



Structural Hazards of Smouldering Fires in Timber Buildings

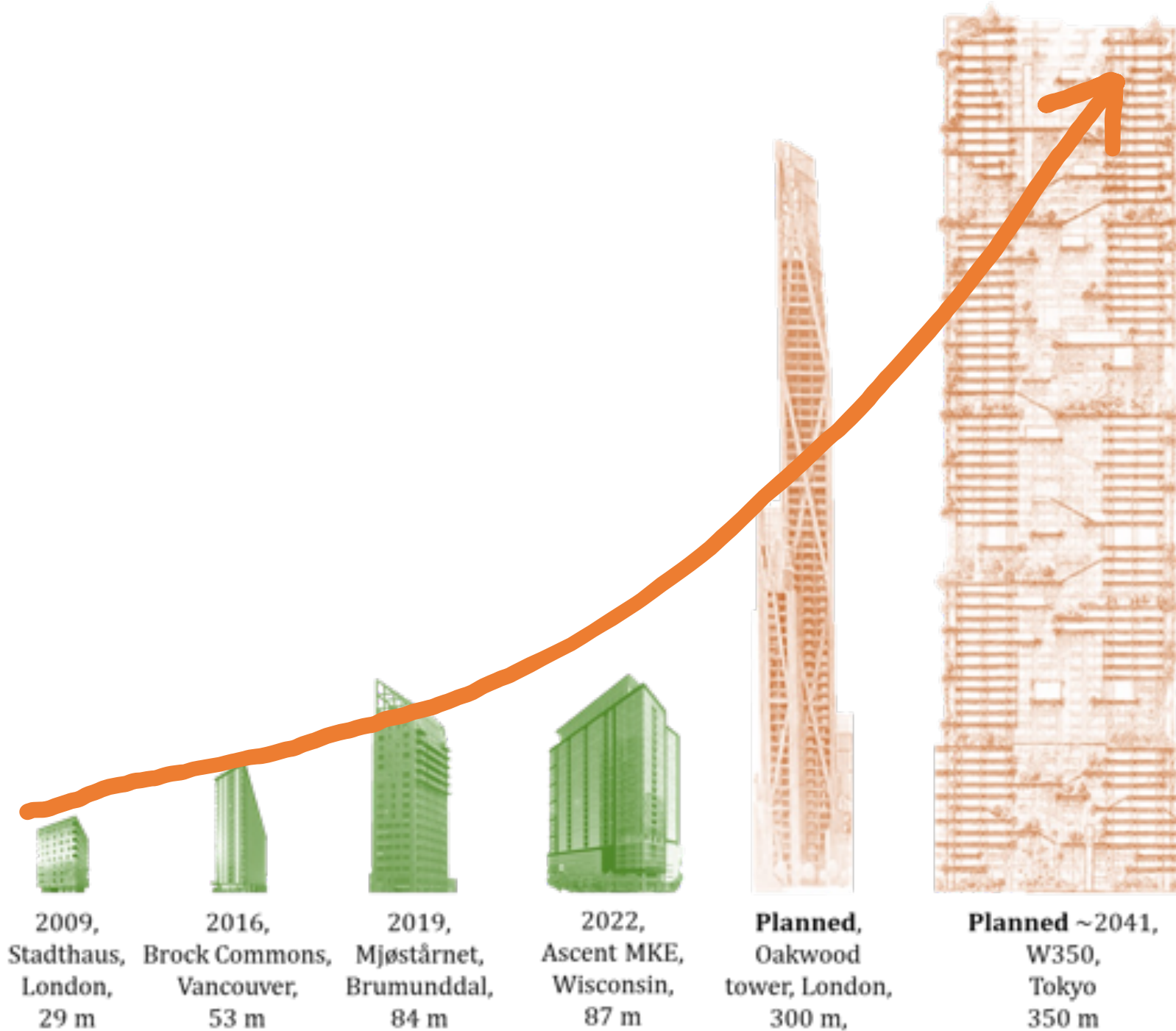
By Harry Mitchell

Supervisor: Guillermo Rein

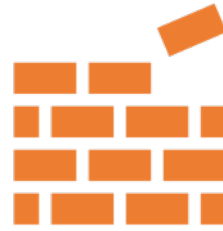
Arup Supervisors: Panos Kotsovinos and Daniel Thomson







Increased fire load



Increased structural requirements



Longer evacuation times



More challenging firefighting

What hazards are present AFTER the fire?

What is smouldering?



