Flame spread in large compartment experiments: comparison of Obora and CodeRed

By Harry Mitchell

IMPERIAL HAZELAB
EPSRC Engineering and Physical Sciences Research Council
ARUP

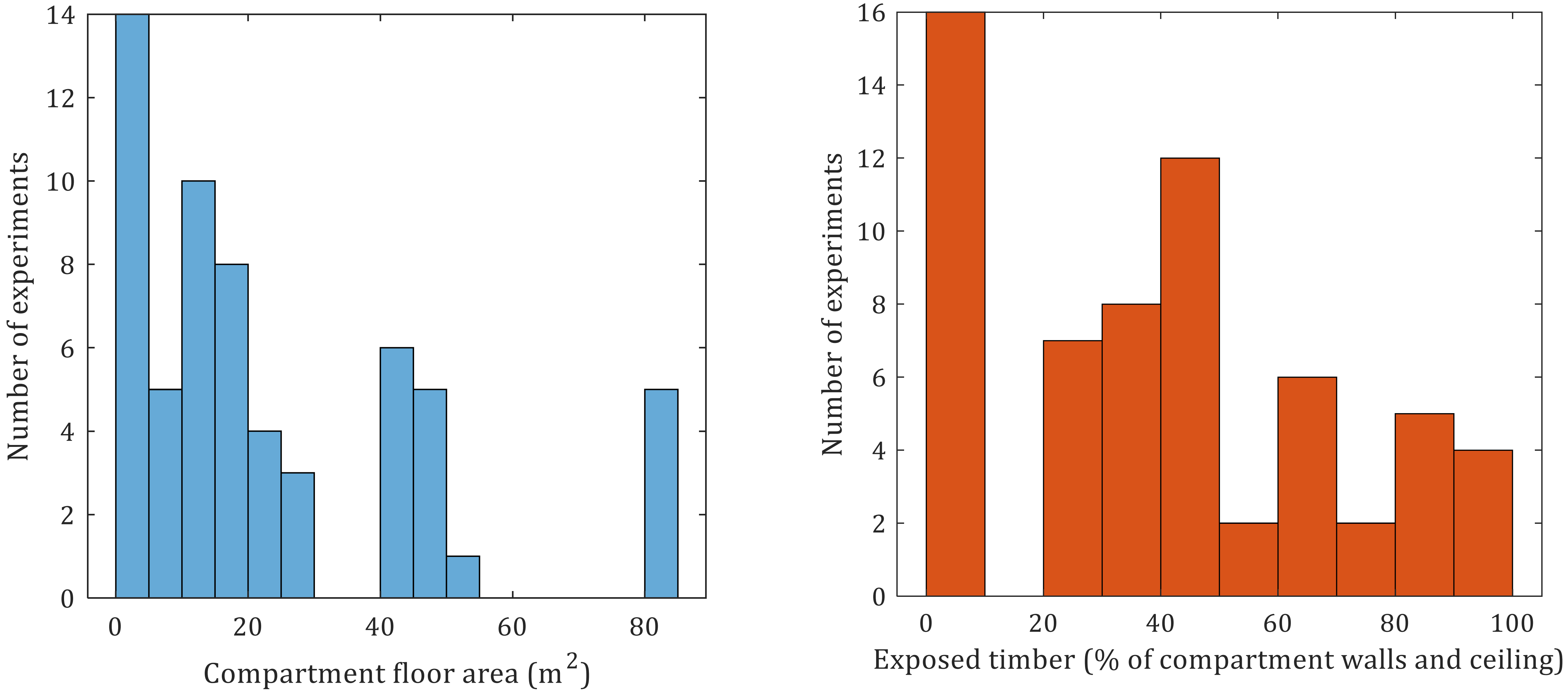
Large compartments and mass timber

Large compartments and mass timber


The Guardian (2013)

- Detection
- Evacuation
- Firefighter response
- Structural response

Current mass timber compartment fire experimentation



Large Open-Plan Compartment Fire Experiments: Obora and CodeRed

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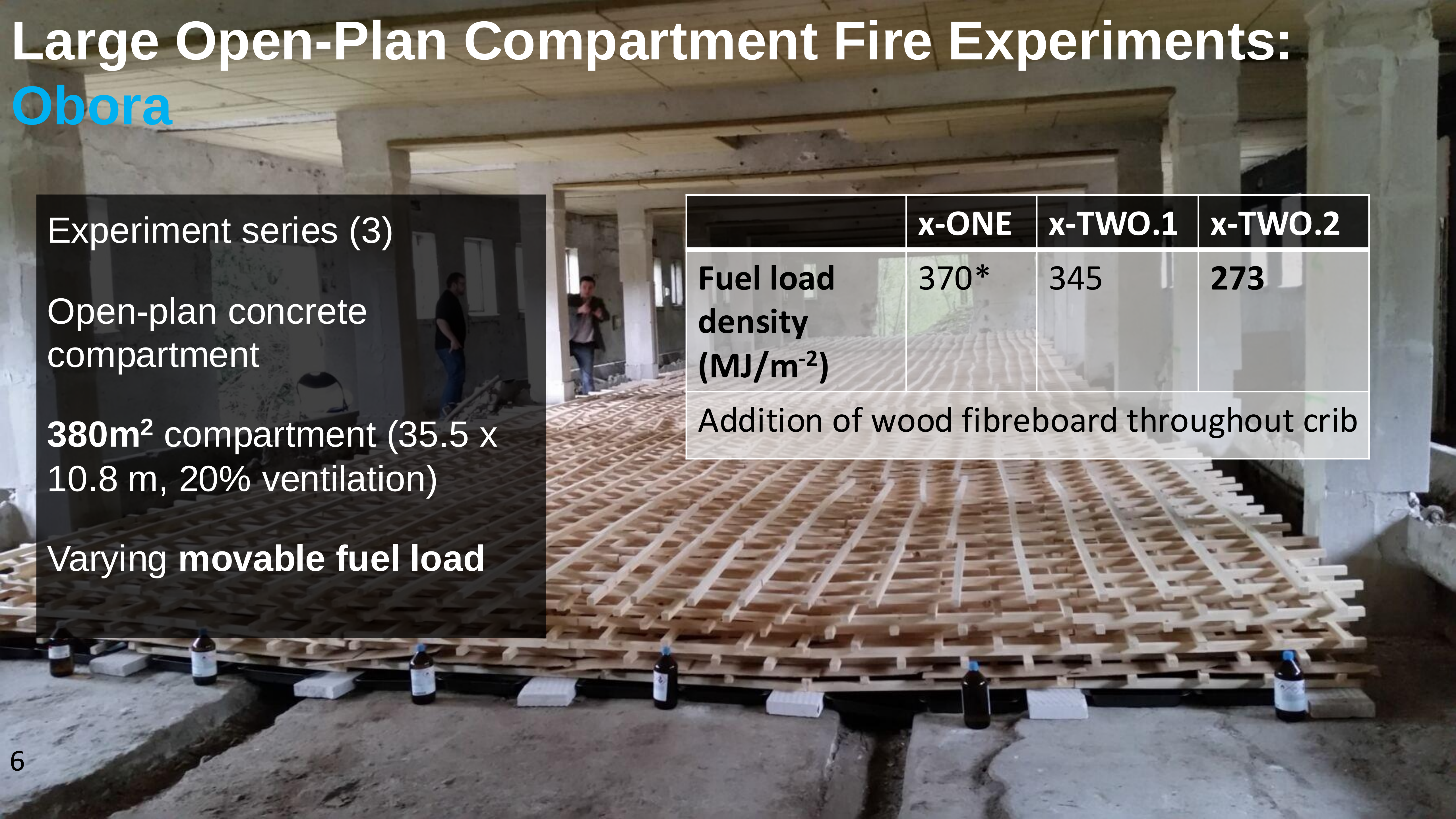
Large Open-Plan Compartment Fire Experiments: Obora



