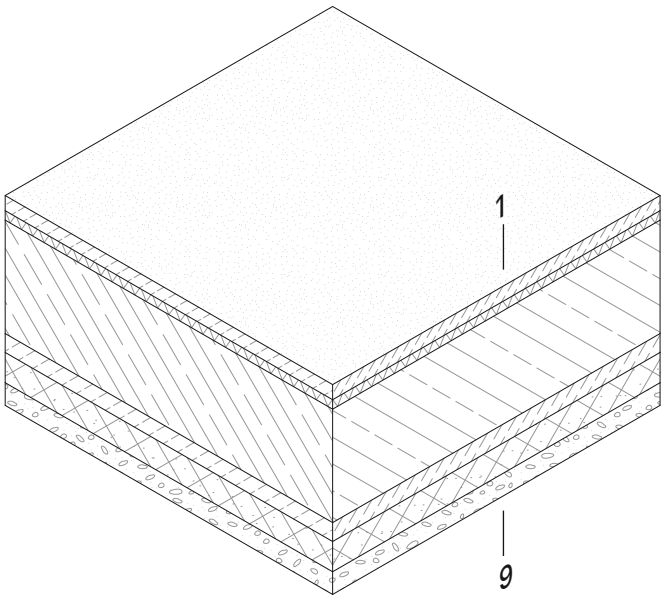
Structure

FLOOR SLAB WATER-RESISTANT
CONCRETE

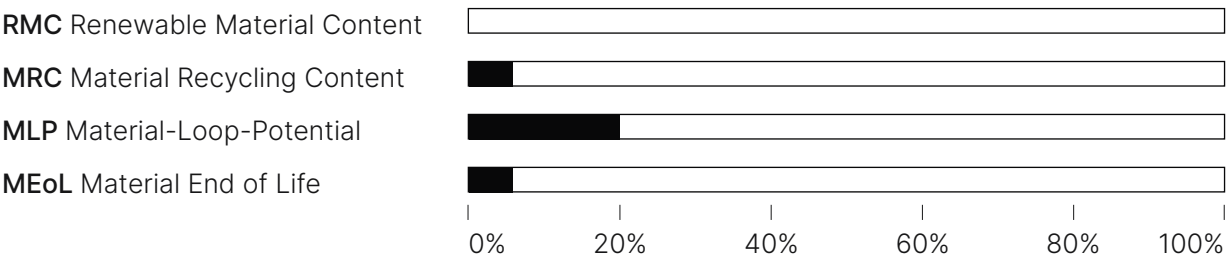
61.54 kg CO2e/m ²	A: 239.1 kg CO2e
320.17 kg CO2e/m ³	C: 311.9 kg CO2e
	D: -230.8 kg CO2e

Section 1m x 1m x 555mm

Foundation slab using water-resistant concrete with low water to cement ratio not exceeding 0.55 with a maximum aggregate diameter of 16mm. The slab is insulated with foam glass and cement screed provides the flooring surface.



RECYCLABILITY STATUS



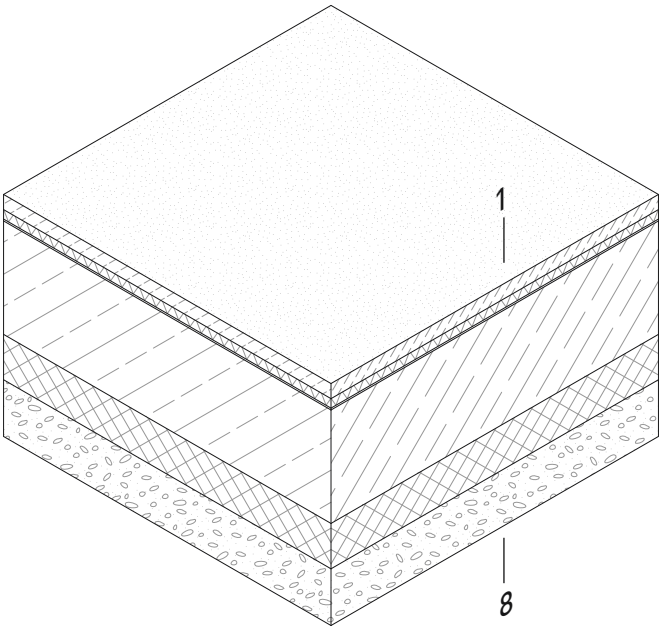
Component	[A • C • D] kg CO2e/m ³	Function	Assembly
1 Cement screed 40mm	[0.18 • 0.03 • 0.00]		
2 PE Foil	[not specified]		
3 Wood Fiber Insulation Board 25mm	[-198.00 • 270.00 • -184.00]		
4 Protective Layer	[not specified]		
5 Water-Resistant Concrete 300mm	[178.00 • 12.00 • -21.40]		
6 Concrete Protective Layer 50mm	[244.00 • 21.11 • -21.40]		
7 Separating Layer	[not specified]		
8 Foam Glass 80mm	[14.80 • 8.74 • -4.00]		
9 Gravel 60mm	[0.10 • 0.01 • -0.01]		

FLOOR SLAB REINFORCED CONCRETE

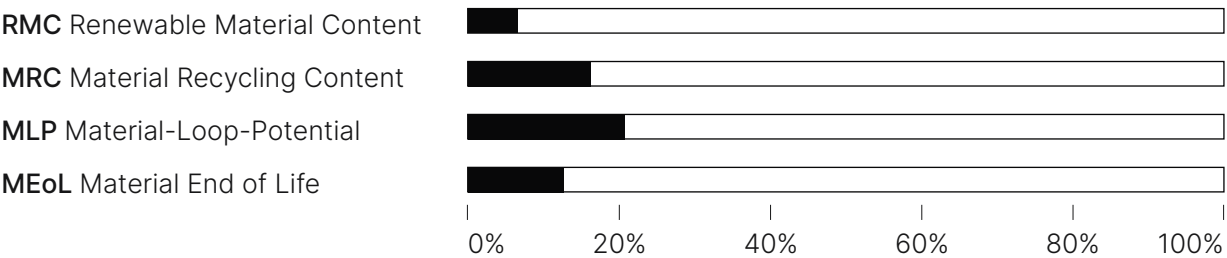
83.54 kg CO2e/m ²	A: 142.6 kg CO2e
297.06 kg CO2e/m ³	B: 409.3 kg CO2e
	C: -254.9 kg CO2e

Section 1m x 1m x 640mm

Foundation slab using reinforced concrete with a breadth of 300mm. The slab is insulated with XPS Board and cement screed provides the flooring surface.



RECYCLABILITY STATUS



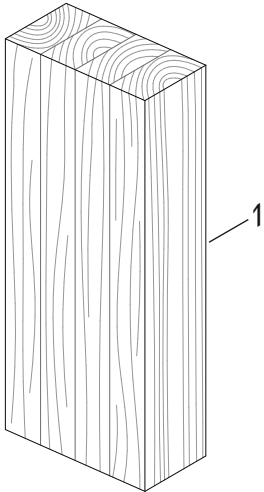
Component	[A + C + D] kg CO2e/m ³	Function	Assembly
1 Cement screed 50mm	[0.18 + 0.03 + 0.00]		
2 PE Foil	[not specified]		
3 Wood Fiber Insulation Board 25mm	[-198.00 + 270.00 + -184.00]		
4 Bituminous Sealing	[not specified]		
5 Bituminous Undercoat	[not specified]		
6 Reinforced Concrete 300mm	[244.00 + 21.11 + -21.40]		
7 XPS-Insulation Board 120mm	[96.34 + 118.20 + -49.51]		
8 Gravel 150mm	[0.10 + 0.01 + -0.01]		

CROSS LAMINATED TIMBER

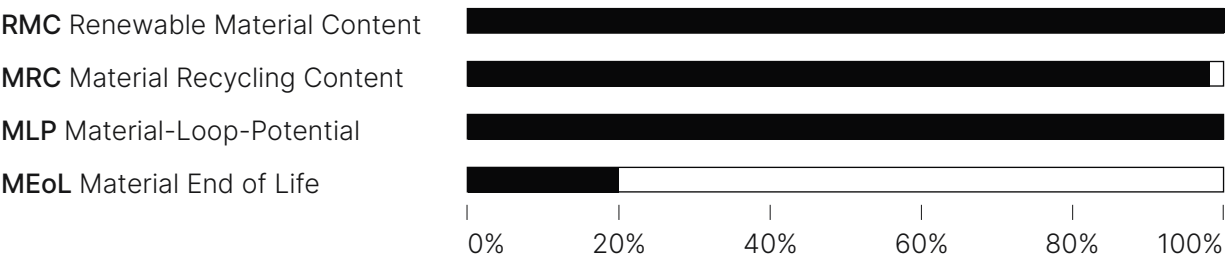
-34.15 kg CO2e/m	A: -639.5 kg CO2e
-284.70 kg CO2e/m³	C: 749.5 kg CO2e
	D: -394.7 kg CO2e

Section 300mm x 400m x 1m

Technically dried softwood lamellas with a wood moisture content of 9-14% are surfacel bonded using adhesive. After curing of the bonding, the final surface treatment are carried out Depending on the intended use and application.



RECYCLABILITY STATUS



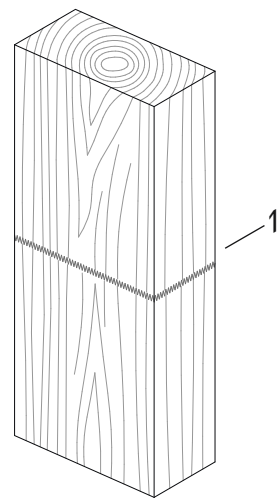
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Cross Laminated Timber	[-639.50 ÷ 749.50 ÷ -394.70]		

STRUCTURAL TIMBER

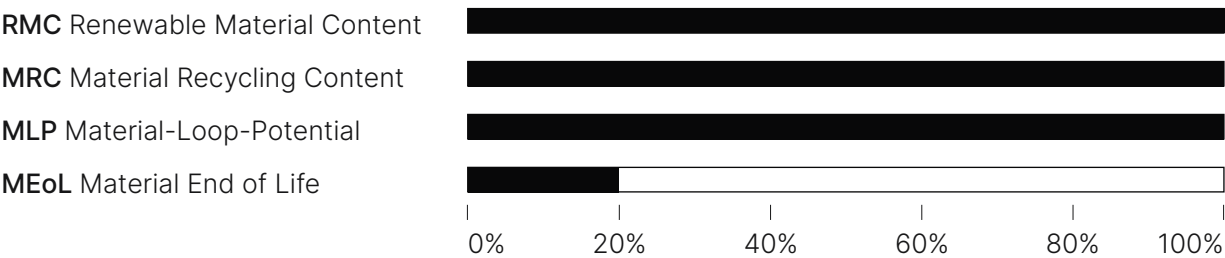
-31.54 kg CO2e/m	A: -721.7 kg CO2e
-262.89 kg CO2e/m³	B: 810.2 kg CO2e
	C: -351.4 kg CO2e

Section 300mm x 400mm x 1m

Kiln-dried softwood squared lumber butted lengthwise by finger joints. The binders contained in the product are mainly based on melamine-urea-formaldehyde and polyurethane. The product is not treated with wood preservatives.



RECYCLABILITY STATUS



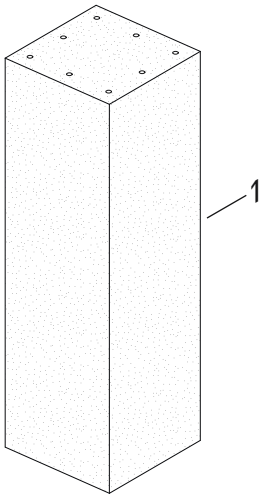
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Structural Timber	[-721.70 ÷ 810.20 ÷ -351.40]		

REINFORCED CONCRETE
(Skeleton Construction, Compression Class 34/45)

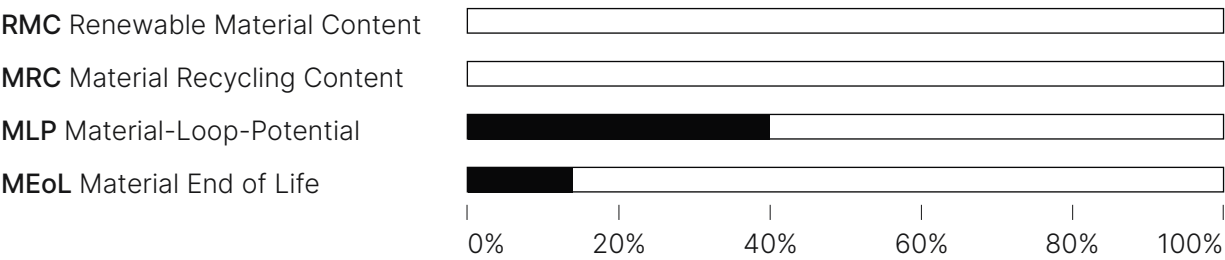
21.93 kg CO2e/m	A: 244.0 kg CO2e
243.71 kg CO2e/m³	C: 21.1 kg CO2e
	D: -21.4 kg CO2e

Section 300mm x 300mm x 1m

Cement, coarse and fine aggregate and water, mixed with admixtures is placed in forms at the construction site or precast plant, compacted and hardens in the desired form by hydration of the cement to form a solid.



RECYCLABILITY STATUS



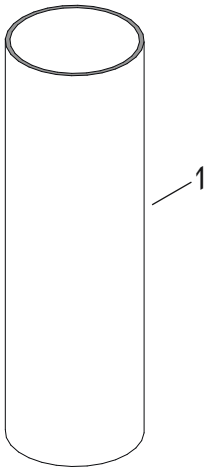
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Reinforced Concrete	[244.00÷ 21.11 ÷ -21.40]		

STEEL
(Skeleton Construction)

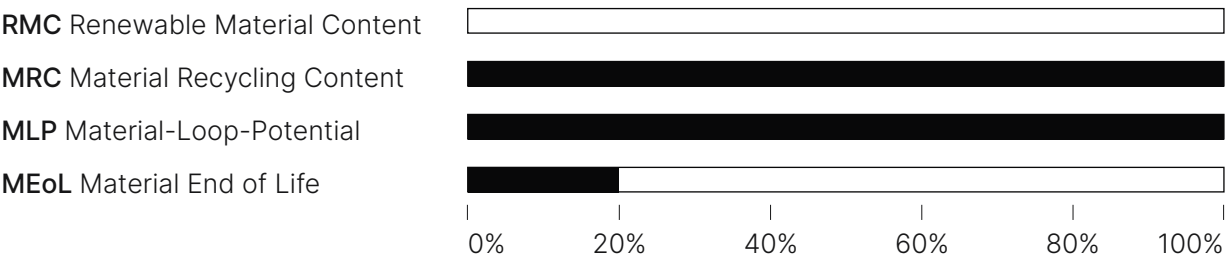
22.40 kg CO2e/m	A: 1125.0 kg CO2e
713.00 kg CO2e/m³	B: 1.0 kg CO2e
	C: -413.0 kg CO2e

Section D=300mm, t=10mm, h=1m

Steel scrap is melted in an electric arc furnace to obtain liquid steel. Refining, alloying are applied to give the steel its required properties. The liquid steel is then transformed into a semi-finished product through continuous casting



RECYCLABILITY STATUS



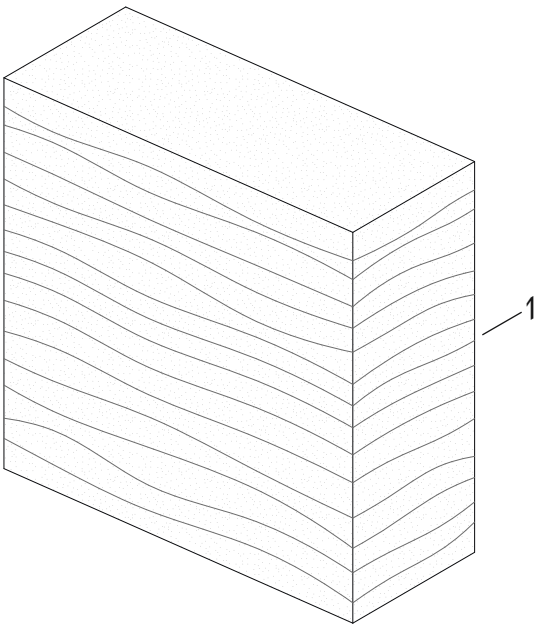
Component	[A ◦ C ◦ D] kg CO2e/m³	Function	Assembly
1 Steel	[1125.00 ◦ 1.00 ◦ -413.00]		

RAMMED EARTH

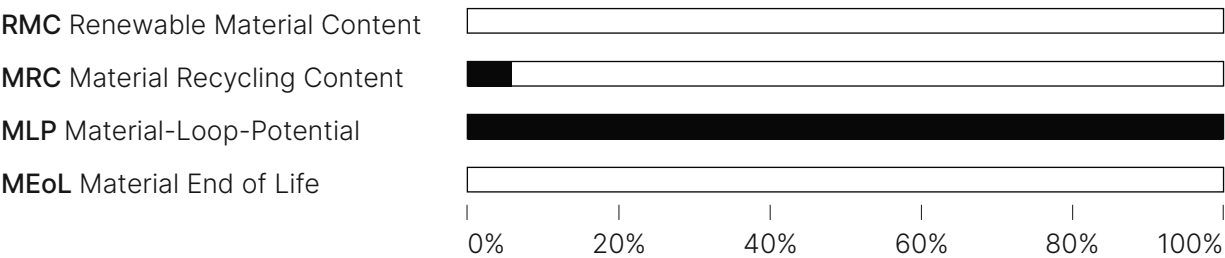
8.30 kg CO2e/m ²	A: 9.3 kg CO2e
20.75 kg CO2e/m ³	C: 14.3 kg CO2e
	D: -2.9 kg CO2e

Section 1m x 1m x 400mm

Clay, sand, chopped straw mixed with other aggregates with coarse-grained components. The processing is carried out with a pneumatic rammer, whereby the material is carefully compacted in layers in a form.



RECYCLABILITY STATUS



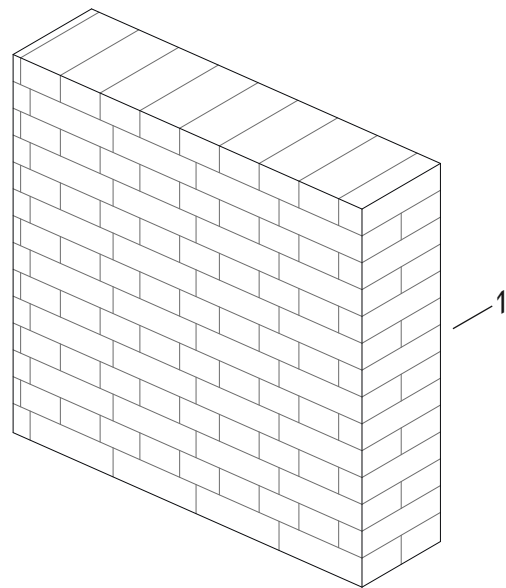
Component	[A ◦ C ◦ D] kg CO2e/m ³	Function	Assembly
1 Rammed Earth	[9.34 ◦ 14.39 ◦ -2.93]		

LOAD BEARING CLAY BRICK

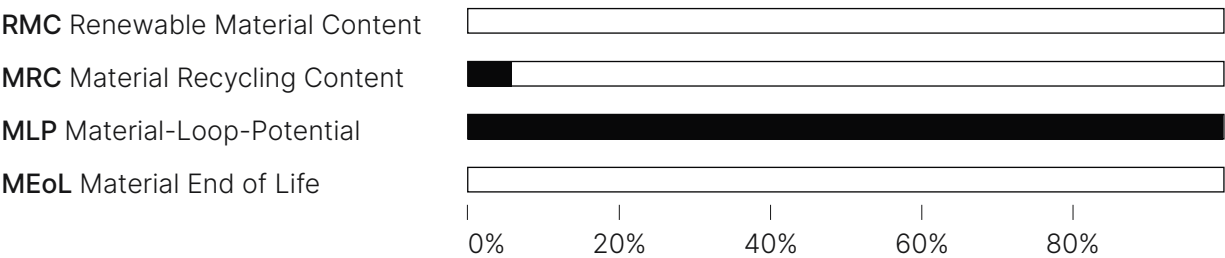
23.89 kg CO2e/m ²	A:	93.6	kg CO2e
99.55 kg CO2e/m ³	B:	7.6	kg CO2e
	C:	-1.7	kg CO2e

Section 1m x 1m x 240mm

Extracted clay is mixed with sand and other aggregates and then shaped and fire heated for the loading bearing standard.



