

 **COMPARATIVE
RISK ANALYSIS**

Technical Summary

Fire performance and post-fire resilience of reinforced concrete and timber structures

SOURCE DOCUMENT

Comparative Risk Analysis

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for Concrete Europe and BIBM

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This summary presents the report's main technical findings, comparative case-study results and implications for whole-building fire resilience.

The full report is available on Concrete Europe and BIBM websites



Fire resilience beyond compliance

Comparative analysis of code-compliant reinforced concrete and encapsulated timber structures

Equivalent fire-resistance ratings did not produce equivalent severe-loss outcomes. Across five case studies, both solutions performed broadly alike under expected conditions. Their performance diverged when active protection was no longer available and design assumptions were invalid.

Normal Loss Expectancy (NLE)

Protection systems operate as designed. Fire separations perform to their rating, and the fire brigade responds within realistic timeframes. RC and timber outcomes were broadly comparable.

Maximum Foreseeable Loss (MFL)

Active systems are ineffective or unavailable. Intervention is delayed, and fire develops until an impassable barrier or fuel exhaustion stops it. Material choice became decisive.

Five headline findings

- Under MFL conditions, timber configurations produced about 80-100% Property Damage. Reinforced concrete ranged from about 25-77%.
- The timber-to-concrete Property Damage ratio rose from 1.3x in the open automated warehouse to 3.8x in the apartment building.
- The gap widened where load-bearing elements also formed fire-compartment boundaries, particularly in cellular and multistorey buildings.
- Concrete did not add fuel. It generally preserved compartmentation and residual capacity, which supported repair.
- Reinforced concrete never produced higher Property Damage or Business Interruption than the corresponding timber solution in the five cases.

Study scope

Property Damage, Business Interruption and post-fire recoverability. The study excludes life safety, evacuation and environmental impacts.

Controlled comparison

Geometry, occupancy, scenarios and protection strategies remained constant. Only the structural material changed.

Interpretation

The values are indicative orders of magnitude from deterministic scenarios. They are not probabilistic forecasts or insurance valuations.

Why the outcomes diverge

Material behaviour, fire development and post-fire recovery

Parameter	Reinforced concrete	Encapsulated timber
Reaction to fire	A1 non-combustible. Does not contribute to fire load	Combustible. Contribution depends on exposure and protection
Section under heat	Slow heating. Geometry remains while strength reduces progressively	The effective cross-section reduces progressively through charring
Predictability	Codified models and extensive evidence under EN 1992-1-2	Affected by charring, delamination, connections and protective-system condition
Fire protection	Fire resistance often comes from the member and cover	Greater reliance on continuous, correctly installed encapsulation
Compartmentation	Structural and separating functions can remain integrated after prolonged exposure	Loss of encapsulation can degrade structural and separating functions together
After the fire	Residual capacity can often be assessed. Local repair may be feasible	Concealed damage and section loss can shift recovery towards replacement

Four mechanisms drive severe-loss performance

1 Available fuel

Concrete remains fuel-neutral. When timber protection fails, exposed structural material can add fuel, prolong combustion and delay burnout.

2 Compartmentation

The gap widens when walls and floors provide both structure and fire separation. Intrinsic barriers remain more robust than protection-dependent barriers.

3 Structural robustness

Concrete capacity reduces progressively and has extensive supporting evidence. Timber capacity depends on the remaining section, connections and cooling-phase behaviour.

4 Recoverability

Stable concrete frames can often be inspected and repaired. Severe timber involvement creates uncertainty that frequently leads to demolition and reconstruction.