Experiment series (3)

Open-plan concrete compartment

380m² compartment (35.5 x 10.8 m, 20% ventilation)

Varying **movable fuel load**

	x-ONE	x-TWO.1	x-TWO.2
Fuel load density (MJ/m^{-2})	370*	345	**273**
Addition of wood fibreboard throughout crib			

Large Open-Plan Mass Timber Compartment Fire Experiments: CodeRed

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Experiment series (3)

Open-plan mass timber compartment

352m² floor area (34.3 x 10.3)

CLT ceiling and glulam columns

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

CodeRed #	01	02	04
Ventilation area (m^2)	57	**28**	57
Opening factor ($m^{1/2}$)	0.071	**0.039**	0.071
Area of exposed timber (m^2)	352	352	**183**
Movable fuel load ($MJ\ m^{-2}$)	374	377	394

Summary

x-ONE – Baseline with fibreboard in fuel load

x-TWO.1 – **Baseline**

x-TWO.2 – reduced fuel load (-20%)

CodeRed #01 – mass timber ceiling

CodeRed #02 – reduced ventilation (-50%)

CodeRed #04 – partially encapsulated timber ceiling (-50%)

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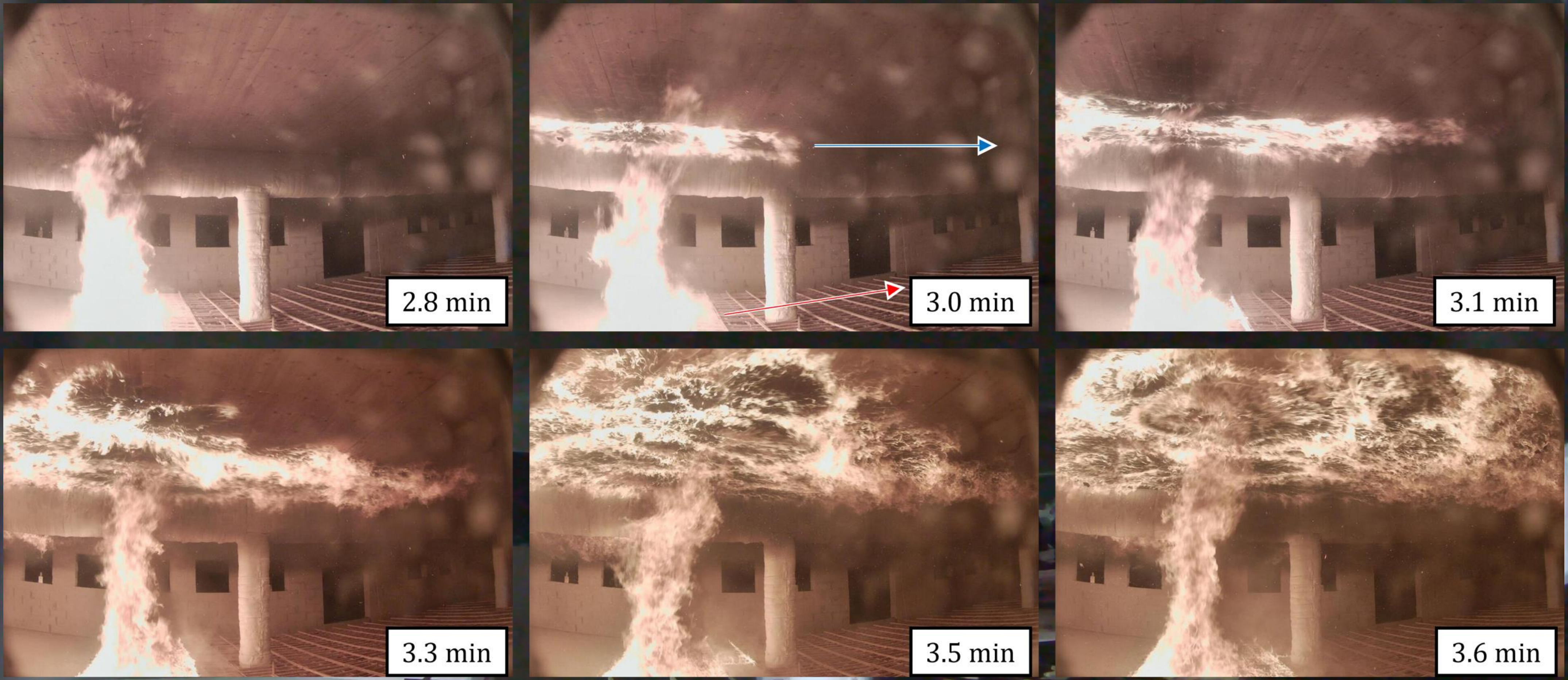
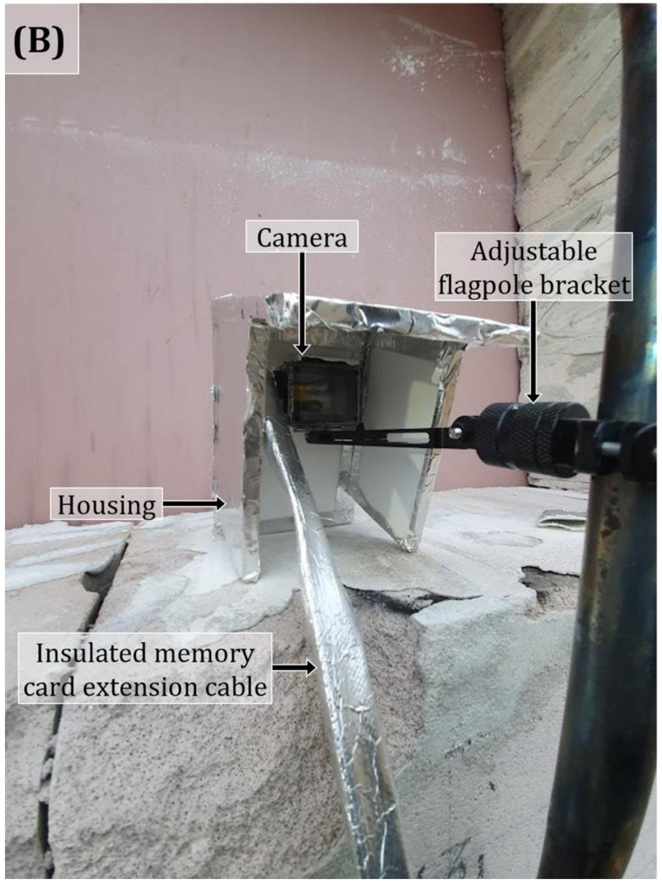
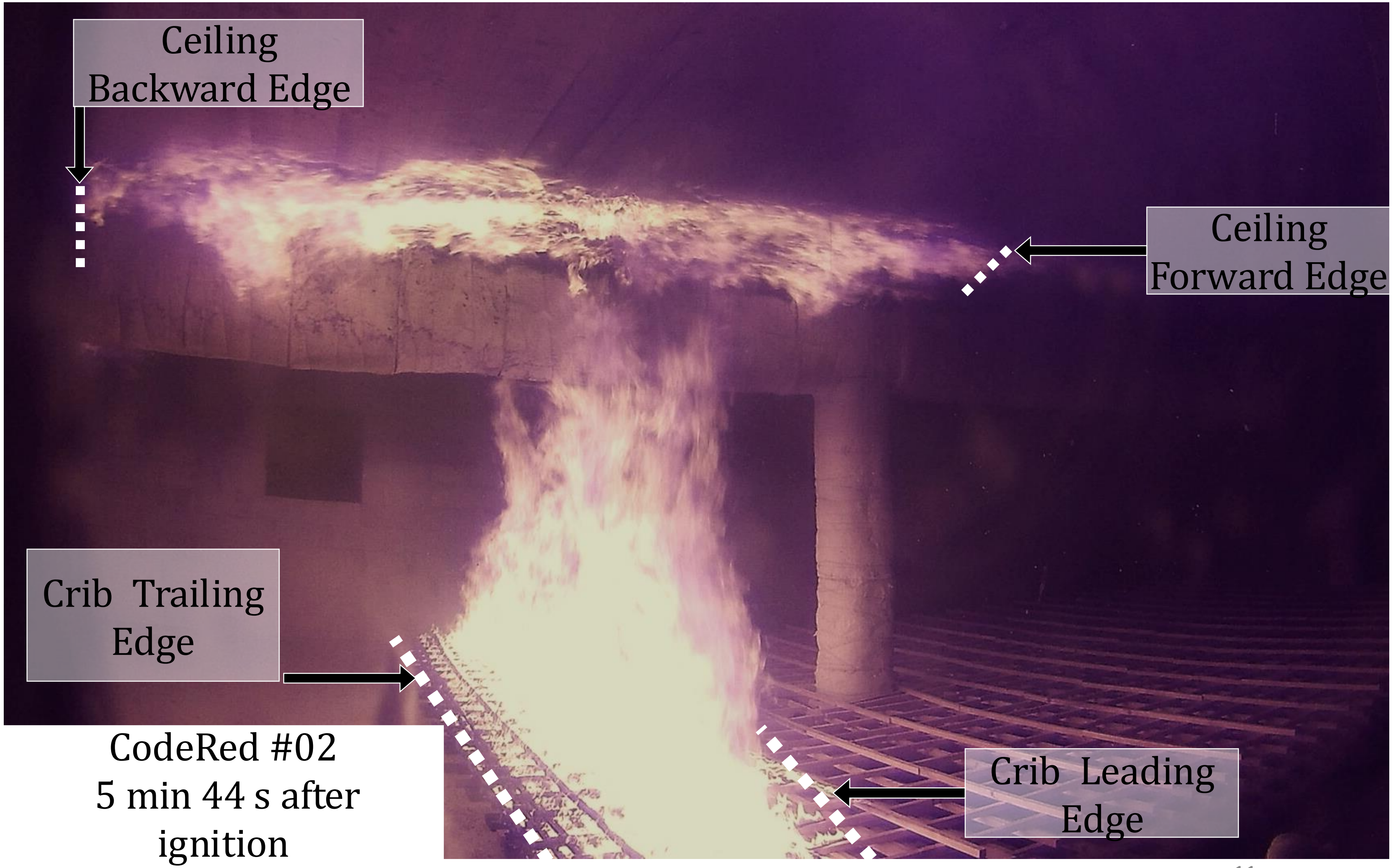