RECYCLABILITY STATUS



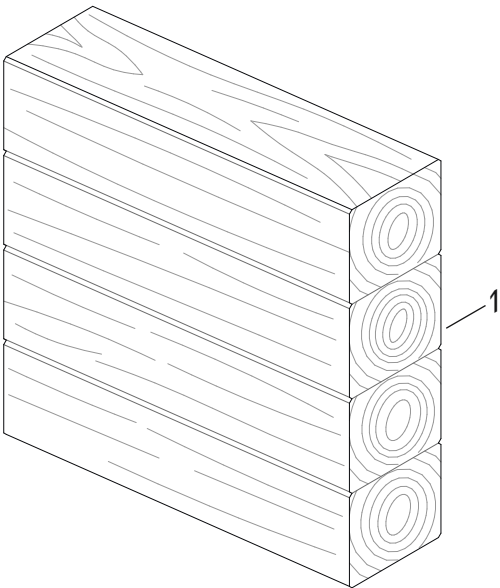
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	
1 Clay Brick	[93.64 ÷ 7.67 ÷ -1.76]		

TIMBER BLOCK

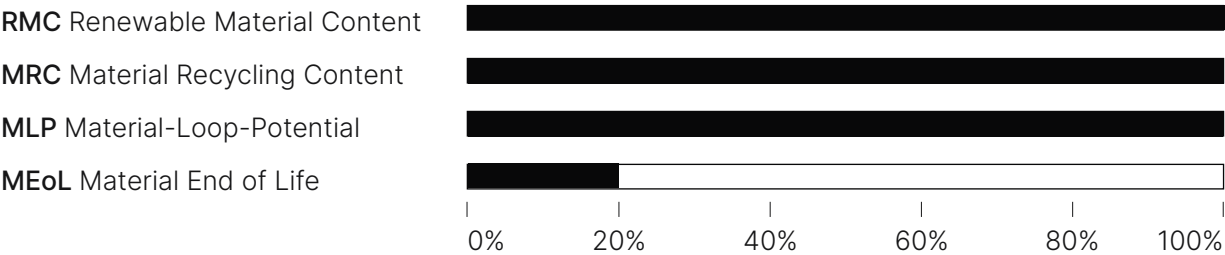
-81.51 kg CO2e/m²	A: -738.9 kg CO2e
-291.10 kg CO2e/m³	C: 797.3 kg CO2e
	D: -349.5 kg CO2e

Section 1m x 1m x 280mm

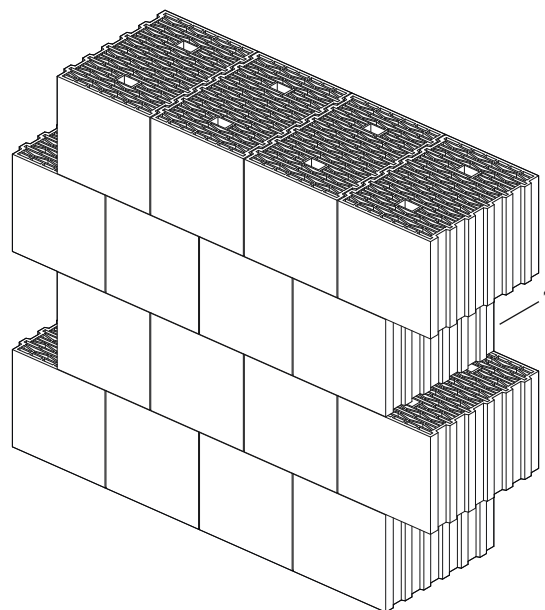
The lumber is bundled and dried in packages using drying chambers with the fresh air exhaust drying method. After drying, the product is stacked and packed for transportation. The product is not treated with wood preservatives.



RECYCLABILITY STATUS



Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Timber Log	[-738.90 ÷ 797.30 ÷ -349.50]		

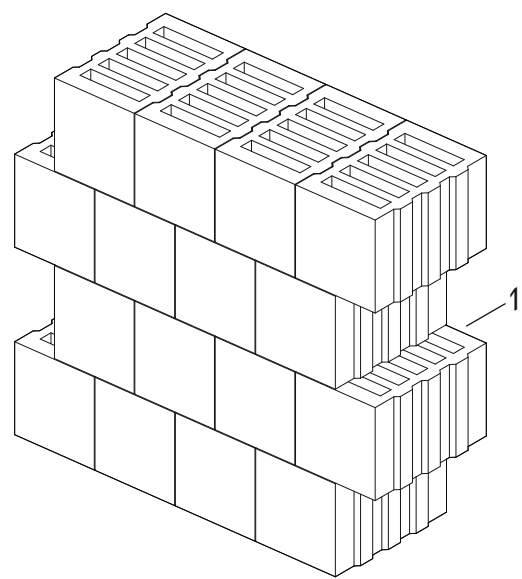


CONCRETE BRICK MASONRY

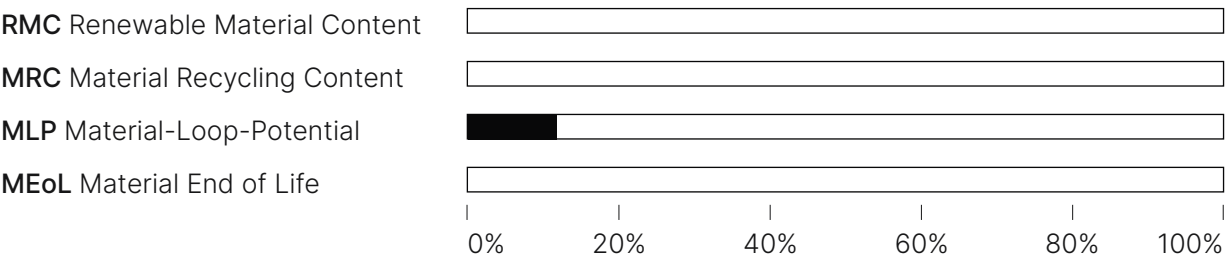
17.29 kg CO2e/m²	A:	42.9 kg CO2e
47.36 kg CO2e/m³	C:	5.4 kg CO2e
	D:	-1.0 kg CO2e

Section 1m x 1m x 365mm

Natural pumice, cement and blast furnace slag are mixed with water, placed in molds, compacted then cured and stored.



RECYCLABILITY STATUS



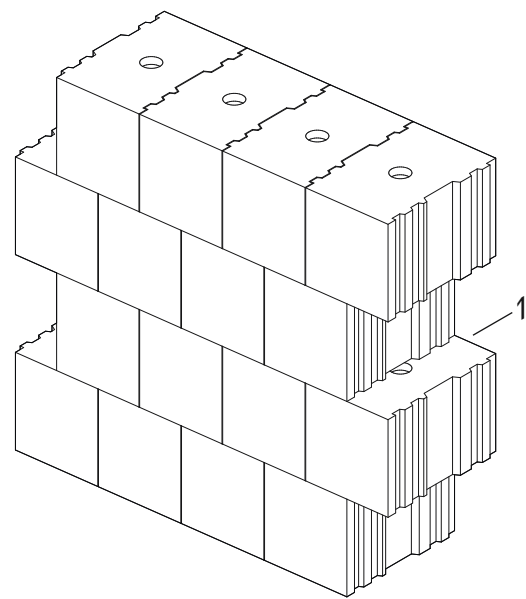
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Concrete Brick	[42.97 ÷ 5.42 ÷ -1.03]		

LIME SILICA BRICK MASONRY

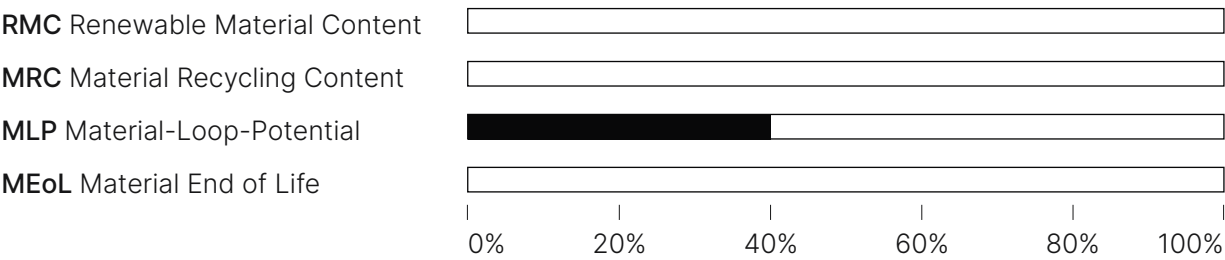
117.48 kg CO2e/m ²	A: 306.1 kg CO2e
321.87 kg CO2e/m ³	C: 19.8 kg CO2e
	D: -4.1 kg CO2e

Section 1m x 1m x 365mm

Lime and sand mixed by weight in a mixing ratio of lime:sand = 1:12. The quicklime/burnt lime is extracted from slaked lime by using water and pressed into bricks which are hardened at 200 °C under steam pressure and then cooled.



RECYCLABILITY STATUS



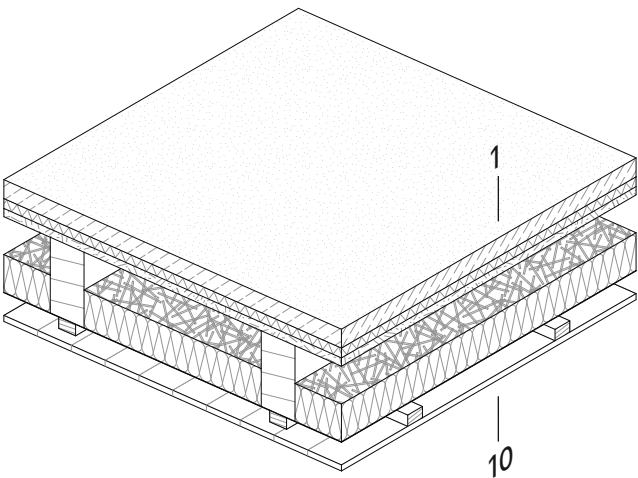
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Lime Silica Brick	[306.10 ÷ 19.87 ÷ -4.11]		

TIMBER FRAME

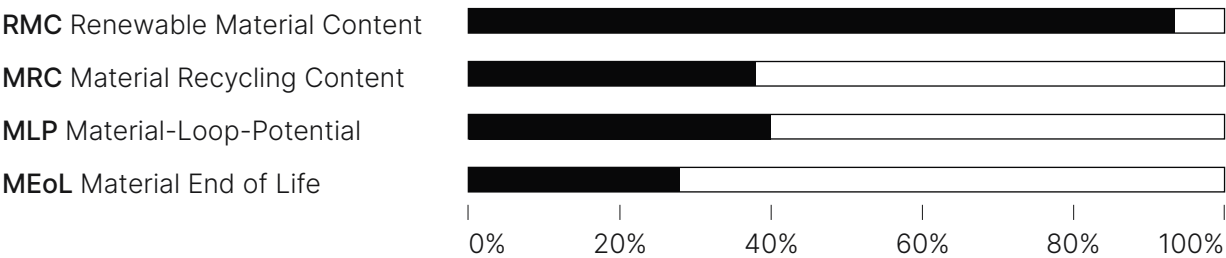
-15.72 kg CO2e/m²	A: -161.0 kg CO2e
-42.14 kg CO2e/m³	C: 238.2kg CO2e
	D: -119.4 kg CO2e

Section 1m x 1m x 375mm

Timber frame floor plate using C24 class timber. Insulation is provided by wood fiber board and timber cladding seals the underside of the floor plate.



RECYCLABILITY STATUS



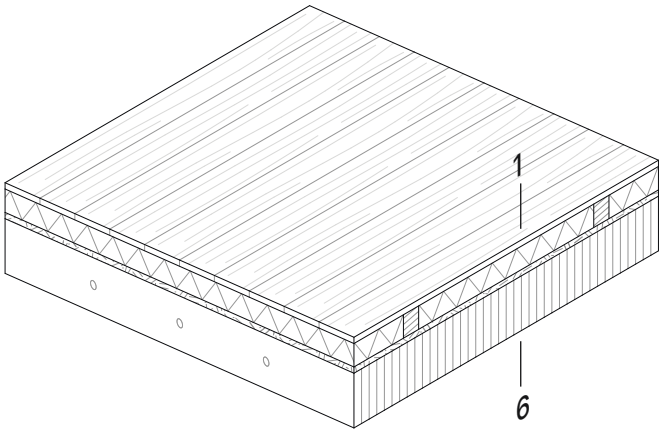
Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Cement screed 50mm	[0.18 + 0.03 + 0.00]		
2 PE Foil	[not specified]		
3 Wood Fiber Insulation Board 25mm	[-198.00 + 270.00 + -184.00]		
4 OSB/3 Wood Particle Board 22mm	[-753.00 + 967.00 + -1.03]		
5 Timber Beam 200×100mm	[-721.70 + 810.21 + -351.40]		
6 Rock Wool 100mm	[133.90 + 3.89 + 0.00]		
7 Vapour Barrier	[not specified]		
8 Vertical Battening 30mm	[-685.70 + 815.02 + -329.50]		
9 Horizontal Battening 30mm	[-685.70 + 815.02 + -329.50]		
10 Cladding 16mm	[-632.25 + 771.74 + -393.60]		

MASSIVE TIMBER

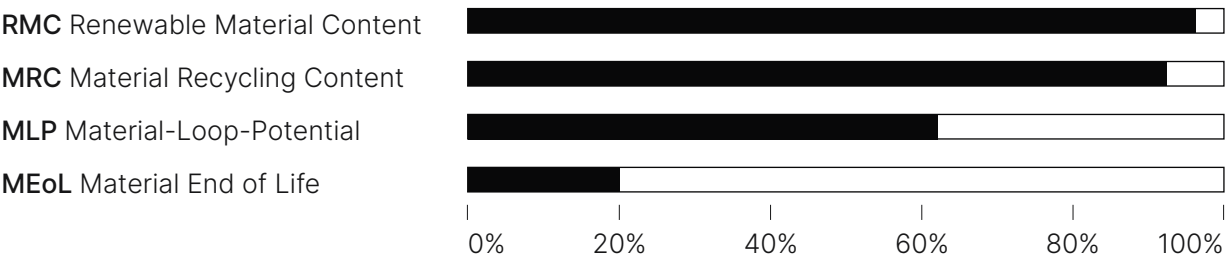
-40.54 kg CO2e/m ²	A -1655.4 kg CO2e
-639.81 kg CO2e/m ³	C: 1911.9 kg CO2e
	D: -896.4 kg CO2e

Section 1m x 1m x 240mm

Massive timber elements connected through dowels supports a wood fiber insulation board with solid wood flooring.



RECYCLABILITY STATUS



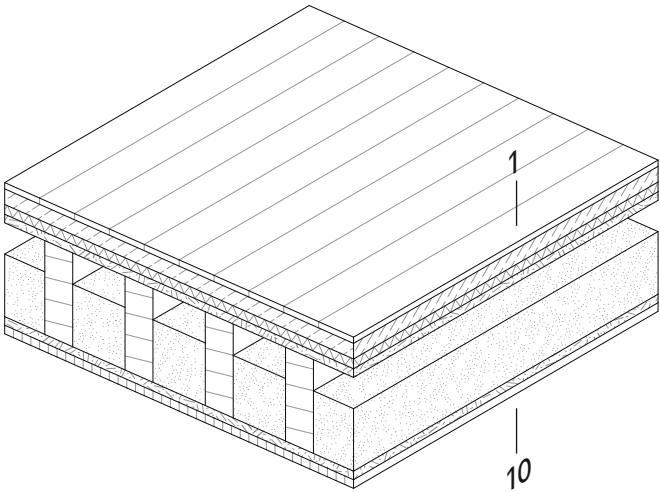
Component	[A ◦ C ◦ D] kg CO2e/m ³	Function	Assembly
1 Oak Parquet 22mm	[-12.63 ◦ 19.93 ◦ -8.93]		
2 Cellulose Cavity Insulation 60mm	[-1.32 ◦ 1.56 ◦ -0.64]		
3 Wood Battening 60×60mm	[-721.70 ◦ 810.21 ◦ -351.40]		
4 Wood Fiber Insulation Board 16mm	[-198 ◦ 270 ◦ -184]		
5 Trickle Protection Foil	[not specified]		
6 Massive Timber (dowelled) 140mm	[-721.70 ◦ 810.21 ◦ -351.40]		

HOLLOW BOX TIMBER

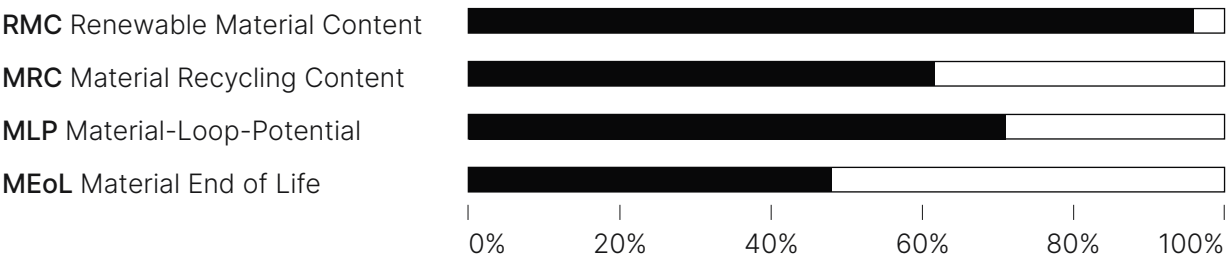
-41.95 kg CO2e/m²	A: -2925.7 kg CO2e
-1134.38 kg CO2e/m³	C: 3579.2 kg CO2e
	D: -1787.8 kg CO2e

Section 1m x 1m x 375mm

Hollow timber box floor plate insulated with a 160mm crushed fill.



