TECHNICAL WHITE PAPER | FIRE PERFORMANCE – CHAR RATE & FIRE PERFORMANCE

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Subject: Comparative Structural Fire Performance, Linear Char Rate Dynamics, and Life-Cycle Sustainability: LoüTeq SEB vs. Traditional Building Materials

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1. Executive Summary

As modern commercial architecture shifts toward sustainable, high-performance structural systems, fire safety and passive resistance remain primary design constraints. Unprotected structural steel exhibits extreme thermal conduction, leading to rapid, abrupt molecular yielding and catastrophic failure without visible warning signs. Traditional mass timber mitigates this vulnerability through standard, predictable surface charring. [1, 2, 3, 4]

LoüTeq Structural Engineered Bamboo (SEB) establishes an advanced industry benchmark for passive fire performance and structural integrity. By combining a highly compressed, ultra-dense fiber matrix (~1,100 kg/m³) with an inherent, naturally occurring silica composition, LoüTeq SEB limits the nominal charring rate to an exceptional **0.42 – 0.50 mm/min**. This white paper presents empirical and analytical data demonstrating how structural engineers can design smaller sacrificial cross-sections while matching or outperforming the safety requirements outlined in international fire codes. [1, 2, 3, 4, 5]

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2. Comparative Material Performance Matrix

Performance Metric [1, 2, 3]	LoüTeq Structural Engineered Bamboo (SEB)	Standard Mass Timber (CLT/Glulam)	Structural Steel (Unprotected)
Nominal Char Rate (β_0)	**0.42 – 0.50 mm/min**	0.65 mm/min	N/A (Does not char)
Volumetric Density	**Ultra-High (~1,100 kg/m³)**	Medium (~450 kg/m³)	Extreme (7,850 kg/m³)
Critical Failure Threshold	**Core retains integrity >400°C**	Core retains integrity >300°C	Loses 50% strength at 550°C
Primary Failure Mode	Linear surface charring	Linear surface charring	Rapid plastic buckling
Sacrificial Profile Added	**Minimal (Slimmer sections)**	Standard depth additions	Heavy intumescent wraps/coatings
Failure Predictability	**Extremely High (Linear)**	High (Linear)	Low (Sudden yield)
Embodied Carbon Profile	**Net-Negative (Carbon Sink)**	Low-Negative (Carbon Sink)	High-Positive (Net Emitter)

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3. Core Engineering & Fire Dynamics

3.1 The LoüTeq Density Shield

The fundamental driver behind LoüTeq SEB's performance under fire exposure is its massive volumetric density. While softwoods contain loose, porous cellular structures that allow rapid oxygen diffusion and quick heat penetration, LoüTeq's highly compressed, closed-cell fiber morphology acts as a solid thermal barrier. This high density restricts oxygen flow below the burning face, reducing the nominal charring rate by **23% to 35%** compared to standard wood mass timber components. [1, 2, 3]

3.2 Silica-Infused Fire Retardancy

LoüTeq SEB utilizes the natural chemical composition of vascular bamboo bundles (*Guadua Angustifolia*), which inherently contain high concentrations of amorphous silica. Under fire exposure matching standard time-temperature curves, this silica vitrifies on the exposed face. It develops a glassy, semi-ceramic layer that delays initial ignition up to **400°C**. This natural chemistry delays ignition and helps preserve the structural unburned core underneath. [1, 2, 3]

3.3 Structural Section Optimization

In mass timber design, engineers calculate a sacrificial thickness (d_{char}) that burns away during a fire event, leaving an "effective core" to safely carry the building's design loads. The calculation follows standard fire engineering formulas: [1]

$$d_{char}=\beta _{0}\times t$$

Where:

- d_{char} = design char depth (mm)
- β_0 = nominal charring rate (mm/min)
- t = time of fire exposure (min)

Because LoüTeq SEB has a low charring rate (β_0 = 0.42), a 2-hour (120 min) fire exposure results in a design char depth of only **50.4 mm**, compared to **78.0 mm** for standard mass timber. This performance allows architects and engineers to specify slimmer structural profiles, reducing raw material volumes while maximizing rentable, open floor space.

3.4 Connection Node Behavior and Thermal Bridging

Structural steel acts as a thermal conductor, rapidly channeling heat deep into connection pins, causing sudden thermal elongation, weld fractures, and joint rotation. LoüTeq SEB eliminates thermal bridging. At critical beam-to-column intersection points, the exterior SEB mass forms an insulative layer that keeps internal steel connector plates or dowels cool and well below their yield temperatures. Joints remain dimensionally rigid and structurally secure. [1, 2]

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4. Sustainability & Life-Cycle Assessment (LCA)

Beyond passive fire performance, LoüTeq SEB provides a superior environmental profile when compared to carbon-intensive structural steel:

- **Rapid Biomass Renewal**: Timber species require 25 to 50 years to mature. LoüTeq SEB utilizes bamboo culms harvested on a sustainable **3-to-5-year cycle** without destroying the root system or causing soil erosion.
- **Carbon Sequestration**: LouTeq SEB acts as a high-capacity carbon sink. It sequesters significantly more carbon per acre over its life cycle than traditional softwoods, helping commercial developments achieve net-zero or net-negative embodied carbon targets.

5. Life Safety & First Responder Protection

Predictability is crucial for emergency crews working inside a burning structure. Steel frame buildings present a constant hazard of sudden collapse due to invisible molecular yielding at 550°C. LouTeq SEB follows a clear, linear time-log degradation pathway. Fire protection engineers can accurately calculate remaining structural capacities based on visual char depth, giving emergency personnel a reliable and calculable safety window. [1, 2, 3]

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6. References & Standards Citations

- **ISO 834-1:2025**, *Fire-resistance tests — Elements of building construction — Part 1: General requirements.* International Organization for Standardization. [1]
- **ASTM E119-25**, *Standard Test Methods for Fire Tests of Building Construction and Materials.* ASTM International. [1]
- **EN 1995-1-2:2004 (Eurocode 5)**, *Design of timber structures — Part 1-2: General rules — Structural fire design.* European Committee for Standardization. [1]
- **National Design Specification (NDS) for Wood Construction**, *Chapter 16: Fire Design of Wood Members.* American Wood Council. [1]
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- **sciencedirect.com/science/article/abs/pii/S0950061825042588**, *Experimental investigation on the charring behavior and density relationships of engineered bamboo profiles.* Construction and Building Materials. [1]
- **materialspalette.org/bamboo/**, *The Carbon Smart Materials Palette: Silicon content and thermal ignition thresholds of bio-composites.* Architecture 2030. [1]