

Independent Committee in relation to the fire at Wang Fuk Court in Tai Po

Experts' Presentation

Prof Asif Sohail Usmani

Prof Jiang Liming

(Fire Engineering Experts for the Independent Committee)

About us

Professor Asif Sohail Usmani

Chair Professor of Building Sciences
and Fire Safety Engineering

Department of Building Environment
and Energy Engineering

The Hong Kong Polytechnic University

BEng: NED University of Eng. Tech.
MS: Stanford University
PhD: University of Wales, Swansea

Performance based structural and fire safety
engineering; development of computational tools for
realistic simulation of structural response to fire
loading; and promoting resilience of infrastructure and
communities to man-made and natural disasters (RGC
SureFire project)



Professor Jiang Liming

Associate Head of the Department and
Associate Professor

Department of Building Environment
and Energy Engineering

The Hong Kong Polytechnic University

BEng: Tongji University
MEng: Tongji University
PhD: University of Edinburgh

Fire behaviour in modern buildings; OpenSees for fire;
structural behaviour in Fire; travelling fire behaviour and
modelling of fire spread; hybrid testing/simulation;
advanced fire safety solutions for built
environment (IAFSS Philip Thomas Medal of Excellence,
CVU Innovation Award)



Before anything else.....

As researchers in the field of fire engineering, we believe we are tasked with the investigation of fire hazards, informing the public, and ultimately mitigating the risk of lives lost to preventable fires.

As such, we deeply lament that the tragedy was not averted, and we wish to express our deepest sympathies and sorrow over the tragic casualties at Wang Fuk Court.

We would also like to pay our tribute to Senior Fireman Ho Wai Ho for his selfless sacrifice in the course of his duties.

Objectives of the report

Assisting the IC by:

- examining in detail the mechanisms and pathways of fire and smoke spread within Wang Fuk Court, and
- providing expert analysis to support the Committee's findings and recommendations.

Scope of work

- Analysing the rapid vertical and lateral spread of fire along the external walls;
- Conducting a detailed fire and smoke spread analysis;
- Analysing the ignition and combustion behaviour of building materials on the external walls (including scaffolding nets, foam boards, etc.);
- Reviewing existing fire safety standards and assessing their adequacy;
- Conducting independent tests on relevant building materials and analysing their fire spread characteristics; and
- Identifying and commenting on recent technological developments that may assist fire-fighting.

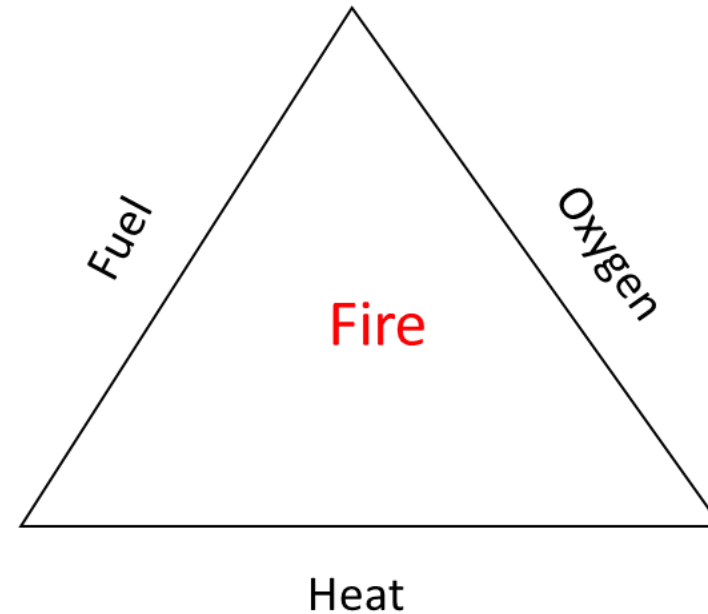
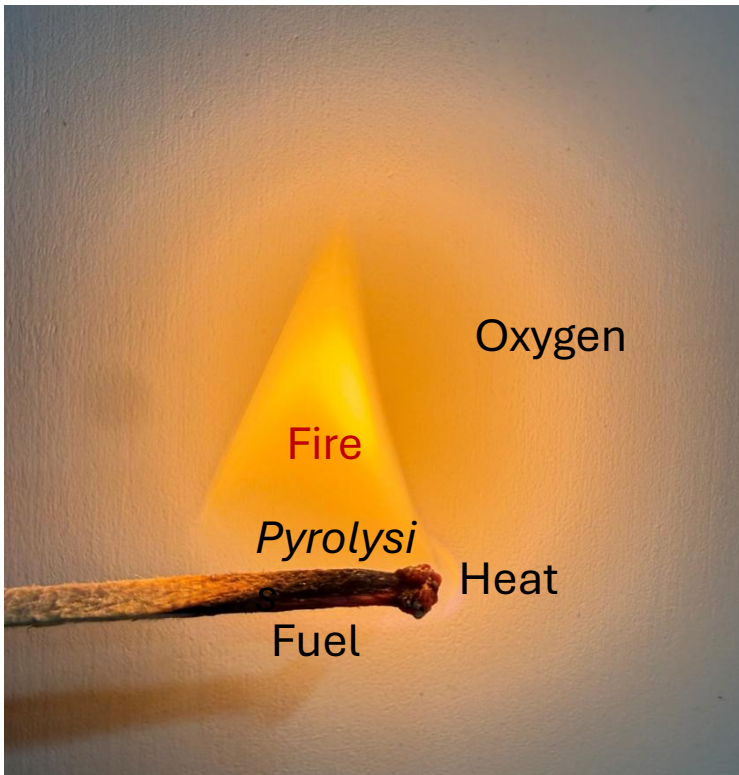
Section 1