RECYCLABILITY STATUS



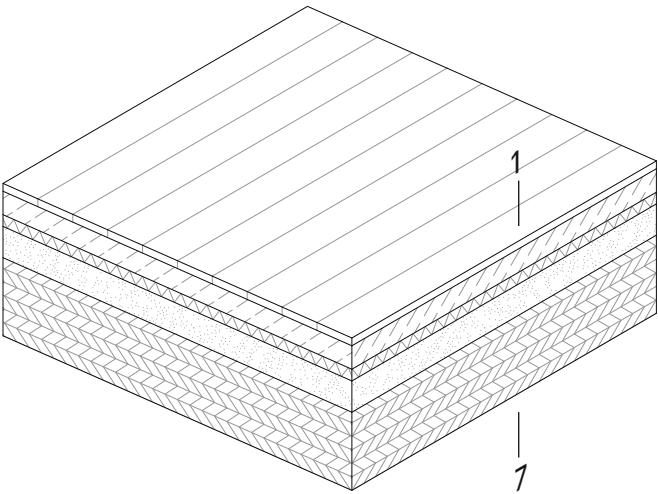
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Oak Parquet 22mm	[-12.63 ÷ 19.93 ÷ -8.93]		
2 Cement Screed 40mm	[0.18 ÷ 0.03 ÷ 0.00]		
3 OSB/3 Wood Particle Board 25mm	[-753.00 ÷ 967.00 ÷ -549.00]		
4 KVH Timber Beam 80×240mm	[-721.70 ÷ 810.21 ÷ -351.40]		
5 Crushed Stone Fill 160mm	[0.10 ÷ 0.01 ÷ -0.01]		
6 Trickle Protection Foil	[not specified]		
7 OSB/3 Wood Particle Board 25mm	[-753.00 ÷ 967.00 ÷ -549.00]		
8 Wood Acoustic Board 25×22mm	[-685.70 ÷ 815.02 ÷ -329.5]		

CROSS LAMINATED TIMBER

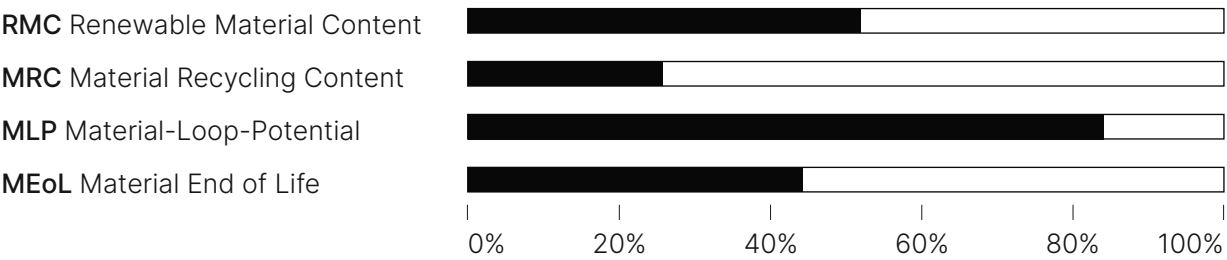
-34.30 kg CO2e/m ²	A: -658.0 kg CO2e
-171.50 kg CO2e/m ³	B: 1082.5 kg CO2e
	C: -498.9 kg CO2e

Section 1m x 1m x 390mm

Massive cross laminated timber panels support a crushed stone fill insulation clad in an oak parquet.



RECYCLABILITY STATUS



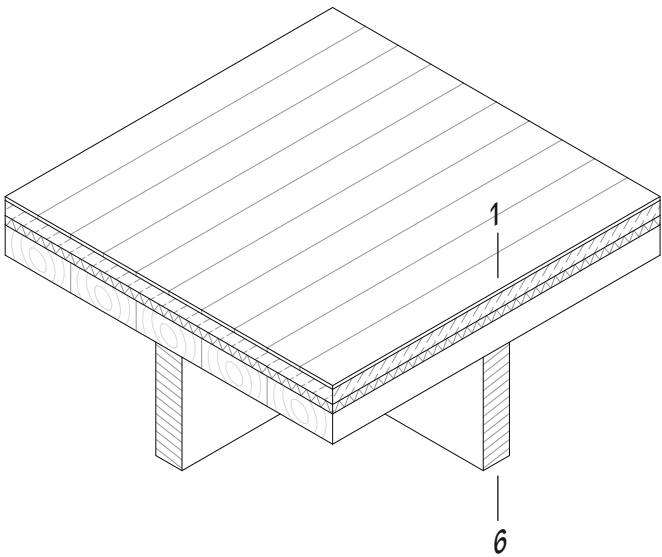
Component	[A ◦ C ◦ D] kg CO2e/m ³	Function	Assembly
1 Oak Parquet 20mm	[-12.63 ◦ 19.93 ◦ -8.93]		
2 Cement Screed 60mm	[0.18 ◦ 0.03 ◦ 0.00]		
3 PE Foil	[not specified]		
4 Wood Fiber Insulation Board 30mm	[-198.00 ◦ 270.00 ◦ -184.00]		
5 Crushed Stone Fill 80mm	[0.10 ◦ 0.01 ◦ -0.01]		
6 PE Foil	[not specified]		
7 Cross Laminated Timber 200mm	[-658.00 ◦ 792.50 ◦ -306.00]		

TIMBER LATTICE AND BEAM

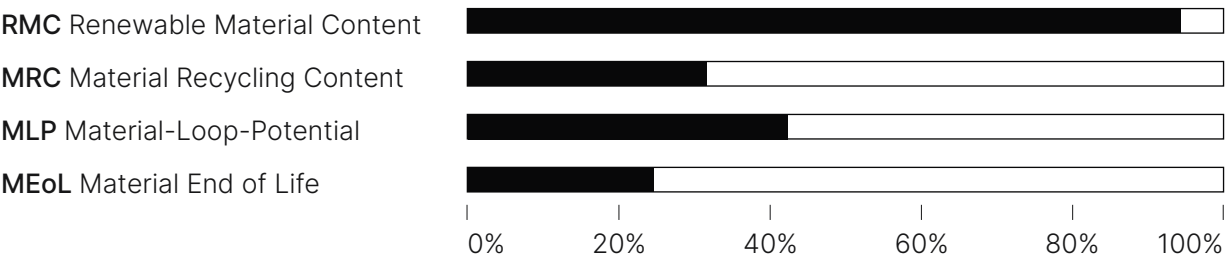
-31.47 kg CO2e/m²	A:-1617.8 kg CO2e
-576.49 kg CO2e/m³	C: 1915.2 kg CO2e
	D: -873.8 kg CO2e

Section 1m x 1m x 455mm

A lattice and beam structure supports a KVH floorplate with wood fiber insulation board doubling as acoustic insulation.



RECYCLABILITY STATUS



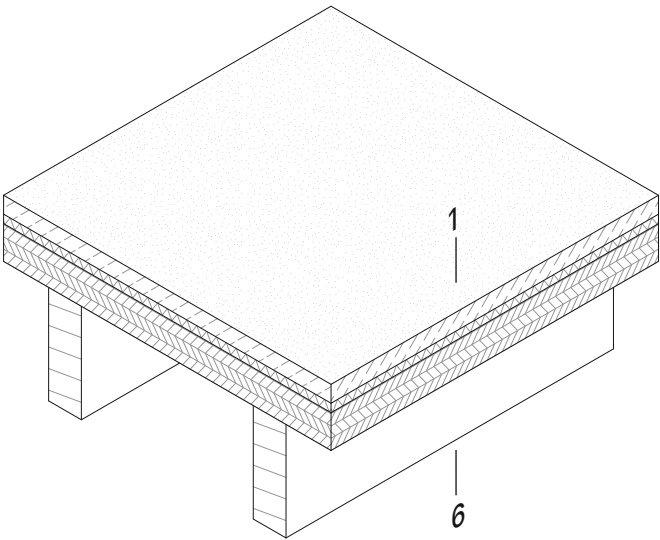
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Oak Parquet 10mm	[-12.63 ÷ 19.93 ÷ -8.93]		
2 Cement Screed 40mm	[0.18 ÷ 0.03 ÷ 0.00]		
3 Wood Fiber Insulation Board 25mm	[-198.00 ÷ 270.00 ÷ -184.00]		
4 PE Foil	[not specified]		
5 KVH Timber Panel 80mm	[-685.70 ÷ 815.02 ÷ -329.50]		
6 Timber-Binder 80×300mm	[-721.70 ÷ 810.21 ÷ -351.40]		

EXPOSED TIMBER FRAME

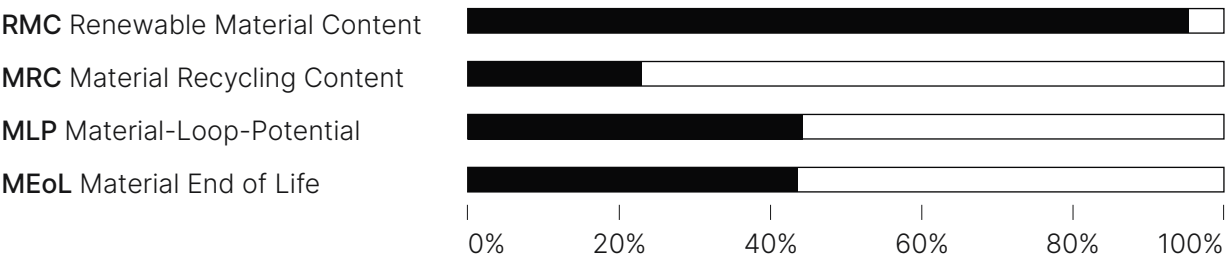
-30.23 kg CO2e/m²	A:-1513.8 kg CO2e
-454.79 kg CO2e/m³	B: 1855.0 kg CO2e
	C: -796.0 kg CO2e

Section 1m x 1m x 475mm

Exposed CLT beams support a 100mm CLT panel floor plat clad in cement screed.



RECYCLABILITY STATUS



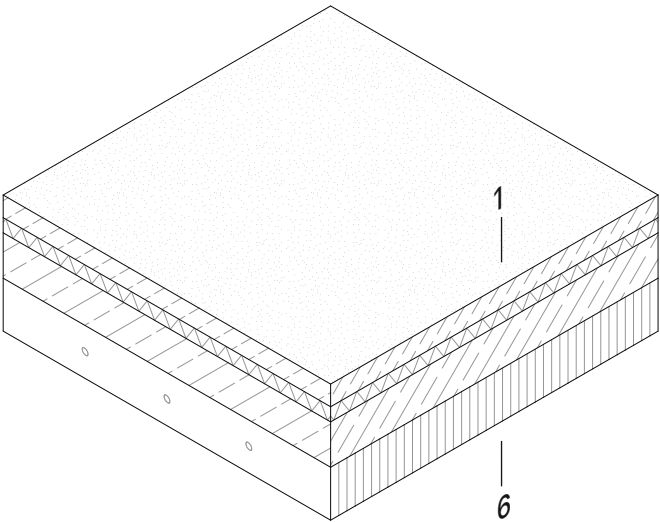
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Cement Screed 50mm	[0.18 ÷ 0.03 ÷ 0.00]		
2 PE Foil	[not specified]		
3 Wood Fiber Insulation Board 25mm	[-198.00 ÷ 270.00 ÷ -184.00]		
4 Trickle Protection Foil	[not specified]		
5 CLT Panel 100mm	[-658.00 ÷ 792.50 ÷ -306.00]		
6 CLT Beam 100×300mm	[-658.00 ÷ 792.50 ÷ -306.00]		

TIMBER CONCRETE COMPOSITE

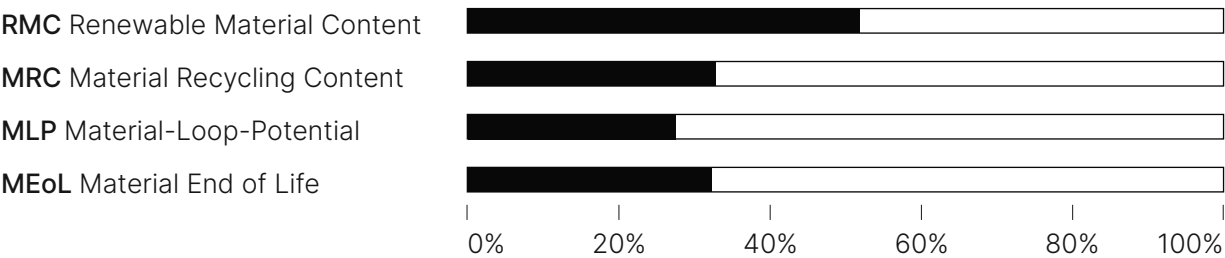
0.77 kg CO2e/m ²	A: -611.8 kg CO2e
-39.58 kg CO2e/m ³	C: 1083.6 kg CO2e
	D: -511.4 kg CO2e

Section 1m x 1m x 360mm

Stacked timber pannels formed to a composite with 120mm of concrete.



RECYCLABILITY STATUS



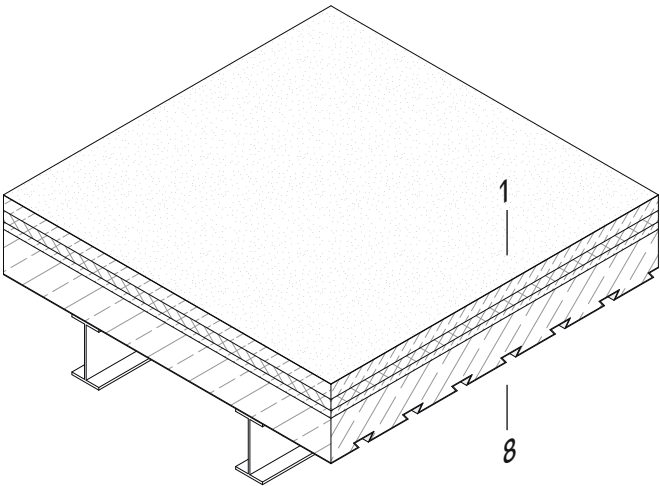
Component	[A ◦ C ◦ D] kg CO2e/m ³	Function	Assembly
1 Cement Screed 60mm	[0.18 ◦ 0.03 ◦ 0.00]		
2 PE Foil	[not specified]		
3 Wood Fiber Insulation Board 40mm	[-198.00 ◦ 270.00 ◦ -184.00]		
4 In-Situ Concrete 120mm	[244.00 ◦ 21.11 ◦ -21.40]		
5 Trickle Protection Foil	[not specified]		
6 Board Stack (dowelled) 140mm	[-658.00 ◦ 792.50 ◦ -306.00]		

STEEL CONCRETE COMPOSITE

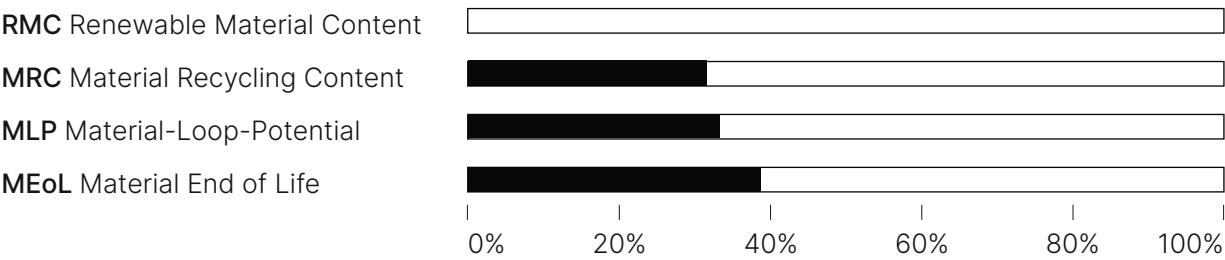
55.67 kg CO2e/m²	A: 2628.3 kg CO2e
713.00 kg CO2e/m³	B: 27.1 kg CO2e
	C: -847.4 kg CO2e

Section 1m x 1m x 370mm

A steel beams support a concrete composite floor plate insulated with rock wool.



RECYCLABILITY STATUS



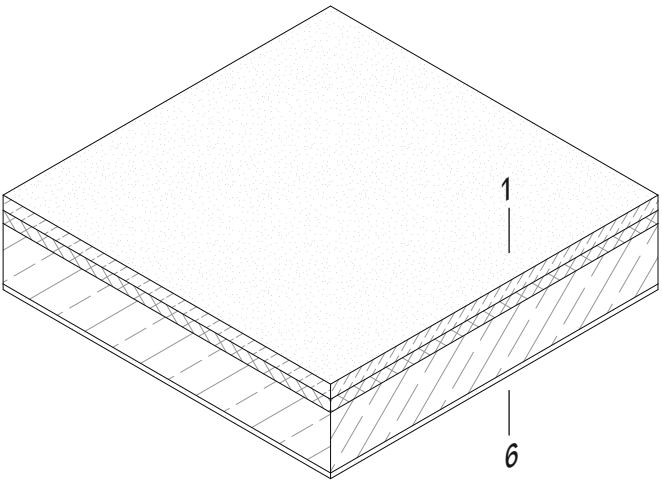
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Impregnation Concrete-Oil	[not specified]		
2 Cement Screed 40mm	[0.18 ÷ 0.03 ÷ 0.00]		
3 PE Foil	[not specified]		
4 Insulation Rock Wool 30mm	[133.90 ÷ 3.89 ÷ 0.00]		
5 Levelling Cement Screed 20mm	[0.18 ÷ 0.03 ÷ 0.00]		
6 In-Situ Reinforced Concrete 120mm	[244.00 ÷ 21.11 ÷ -21.40]		
7 Profiled Steel Sheet	[1125.00 ÷ 1.00 ÷ -413.00]		
8 Steel Beam IPE 82×160mm	[1125.00 ÷ 1.00 ÷ -413.00]		

REINFORCED CONCRETE

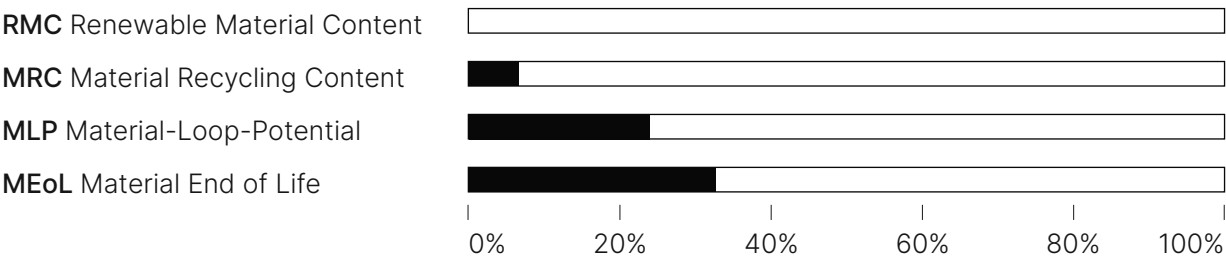
585.26 kg CO2e/m ²	A: 574.9 kg CO2e
48.00 kg CO2e/m ³	C: 37.1 kg CO2e
	D: -26.8 kg CO2e

Section 1m x 1m x 250mm

Rebar reinforced concrete forms a floor plate for a 40mm cement screed flooring.



