

ABSTRACT

Title:

Use of Selected Technical Fabrics Based on Glass Fibre for Fire Protection of Solid Softwood Timber Elements

The growing interest in timber as a structural material — driven by energy-efficient construction and climate pressure favouring low-carbon materials — stands in contrast to a persistent gap in the availability of effective passive fire protection methods for structures with complex geometries or subject to heritage conservation requirements. Conventional technologies such as board linings, spray-applied materials, intumescent coatings, and impregnation treatments fail particularly in historic roof structures and open timber ceilings, where intervention in the historic fabric is excluded yet fire risk is highest.

A systematic literature review revealed an absence of dedicated research on technical glass-fibre fabrics used as standalone external thermal barriers on load-bearing solid softwood elements under internal fire conditions. Although the material has long been proven in fire curtains, fire blankets, and protective clothing, it had not previously been evaluated in this role — a precisely identified research gap that justifies the scope of the study.

The work is based on an original, three-level experimental programme. At the laboratory level, two bespoke test rigs were designed and built: one using an infrared radiant panel array (radiative exposure) and one combining a gas burner with radiant panels (combined exposure). Solid softwood specimens were shielded by four fabric variants: (A) vermiculite-modified glass fabric, (B) single-sided aluminium-coated glass fabric, (C) plain glass fabric ECTS 530 g/m², (D) plain glass fabric 560 g/m² — each tested against an unprotected reference specimen. At the full-scale level, a field fire trial was conducted to verify the laboratory findings and assess the practical suitability of the materials for protecting timber elements. The third level comprised a computational fluid dynamics (CFD) analysis in the FDS/PyroSim environment, serving a validation and comparative role.

Every fabric variant effectively reduced the char depth at both scales: 45–60 % in the laboratory and 23–43 % at full scale. Absolute values after a 30-minute field exposure were: reference specimen 23.6 mm, vermiculite fabric 15.9 mm, coarse-weave fabric ("kocówka") 13.5 mm, aluminium-coated fabric 18.2 mm. The protection mechanism is multifactorial: the fabric simultaneously attenuates the radiative heat flux, limits oxygen access to the pyrolysing layer, and retards the migration of fire gases, maintaining structural integrity for the first 12–20 minutes depending on the variant.

The effectiveness ranking is consistent across scales — the vermiculite-modified and coarse-weave fabrics perform best under prolonged exposure, while the aluminium-coated fabric dominates in the early phase due to high reflectivity, but its effectiveness drops markedly after mechanical degradation of the coating at approximately 12 minutes. Higher-grammage fabrics without surface modification show the greatest mechanical continuity over time. The laboratory results have confirmed predictive power for material ranking; absolute char depth values require correction by an experimentally derived scaling factor when transferring to full scale.

The tested fabrics effectively delay charring — a finding confirmed at both experimental scales. Their suitability as an equivalent solution in passive fire protection has also been demonstrated: the technical prerequisites are met, although the certification pathway remains a prerequisite for adoption as a standard solution.

From a practical standpoint, technical fabrics open two application routes previously lacking an appropriate tool: protection of heritage buildings — reversible installation, no intervention in historic substance, adaptability to complex geometries — and temporary protection during renovation and construction works, which can be introduced through construction documentation and a health-and-safety plan without requiring certification as a permanent solution. Further research should encompass tests under mechanical load, extended thermal exposure, durability analysis under service conditions, and extension of the material range to hardwoods and engineered timber products (CLT, LVL).