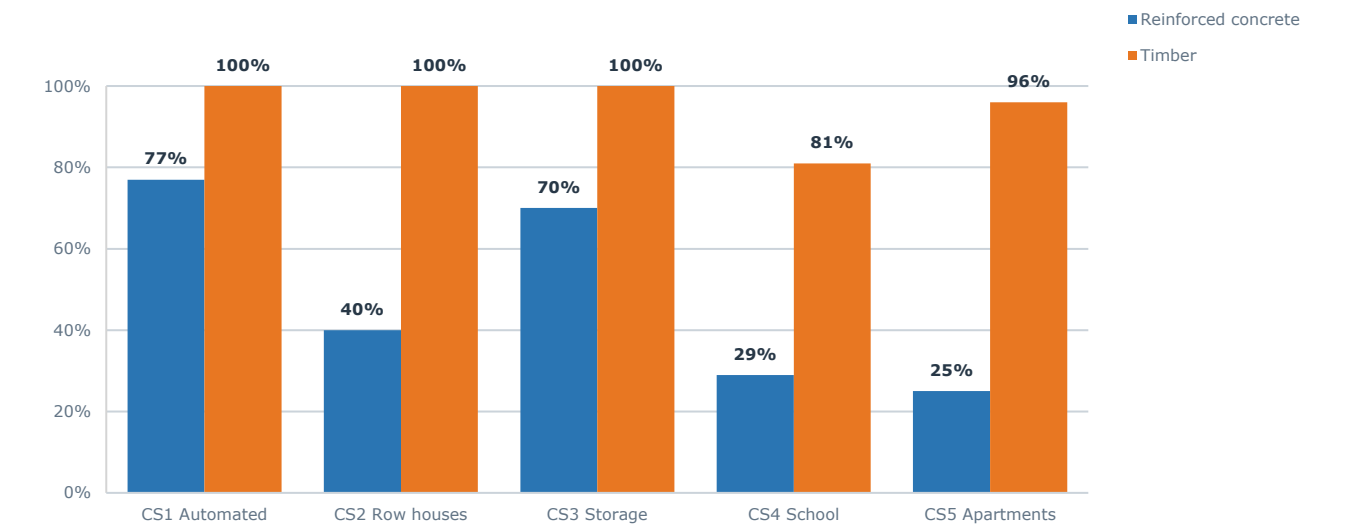
Engineering meaning

The study accepts that timber can meet prescribed R or REI classes. A common classification describes performance under its design assumptions, but it may not capture robustness, loss severity or recoverability when a real fire exceeds those assumptions.

Results across the five case studies

MFL Property Damage and indicative monetary loss estimates

Approximate MFL Property Damage as a share of exposed asset value



Case	Geometry / use	MFL PD RC / timber	MFL total loss (€m) RC / timber	NLE total loss (€m) RC / timber
CS1	Automated warehouse, open plan	77% / 100%	40.0 / 74.5	3.0 / 5.7
CS2	Low-rise residential row houses	40% / 100%	0.80 / 2.00*	0.07 / 0.18*
CS3	Storage warehouse, single compartment	70% / 100%	7.0 / 10.0	0.50 / 1.20
CS4	School campus, highly compartmented	29% / 81%	7.1 / 19.8*	1.3 / 1.8*
CS5	Eight-storey apartment building	25% / 96%	3.1 / 11.6	0.15 / 0.35

MFL PD percentages combine building and contents damage as a share of total exposed asset value. Monetary totals include Business Interruption where monetised. *CS2 loss of use and CS4 educational displacement were not monetised.

Case-study pattern

Open industrial buildings

Stored goods dominate the loss. RC mainly improves stability and recoverability.

Cellular buildings

RC preserves compartments and limits correlated loss. Timber loss rises as boundaries fail.

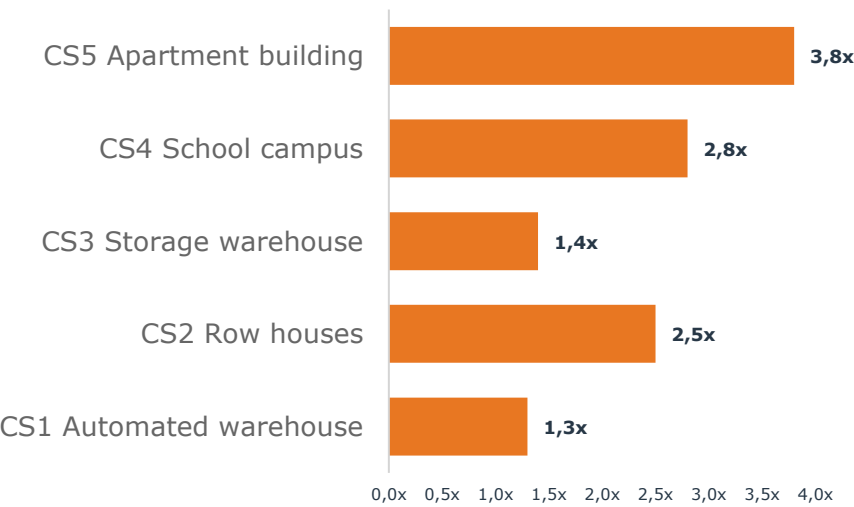
Multi-storey buildings

The largest gap occurs where floors provide structure and vertical fire separation.