Introduction to fire fundamentals

Presented by Prof Asif Usmani

Introduction to fire fundamentals

The fire triangle is a fundamental concept in fire science that illustrates the three essential elements required for a fire to ignite: fuel, oxygen, and heat.



NECESSARY CONDITION
FOR A FIRE TO EXIST

Figure 2.1. Fire triangle

The tetrahedron adds a critical fourth element: a self-sustaining chemical chain reaction. Once ignition occurs, the heat generated by the flame breaks down nearby fuel molecules into volatile gases.

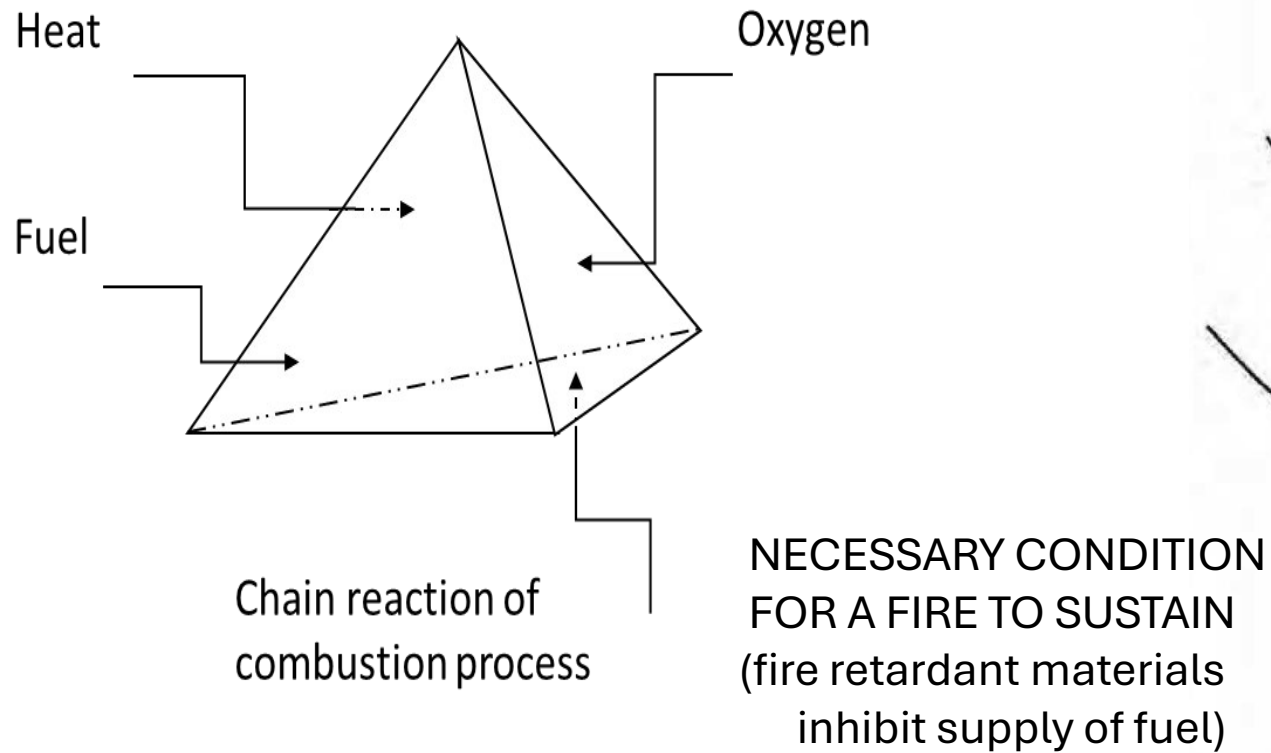
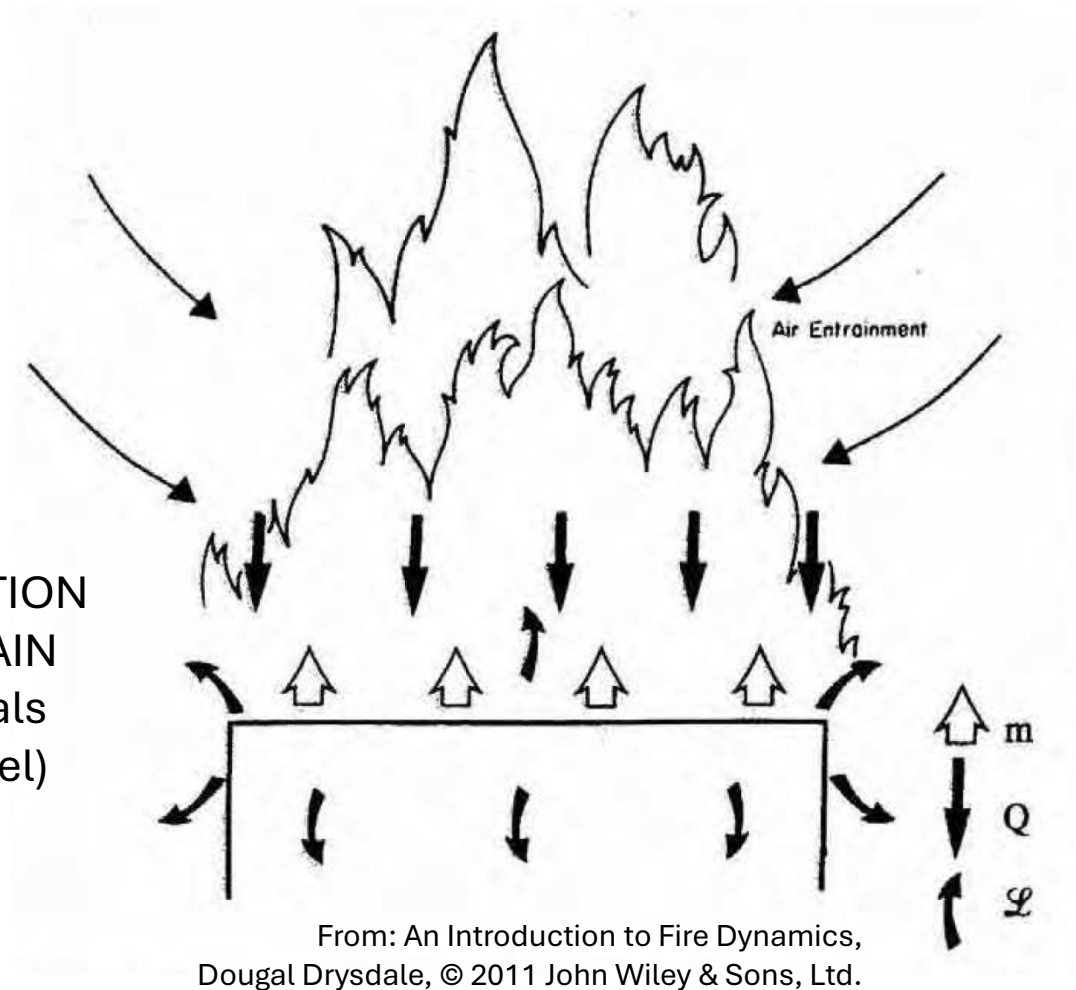