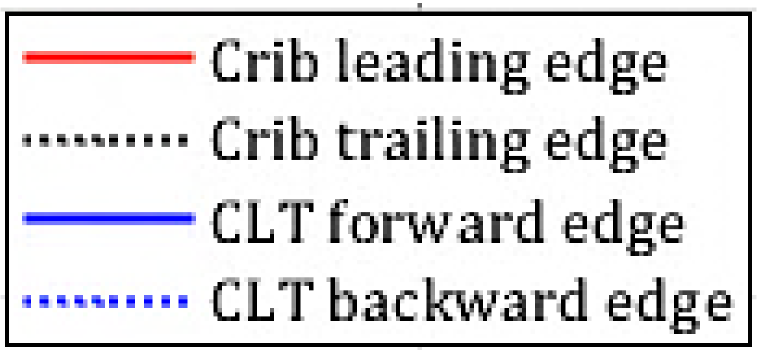
55 x speed



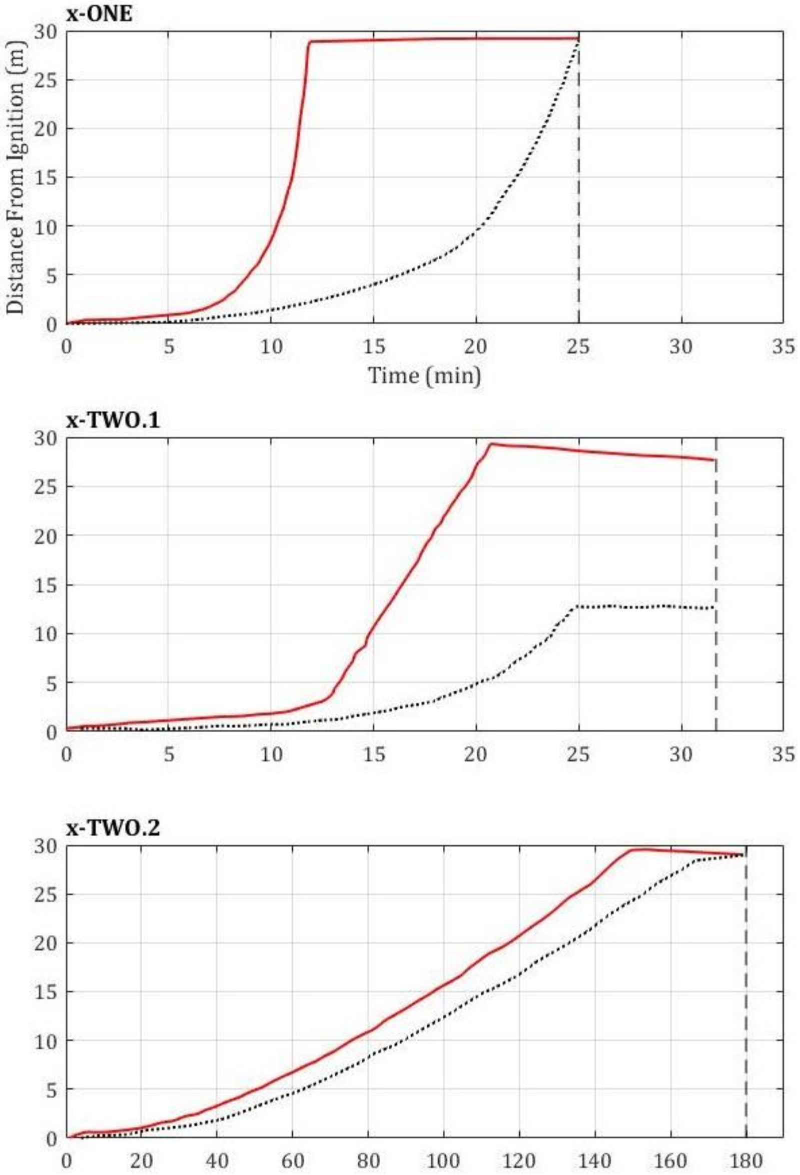


CodeRed #02
5 min 44 s after ignition

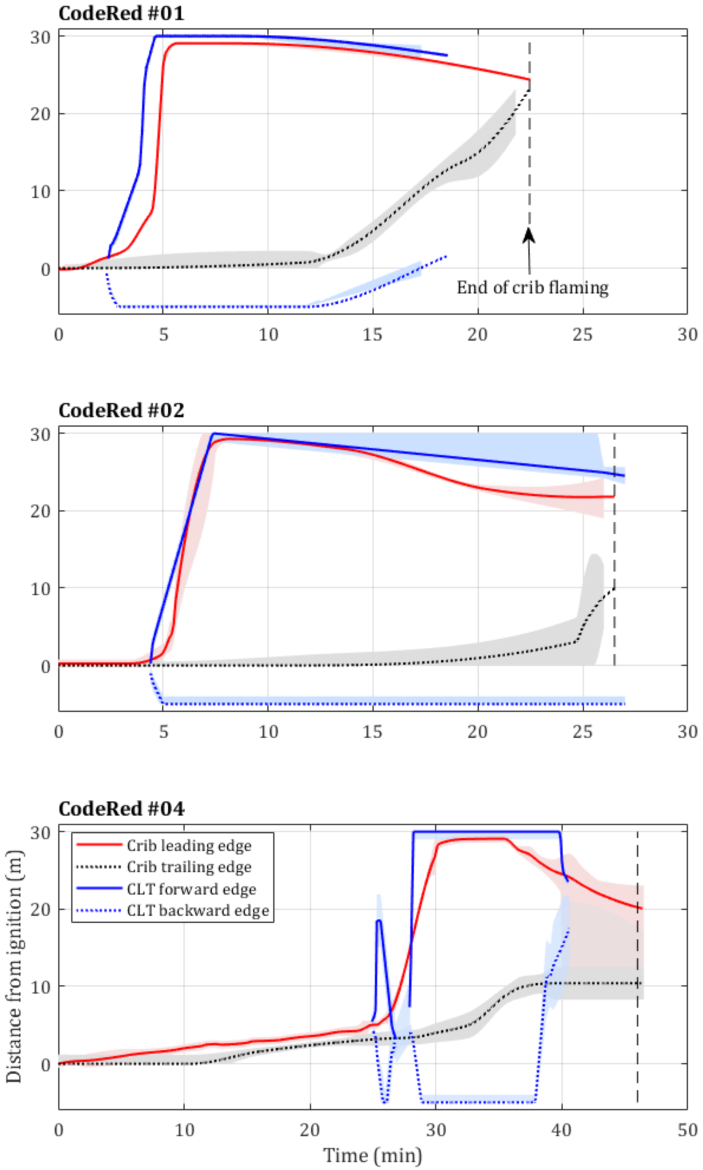
Flame spread results



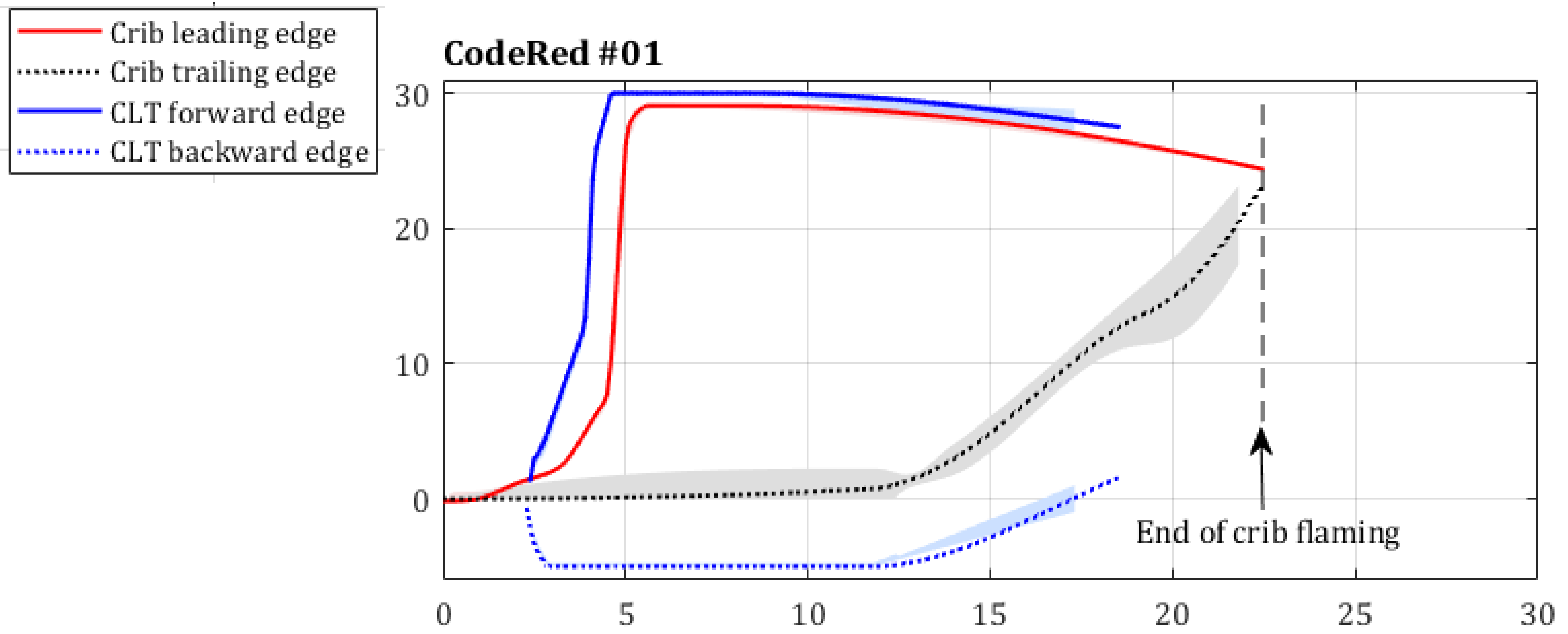
Obora



