WORLD CONFERENCE ON TIMBER ENGINEERING 2025
BRISBANE, AUSTRALIA
Advancing Timber for the Future Built Environment

SCRIMBER - A CONTRIBUTION TO CLIMATE PROTECTION

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ABSTRACT: Timber construction is a growing trend driven by an increase in global demand for wood and the urgent need for environmentally friendly and resource-saving materials. In response to this need, Scrimber technology has been advanced to convert low-grade wood, which has traditionally been used as energy wood, into high-quality, load-bearing components. This innovative approach not only enhances the wood utilization efficiency from 30 % to 90 %, but also significantly contributes to the reduction of CO_2 emissions. The Scrimber process is aligned with the principles of a circular economy, which ensures the prolonged carbon sequestration and the potential for direct reuse or reintegration into the Scrimber production cycle. This makes a substantial contribution to sustainable development and climate change mitigation.

KEYWORDS: wood, wood product, fibre, strands, scrimber, sustainable, reuse

1 INTRODUCTION

Timber construction is a megatrend, with global demand for wood set to increase. To meet this demand sustainably, there is a need for more efficient timber construction products. Furthermore, in view of increasing global warming and the associated environmental problems, the reduction of CO_2 emissions is a key objective. The development of the Scrimber technology is based on two key factors: climate change and the urgent need for sustainable materials in the construction industry. The Scrimber CSC AG team and partners from the universities are addressing this challenge by converting locally available low-grade wood, previously used mainly as energy wood, into high quality, loadbearing components. This innovative utilisation of wood resources not only helps to reduce CO_2 emissions, but also promotes the sustainable management of forests. The creation of durable and ecologically beneficial building materials using scrimber technology represents a significant contribution to advancing sustainable development and mitigating of climate change.

Scrimber CSC AG is undertaking the challenge of developing an innovative engineered wood product that enables the use of low-quality wood assortments to create a structurally load-bearing material. By reaching this objective, Scrimber CSC AG from Switzerland not only enhances resource efficiency but also contributes to sustainable forest management and climate protection. In contrast, the scrimber product aims for a utilisation rate of wood of 90 %. Furthermore, each cubic metre of scrimber sequesters permanently approximately one ton of carbon dioxide, because the wood captures and stores the carbon contained in the atmospheric CO_2. The ultimate objective of Scrimber CSC AG is to achieve a production capacity of 600,000 m^3 of scrimber per year at the first large-scale industrial plant. This is a significant amount that is also relevant in terms of climate policy. The core concept underpinning this initiative is that of a circular economy, with the overarching objective of keeping CO_2 sequestered for an extended period.

2 STATE OF ART FOR ENGINEERED WOOD PRODUCT - SCRIMBER

The development of Engineered Wood Products (EWP) is a contemporary issue. In relation to larger wood particles, often referred to as strands, the practice can be traced back to the 1970s. The scrimber technology, derived from “scrim” and “timber”, is an innovative and sustainable wood product that offers an alternative approach to traditional wood processing. Instead of sawing logs into boards, they are processed in a special rolling process into fibre strands, also known as "macrofibres", "strands", "scrims" or "splits"), [1]. The use of strands in

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https://doi.org/10.52202/080513-0648

technological applications has evolved independently in various geographical regions worldwide, often leading to the development of diverse nomenclatures and methodologies.

Harvey Jr.'s patent (US3674219) from 1972 in Tennessee is the first known source for the extraction of strands using a rolling process. In the German Democratic Republic GDR, Götz & Luthardt (1974) referred to the process as “Quetschholz - Squeezed wood” and used a rolling process to produce a single strand. The Quetschholz was only produced on a laboratory scale and was never developed further. In Australia, another process was developed by Coleman (1975), which was named “scrimber”. The first plant was built in Australia, but ceased operations in 1992, [12], [17].

Following a period of inactivity, the Australian process was revived in the USA in 2003 under the designation “Tim Tek” [4], [5], [12]. Concurrently, research on “recombined wood composite” was conducted at the University of China (2004), leading to the construction of a plant near Beijing [12]. The Chinese technology is based on the Australian approach. In Japan, the focus had already shifted to narrower diameters in 1999, and research was driven forward under the name “superposed strand timber-SST”, [12]. It is assumed that a plant has also been established near Tokyo.