Figure 2.2. Fire tetrahedron



Stages of fire development

1. **Incipient Phase:** The incipient stage of a fire may last from a very short time to days depending on the initial fuels involved, ambient conditions, ignition source, etc.
2. Growth Phase: The growth phase is considered to begin when the radiation feedback from the flame governs the mass loss rate.
3. Flashover: It is commonly described as the transition from a developing fire to full room (or compartment) involvement.
4. Fully Developed / Post-Flashover: In the fully developed or post-flashover phase of a fire, all combustible objects in the compartment are burning, including the floor if it is combustible.
5. Decay Phase: Once a fire has consumed most of the available fuel, the heat release rate (HRR) will diminish.

At Wang Fuk Court, many flats caught fire. Those classified by the Inter-Departmental Fire Investigation Task Force (IFITF) (as having suffered 'Extremely Severe Damage' or 'Severe Damage' must have experienced all of the fire development stages described above)

Internal (indoor) fire

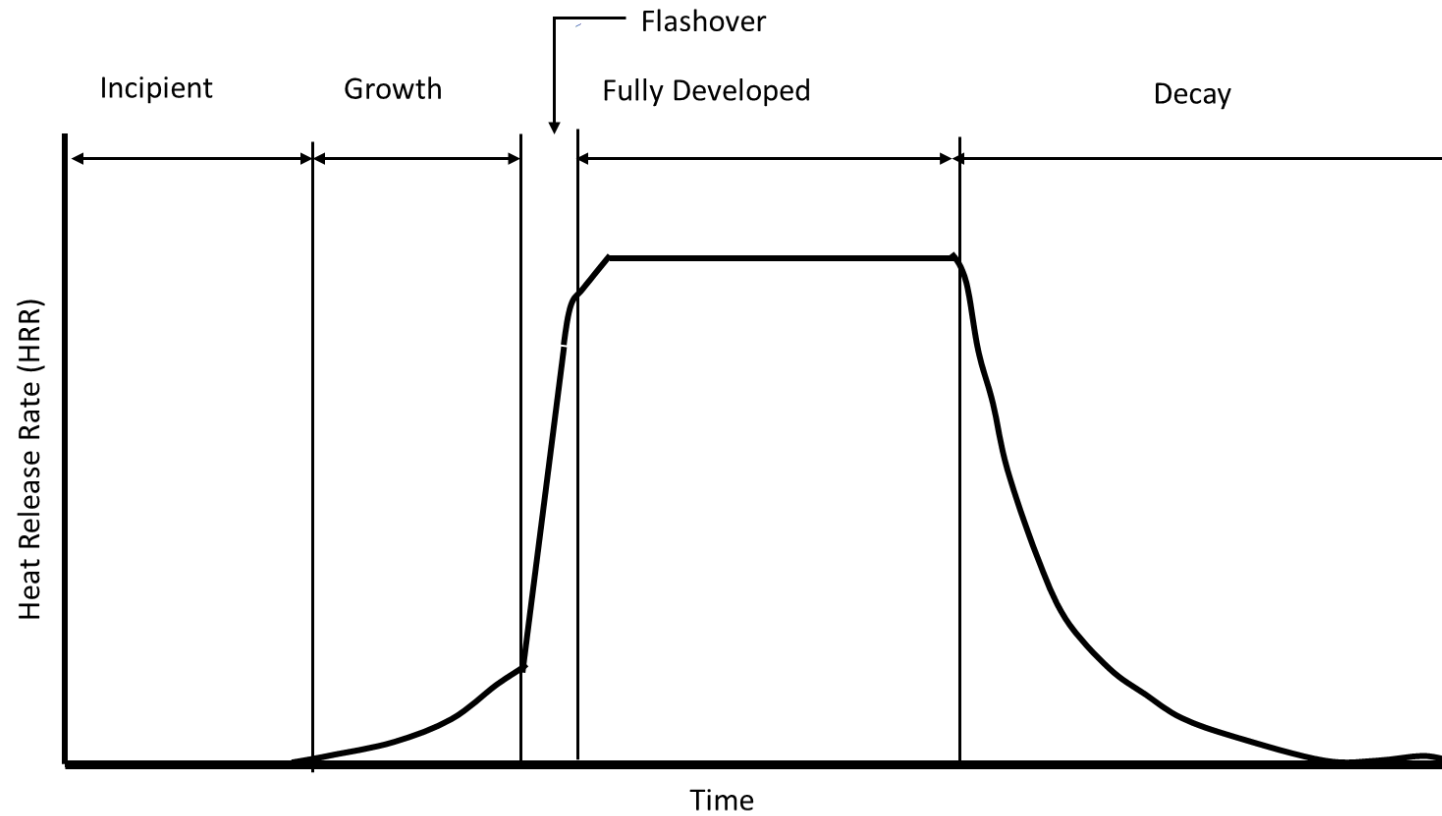


Figure 2.3. Typical phases of a fire curve

Flashover (*a critical event*)



THE KEY DIFFERENCE BETWEEN
A FIRE IN THE OPEN (LIKE WILDFIRES)
AND A COMPARTMENT FIRE

Flashover occurs because of a thermal feedback of reflected radiation from compartment boundaries which makes fuel burn faster and fire burn hotter.

