Fire in Historic Building

Fire-Structure Interaction in Notre Dame

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Structures in Fire Forum
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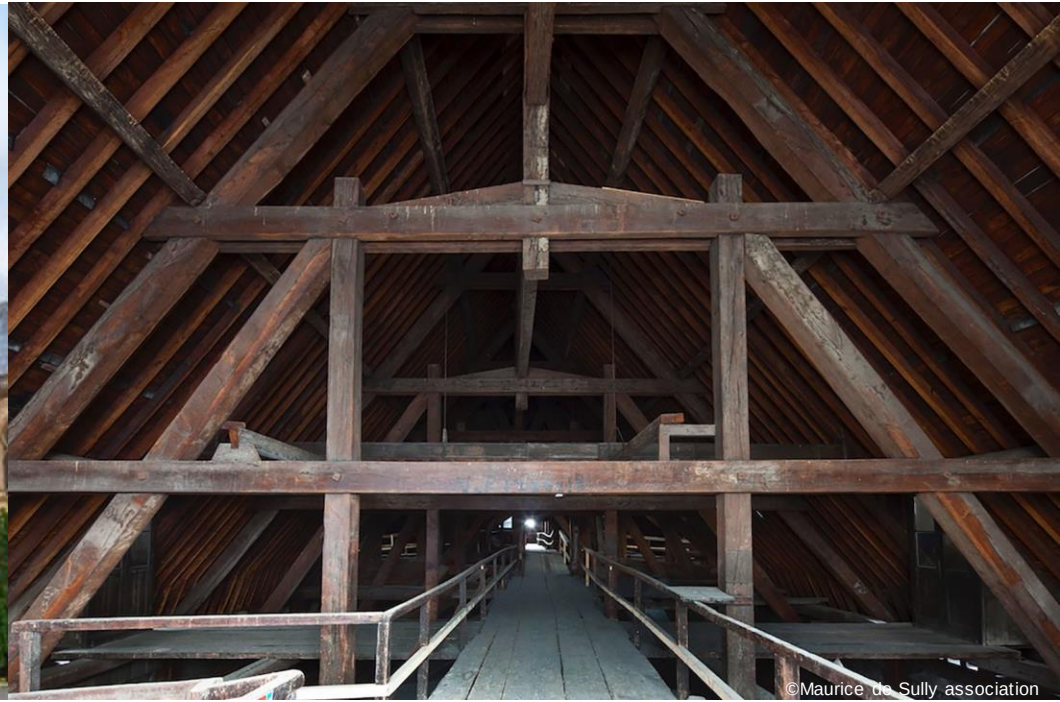
Fire-Structure Interaction in Notre Dame

Notre Dame: Gothic Architecture



Listed in World Heritage Site by UNESCO

Fire-Structure Interaction in Notre Dame

Recent fires in heritage sites

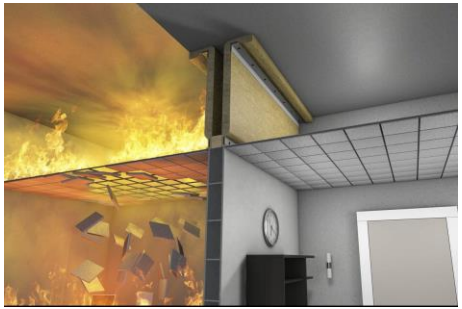
Notre Dame
(France – 2019)

Shuri Castle (Japan – 2019)

St John's Wood
(UK – 2023)

Charter of Venice: Notre Dame as a historic monument, should be restored as identical.