The focal point of these procedures was to enhance the efficiency of wood utilisation, accomplished by the disruption of the wood structures through the implementation of multiple cycles of crushing apparatus, such as rollers or press plates. It is important to note that the wood was not cut during the process. The outcome of this process was a range of end products, including cohesive mats or individual strands. The degree of separation of the strands was influenced by various factors, including log length, roller profile and the number of passes (cf. Adachi 2002) [12], [13]. Most of the strands were processed directly into EWP as so-called spreader mats.

The product properties exhibit significant variability, which has ramifications for their applicability in different construction contexts see Table 1. Müller [12] has provided a comprehensive overview of these differences and demonstrated a correlation between the length of the strands and the modulus of elasticity (MOE). These findings have the potential to inform future developments and optimisations in this field.

Notwithstanding the promising theoretical underpinnings, no production line is currently operational. The reasons for the discontinuation of production are numerous and varied, including economic factors, technological challenges, and insufficient market penetration. While production facilities exist within the bamboo sector, these are not dedicated to the fabrication of load-bearing building products for residential and infrastructure construction. Nevertheless, the potential of this technology remains undisputed, particularly in terms of resource efficiency and sustainability.

In conclusion, it can be stated that scrimber and related technologies offer promising approaches for the sustainable use of wood. Despite the challenges encountered thus far, there is potential for the resumption of production, contingent on future technological advancements and prevailing economic conditions. The Scrimber CSC AG has taken on the challenge of achieving industrial implementation by building on the insights gained from previous investigations.

Table 1: Characteristics and technology data for engineered wood products related to long strands, according to [12], [15], [16]

Product	**Quetschholz** GDR (1974)	**Scrimber (AU)** Australia (1975)	**SST** Japan (1999)	**TimTek** USA (2003)	**Recombined wood composite** China (2004)	**Solid Wood C16** EN 338:2016	**Lamella T14 (C24)** EN14080:2013
Adhesive *Adhesive content*	PF (IC) 10-20 %	UF/TaninF 5-12 %	PF (IC) 5 %	PF 10-12 %	Carbamid 8-10 %	-	-
Press *Pressure*	Plate press *1.2 MPa*	Plate press *> 2.7 MPa*	Steam press 0.6-1 MPa	Steam injection -	Plate press *4-6 MPa*	-	-
Size [mm]	21 x 430 x 1000	124 x 1200 x 12’000	12 x 750 x 4400	184 x 1219 x 1422	20 x 1200 x 2400		
Density [kg/m^3]	700 - 750	540 - 670	460 - 660	688 - 720	880 – 930	370	420
MOE [MPa]	10700 -12000	9200 - 10800	7670 - 10820	8274 - 15858	5000 - 9000	8’000	11’000
MOR [MPa]	60 - 85	6 -9[1)]	27 - 41	14 - 17[2)]	-	500	690

[1)] design value
[2)] particleboard resin

3 SCRIMBER (CH) TECHNOLOGY

3.1 RESSOURCE

The Scrimber (CH) technology has been developed for the purpose of enabling the efficient and sustainable use of wood resources. This is achieved by transforming low-quality wood into high-performance, load-bearing construction materials. While conventional wood processing relies on high-grade log timber; Scrimber allows for the utilisation of lower-grade and residual wood. Such wood would otherwise remain unused or be subjected to thermal processing. As illustrated in Figure 1, the current consumption of wood in that sector is projected to reach 40%. The current types of wood species concentrate on European forest stock, but several other wood species are also being evaluated.

The implementation of this approach by Scrimber (CH) results in a reduction in demand for primary forest timber, whilst concomitantly effecting a substantial enhancement in material efficiency within the construction industry. Furthermore, the CO_2 stored in the wood fibres is retained long-term, making Scrimber products an active contributor to climate change mitigation and a sustainable circular economy. The reuse strategy for Scrimber products follows a two-phase circular model: in the first cycle, elements are reused on a 1:1 basis, while in the second cycle, materials are reprocessed and repurposed into new Scrimber products. The incorporation of reclaimed timber from deconstructed buildings is also being considered, although this approach has yet to be technically validated (see Figure 4).

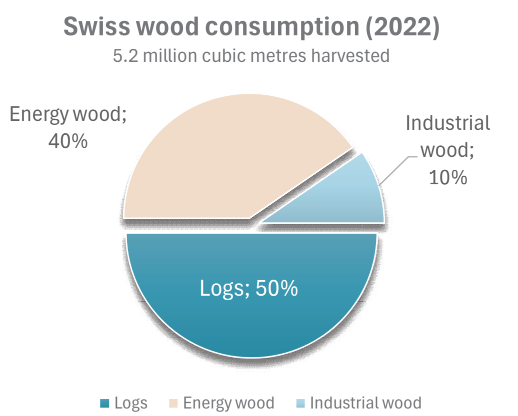

Figure 1. Swiss wood consumption of the year 2022, according to [18]

Figure 2. Illustration of the resource stock in the forest with thin diameters of logs (left), a saw cutting sample for boards and beams (middle), and a comparison of utilisation rate to conventional cutting [14] and scrimber (CH) (right).