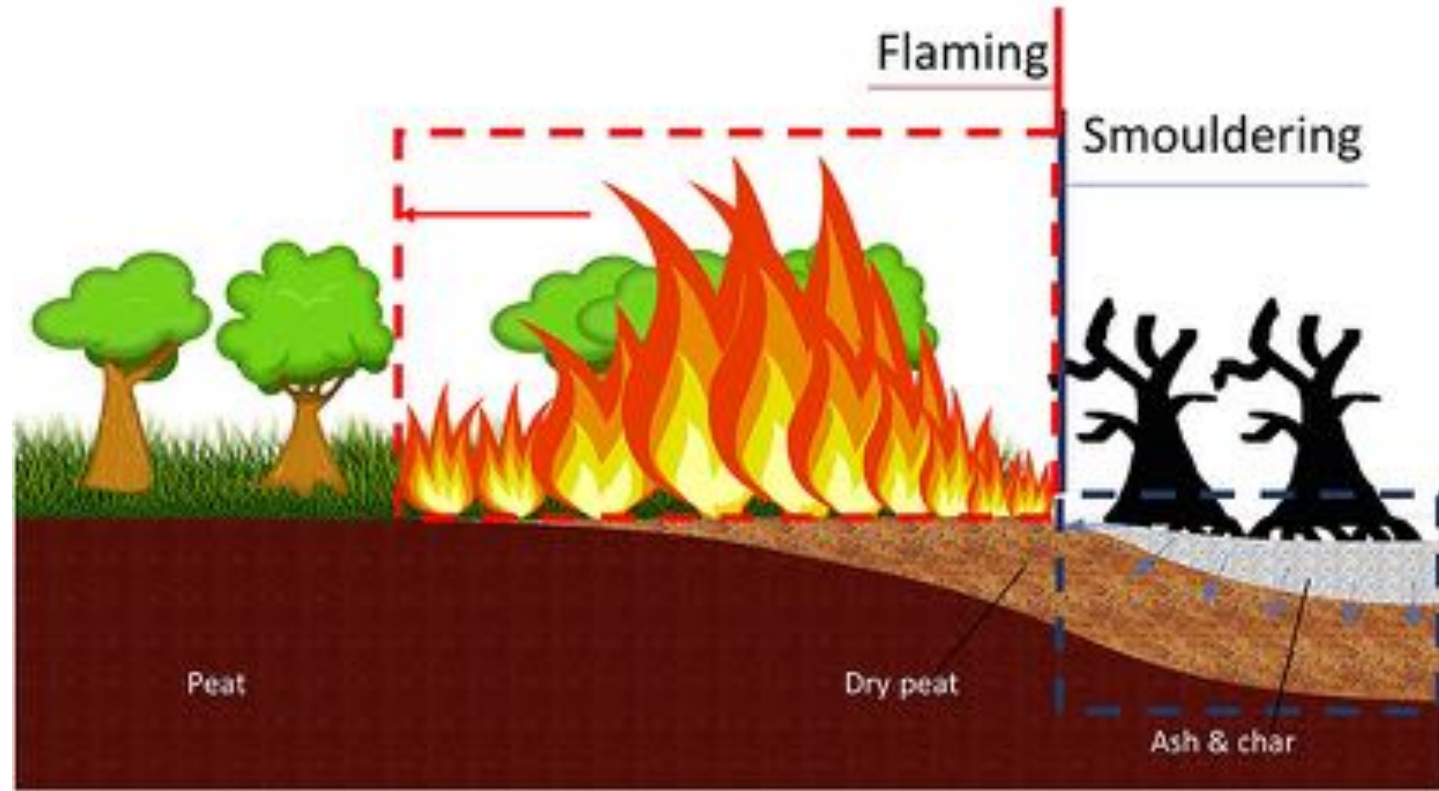
Slow, flameless combustion



Hard to detect and extinguish



Studied in context of **wildfires**



BBC News (2015) (2019)

Mass Timber Compartment Fire Experiments



CodeRed experiment series (3 experiments)