RECYCLABILITY STATUS



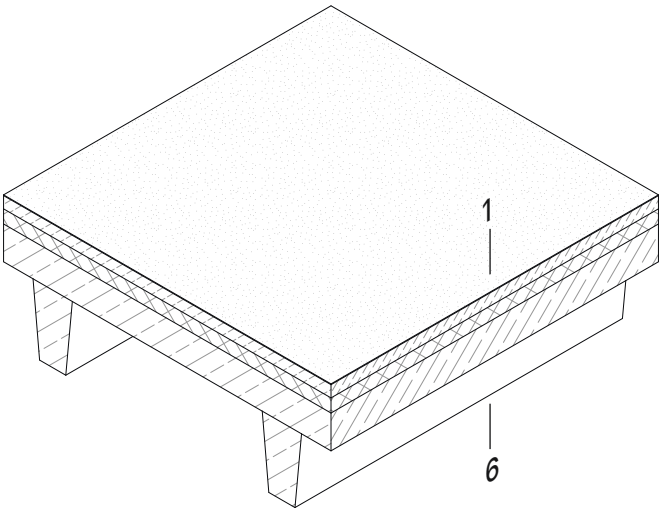
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Wax Coating	[not specified]		
2 Cement Screed 40mm	[0.18 ÷ 0.03 ÷ 0.00]		
3 PE Foil	[not specified]		
4 Insulation Rock Wool 35mm	[196.60 ÷ 2.46 ÷ -5.42]		
5 Reinforced Concrete 160mm	[244.00 ÷ 21.11 ÷ -21.40]		
6 Gypsum Plaster 15mm	[134.20 ÷ 13.50 ÷ 0.00]		

REINFORCED CONCRETE RIB FLOOR

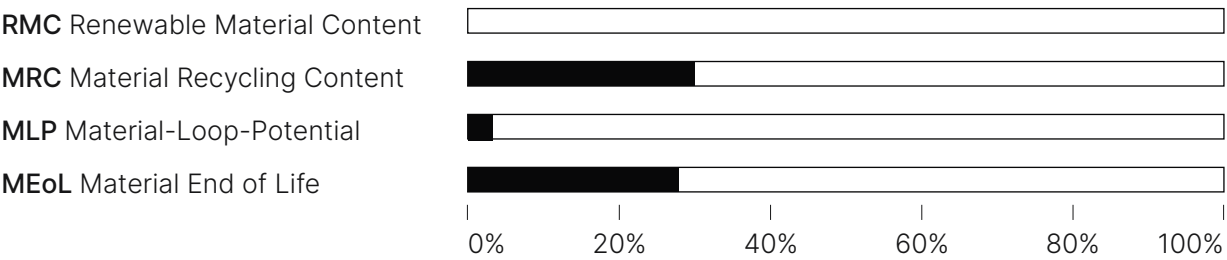
39.88 kg CO2e/m ²	A: 622.1 kg CO2e
625.43 kg CO2e/m ³	B: 46.1 kg CO2e
	C: -42.8 kg CO2e

Section 1m x 1m x 530mm

Prefabricated concrete rib elements support an epoxy coated cement screed floor structure.



RECYCLABILITY STATUS



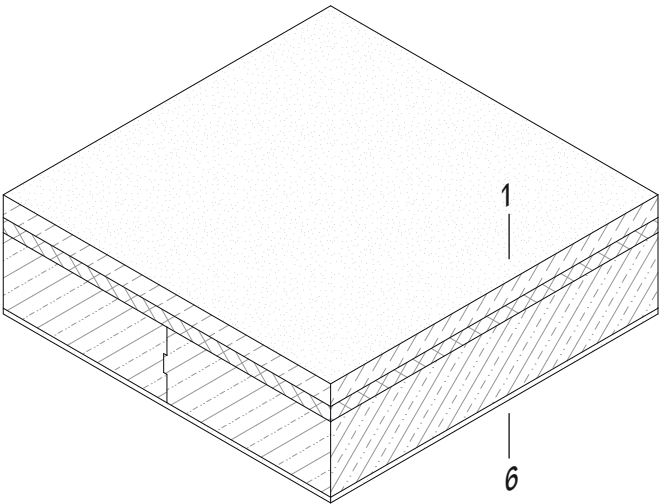
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Epoxy Resin Sealant	[not specified]		
2 Cement Screed 35mm	[0.18 ÷ 0.03 ÷ 0.00]		
3 PE Foil	[not specified]		
4 Insulation Rock Wool 40mm	[133.90 ÷ 3.89 ÷ 0.00]		
5 Reinforced Concrete 100mm	[244.00 ÷ 21.11 ÷ -21.40]		
6 Concrete Rib Beams 80/120×205mm	[244.00 ÷ 21.11 ÷ -21.40]		

AERATED CONCRETE

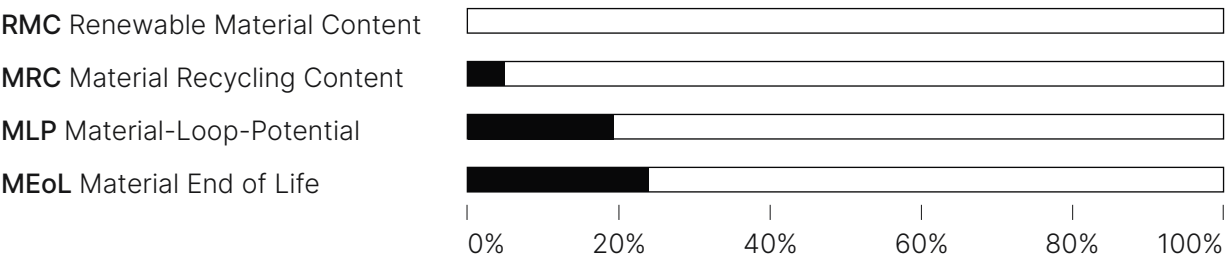
34.99 kg CO2e/m ²	A: 134.20kg CO2e
466.65 kg CO2e/m ³	C: 9.81 kg CO2e
	D: -12.45 kg CO2e

Section 1m x 1m x 315mm

Perforated concrete parts form a modular floor plate supporting an expoxy seals cement screed floor.



RECYCLABILITY STATUS



Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Epoxy Resin Sealant	[not specified]		
2 Cement Screed 60mm	[0.18 ÷ 0.03 ÷ 0.00]		
3 PE Foil	[not specified]		
4 Insulation Rock Wool 40mm	[196.60 ÷ 2.46 ÷ -5.42]		
5 Aerated Concrete Precast 200mm	[138.30 ÷ -6.18 ÷ -7.03]		
6 Lime Cement Plaster 15mm	[134.20 ÷ 13.50 ÷ 0.00]		

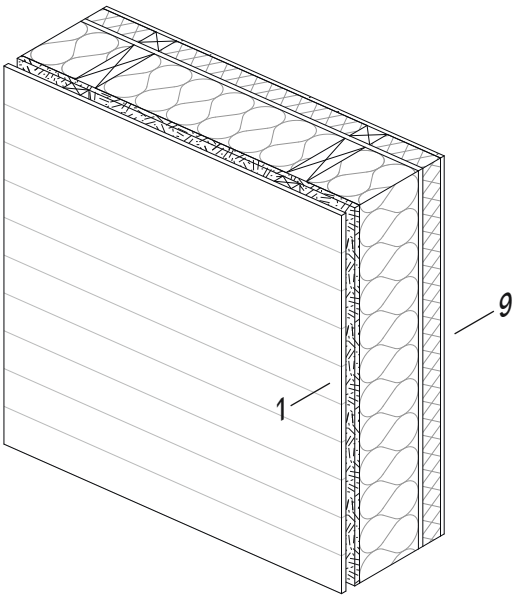
Envelope

TIMBER FRAME FACADE
(Insulated)

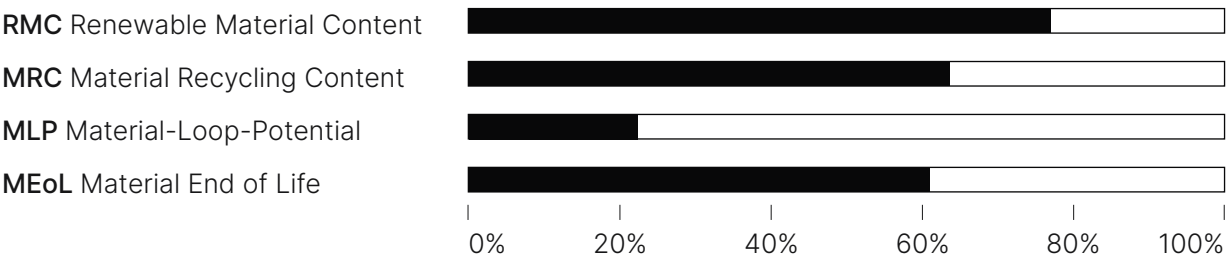
-19.60 kg CO2e/m²	A: -2217.5 kg CO2e
-1090.55 kg CO2e/m³	C: 5538.1 kg CO2e
	D: -4411.1 kg CO2e

Section 1m x 1m x 335mm

Timber frame facade clad in wood and insulated with wood cellulose.



RECYCLABILITY STATUS



Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Wood Facade Cladding 15mm	[-632.25 + 771.74 + -393.60]		
2 Wood Battening 30×50mm	[-685.70 + 815.02 + -329.50]		
3 Hydrophobic MDF Board 16mm	[-734.80 + 1086.75 + -79.88]		
4 KVH-Ständer 60×200mm	[-721.70 + 810.21 + -351.40]		
5 Cellulose Insulation 200mm	[-1.32 + 1.56 + -0.64]		
6 OSB/3 Wood Particle Board 15mm	[-753.00 + 967.00 + -549.00]		
8 Vertical Battening 60×60mm	[-685.70 + 815.02 + -329.50]		
8 Wood Fiber Insulation Board 60mm	[-198.00 + 270.00 + -184.00]		
9 Plaster Board 12.5mm	[1.38 + 0.77 + -0.02]		

CROSS LAMINATED TIMBER (Insulated)

-205.63 kg CO₂e/m²

-300.57 kg CO₂e/m³

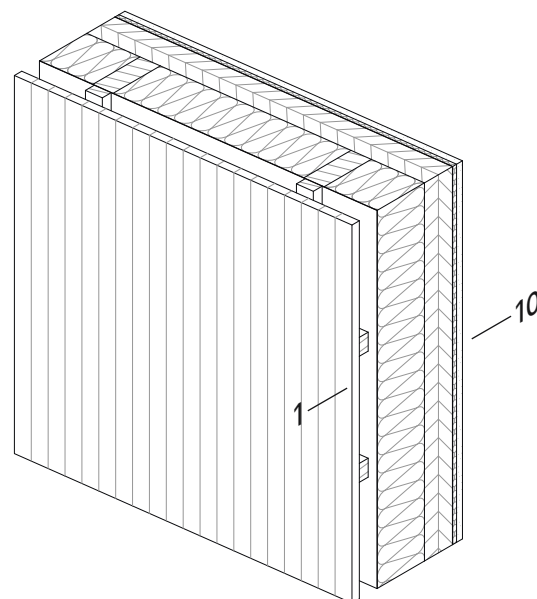
A: -970.0 kg CO₂e

B: 2052.9 kg CO₂e

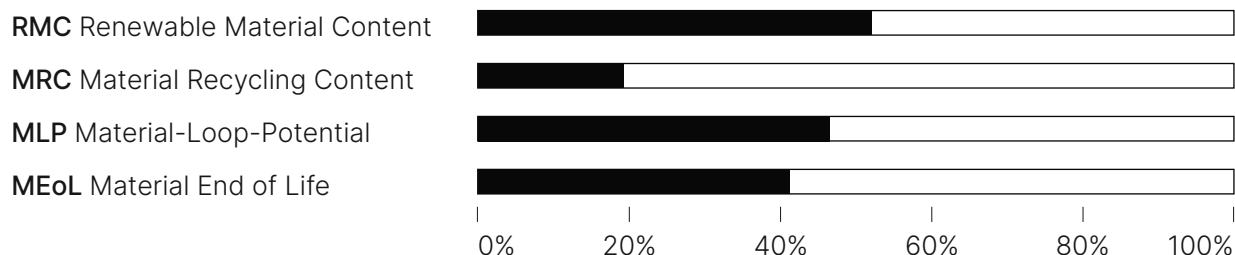
C: -1383.5 kg CO₂e

Section 1m x 1m x 375mm

Cross laminated timber support by a frame construction insulated with rock wool.



RECYCLABILITY STATUS



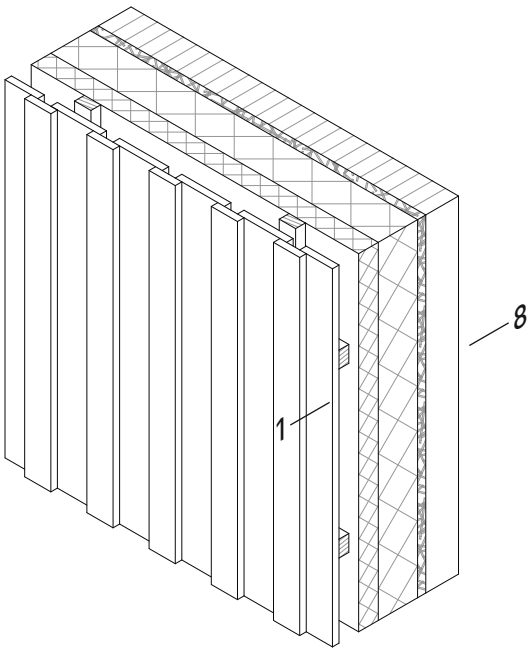
Component	[A • C • D] kg CO ₂ e/m ³	Function	Assembly
1 Wooden Cladding 25mm	[-632.25 • 771.74 • -393.60]		
2 Horizontal Battening 30×50mm	[-685.70 • 815.02 • -329.50]		
3 Vertical Battening 30×50mm	[-685.70 • 815.02 • -329.50]		
4 Lamination Layer	[not specified]		
5 Rock Wool 160mm	[133.90 • 3.89 • 0.00]		
6 KVH-Ständer 80×160mm	[-721.70 • 810.21 • -351.40]		
7 CLT Panel 95mm	[-658.00 • 792.50 • -306.00]		
8 Vapour Barrier	[not specified]		
9 Reed Mat 12.5mm	[0.05 • 0.08 • -0.02]		
10 Clay Plaster 20mm	[93.00 • 4.00 • -3.00]		

STRUCTURAL TIMBER
(Insulated)

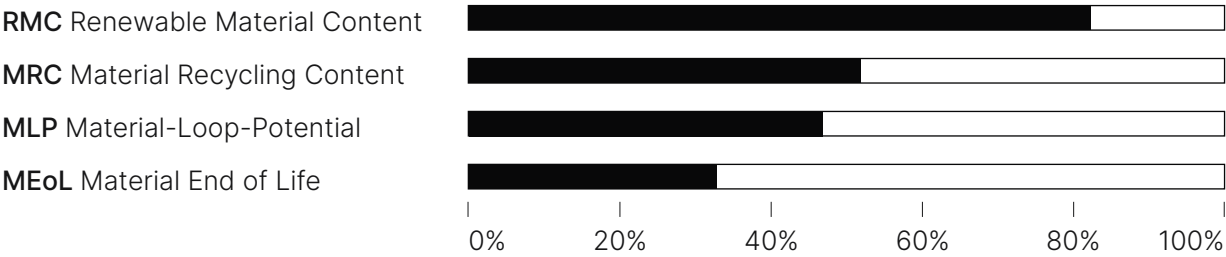
-52.34 kg CO2e/m²	A: -3161.0 kg CO2e
-1247.50 kg CO2e/m³	C: 3881.4 kg CO2e
	D: -1968.0 kg CO2e

Section 1m x 1m x 385mm

Massive timber panels support a wood fiber insulation clad in wood slats.



RECYCLABILITY STATUS



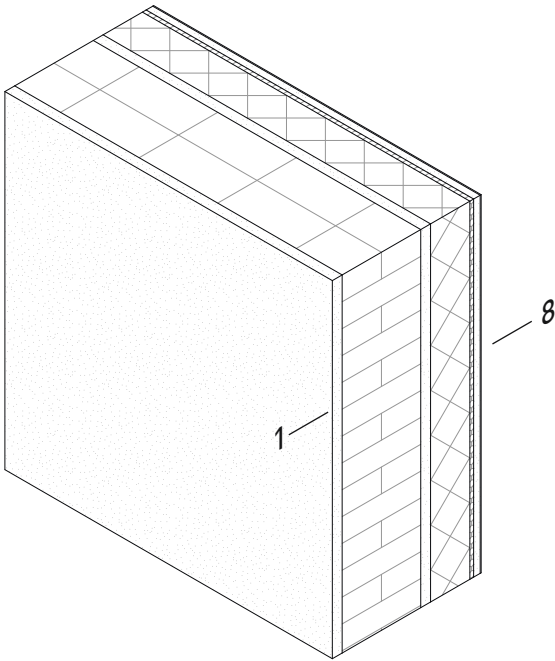
Component	[A • C • D] kg CO2e/m³	Function	Assembly
1 Wooden Cladding 25mm	[-632.25 • 771.74 • -393.60]		
2 Horizontal Battening 30×50mm	[-721.70 • 810.21 • -351.40]		
3 Vertical Battening 30×50mm	[-721.70 • 810.21 • -351.40]		
4 PE Foil	[not specified]		
5 Wood Fiber Underlay Board 60mm	[-198.00 • 270.00 • -184.00]		
6 Wood Fiber Insulation Board 120mm	[-198.00 • 270.00 • -184.00]		
7 OSB/3 Wood Particle Board 25mm	[-753.00 • 967.00 • -549.00]		
8 Board Stack (dowelled) 100mm	[-658.00 • 792.50 • -306.00]		

CLAY BRICK MASONRY
(Insulated)

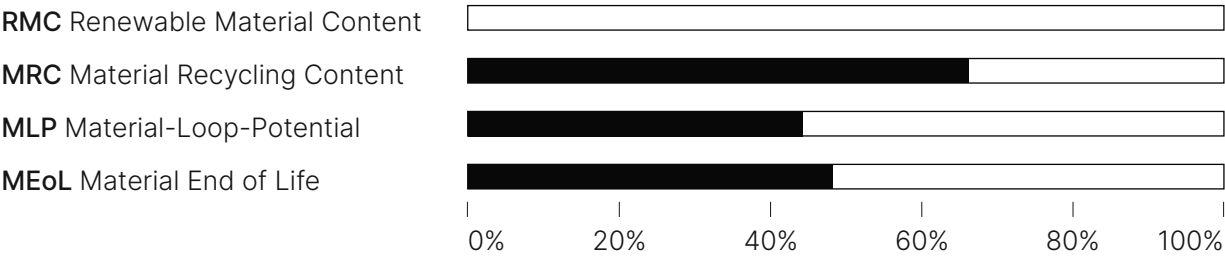
20.58 kg CO2e/m²	A: 268.2 kg CO2e
355.81 kg CO2e/m³	B: 288.9 kg CO2e
	C: -201.3 kg CO2e

Section 1m x 1m x 455mm

Unfired clay brick masonry supports a wood fiber insulation board and finished in a clay plaster.