The entire production process is optimised to minimise resource losses, with the objective of achieving a 90% material utilisation rate (see Figure 2). This includes branches and upper sections of tree trunks, which are typically unsuitable for sawn timber production. In the case of other load-bearing solid wood construction elements, such as Glulam and Cross-Laminated-Timber (CLT), saw able and therefore significantly larger log diameters are required to produce solid wood lamellas. The yield for Glulam or CLT is approximately 30 %. By optimising the use of raw materials, Scrimber (CH) enhances environmental sustainability while improving the economic viability of wood processing. This represents a highly efficient and innovative solution for the construction sector.

3.2 PROCESS

In a multi-stage rolling crushing process, raw logs are subject to mechanical fragmentation into fibre strands. These strands then undergo a controlled drying phase before being bonded into high-performance wood-based panels (see Figure 2). A key advantage of this method is the minimal alteration of the wood fibres during strand production, preserving their natural structure and orientation, see Figure 3. Conventional wood-processing techniques frequently disrupt the intrinsic fibre alignment, whereas this approach preserves the original mechanical integrity of the wood [2, 3]. Consequently, the resulting wood-based material displays enhanced mechanical properties, leveraging on the inherent strength and durability of the wood fibres while simultaneously optimising material efficiency and structural performance.

Figure 3. Fibre strands of the new Scrimber (CH)

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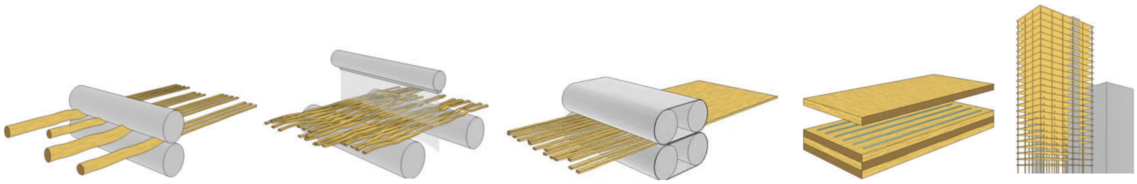

Figure 4. Scrimber process: rolling and crushing of logs, drying and glueing, pressing of strands to raw scrimber panel, Scrimber plywood panels as cross laminated scrimber (CLS), CLS in use (from left to right)

3.3 PRODUCTS

Scrimber (CH) raw panels are composed of wood strands that are longitudinally aligned and bonded together, with thicknesses ranging from approximately 20 to 40 mm. The adhesive content is kept below 5%, and future production will exclusively incorporate bio-based adhesives to enhance environmental sustainability. Scrimber (CH) raw panels offer a viable and sustainable alternative to conventional solid wood lamellas, exhibiting comparable structural properties while utilising lower-grade wood resources more efficiently. These engineered wood products have been engineered to meet the mechanical performance requirements of C16 and T14 lamellas, as defined in SN EN 338 [15] and SN EN 14080 [16], making them suitable for use in glulam and CLT applications.

A key development objective is to achieve a density comparable to that of C16 and T14 lamellas, as outlined in Table 1. However, this presents a significant technical challenge, requiring the optimisation of multiple interdependent process parameters, including adhesive composition, pressing pressure, and strand arrangement. Achieving the right balance among these factors is imperative to ensure both structural integrity and material efficiency, while preserving the sustainability benefits of Scrimber (CH) technology.

4 ADAVANTAGES OF SCRIMBER

In contrast to the manufacturing processes of Laminated veneer lumber LVL, Timber strand LSL and Oriented strand board OSB, where the natural fibres are damaged by cutting processes, scrimber panels are manufactured without cutting. Instead, the strands are produced by splitting the natural fibre along its natural course by rolling processes. This approach results in improved mechanical strength properties of the individual strands, which in turn leads to better overall strength of the scrimber raw panel. The naturally occurring ability of the undamaged fibre to withstand high tensile forces is retained [3]. As a result, the same strength values can be achieved with a lower bulk density, meaning fewer resources are required.