Open-plan mass timber compartment



352m² of CLT, and glulam columns



Varying **ventilation** and mass timber **protection**



The Team



Tracking smouldering

t = 3.18h

t = 14.28h

t = 38.08h

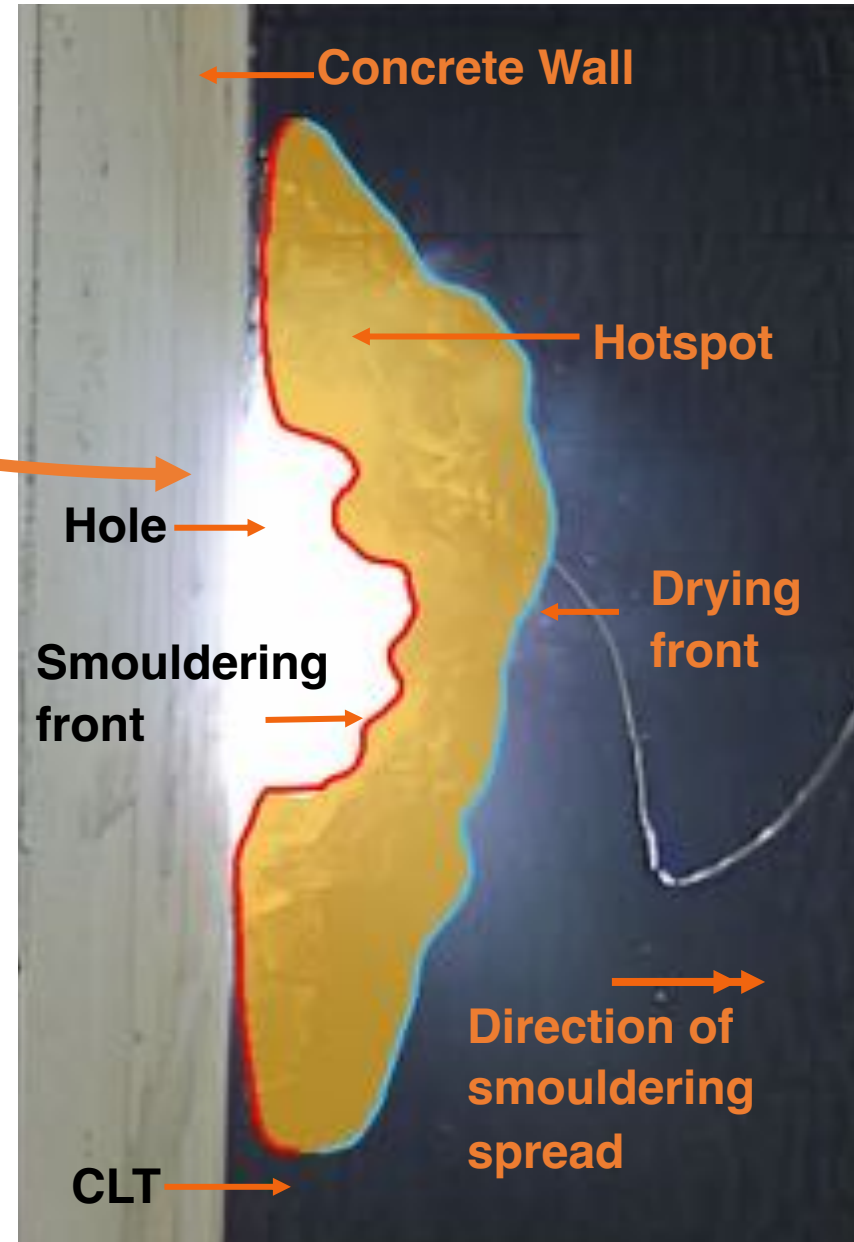
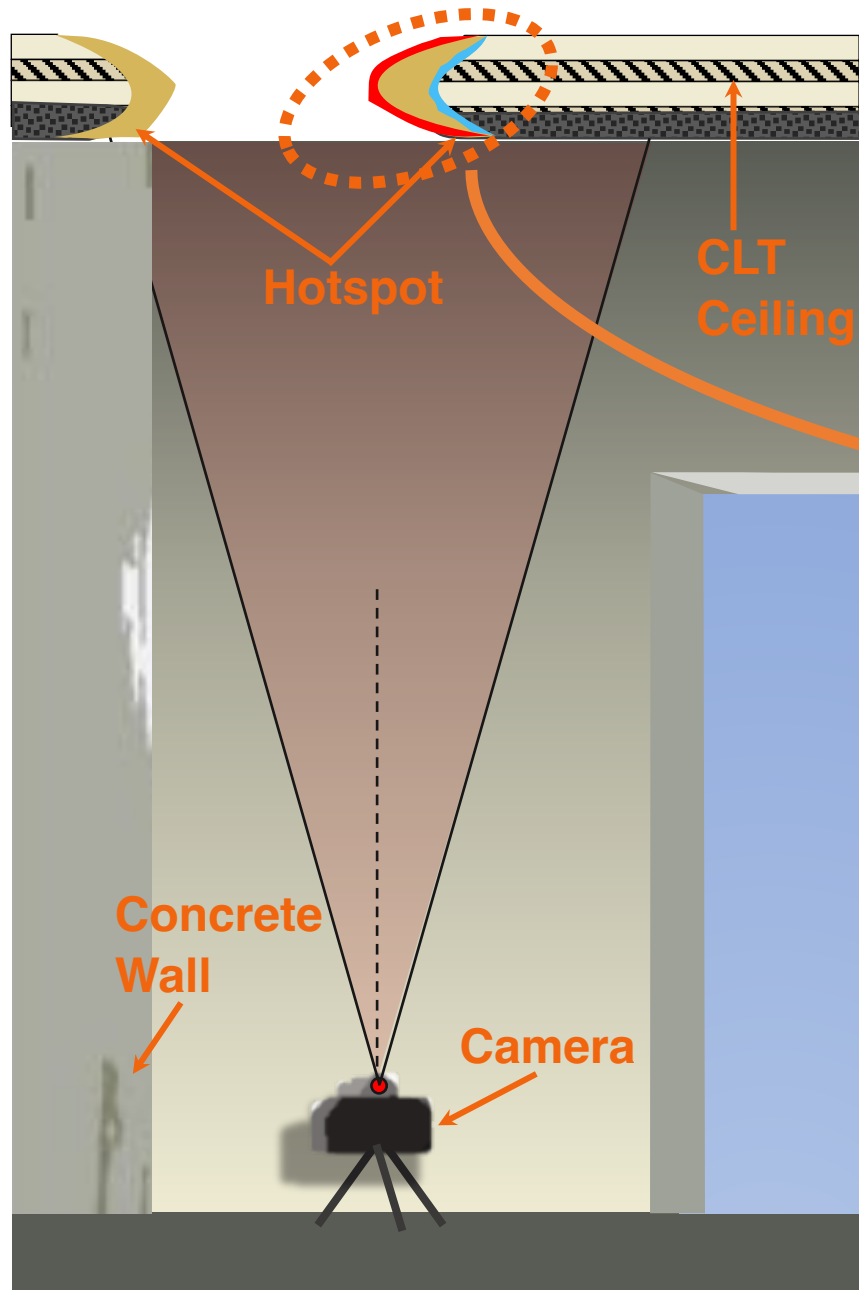
Visual