CodeRed

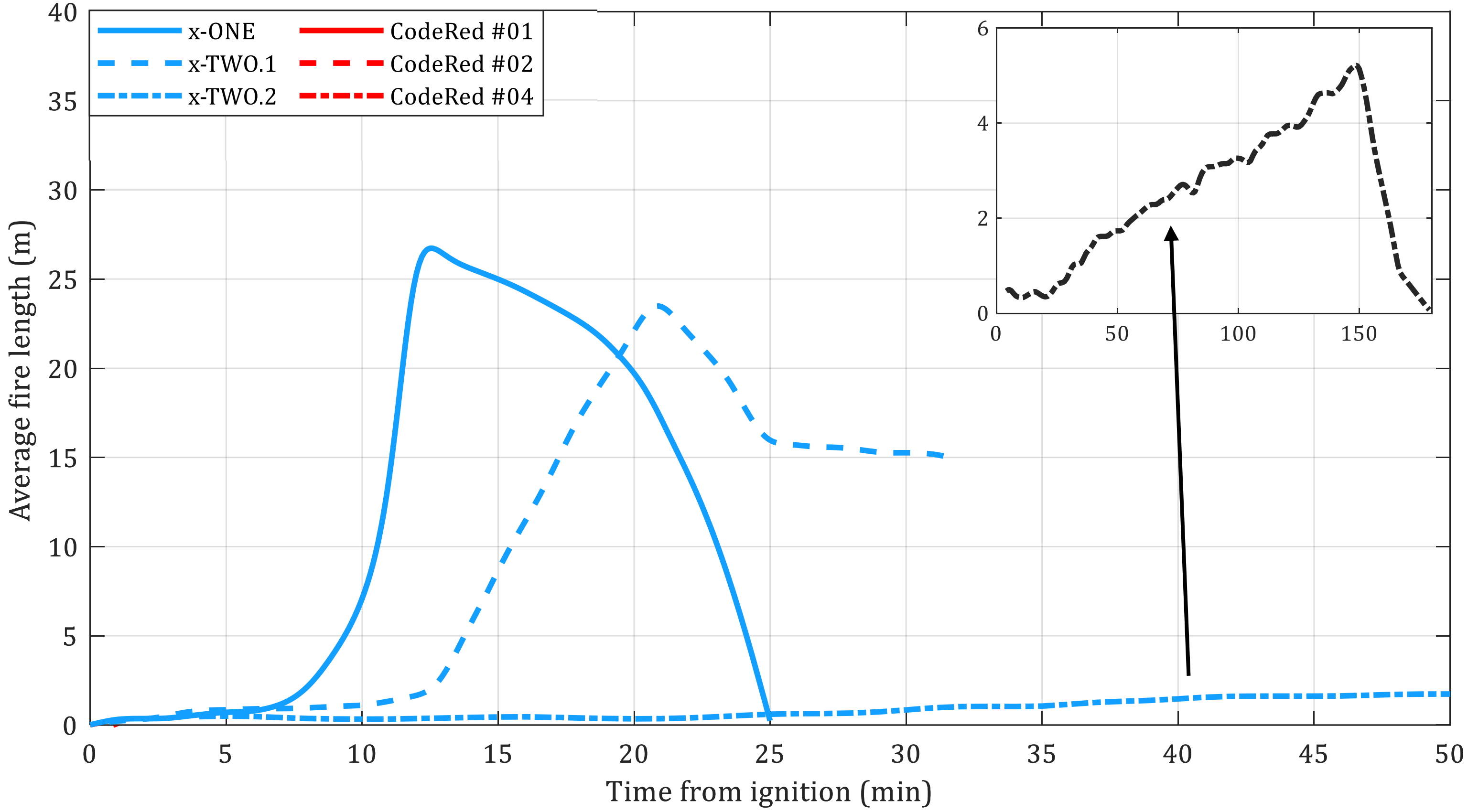


Flame spread results: CodeRed #01



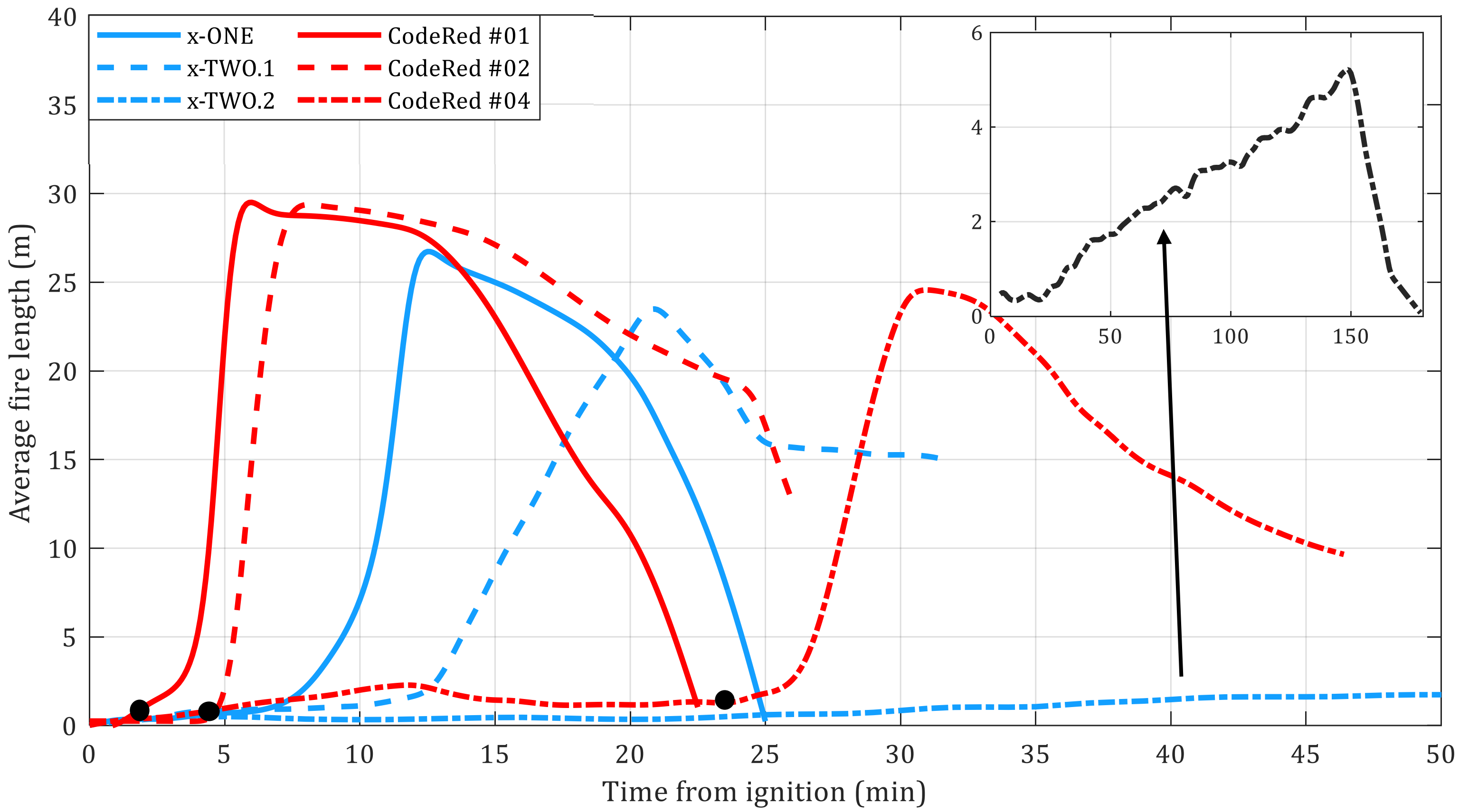
Crib flame spread

- Reduction of fuel load reduces flame spread rates significantly



Crib flame spread