RECYCLABILITY STATUS



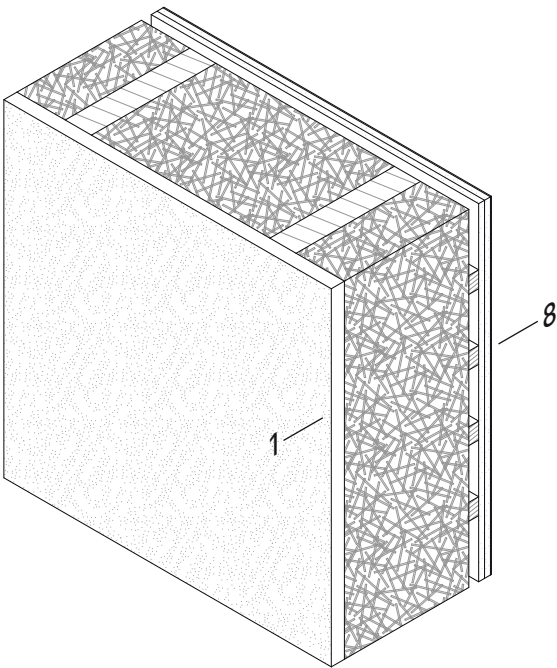
Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Clay Exterior Plaster 30mm	[93.15 + 2.81 + -3.89]		
2 Wire Mesh	[not specified]		
3 Clay Brick Masonry 240mm	[93.64 + 7.68 + -1.76]		
4 Clay Primer Plaster 30mm	[93.15 + 2.81 + -3.89]		
5 Wood Fiber Insulation Board 120mm	[-198.00 + 270.00 + -184.00]		
6 Reed Mat	[not specified]		
7 Clay Primer Plaster 20mm	[93.15 + 2.81 + -3.89]		
8 Clay Finishing Plaster 3mm	[93.15 + 2.81 + -3.89]		

TIMBER-STRAW FRAME
(Insulated)

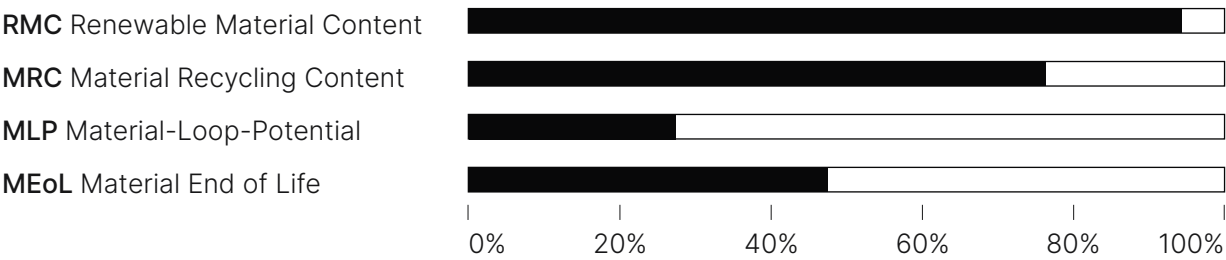
-29.48 kg CO2e/m²	A: -1281.3 kg CO2e
-639.88 kg CO2e/m³	C: 1771.0 kg CO2e
	D: -706.7 kg CO2e

Section 1m x 1m x 490mm

A timber frabem supports a straw bale insulation fill of 380mm clad in an exterior lime plaster.



RECYCLABILITY STATUS



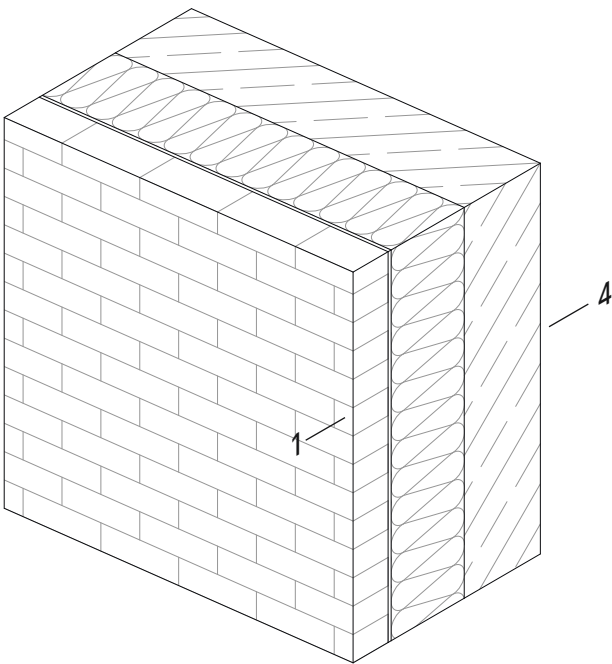
Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Lime Plaster 40mm	[190.60 + 13.50 + 0.00]		
2 Wire Mesh	[not specified]		
3 Holzständer 80×380mm	[-721.70 + 810.21 + -351.40]		
4 Straw Bale Infill 380mm	[-127.00 + 134.00 + 0.00]		
5 Horizontal Battening 30×50mm	[-721.70 + 810.21 + -351.40]		
6 Gypsum Fiberboard 18mm	[5.37 + 0.24 + -0.05]		
7 Gypsum Fiberboard 18mm	[5.37 + 0.24 + -0.05]		
8 Clay Plaster 3mm	[93.15 + 2.81 + -3.89]		

REINFORCED CONCRETE
WITH FACED BRICKWORK
(Double Shell)

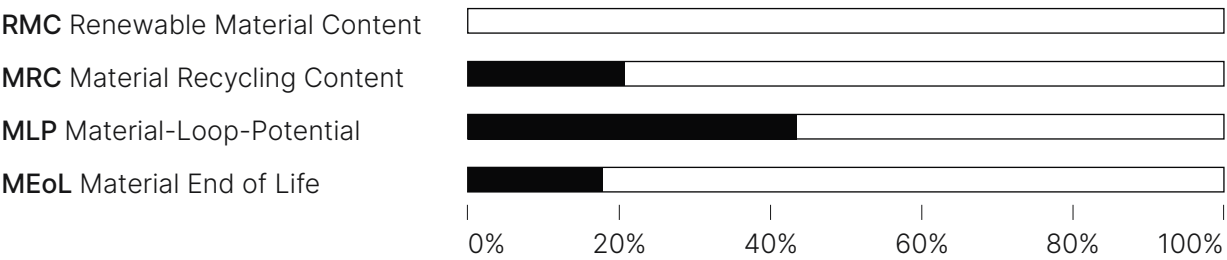
156.46 kg CO2e/m ²	A: 789.8 kg CO2e
928.85 kg CO2e/m ³	B: 34.6 kg CO2e
	C: -25.5 kg CO2e

Section 1m x 1m x 615mm

Reinforced concrete supports a faced brickwork overlay insulated with rockwool.



RECYCLABILITY STATUS



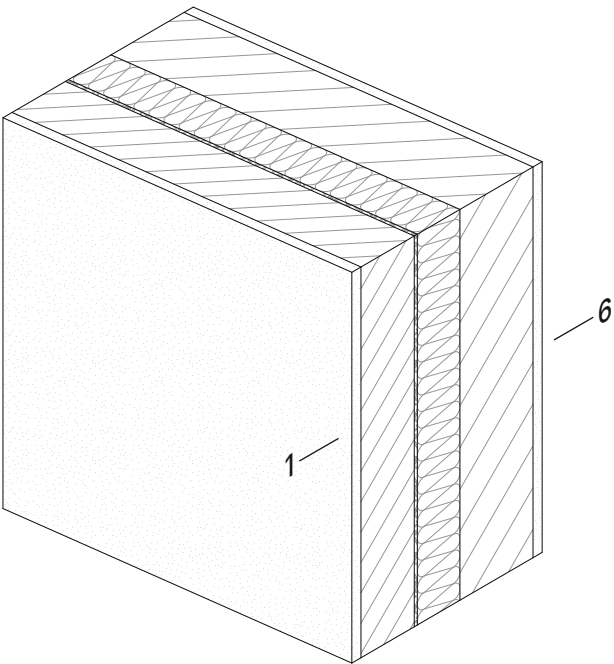
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Solid Brick Masonry 115mm	[541.90 ÷ 13.45 ÷ -4.11]		
2 Air Layer 10mm	[not specified]		
3 Rock Wool 240mm	[133.90 ÷ 3.89 ÷ 0.00]		
4 Reinforced Concrete 250mm	[244.00 ÷ 21.11 ÷ -21.40]		

LIME SILICA MASONRY
(Double Shell)

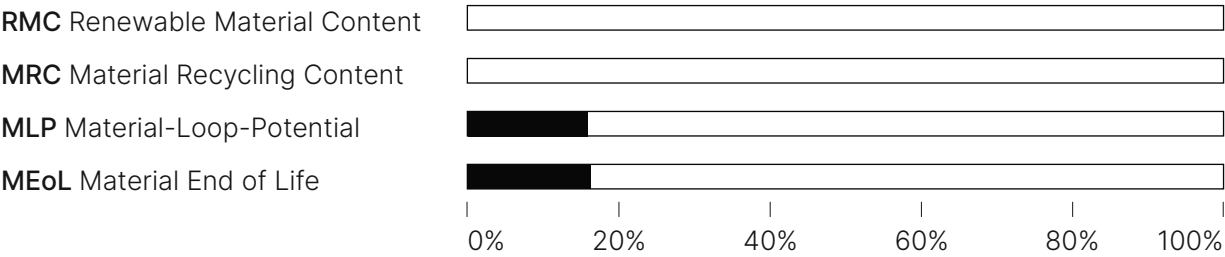
6.12 kg CO2e/m²	A: 1127.3 kg CO2e
204.10 kg CO2e/m³	C: 70.6 kg CO2e
	D: -8.2 kg CO2e

Section 1m x 1m x 625mm

Lime silica brickwork supports a rock wool insulation clad in lime plaster.



RECYCLABILITY STATUS



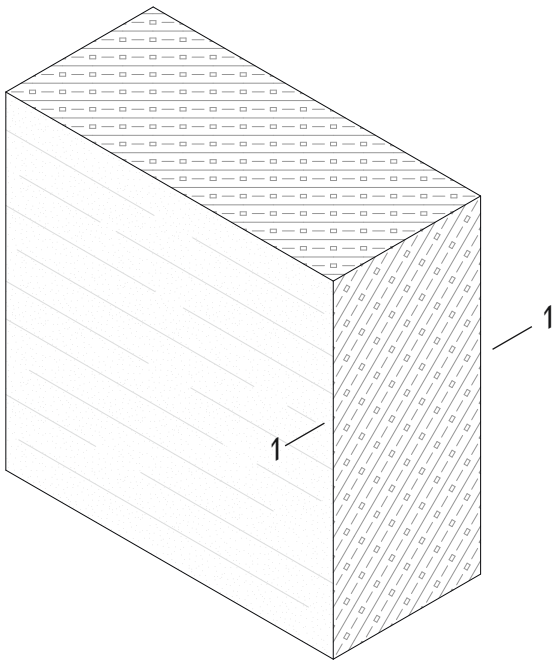
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Lime Plaster 30mm	[190.60 ÷ 13.50 ÷ 0.00]		
2 Sand-Lime Brick Masonry 175mm	[306.10 ÷ 19.87 ÷ -4.11]		
3 Air Layer 10mm	[not specified]		
4 Rock Wool 140mm	[133.90 ÷ 3.89 ÷ 0.00]		
5 Sand-Lime Brick Masonry 240mm	[306.10 ÷ 19.87 ÷ -4.11]		
6 Lime Plaster 30mm	[190.60 ÷ 13.50 ÷ 0.00]		

THERMO-CONCRETE

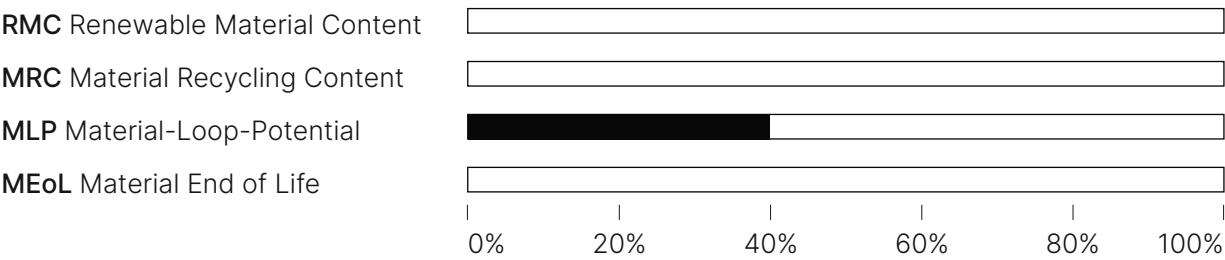
98.37 kg CO2e/m ²	A: 292.0 kg CO2e
218.60 kg CO2e/m ³	B: 20.7 kg CO2e
	C: -94.1 kg CO2e

Section 1m x 1m x 450mm

Thermoe concrete acts as both a self supporting as well as insulating envelope component.



RECYCLABILITY STATUS



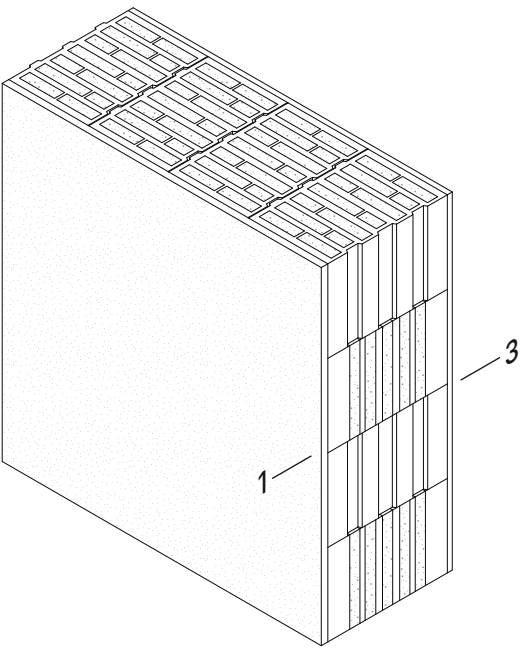
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Insulating Concrete 450mm	[292.00 ÷ 20.70 ÷ -94.10]	<div><div></div><div>°C</div><div></div></div>	<div></div>

INSULATING BRICK
(Poroton)

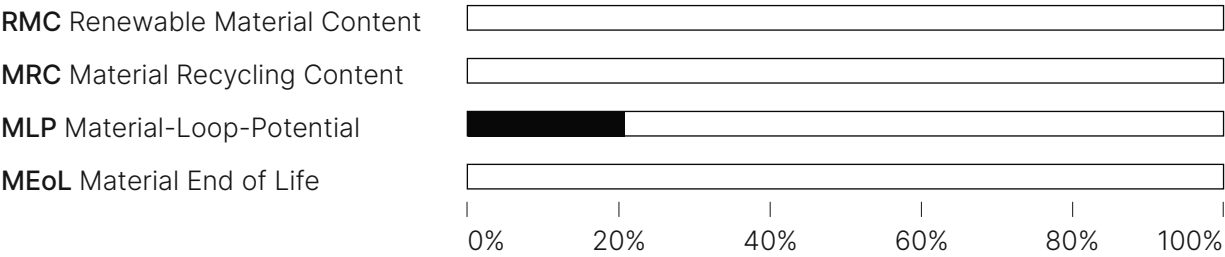
60.07 kg CO2e/m²	A: 527.2 kg CO2e
553.21 kg CO2e/m³	C: 27.9 kg CO2e
	D: -1.9 kg CO2e

Section 1m x 1m x 400mm

Insulated Poroton bricks for a modular support structure clad in lime plaster.



RECYCLABILITY STATUS



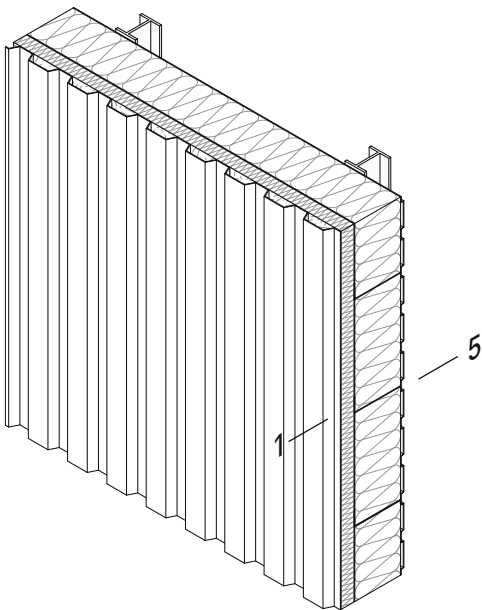
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Lime Lightweight Plaster 20mm	[190.60 ÷ 13.50 ÷ 0.00]		
2 Perlite-Filled Porotone Brick 365mm	[146.00 ÷ 0.91 ÷ -1.90]		
3 Lime Lightweight Plaster 15mm	[190.60 ÷ 13.50 ÷ 0.00]		

STEEL FRAME
(Insulated)

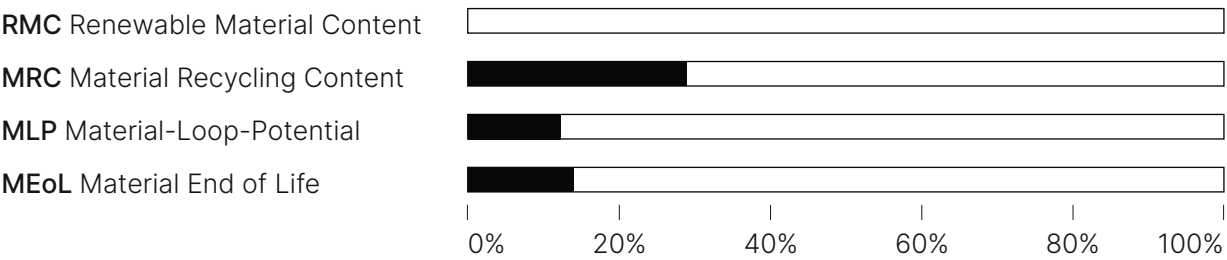
40.63 kg CO2e/m ²	A: 3642.8 kg CO2e
2414.59 kg CO2e/m ³	B: 10.7 kg CO2e
	C:-1239.0 kg CO2e

Section 1m x 1m x 280mm

Steel cassette acts as a supporting structure for a rock wool insulation clad in steel sheeting.



RECYCLABILITY STATUS



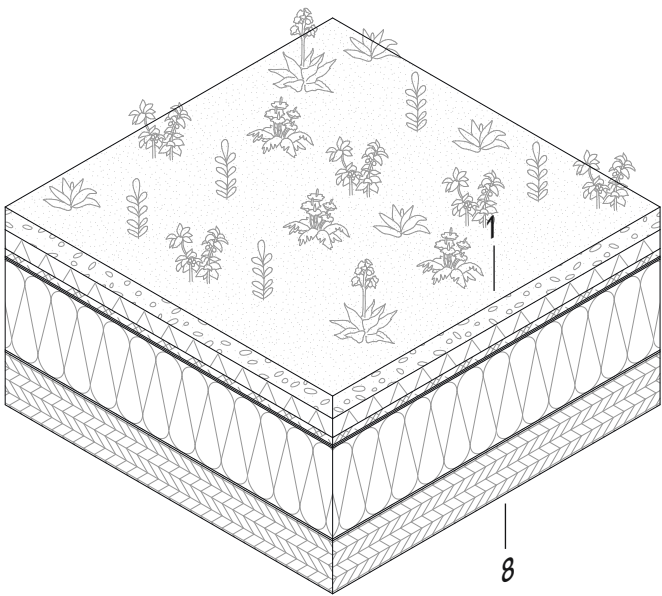
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Trapezoidal Steel Sheet t=2mm	[1125.00 ÷ 1.00 ÷ -413.00]		
2 Mineral Fiber Insulation Board 40mm	[133.90 ÷ 3.89 ÷ 0.00]		
3 Steel Cassette 140mm (t=2mm)	[1125.00 ÷ 1.00 ÷ -413.00]		
4 Rock Wool Infill 140mm	[121.00 ÷ 1.00 ÷ -3.00]		
5 Steel Column 60×80mm	[1125.00 ÷ 1.00 ÷ -413.00]		

FLAT ROOF
(Solid Wood Construction)

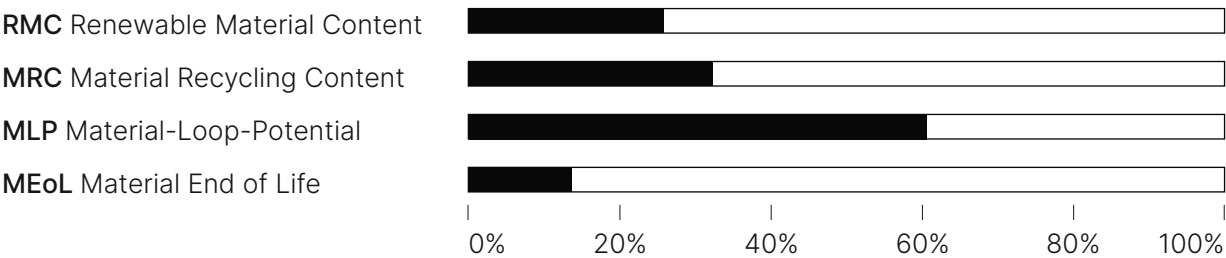
-24.01 kg CO2e/m²	A: -606.3 kg CO2e
-171.50 kg CO2e/m³	C: 915.3 kg CO2e
	D: -364.9 kg CO2e

Section 1m x 1m x 525mm

A green roof is supported by a CLT panel structure and insulated with EPS boards.