The separation of fibres by rolling processes is less abrasive on machinery and results in longer service life than cutting separation methods, such as the use of knife ring flakers for OSB and LSL production. This eliminates the need for time-consuming and cost-intensive resharpening of the cutting edges, [4], [12].

The raw material used to produce scrimber panels is underutilised, non-saw able assortments, such as thinning wood. This means that a resource is utilised and 'made to last longer' (upcycling), which would otherwise be industrial wood and used to produce short-lived products such as paper, cardboard or packaging or even thermally used (downcycling), [7]. The excellent upcycling possibilities of the scrimber process were also emphasised by winning the Bern upcycling challenge [8] and is shown in Figure 5.

Cross-laminating the new Scrimber (CH) raw panels to form a CLT (or CLS-Cross Laminated Scrimber) creates a construction element that stores the CO_2 bound in the wood as a long-term statically load-bearing component in the building. The utilisation of CLS for structural elements, such as ceilings, roofs, and walls, is analogous to that of a standard CLT composed of solid wood lamellas, as illustrated in Figure 5. Due to the higher surface area, the strands require less energy to dry than solid wood lamellas. This results in a reduced energy consumption during the production of CLS.

The performance of CLS in comparison to concrete is also noteworthy. It has been demonstrated that the production of one cubic metre of CLS results in the absorption of approximately one tonne of carbon dioxide, whereas the production of concrete is known to be highly carbon-intensive[9]. In addition to its acoustic, fire protection, seismic and thermal properties, CLS can be regarded as a sustainable alternative to concrete.

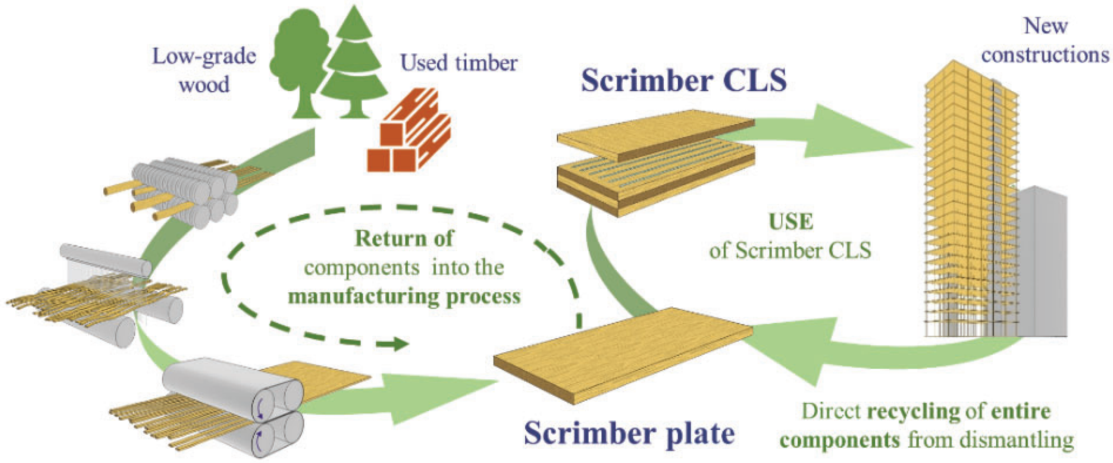

Figure 5. Circularity of Scrimber: Recycling within the manufacturing process (left) and direct reuse (right)

5 CONCLUSIONS AND VIEW

Scrimber represents a pioneering and sustainable advancement in timber construction. The latest advancements in state-of-the-art technology are pivotal for the revival and market establishment of Scrimber as a viable alternative in the building industry. The primary objective of this project is to position Scrimber technology as a sustainable solution in the timber sector while highlighting its economic and climate-friendly potential. This objective will be accomplished through a combination of theoretical research and practical application.

The versatility of Scrimber enables its use in columns, beams, and slabs in load-bearing structures, effectively replacing reinforced concrete while simultaneously storing CO_2. The integration of Scrimber technology into contemporary construction practices is set to drive the industry towards a paradigm of enhanced resource efficiency, reduced carbon emissions, and a more circular approach to building.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to our research partners at the Bern University of Applied Sciences, as well as to the funding agency Innosuisse, the Swiss Federal Office for the Environment (BAFU), within the Aktionsplan Holz for their valuable support.

Our appreciation also extends to the Wyss Academy, our investors, and the numerous experts from industry and forestry who have contributed their knowledge and expertise to this project. Their support has been instrumental in advancing our work, the development and bringing Scrimber technology closer to market implementation.

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