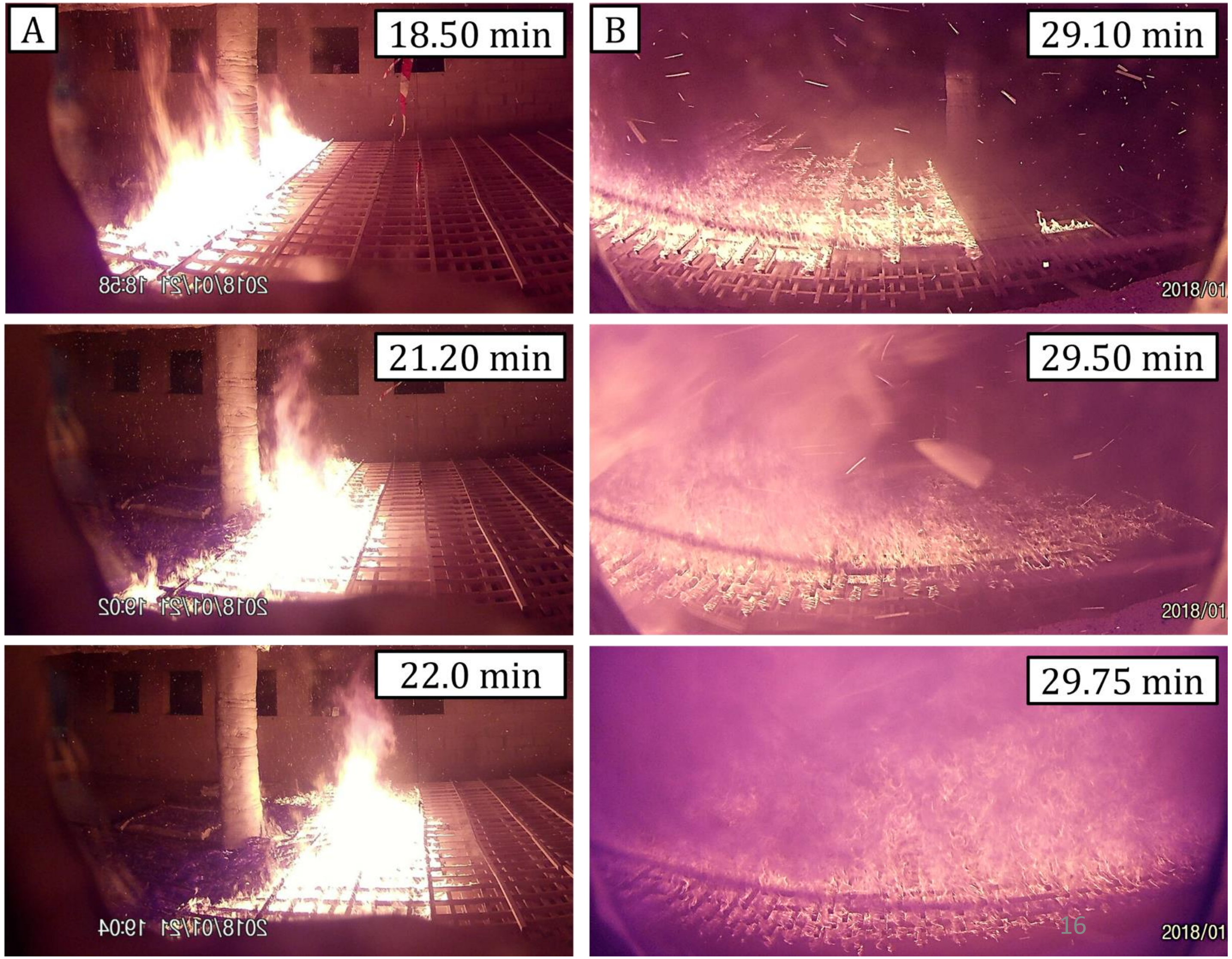
- Reduction of fuel load reduces flame spread rates significantly
- Mass timber accelerates crib flame spread after ceiling ignition
- Reduction of ventilation slightly delays ceiling ignition and rapid flame spread