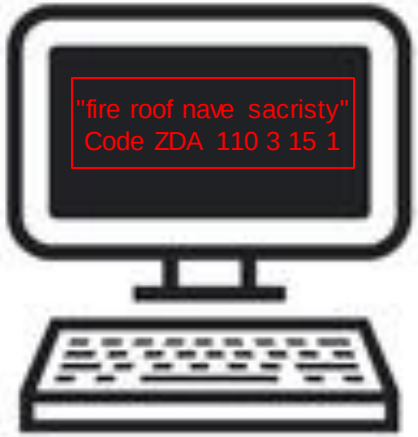
Fire strategies



Modern fire strategies vs historic buildings fire strategies

Timeline of the Notre Dame fire

06.18 pm



06.45 pm The alarm rings out a second time (300 stairs, limited access)

07.00 pm Fire brigade arrives

07.57 pm The spire collapses

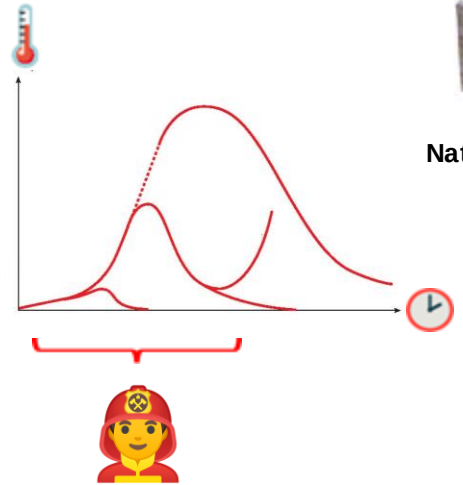
Failed to identify the trigger to alarm (Barthelemy, 2023)

Fire triangle

O_2

Lead melting point 286 ^{0}C
(Joost Frenken, 1985)

Oak wood ignition point 398 ^{0}C ~ The forest
(Long Shi, 2012)



Radiation

Natural convection

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Assumption: The fire grows slowly over mass structural timber

Reality: The mass structural timber collapses because of the fire.

HOW?

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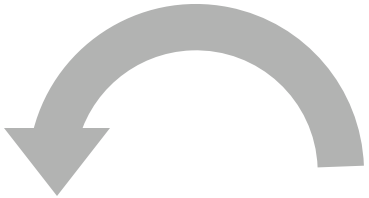
Fire – Structure Interaction in Historic Timber Structure

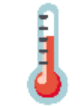
Aims: To assess the structural capacity of historical timber frames under fire load and compare the differences between fire strategies in historic and modern building.



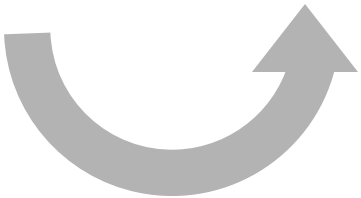
Computational Fluid Dynamics (CFD)

Coupling

Finite Element Method (FEM)



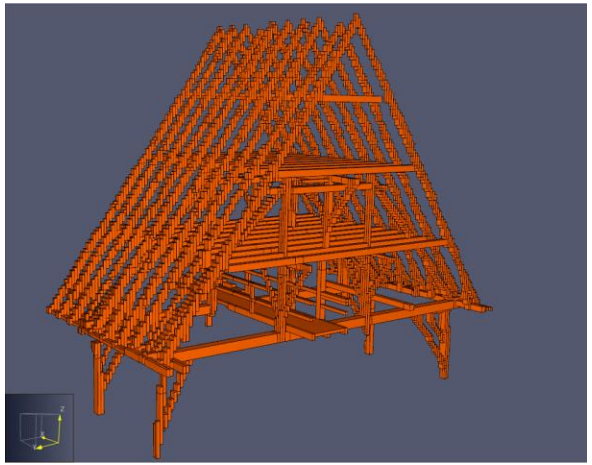
Temperature
Heat fluxes
Material degradation



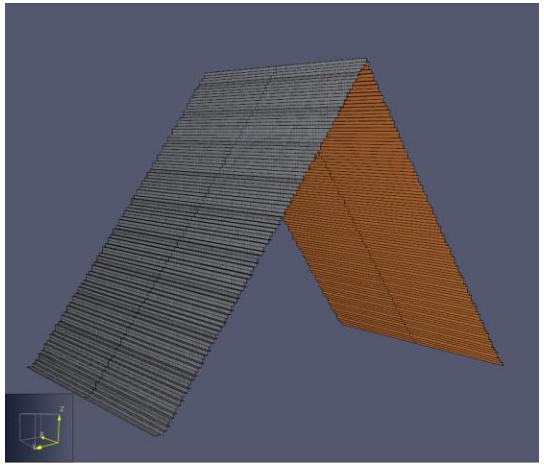
Structural integrity
Time to collapse
Connections