RECYCLABILITY STATUS



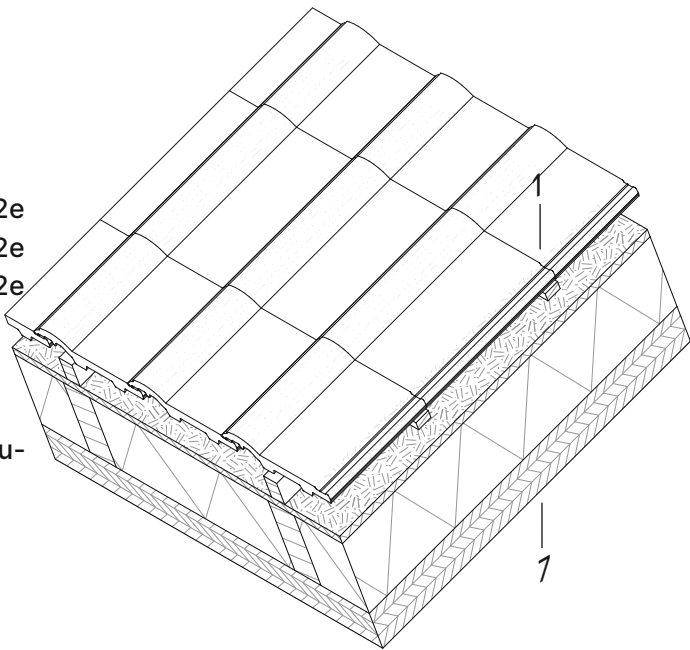
Component	[A • C • D] kg CO2e/m³	Function	Assembly
1 Extensive Roof Greening	[not specified]		
2 Planting Substrate 60mm	[-0.05 • 0.01 • 0.00]		
3 Drainage Layer 50mm	[3.79 • 67.80 • -35.90]		
4 Protection / Storage Fleece	[not specified]		
5 Bituminous Sheeting	[not specified]		
6 EPS Insulation Board 240mm	[48.00 • 55.00 • -23.00]		
7 Bituminous Sheeting	[not specified]		
8 CLT Panel 140mm	[-658.00 • 792.50 • -306.00]		

SLOPED ROOF
(Lightweight Construction)

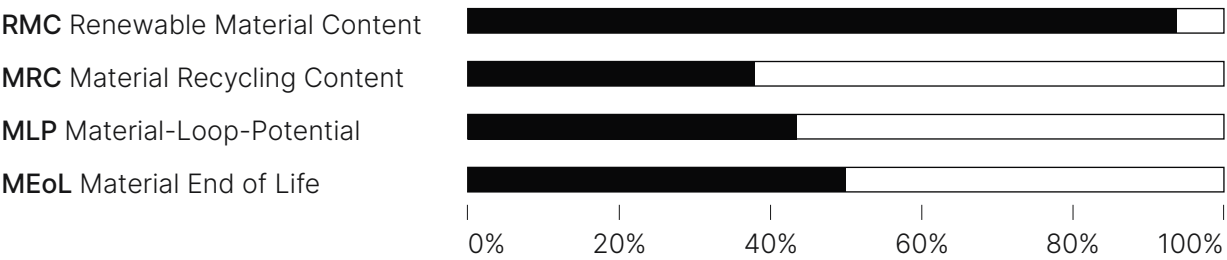
-20.58 kg CO2e/m ²	A:-2481.5 kg CO2e
-171.50 kg CO2e/m ³	B: 2953.2 kg CO2e
	C:-1376.9 kg CO2e

Section 1m x 1m x 500mm

Timber CLT panel supports a clay tiled roof insulated with wood fiber boards.



RECYCLABILITY STATUS



Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Clay Roof Tiles 50mm	[15.88 ÷ 0.03 ÷ -0.09]		
2 Horizontal Battening 24×30mm	[-721.70 ÷ 810.21 ÷ -351.40]		
3 Vertical Battening 40×60mm	[-721.70 ÷ 810.21 ÷ -351.40]		
4 Wood Fiber Sarking Board 22mm	[-198.00 ÷ 270.00 ÷ -184.00]		
5 Wood Fiber Insulation Board 240mm	[-198.00 ÷ 270.00 ÷ -184.00]		
6 Sealing Sheet	[not specified]		
7 CLT Panel 120mm	[-658.00 ÷ 792.50 ÷ -306.00]		

FLAT ROOF (Green Roof)

53.62 kg CO₂e/m²

243.71 kg CO₂e/m³

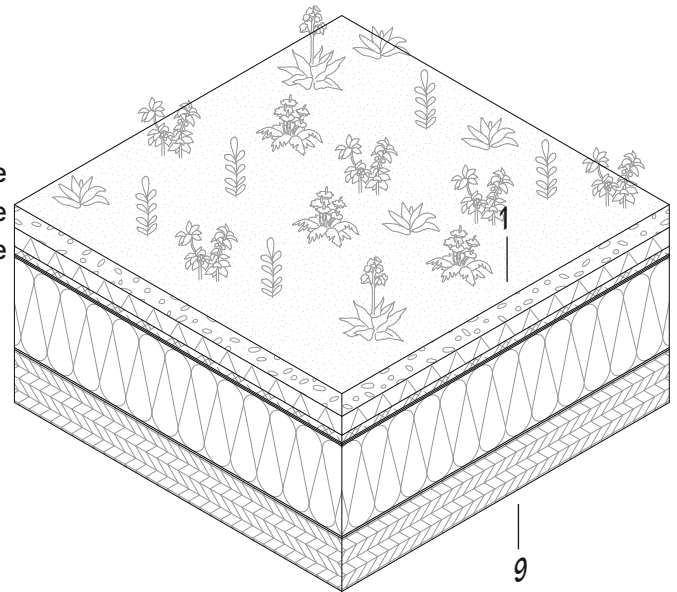
A: 323.1 kg CO₂e

C: 81.3 kg CO₂e

D: -172.4 kg CO₂e

Section 1m x 1m x 600mm

A green roof is supported by a reinforced concrete plan and insulated with EPS board.



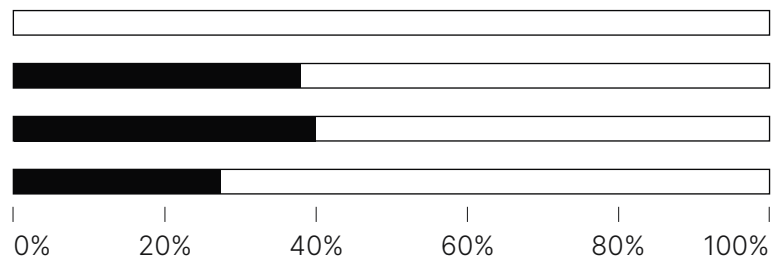
RECYCLABILITY STATUS

RMC Renewable Material Content

MRC Material Recycling Content

MLP Material-Loop-Potential

MEoL Material End of Life



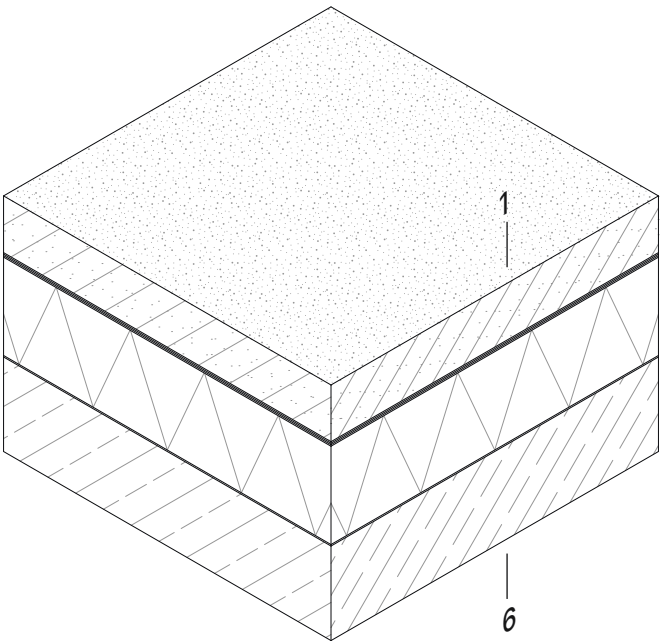
Component	[A • C • D] kg CO ₂ e/m ³	Function	Assembly
1 Extensive Roof Greening	[not specified]		
2 Planting Substrate 80mm	[-0.05 • 0.01 • 0.00]		
3 Drainage Layer 40mm	[31.16 • 5.19 • -128.00]		
4 Protection / Storage Fleece	[not specified]		
5 Bituminous Sheeting	[not specified]		
6 EPS Insulation Board 240mm	[48.00 • 55.00 • -23.00]		
7 Bituminous Sheeting	[not specified]		
8 Bituminous Primer	[not specified]		
9 Reinforced Concrete 220mm	[244.00 • 21.11 • -21.4]		

FLAT ROOF
(Top Shell)

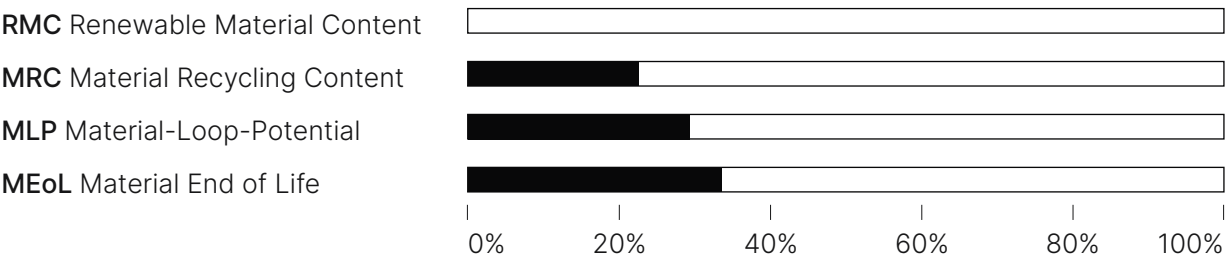
81.74 kg CO2e/m ²	A: 292.1 kg CO2e
323.81 kg CO2e/m ³	B: 76.1 kg CO2e
	C: -44.4 kg CO2e

Section 1m x 1m x 675mm

Reinforced concrete insulated with EPS boards and clad in a gravel substrate.



RECYCLABILITY STATUS



Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Gravel 150mm	[0.10 ÷ 0.01 ÷ -0.01]		
2 Bituminous Sheetting	[not specified]		
3 EPS Insulation Board 260mm	[48.00 ÷ 55.00 ÷ -23.00]		
4 Bituminous Sheetting	[not specified]		
5 Bituminous Primer	[not specified]		
6 Reinforced Concrete 250mm	[244.00 ÷ 21.11 ÷ -21.40]		

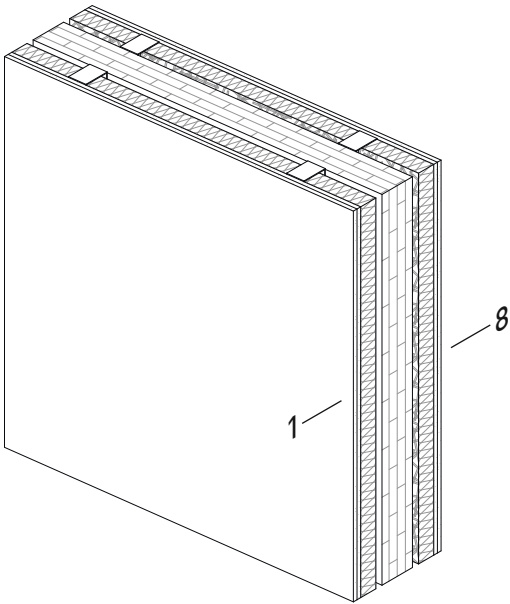
Space

STRUCTURAL TIMBER

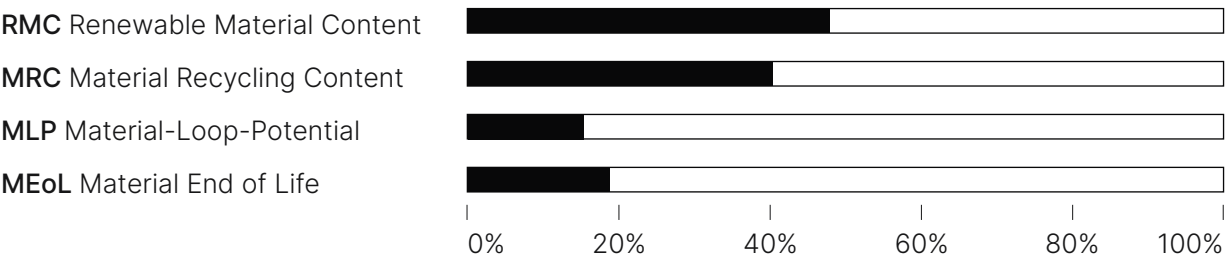
-21.80 kg CO2e/m²	A:-1958.3 kg CO2e
-549.80 kg CO2e/m³	C: 2417.4 kg CO2e
	D:-1008.9 kg CO2e

Section 1m x 1m x 288mm

Gypsum fiberboard are supported by CLT paneling connected over a vertical battening.



RECYCLABILITY STATUS



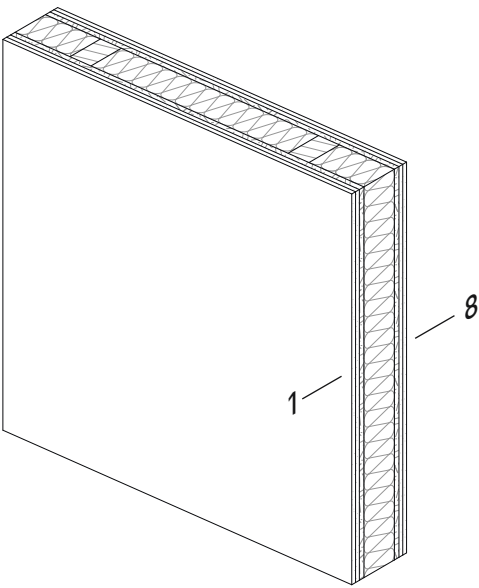
Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		
2 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		
3 Vertical Battening 50×70mm	[-721.70 + 810.21 + -351.40]		
4 Mineral Fiber Insulation Board 50mm	[133.90 + 3.89 + 0.00]		
5 CLT Panel 100mm	[-658.00 + 792.50 + -306.00]		
6 Vertical Battening 50×70mm	[-721.70 + 810.21 + -351.40]		
7 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		
8 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		

TIMBER FRAME

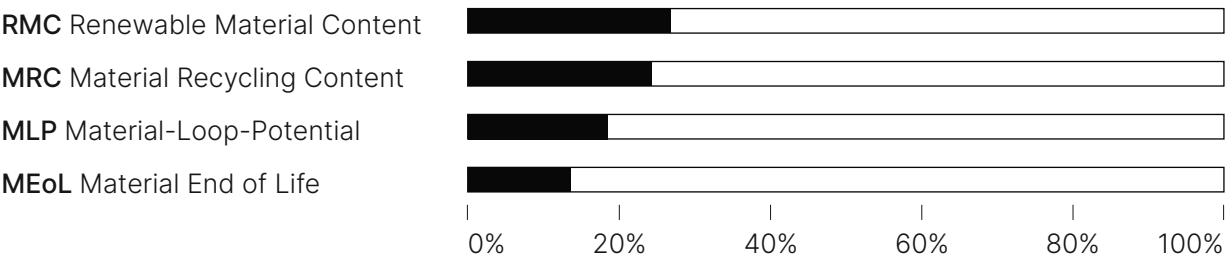
6.40 kg CO2e/m²	A:-2021.9 kg CO2e
-729.57 kg CO2e/m³	B: 2747.2 kg CO2e
	C:-1455.0 kg CO2e

Section 1m x 1m x 180mm

Bypsum fiberboard is supported by a solid wood frame and insulated with rock wool.



RECYCLABILITY STATUS



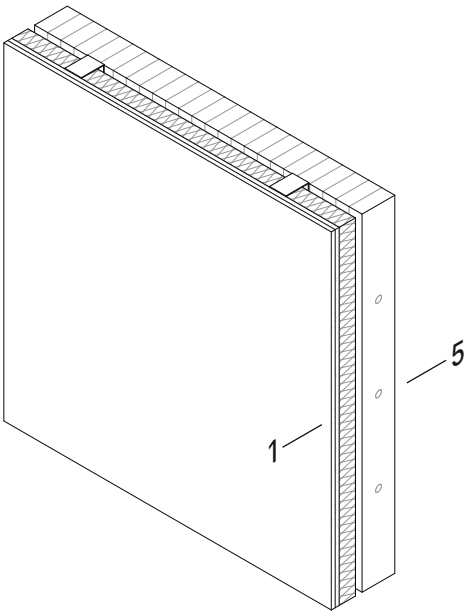
Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		
2 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		
3 OSB/3 Wood Particle Board 15mm	[-753.00 + 967.00 + -549.00]		
4 KVH Ständer 60×100mm	[-721.70 + 810.21 + -351.40]		
5 Rock Wool 100mm	[196.6 + 2.46 + -5.42]		
6 OSB/3 Wood Particle Board 15mm	[-753.00 + 967.00 + -549.00]		
7 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		
8 Gypsum Fiberboard 12.5mm	[4.62 + 0.29 + -0.07]		

DOWEL LAMINATED TIMBER

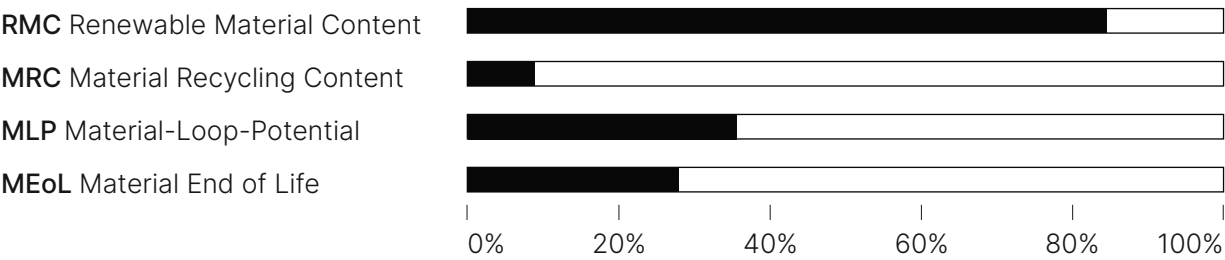
-28.54 kg CO2e/m²	A:-1241.2 kg CO2e
-291.75 kg CO2e/m³	C: 1606.9 kg CO2e
	D: -657.4 kg CO2e

Section 1m x 1m x 195mm

Massive timber panels connected via dowls are clad in gypsum fiberboard.