Crib flame spread – key behaviours

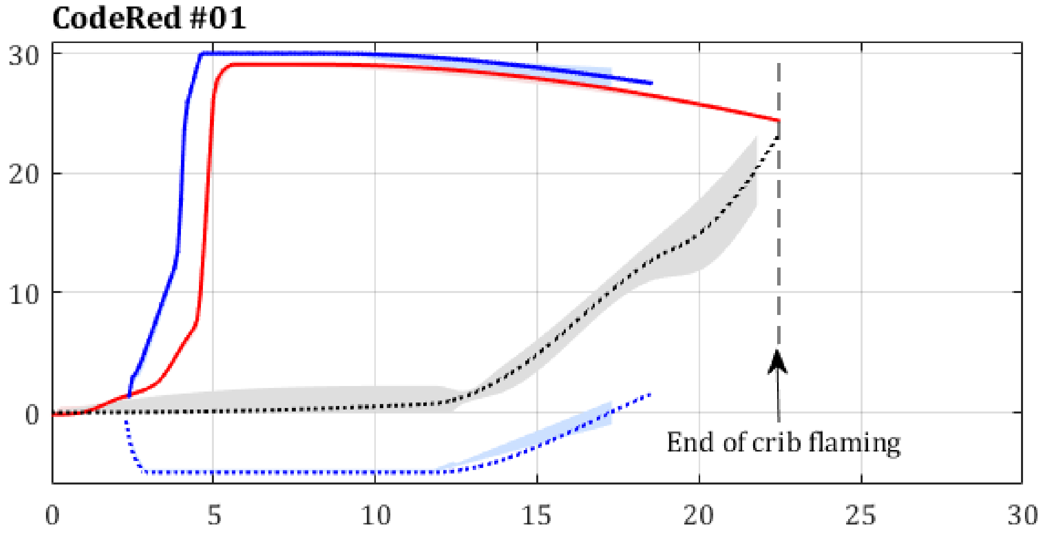
- Initial flame spread in all experiments occurred slowly (**2.1 – 3.3 mm s^{-1}**), depending on crib
- Flame spread accelerated in x-ONE and x-TWO.1 after formation of smoke layer (**34 - 67 mm s^{-1}**).
- x-TWO.2 did not spread as rapidly
- Flame spread accelerated in CodeRed post- ceiling ignition (**97 – 161 mm s^{-1}**)
- During rapid flame spread, flames first spread along upper layers of fuel load
- Moisture content is an important consideration

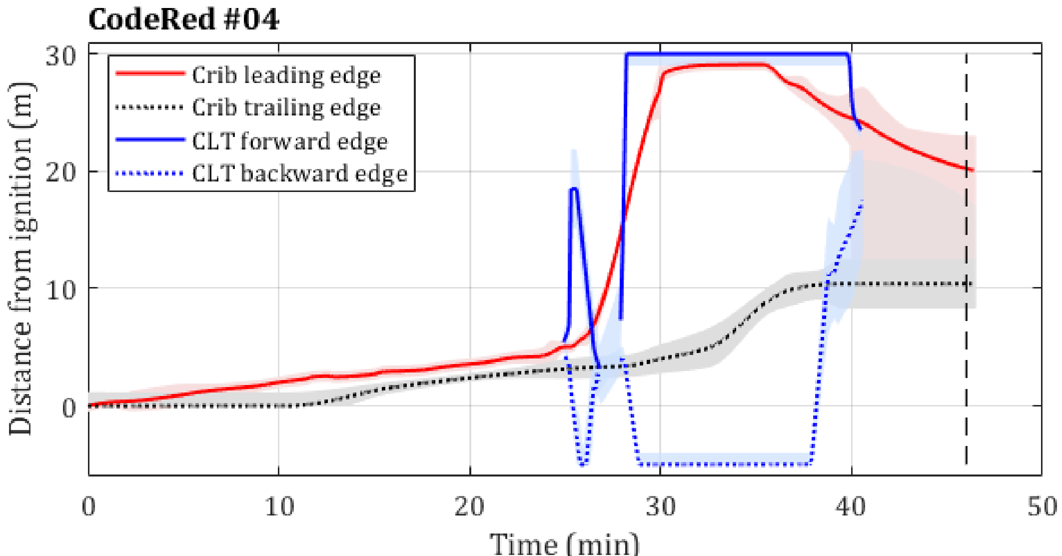
Before ceiling ignition | **After ceiling ignition**