Materials

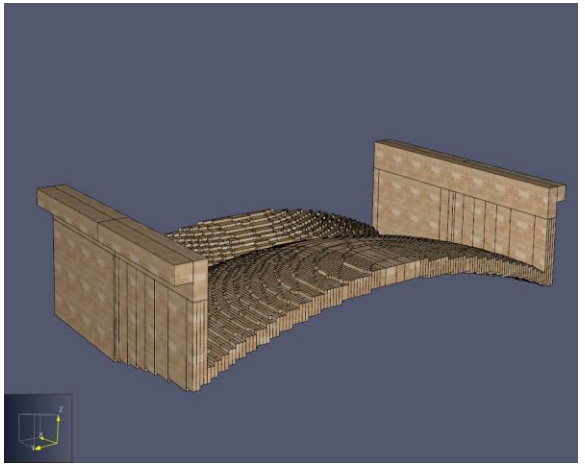
Oak



Fir wood and Lead



Masonry

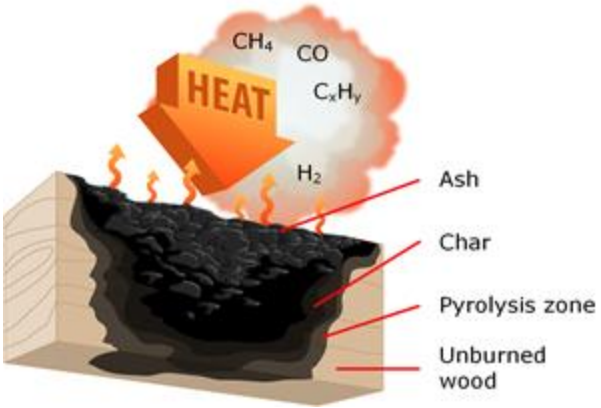


Boundaries

Notre Dame FDS model: 9 x 14 x 15 meter (choir) – meshing

Reactions

Oak



Lead

Oak + air → carbon dioxide + carbon monoxide + nitrogen + soot + water vapour

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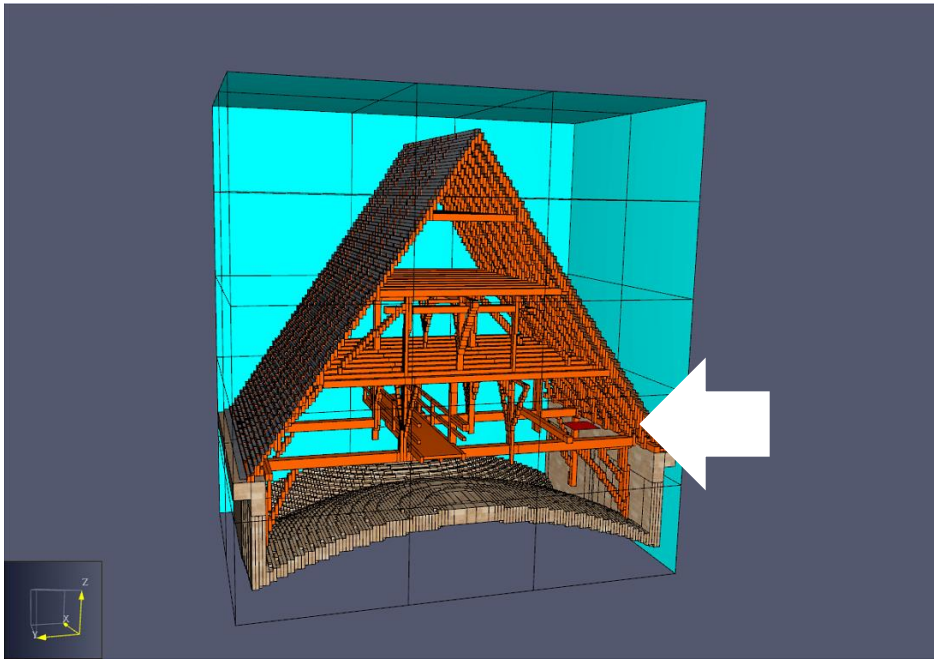
Ignitor