RECYCLABILITY STATUS



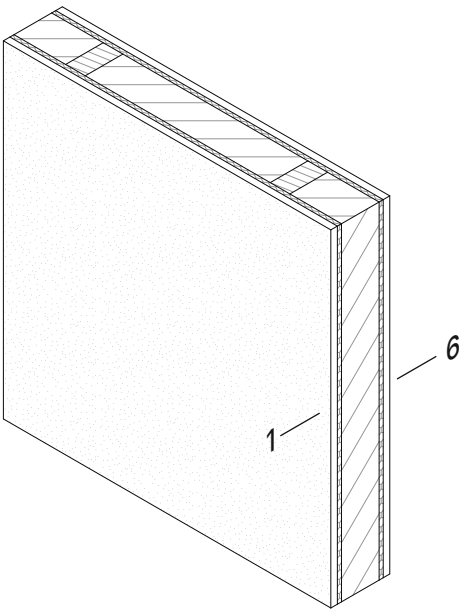
Component	[A ◦ C ◦ D] kg CO2e/m³	Function	Assembly
1 Gypsum Fiberboard 12.5mm	[0.18 ◦ 0.03 ◦ 0.00]		
2 Gypsum Fiberboard 12.5mm	[4.62 ◦ 0.29 ◦ -0.07]		
3 Vertical Battening 40×70mm	[-721.70 ◦ 810.21 ◦ -351.40]		
4 Mineral Fiber Insulation Board 50mm	[133.90 ◦ 3.89 ◦ 0.00]		
5 Board Stack (dowelled) 100mm	[-658.00 ◦ 792.50 ◦ -306.00]		

TIMBER POST AND BEAM
WITH CLAY BRICK

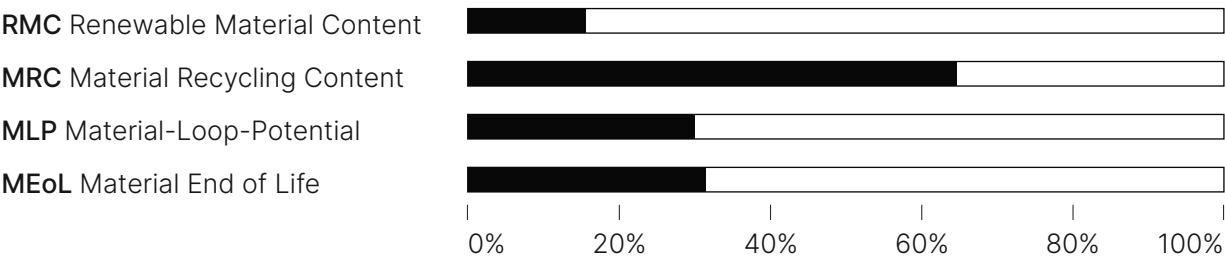
11.50 kg CO2e/m²	A: -441.8 kg CO2e
20.79 kg CO2e/m³	B: 823.5 kg CO2e
	C: -360.9 kg CO2e

Section 1m x 1m x 180mm

Unfired clay brick supported by a solid timber frame are clad in clay plaster.



RECYCLABILITY STATUS



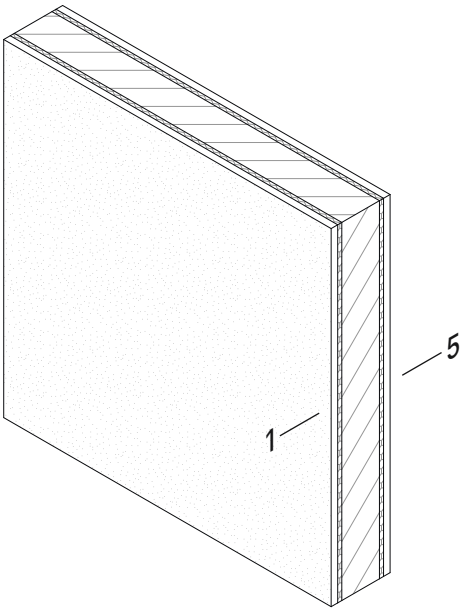
Component	[A ◦ C ◦ D] kg CO2e/m³	Function	Assembly
1 Clay Plaster 20mm	[93.15 ◦ 2.81 ◦ -3.89]		
2 Reed Mat	[not specified]		
3 Clay / Adobe Masonry 115mm	[93.64 ◦ 7.68 ◦ -1.76]		
4 KVH-Ständer 60×115mm	[-721.70 ◦ 810.21 ◦ -351.40]		
5 Reed Mat	[not specified]		
6 Clay Plaster 20mm	[93.15 ◦ 2.81 ◦ -3.89]		

CLAY BRICK MASONRY

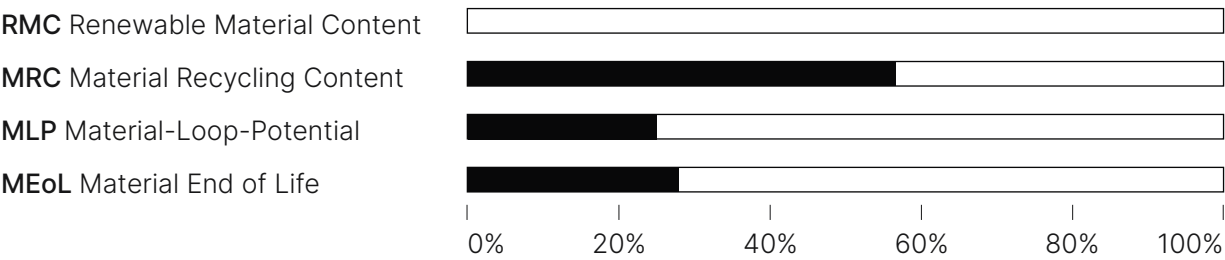
15.13 kg CO2e/m ²	A: 279.9 kg CO2e
283.68 kg CO2e/m ³	C: 13.3 kg CO2e
	D: -9.5 kg CO2e

Section 1m x 1m x 180mm

A solid unfired clay brick masonry is clad in an air moisture regulating clay plaster.



RECYCLABILITY STATUS



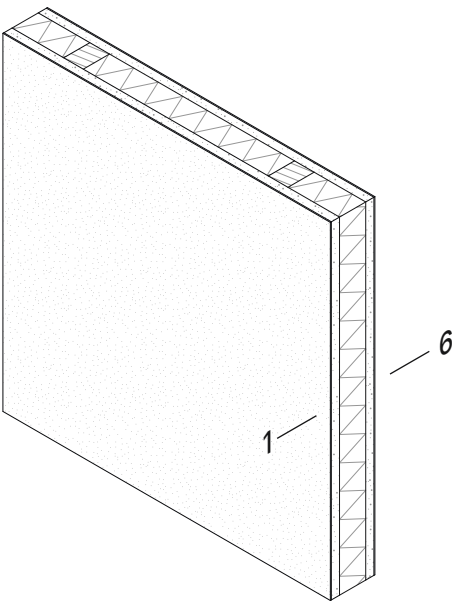
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Clay Plaster 20mm	[93.15 ÷ 2.81 ÷ -3.89]		
2 Reed Mat	[not specified]		
3 Clay Brick Masonry 115mm	[93.64 ÷ 7.68 ÷ -1.76]		
4 Reed Mat	[not specified]		
5 Clay Plaster 20mm	[93.15 ÷ 2.81 ÷ -3.89]		

TIMBER FRAME
WITH CLAY DRYWALL BOARDS

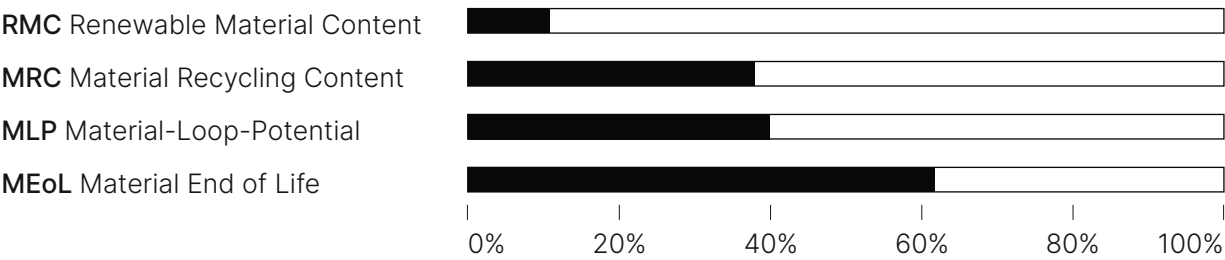
-10.93 kg CO2e/m²	A: -733.3 kg CO2e
-190.53 kg CO2e/m³	B: 1086.0 kg CO2e
	C: -543.2 kg CO2e

Section 1m x 1m x 135mm

A timber frame insulated with wood fiber board is clad in clay building board finished with clay plaster.



RECYCLABILITY STATUS



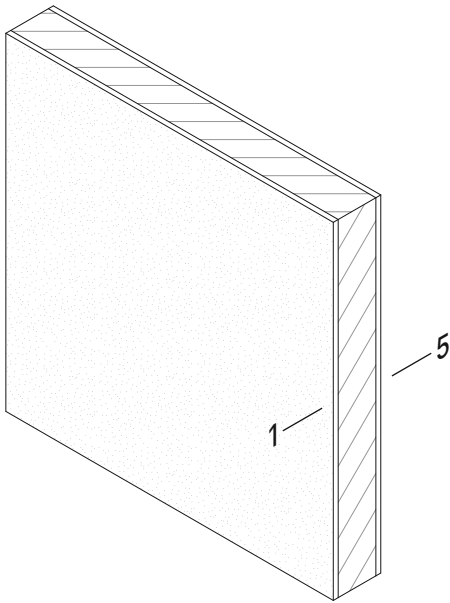
Component	[A ◦ C ◦ D] kg CO2e/m³	Function	Assembly
1 Clay Finishing Plaster 3mm	[93.15 ◦ 2.81 ◦ -3.89]		
2 Clay Building Board 25mm	[0.05 ◦ 0.08 ◦ -0.02]		
3 Wood Fiber Insulation Board 80mm	[-198.00 ◦ 270.00 ◦ -184.00]		
4 KVH-Ständer 60×80mm	[-721.70 ◦ 810.21 ◦ -351.40]		
2 Clay Building Board 25mm	[0.05 ◦ 0.08 ◦ -0.02]		
6 Clay Finishing Plaster 3mm	[93.15 ◦ 2.81 ◦ -3.89]		

BRICK MASONRY

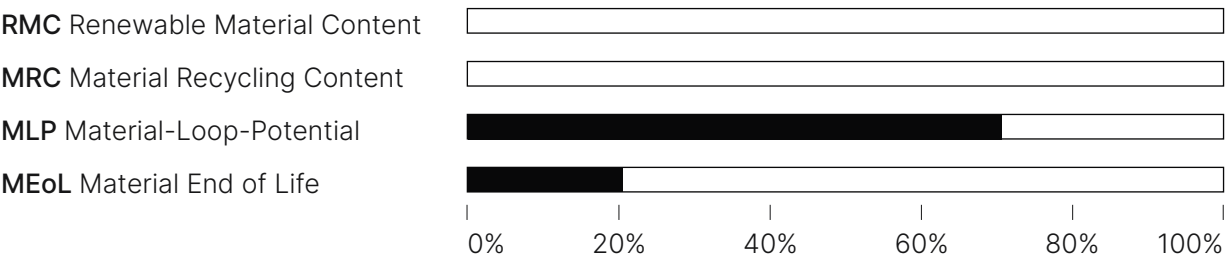
69.52 kg CO2e/m²	A: 923.1 kg CO2e
959.44 kg CO2e/m³	C: 40.4 kg CO2e
	D: -4.1 kg CO2e

Section 1m x 1m x 150mm

Brick masonry clad in a lime cement plaster.



RECYCLABILITY STATUS



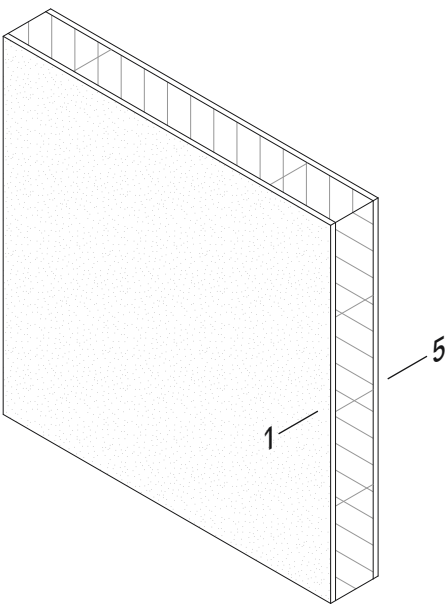
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Lime-Cement Plaster 15mm	[190.60 ÷ 13.50 ÷ 0.00]		
2 Fiber Fabric	[not specified]		
3 Brick Masonry 115mm	[541.90 ÷ 13.45 ÷ -4.11]		
4 Fiber Fabric	[not specified]		
5 Lime-Cement Plaster 15mm	[190.60 ÷ 13.50 ÷ 0.00]		

CONCRETE BRICK MASONRY

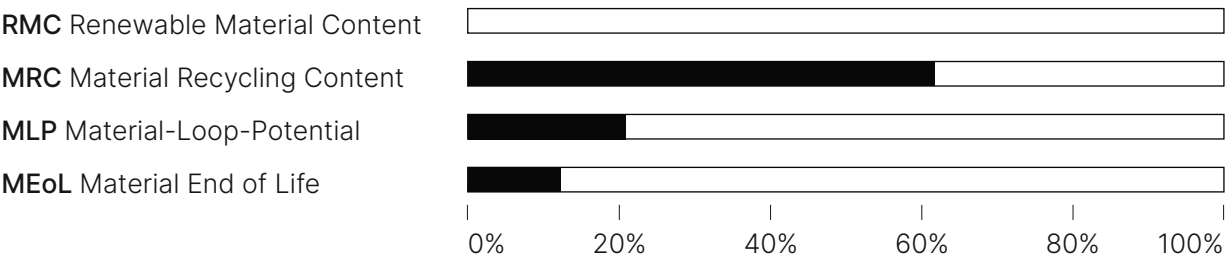
11.57 kg CO2e/m ²	A: 424.2 kg CO2e
455.56 kg CO2e/m ³	B: 32.4 kg CO2e
	C: -1.0 kg CO2e

Section 1m x 1m x 150mm

Concrete brick masonry clad in a lime cement plaster.



RECYCLABILITY STATUS



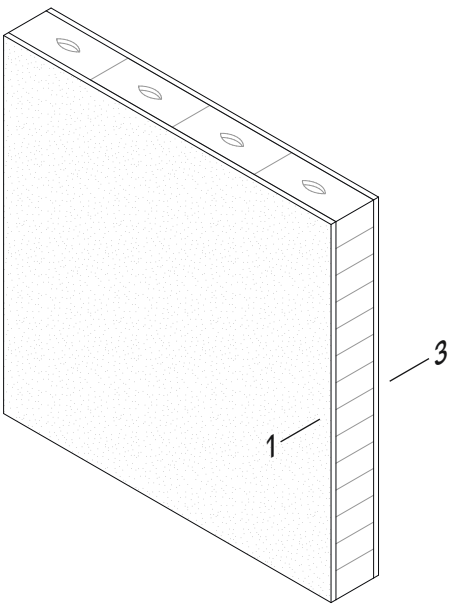
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Lime-Cement Plaster 15mm	[190.60 ÷ 13.50 ÷ 0.00]		
2 Fiber Fabric	[not specified]		
3 Concrete Brick Masonry 115mm	[42.97 ÷ 5.42 ÷ -1.03]		
4 Fiber Fabric	[not specified]		
5 Lime-Cement Plaster 15mm	[190.60 ÷ 13.50 ÷ 0.00]		

LIME SILICA MASONRY

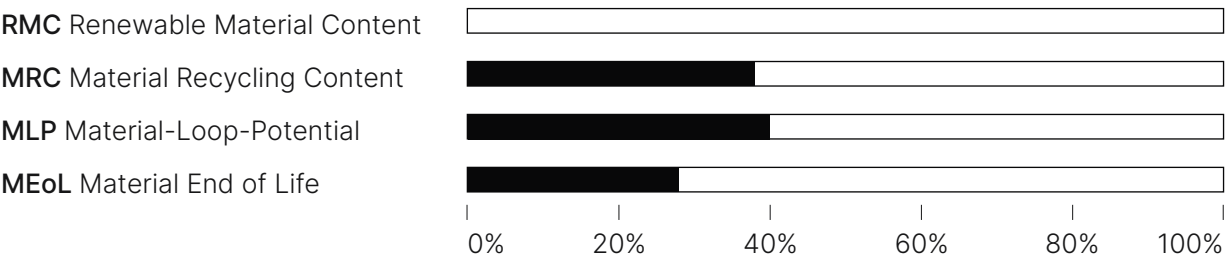
38.99 kg CO2e/m ²	A: 544.1 kg CO2e
585.87 kg CO2e/m ³	C: 45.8 kg CO2e
	D: -4.1 kg CO2e

Section 1m x 1m x 150mm

Lime silica brickwork clad in gypsum plaster.



RECYCLABILITY STATUS



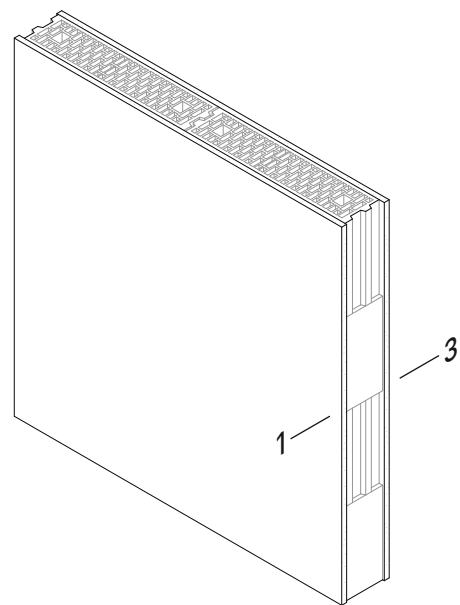
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Gypsum Plaster 15mm	[119.00 ÷ 13.00 ÷ 0.00]		
2 Sand Lime Brick Masonry 115mm	[0.18 ÷ 0.03 ÷ -4.11]		
3 Gypsum Plaster 15mm	[119.00 ÷ 13.00 ÷ 0.00]		

PERFORATED BRICK MASONRY

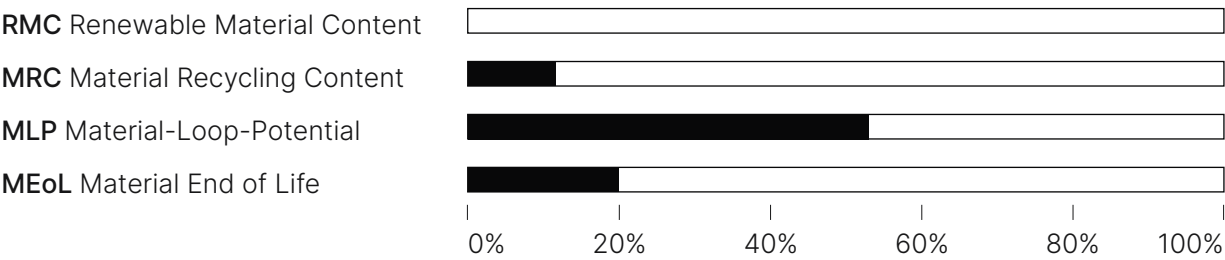
18.35 kg CO2e/m ²	A: 376.3 kg CO2e
389.09 kg CO2e/m ³	B: 19.7 kg CO2e
	C: -7.0 kg CO2e

Section 1m x 1m x 150mm

Perforated brick masonry is clad in gypsum plaster.