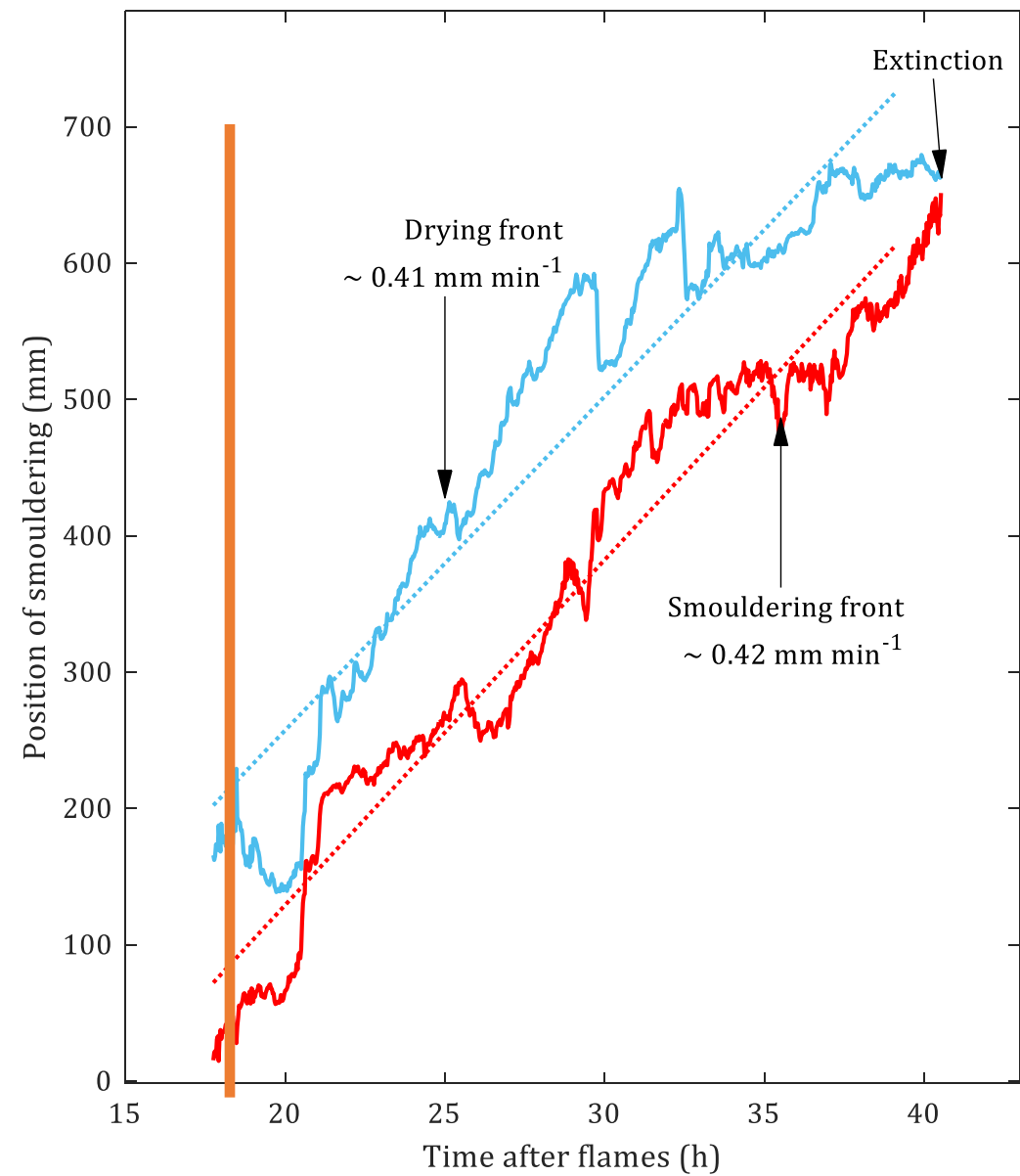
Infrared



Smouldering hotspot spread



Smouldering hotspot spread



17h

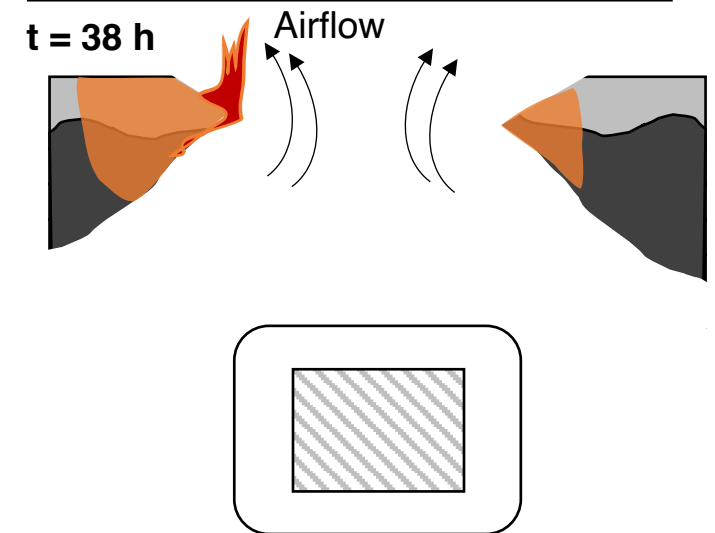
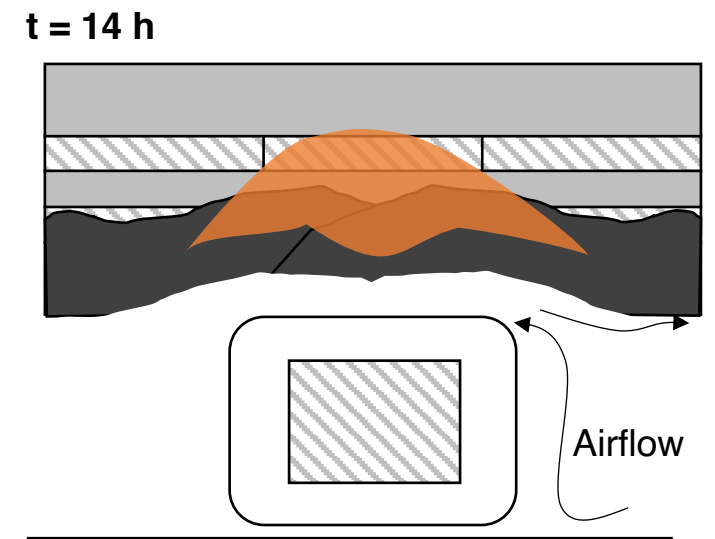
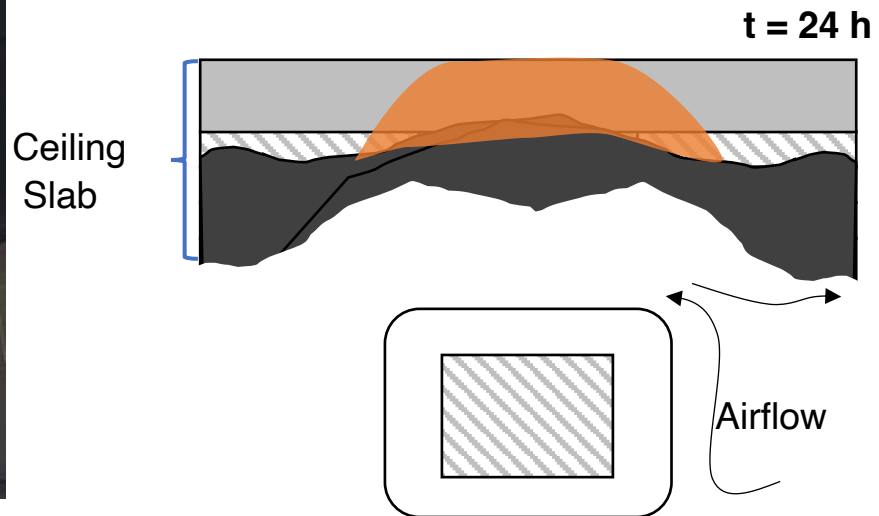
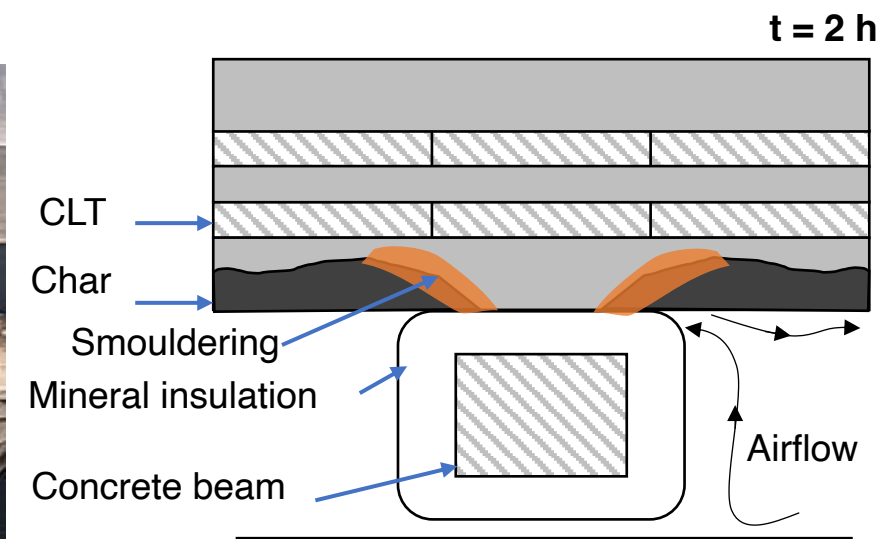
24h