Near the lattice, 1000 kW fire



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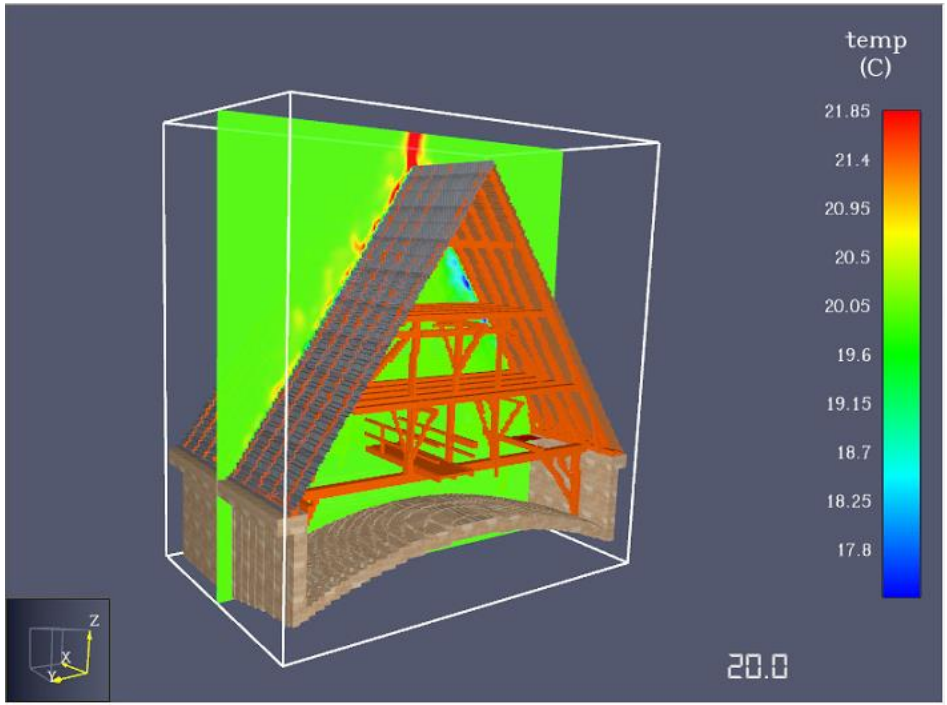
Fire Dynamics Simulation visualisation



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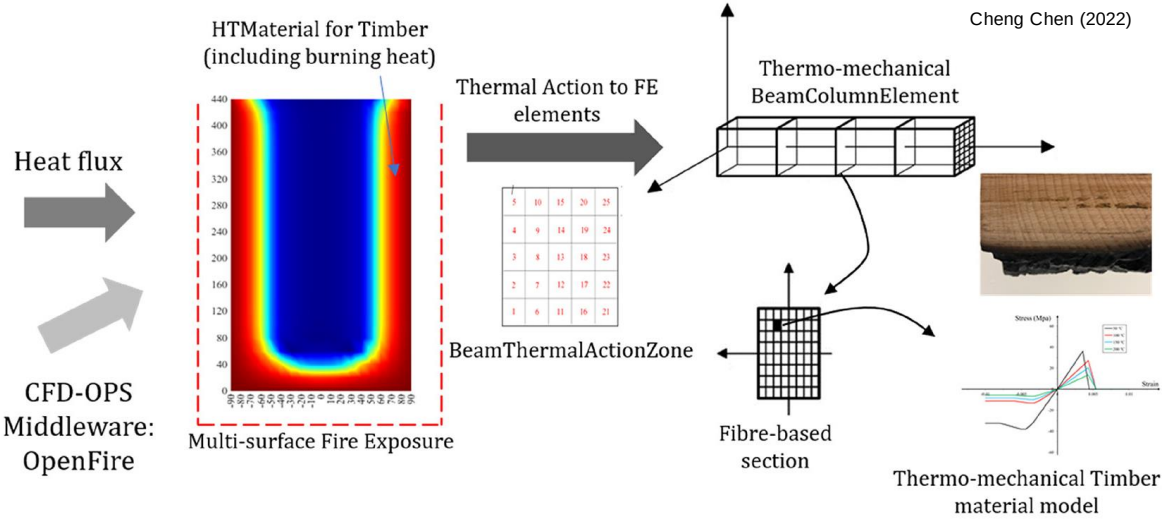
Expected material degradation