RECYCLABILITY STATUS



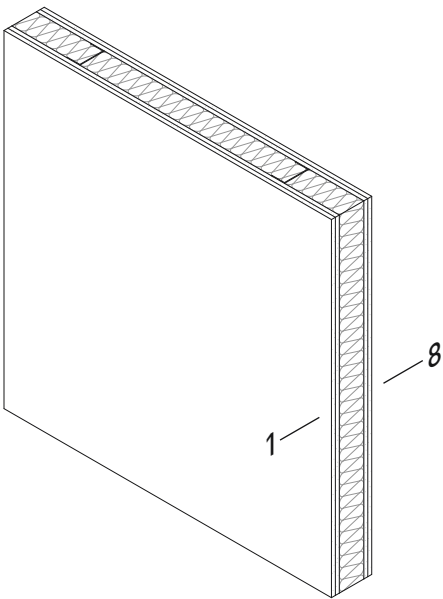
Component	[A ÷ C ÷ D] kg CO2e/m ³	Function	Assembly
1 Gypsum Plaster 15mm	[119.00 ÷ 13.00 ÷ 0.00]		
2 Porotone Brick Masonry 115mm	[138.30 ÷ -6.18 ÷ -7.03]		
3 Gypsum Plaster 15mm	[119.00 ÷ 13.00 ÷ 0.00]		

STEEL FRAME
(Aluminium)

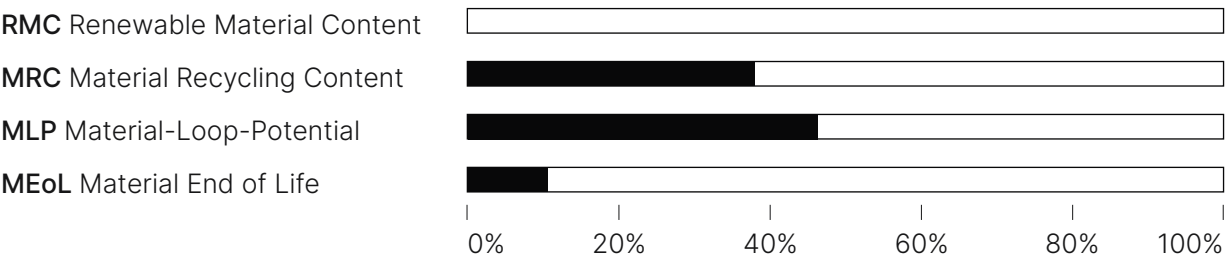
8.15 kg CO2e/m²	A: -577.1 kg CO2e
-114.00 kg CO2e/m³	B: 814.5 kg CO2e
	C: -351.5 kg CO2e

Section 1m x 1m x 125mm

Steel frame supports a rock wool insulation clad in gypsum fiberboard.



RECYCLABILITY STATUS



Component	[A + C + D] kg CO2e/m³	Function	Assembly
1 Gypsum Fiberboard 12.5mm	[5.37 + 0.24 + -0.05]		
2 Gypsum Fiberboard 12.5mm	[5.37 + 0.24 + -0.05]		
3 Separating Strips	[not specified]		
4 Steel Stud Construction 75mm	[-721.70 + 810.21 + -351.40]		
5 Rock Wool Board 75mm	[133.90 + 3.89 + 0.00]		
6 Separating Strips	[not specified]		
7 Gypsum Fiberboard 12.5mm	[5.37 + 0.24 + -0.05]		
8 Gypsum Fiberboard 12.5mm	[5.37 + 0.24 + -0.05]		

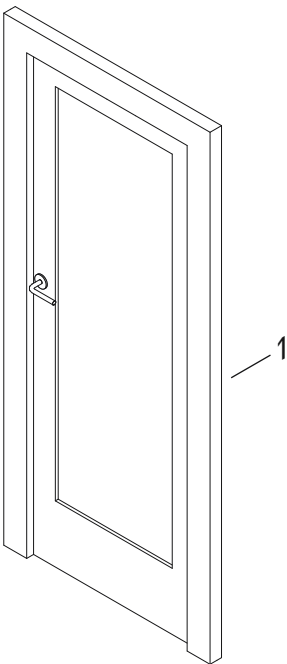
Fittings

WOOD DOOR

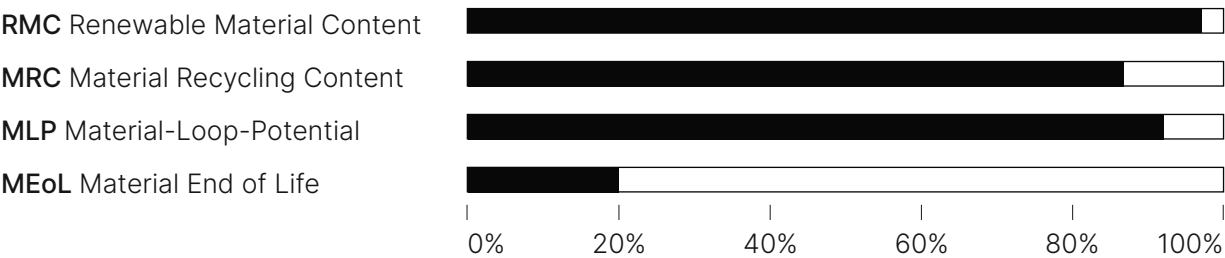
60.04 kg CO2e	A:	6.8 kg CO2e
33.19 kg CO2e/m²	C:	0.4 kg CO2e
	D:	26.0 kg CO2e

Section w=90cm, h=201cm

Timber framed door with solid timber door wing.



RECYCLABILITY STATUS



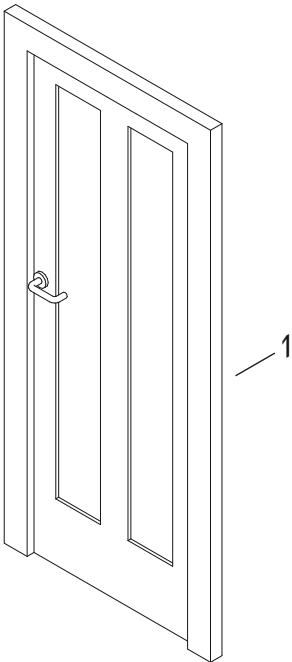
Component	[A ◦ C ◦ D] kg CO2e/m³	Function	Assembly
1 Solid Wooden Door	[6.80 ◦ 0.39 ◦ 26.00]	<div><div></div><div></div></div>	<div><div></div><div></div></div>

WOOD-ALUMINUM-DOOR

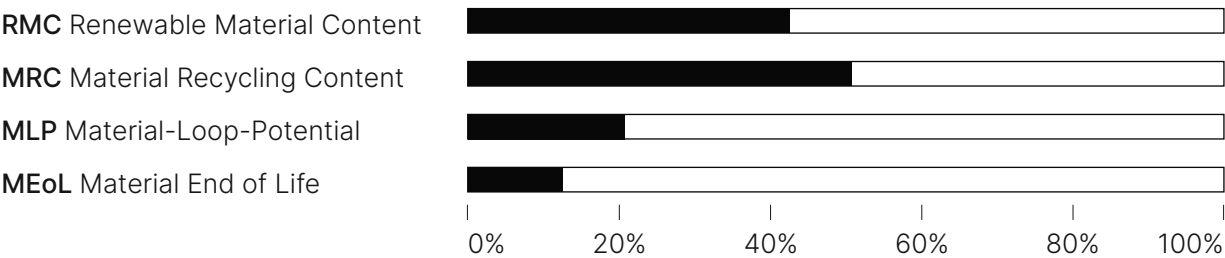
47.03 kg CO2e	A: 38.0 kg CO2e
26.00 kg CO2e/m²	B: 29.0 kg CO2e
	C: -41.0 kg CO2e

Section w=90cm, h=201cm

Timber door frame clad in aluminum with a solid timber door wing.



RECYCLABILITY STATUS



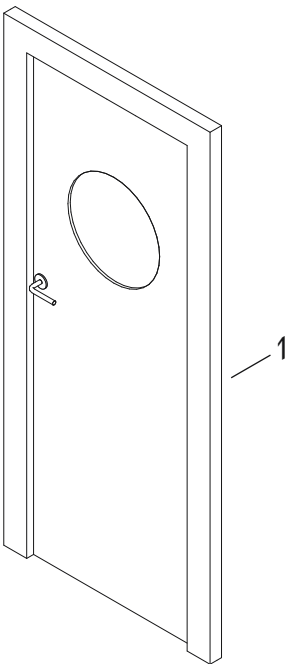
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Aluminium-reinforced Wood Door	[38.00 ÷ 29.00÷ -41.00]		

ALUMINUM-DOOR

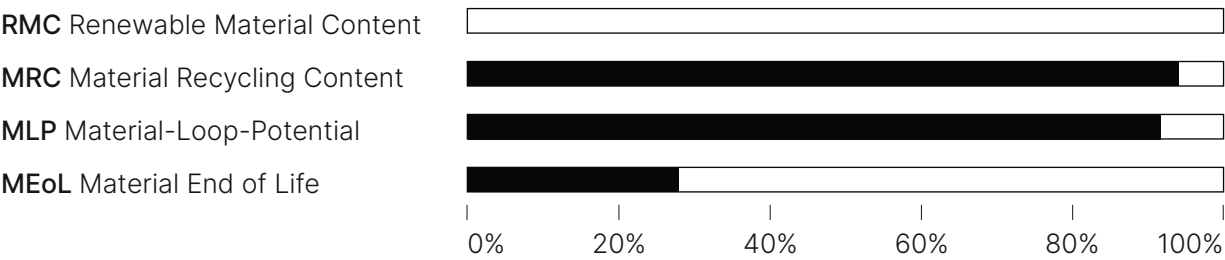
803.20 kg CO2e	A: 629.0kg CO2e
444.0 kg CO2e/m²	C: 4.0 kg CO2e
	D: -189.0 kg CO2e

Section w=90cm, h=201cm

Aluminum door frame filled with an aluminum door wing.



RECYCLABILITY STATUS



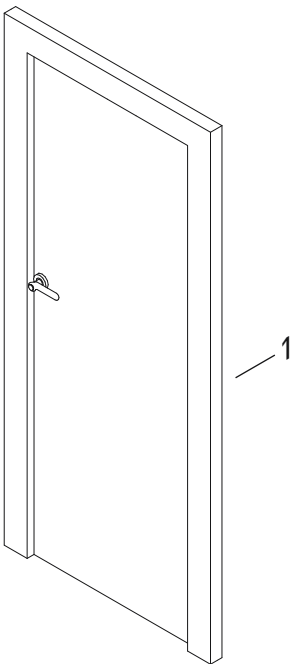
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Aluminium Door (insulated)	[629.00 ÷ 4.00 ÷ -189.00]		

STEEL-DOOR

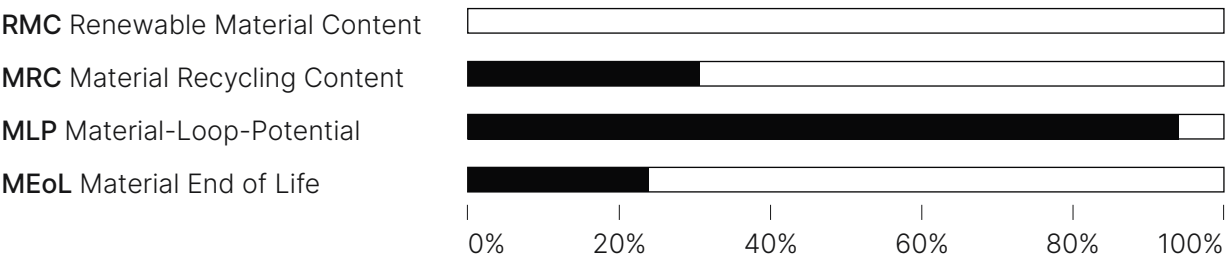
102.69 kg CO2e	A: 86.7 kg CO2e
35.3 kg CO2e/m²	B: -8.8 kg CO2e
	C: -42.6 kg CO2e

Section w=90cm, h=201cm

Steel door frame filled with steel door wing.



RECYCLABILITY STATUS



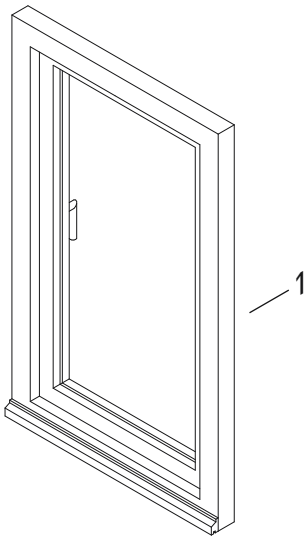
Component	[A ◦ C ◦ D] kg CO2e/m³	Function	Assembly
1 Steel Door (insulated)	[86.70 ◦ -8.81 ◦ -42.60]		

WOOD WINDOW

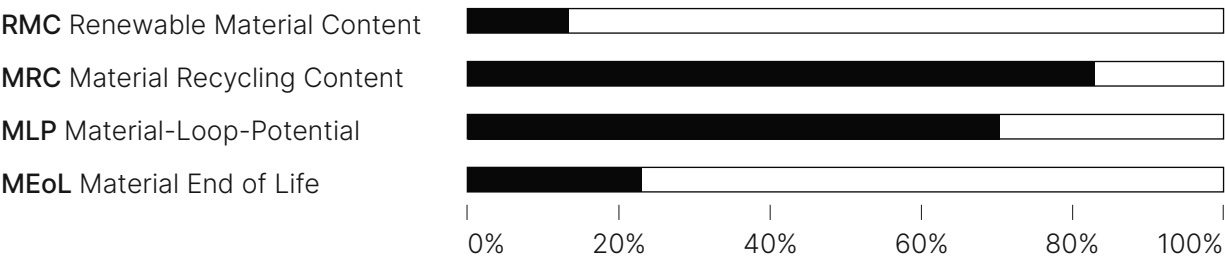
35.10 kg CO2e	A: 38.0 kg CO2e
26.00 kg CO2e/m²	C: 29.0 kg CO2e
	D: -41.0 kg CO2e

Section w=90cm, h=150cm

Timber window frame with double glazing.



RECYCLABILITY STATUS



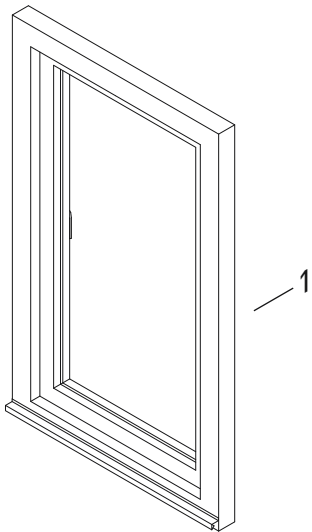
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Solid Wood Window	[38.00 ÷ 29.00 ÷ -41.00]		

WOOD-ALUMINUM-WINDOW

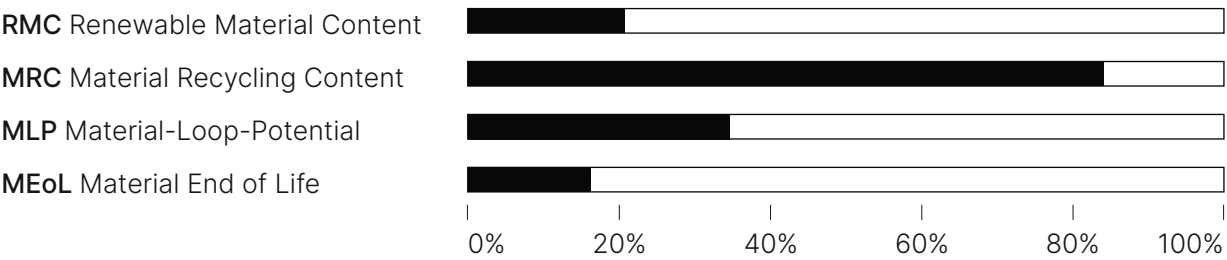
-28.62 kg CO2e	A: 66.6 kg CO2e
-21.2 kg CO2e/m²	B: 1.8 kg CO2e
	C: -23.0 kg CO2e

Section w=90cm, h=150cm

Timber window frame clad in aluminum with a double glazing panel.



RECYCLABILITY STATUS



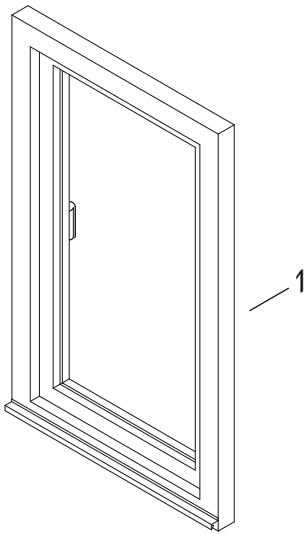
Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Aluminium-reinforced Wood Window	[66,59 ÷ 1.76 ÷ -22.96]		

ALUMINUM-WINDOW

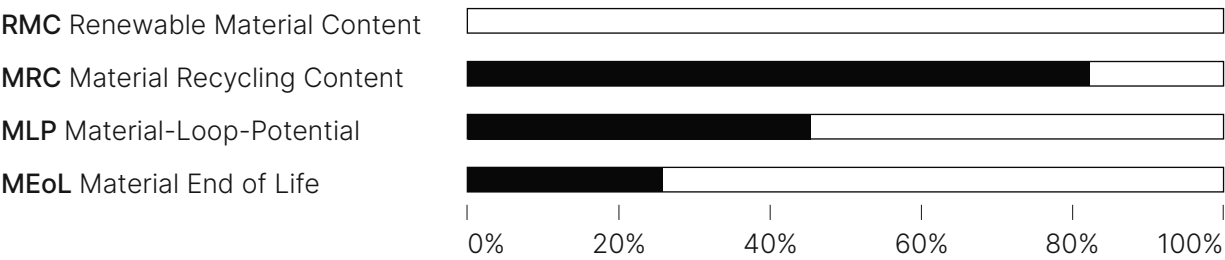
156.06 kg CO2e	A: 173.0 kg CO2e
115.6 kg CO2e/m²	C: 9.7 kg CO2e
	D: -67.1 kg CO2e

Section w=90cm, h=150cm

Aluminum window frame with a double glazed window element.



RECYCLABILITY STATUS



Component	[A ÷ C ÷ D] kg CO2e/m³	Function	Assembly
1 Aluminium Window (insulated)	[173.00 ÷ 9.70 ÷ -67.1]		

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Steel (Column)

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Timber Frame (Ceiling)

Mehrgeschossige Gebäude aus Holz, Lignum (2015)

Massive Timber (Ceiling)

dataholz.eu, Holzbauprojekte (2012)

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Bauder Gründächer, Wandanschluss-Detail (2022)

Flat Roof (Top Shell)

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Structural Timber (Interior Wall)

Atlas Detail: Mehrgeschossiger Holzbau (2017)

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Atlas Detail: Mehrgeschossiger Holzbau (2017)

Dowel Laminated Timber (Interior Wall)

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Knauf Products (2022)

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ift Rosenheim (2011)

Aluminium-Door

ift Rosenheim (2011)

Steel-Door

RWD Schlatter (2013)

Wood Window

ift Rosenheim (2011)

Wood-Aluminium-Window

Wiegend Fensterbau (2012)

Aluminium-Window

ift Rosenheim (2011)

Plastic-Window

ift Rosenheim (2011)

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