30h

36h

10

In-depth smouldering



Transition to Flaming



Flaming observed at hotspots hours after fire



Transition to flaming can present a hazard (starting a new fire!)

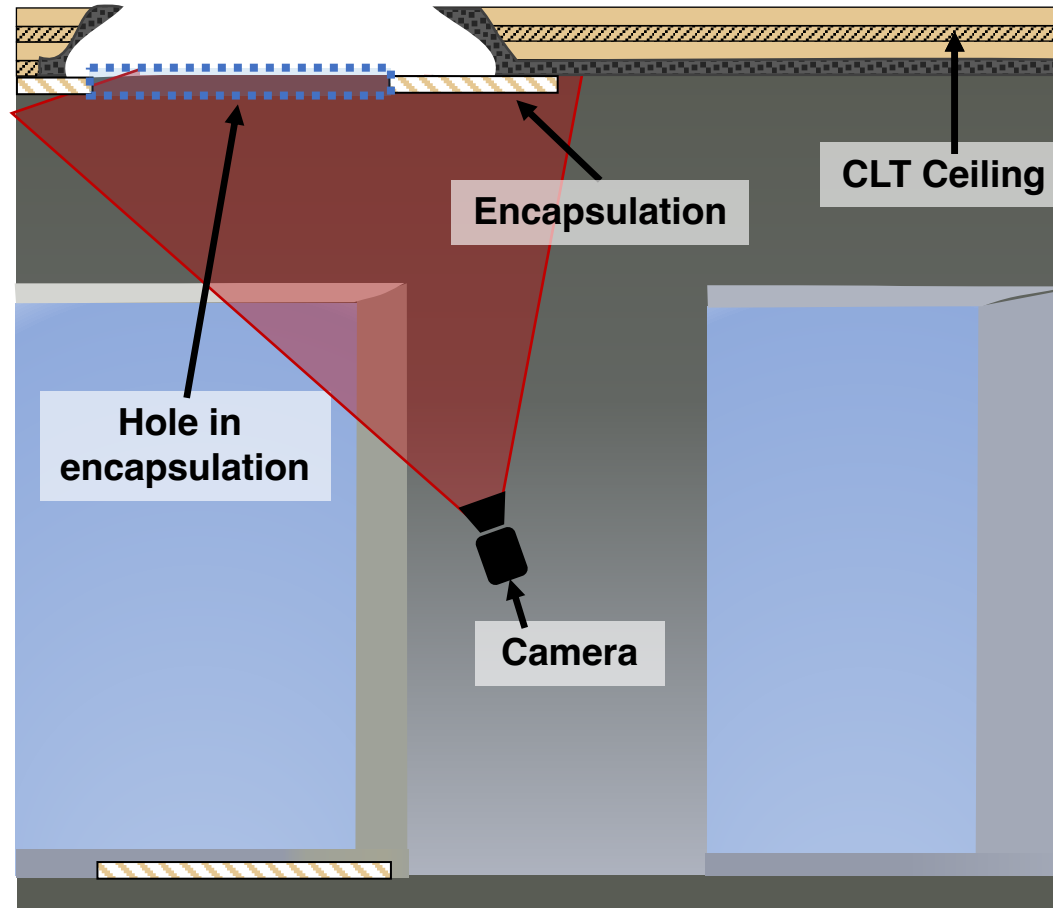


CodeRed 02, 36 h after flames