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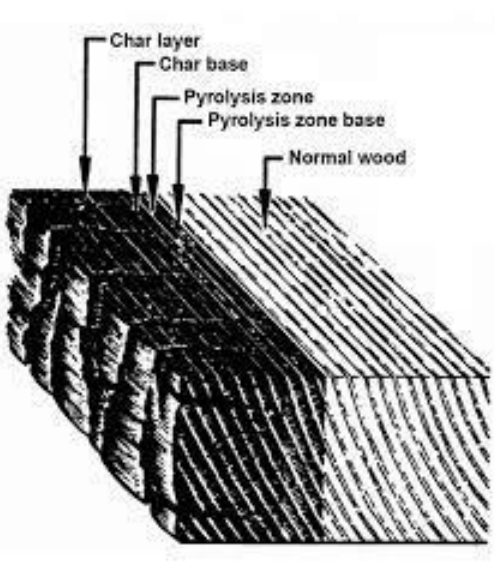
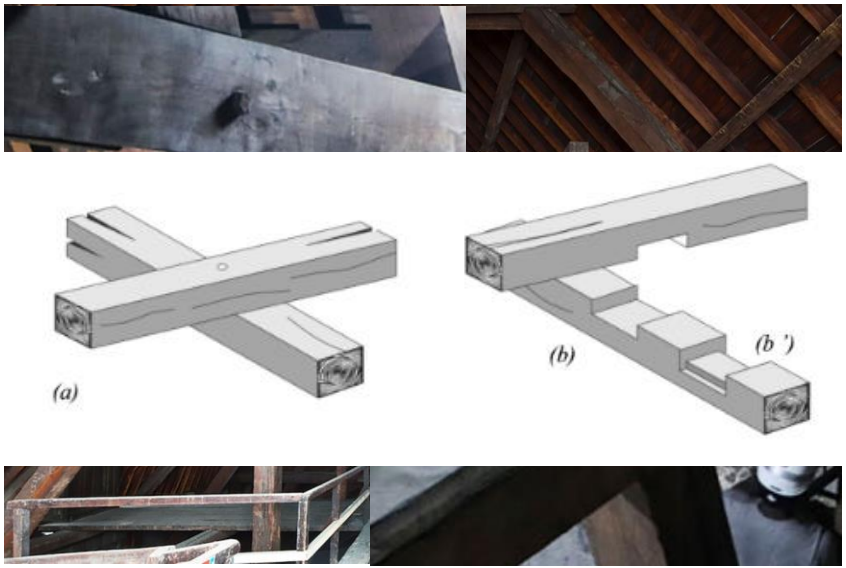
Expected failure modes