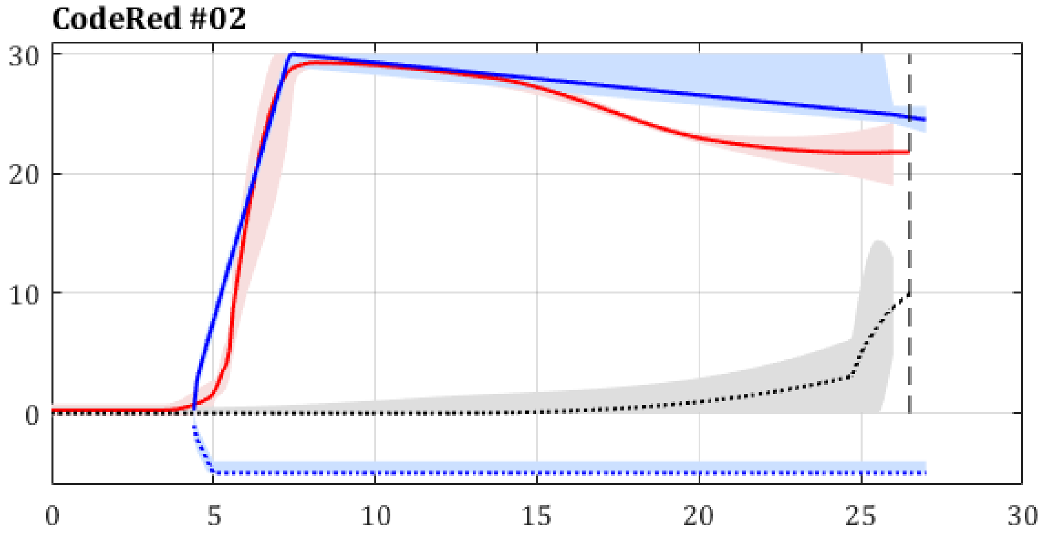


Ceiling flame spread

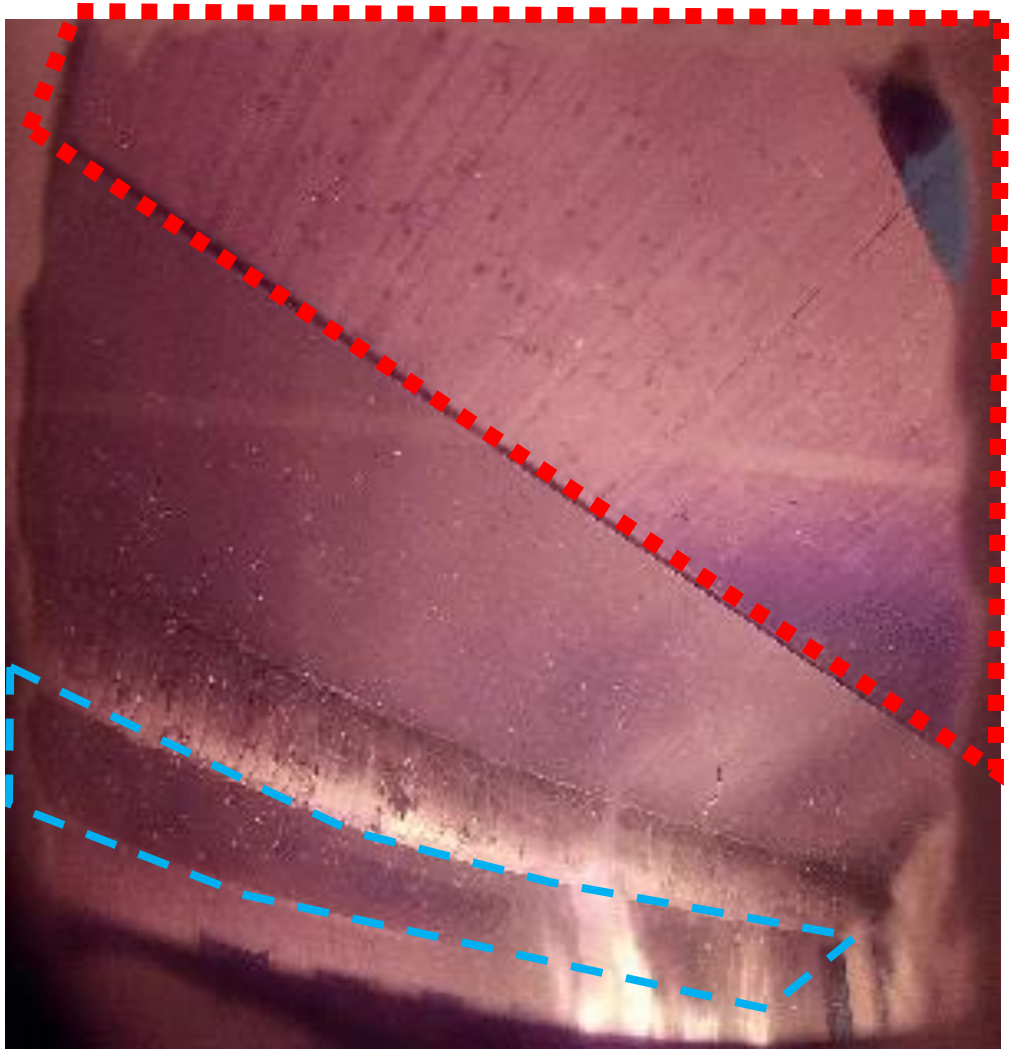
- Ceiling ignition occurred at similar times in CodeRed #01 and #02, but significantly later (~ 24 min) in #04.
- Flames spread rapidly in #01 **(200 mm s^{-1})** and #02 **(153 mm s^{-1})**
- Ceiling flame spread was slower **(-23%)** in CodeRed #02 than #01 – deeper and denser smoke layer
- Flame spread was significantly faster in #04 **(533-1260 mm s^{-1})**