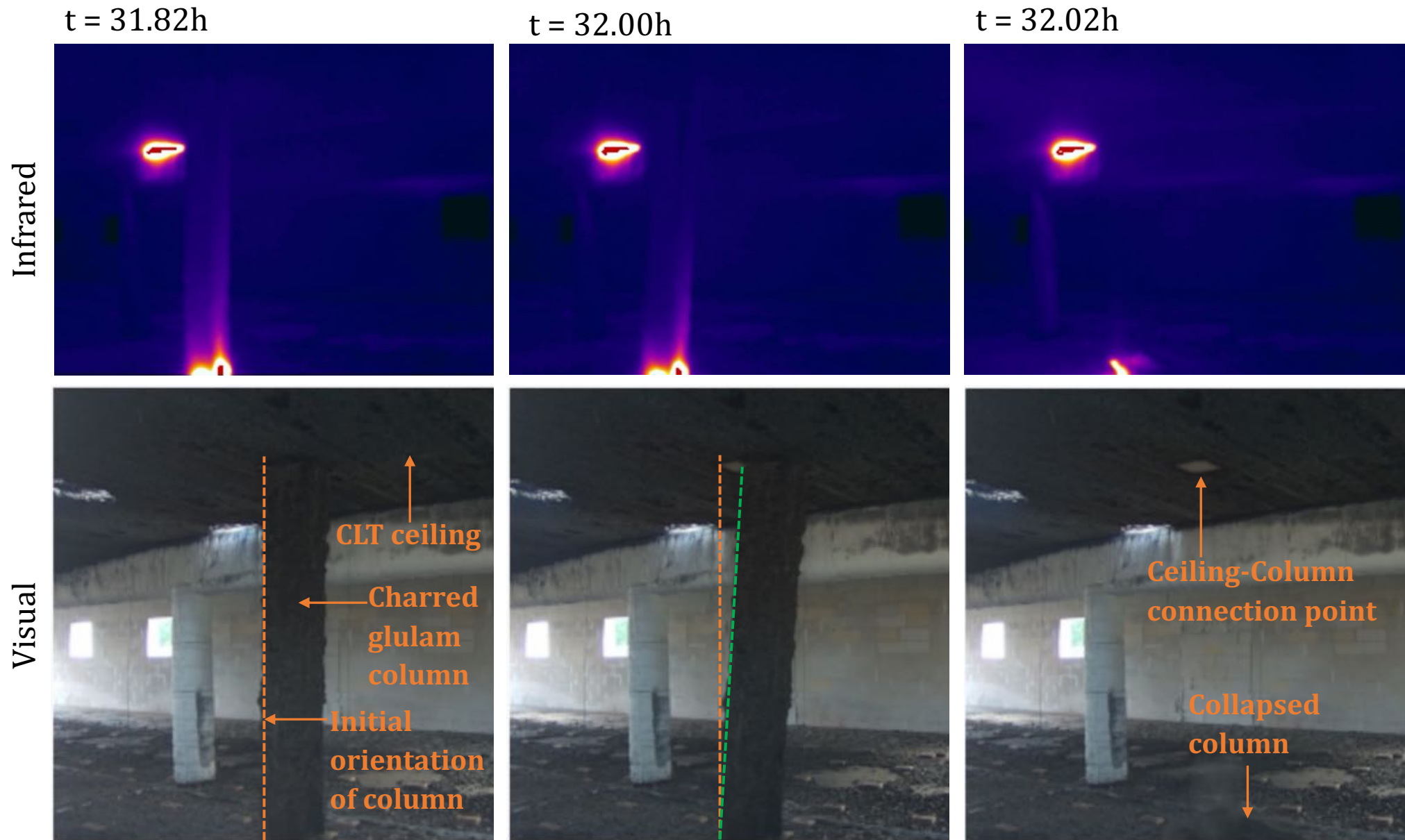
Encapsulation - Hidden fires!

✓ No smouldering detected under protection over 48h following the end of flames.

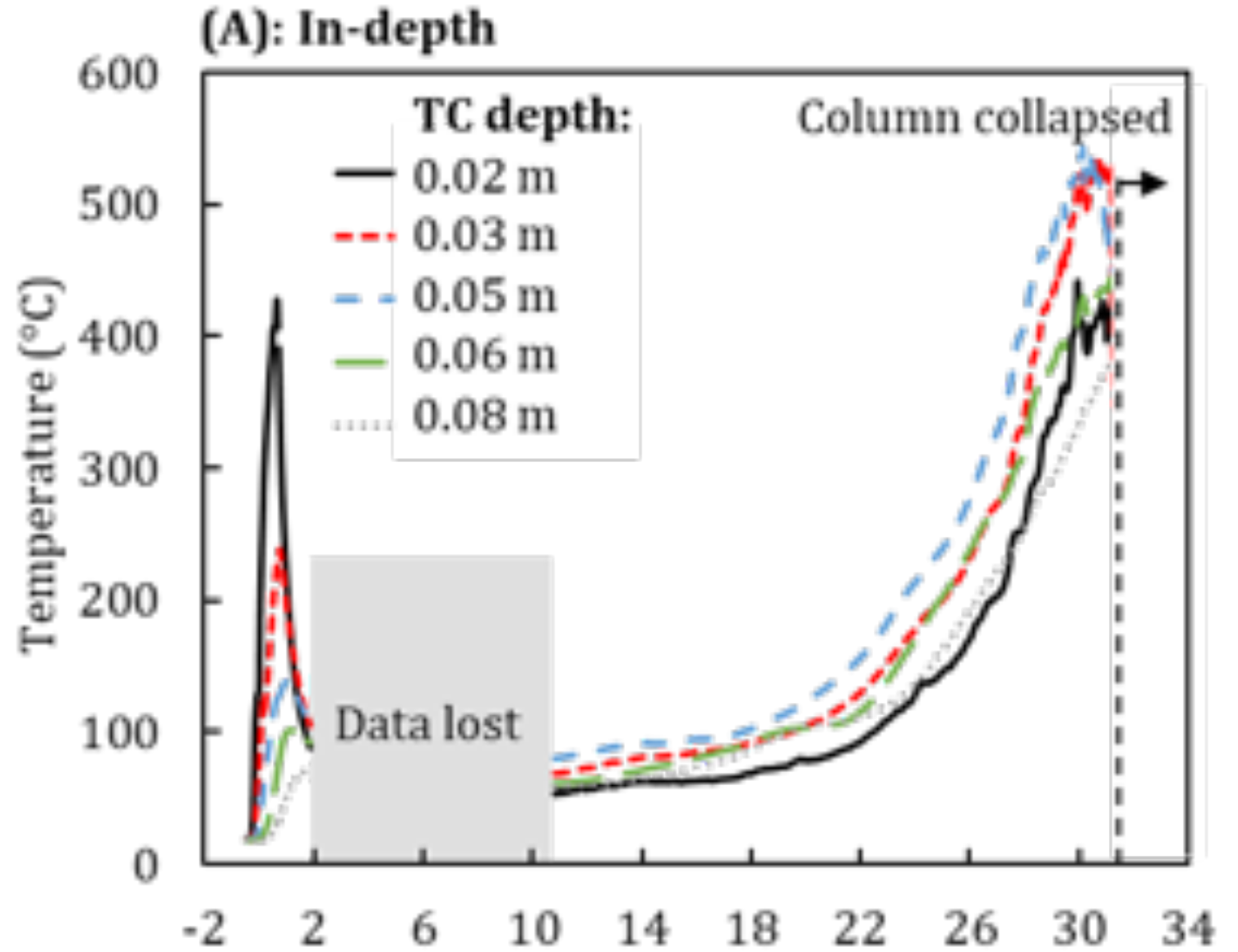
⚠ After 22 days, encapsulation fell through, exposing hole in CLT.