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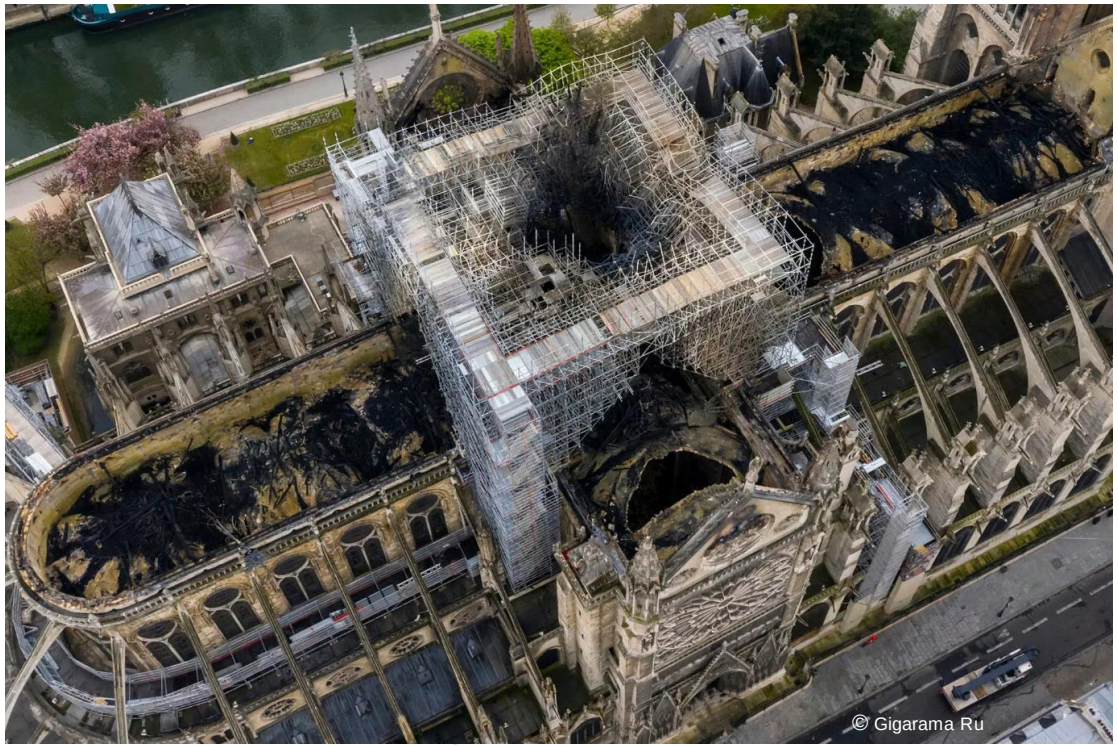
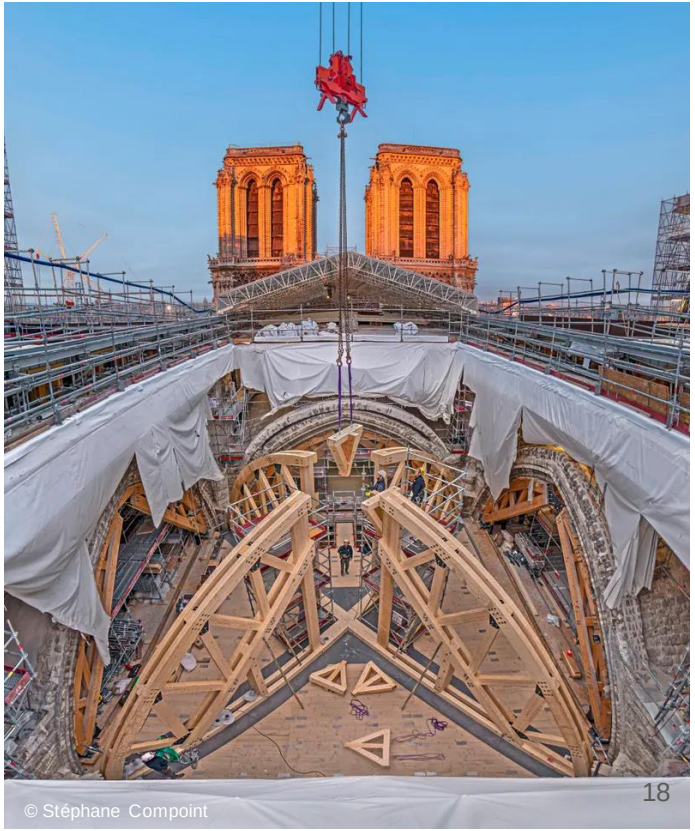
Expected outcome of the study



Thank you for your attention!

Any question?



Feedback and discussion:
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