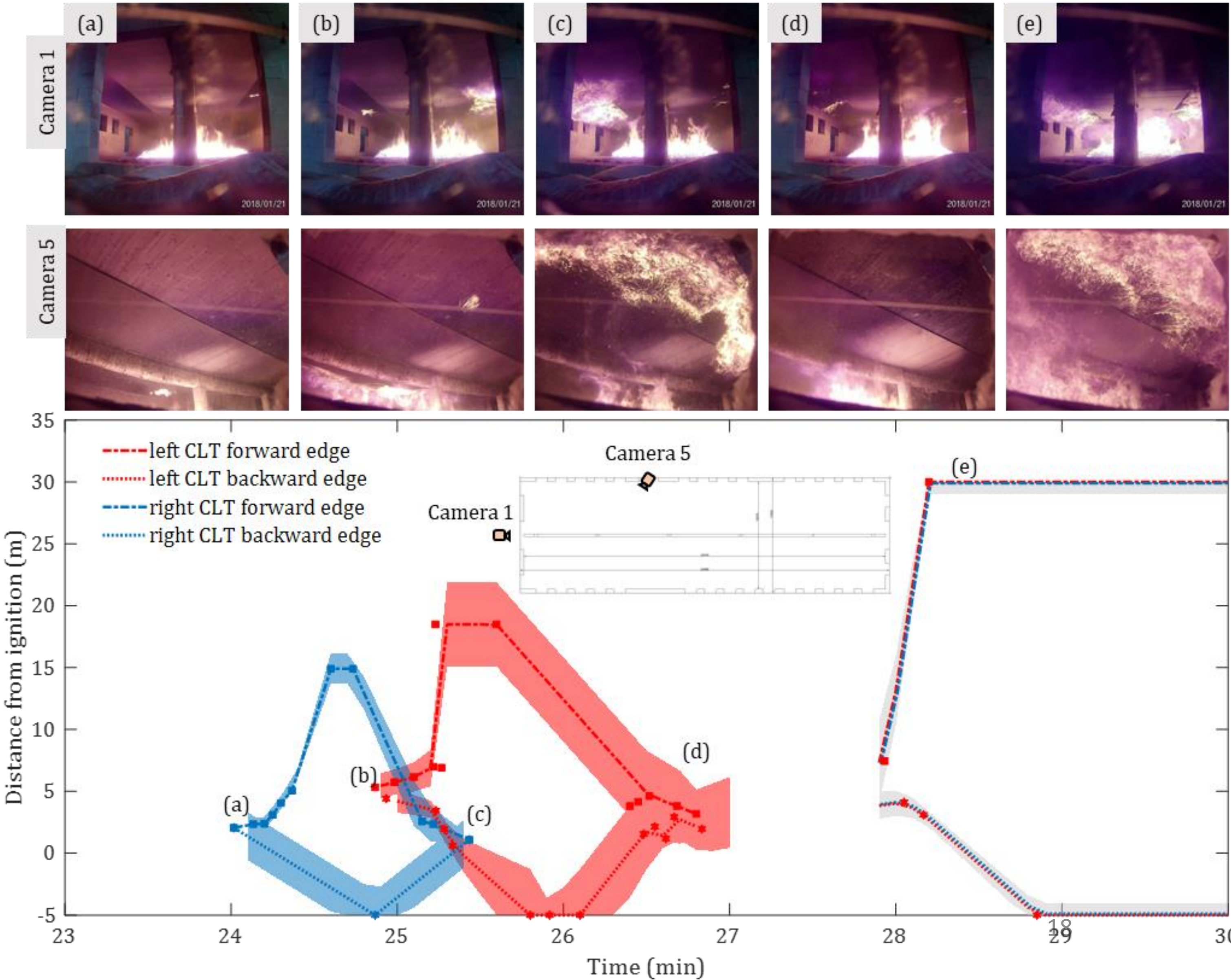






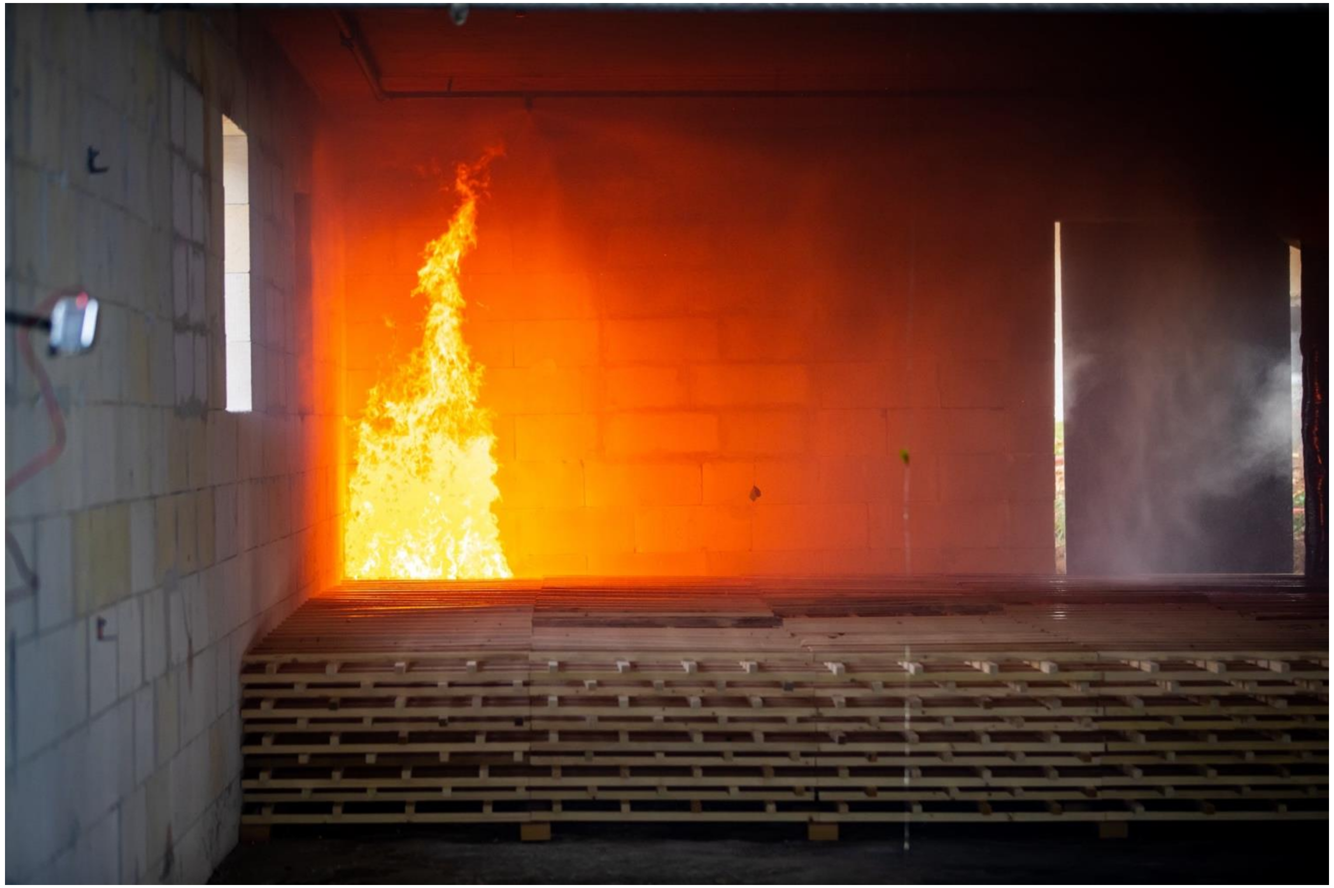
Ceiling flame spread – flashing waves





Other factors with mass timber flame spread

- Managing movable fuel load
- Sprinklers & water mist systems (CodeRed #03)
- If partial encapsulation, where?



Summary

- Flame spread is an important phenomena in large compartments (timber & concrete!).
- Reducing the movable fuel load can reduce flame spread rates significantly.
- Exposed timber ceilings can rapidly increase flame spread rates inside compartment once ignited.
- Ventilation had minimal impact on flame spread rate on crib, but significant on ceiling.
- Partial encapsulation can delay rapid flame spread, but does not prevent it entirely.
- Flame spread inside compartments is a complex process that requires further study.

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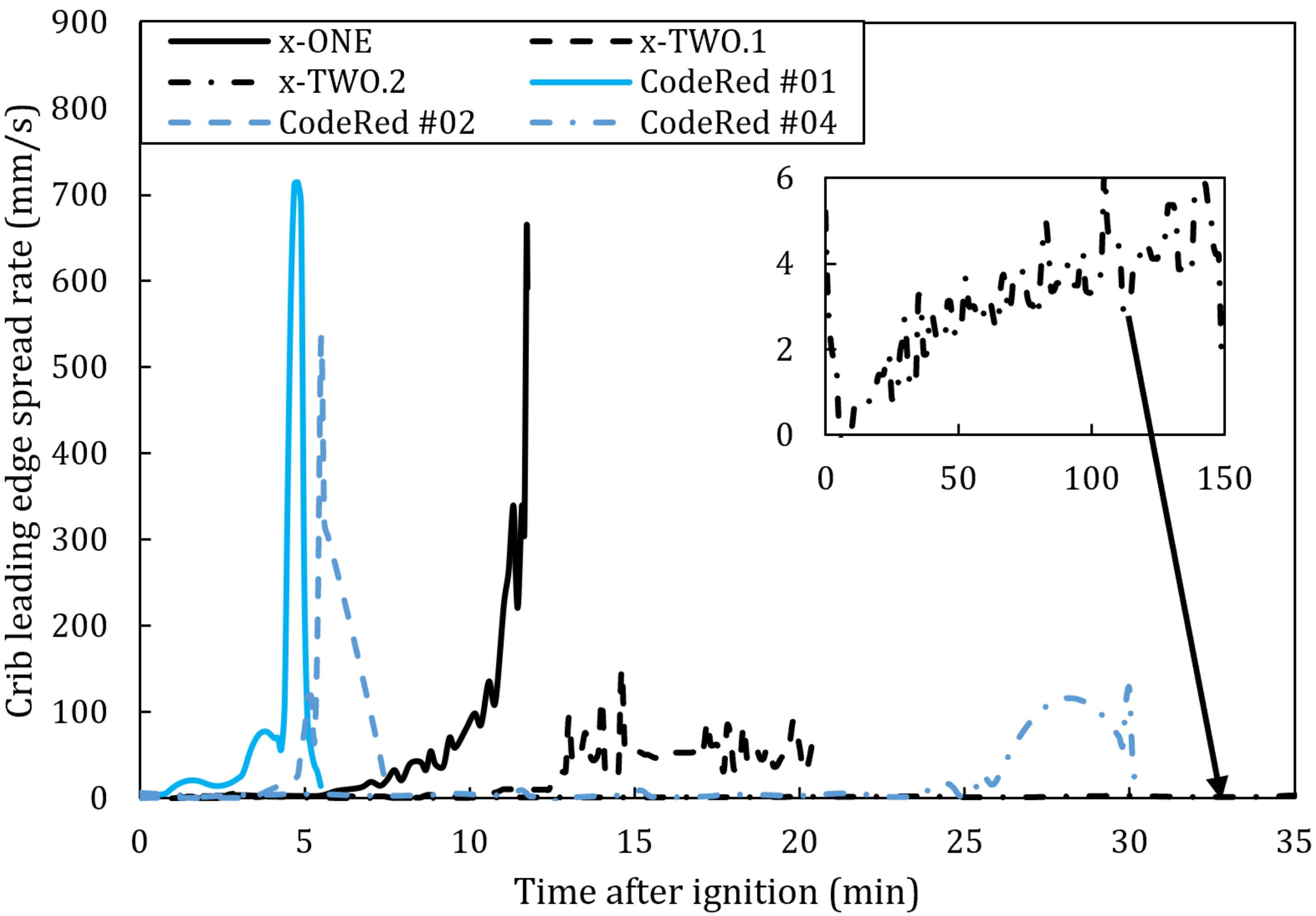
Thank you!

Backup slides

Crib spread rates



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