Column Smouldering



Column Smouldering



Extinction



Hotspots extinguished without intervention



Rainfall effective at extinguishing some hotspots.



Successful manual extinguishment of smouldering hotspot

**When do we define
“extinction”?**







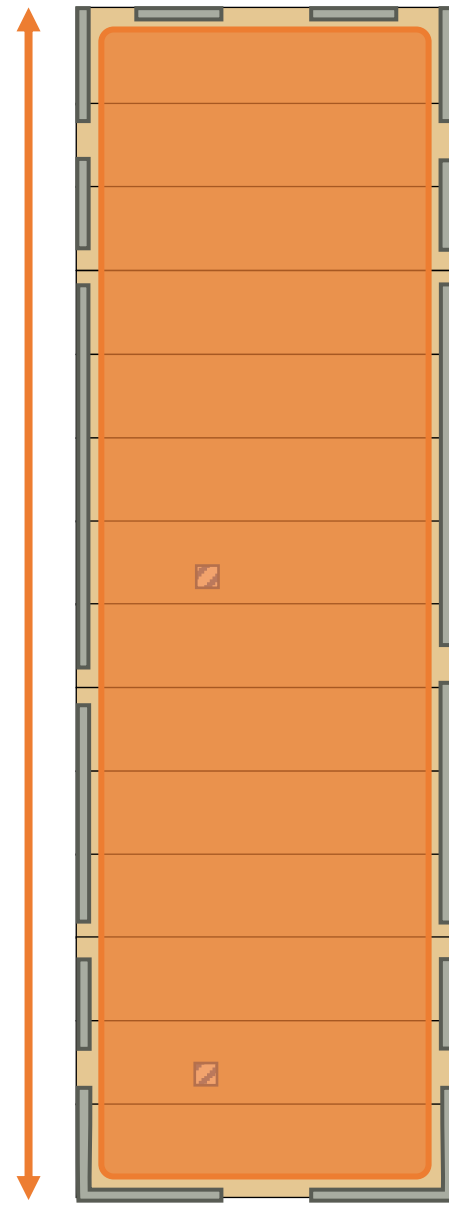
Hotspot locations

34.3 m

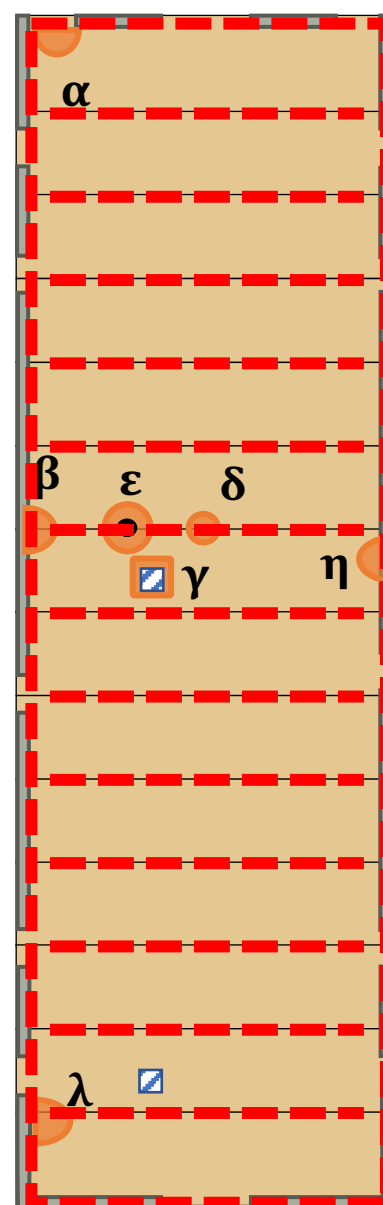
10.8 m

CodeRed #02

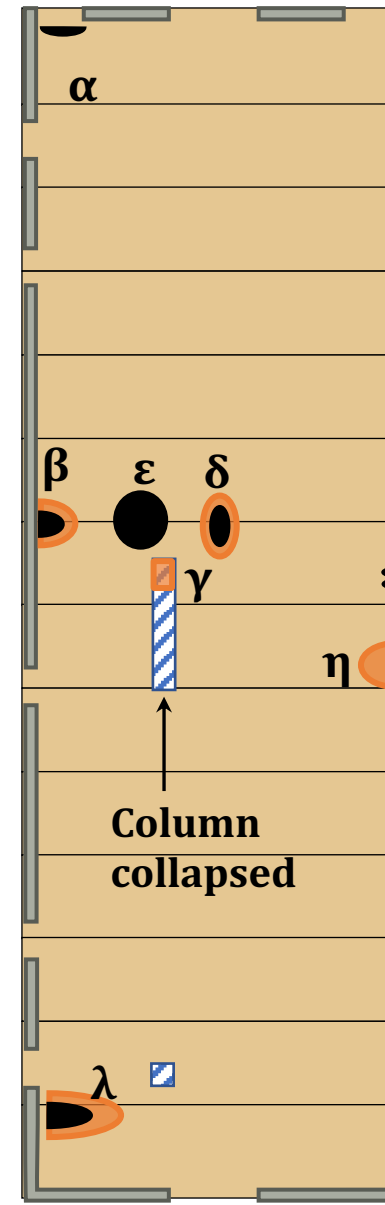
-  CLT ceiling
-  Smouldering
-  Hole in ceiling
-  Glulam column