What the findings mean

Geometry, recovery and risk-management implications

Approximate timber-to-concrete MFL Property Damage ratio



The decisive variable was geometry

The relative advantage of a non-combustible structure was smallest in open buildings and greatest in highly compartmented or vertical buildings, where structural failure can also dissolve fire boundaries.

Case	Reinforced concrete	Timber	Dominant driver
CS1 Automated warehouse	Repair and re-equipment	Demolition and reconstruction	Operational dependency and structural fuel
CS2 Row houses	Partial repair, units retained	Total reconstruction	Loss of inter-unit compartmentation
CS3 Storage warehouse	Partial frame reuse and repair	Full demolition	Structural fuel in one compartment
CS4 School campus	Compartment repair	Wing reconstruction	Intrinsic and conditional compartmentation
CS5 Apartment building	Sector refurbishment	Building reconstruction	Vertical spread and structure as boundary

Risk and policy implications

- Assess fire safety at whole-building level. Material, compartmentation, active systems, occupancy and geometry interact.
- Identical ratings may conceal different tail-loss and recovery profiles.
- Resilience and sustainability assessments should cover damage limitation, continuity and repairability.
- Automated facilities may lose more through downtime than through physical damage.

Scope and limitations: Five deterministic scenarios used real RC buildings and design-level timber substitutions. The values are indicative. The study excludes life safety, evacuation, firefighter intervention, environmental impacts and embodied carbon from reconstruction.

Conclusion: Fire resilience depends on the conditions that must remain intact for rated performance to persist in a severe fire. Reinforced concrete consistently reduced or matched loss and offered the stronger recovery pathway in this study.

Comparative fire behaviour

Indicative whole-building resilience ratings. Five stars indicate the most favourable performance or lowest dependence on additional measures.

Fire behaviour	Concrete		Timber	
Life protection	★★★★★	Stable, non-combustible structure supports evacuation and intervention.	★★★★☆	Can comply but relies more on protection and compartment integrity.
Reaction to fire	★★★★★	A1 material. It does not ignite, burn or add fuel.	★★☆☆☆	Combustible unless adequately protected or treated.
Contribution to fire load and growth	★★★★★	The structure adds no fuel to the compartment fire.	★★☆☆☆	Exposed wood adds heat and can prolong a developed fire.
Predictability	★★★★☆	Well-codified thermal response. Spalling remains a variable.	★★★★☆	Charring is calculable, but ventilation, delamination and protection affect outcomes.
Structural fire resistance	★★★★☆	Concrete cover and section mass provide substantial inherent resistance.	★★★★☆	Ratings rely on sacrificial section size, encapsulation or both.
Additional protection needed	★★★★☆	The section and cover often provide the required resistance.	★★☆☆☆	Often needs cladding, oversized sections and carefully detailed joints.
Compartmentation	★★★★★	Walls and floors can combine structural and separating functions.	★★☆☆☆	Often depends on linings, joints, penetrations and their continued integrity.
Robustness under non-ideal conditions	★★★★☆	Generally, less dependent on applied protection and auxiliary components.	★★☆☆☆	More sensitive to damaged linings, defects and system failure.
Fire decay and re-ignition	★★★★★	Concrete does not sustain combustion after contents burn out.	★★☆☆☆	Charring, smouldering or delamination can sustain or restart fire.
Firefighting conditions	★★★★☆	Stable, non-combustible barriers generally support intervention.	★★☆☆☆	Hidden burning and possible re-ignition can complicate response.
Post-fire residual capacity	★★★★☆	Residual strength can often be assessed and local damage repaired.	★★☆☆☆	The charred cross-section is permanently lost and connections need assessment.
Repairability and recovery	★★★★☆	Damage often permits targeted repair and reinstatement.	★★☆☆☆	Severe exposure may require element replacement or reconstruction.
Long-term maintainability	★★★★☆	Performance mainly depends on measurable cover and section dimensions.	★★★★☆	Linings, joints and service penetrations require continued inspection.

Editorial synthesis for comparison and communication. The stars are not regulatory classifications. Although different technical approaches can satisfy fire-resistance requirements, they do not necessarily offer equivalent reliability or safety under real fire conditions