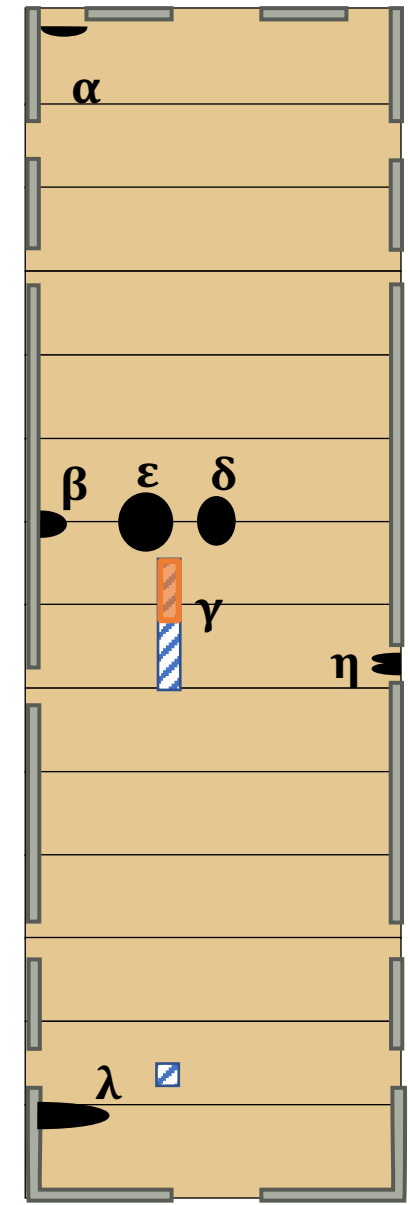
$t \approx 0h$ (after flames)



$t \approx 12h$



$t \approx 36h$



$t \approx 60h$

Summary of findings

CodeRed	#01	#02	#04
Number of hotspots	3	7	9
Number of holes	2	5	2
Suppression method	Rainfall	Fire hose and rainfall.	-
Analysed hotspot spread rate	1.3 mm/min	0.42 mm/min	-



Summary



Smouldering presents a **significant hazard** to timber buildings.



First study focused on smouldering fires in mass timber.



Smouldering is proven to be a **structural hazard**.



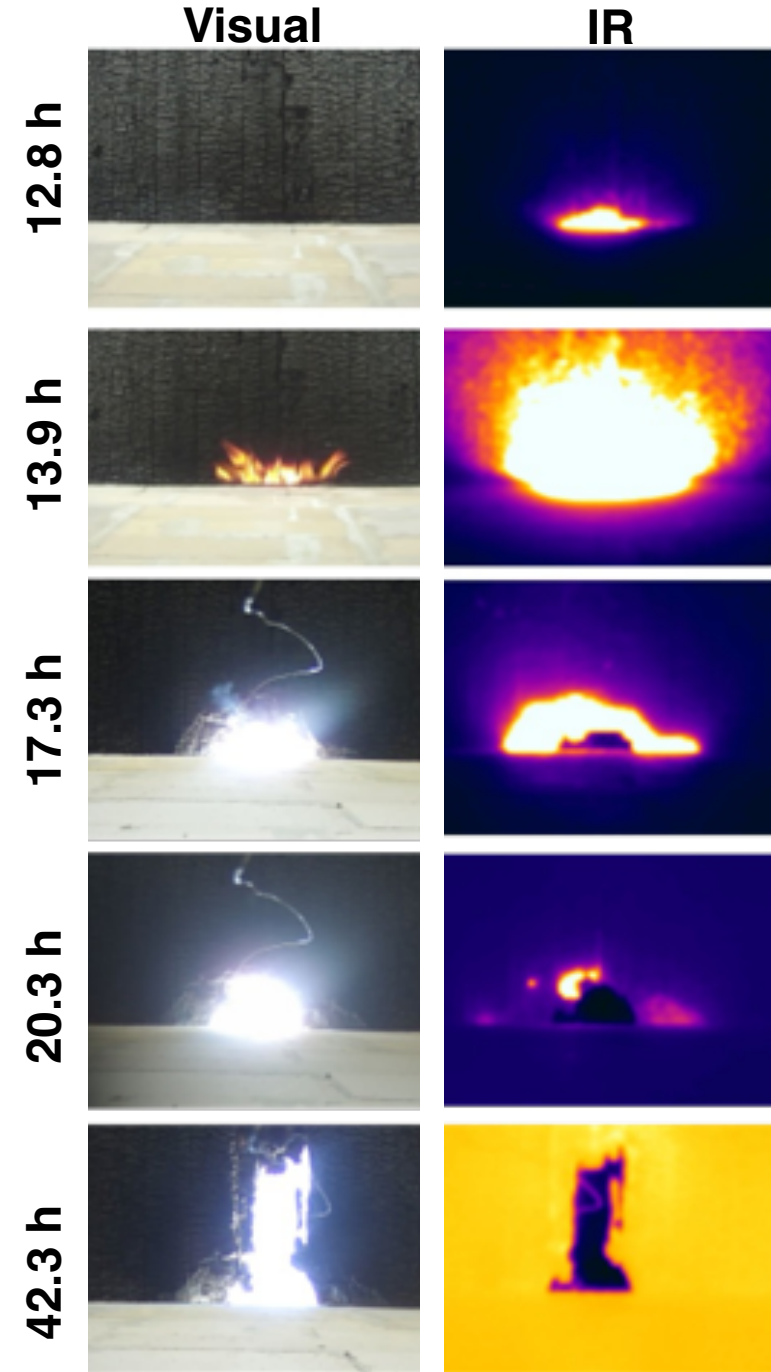
Hard to **detect and suppress**.



Transition to flaming creates pathways to further fires hours after extinction



Encapsulation helps **prevent smouldering**, but encapsulation edges are **not protected**





Imperial College
London



ARUP

EPSRC

Engineering and Physical Sciences
Research Council



Thank you!