Ventilation (fresh supply of air) is the key controlling parameter. When ventilation is limited, sudden introduction of air (e.g. window breaking) leads to **backdraft**

Backdraft (another *critical* event)



THIS IS ONE OF THE MOST
DANGEROUS
HAZARDS THAT FIREFIGHTERS
ROUTINELY FACE WHEN ENTERING A
BUILDING

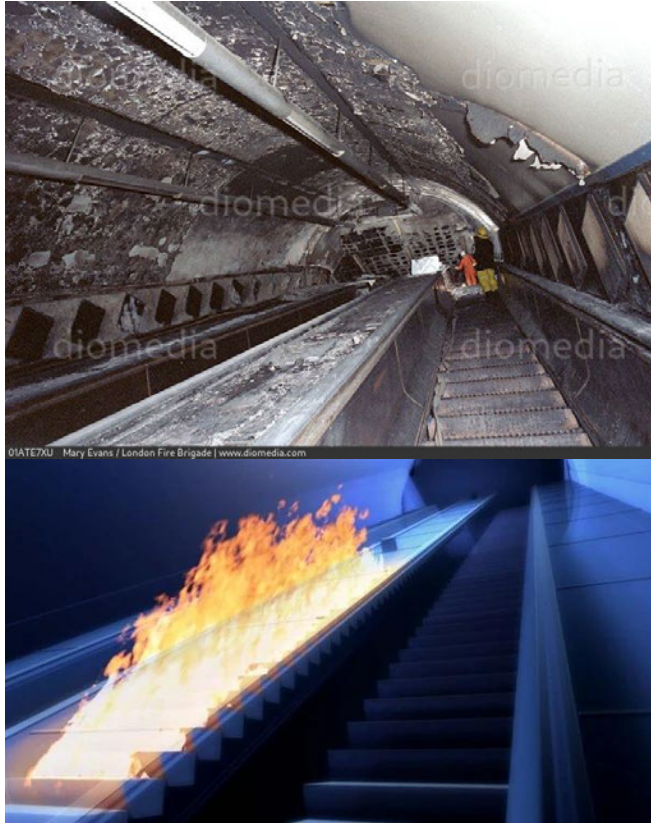
Backdraft training at HKFSD

External fire

When a fire reaches a building's exterior, it can potentially propagate upward and laterally, threatening the entire structure. This rapid external spread is driven by specific aerodynamic and thermodynamic phenomena.

1. The Chimney Effect in Cavities: Re-entrant at Wang Fuk Court creates a space where chimney effect occurs.
2. The Leap-Frog Effect: When an internal fire breaks through a window, the flames naturally plume upward. The effect causes these flames to hug the exterior façade and spread the fire to the room above.

Wang Fuk Court was strictly not the first instance of this kind, except for its magnitude



Kings Cross fire, 18 Nov 1987, 31 deaths

AN INCLINED CHIMNEY!

“Trench effect”

Accelerated vertical spread



Garley Building Fire, 20 Nov 1996, 41 deaths

**LIFT WELL FIRE CAUSED BY
WELDING SPARKS DURING
RENOVATION!**

A chimney!

Accelerated vertical spread

A FAILURE TO CONNECT THE DOTS



Grenfell Tower Fire, 14 June 2017, 72 deaths

**COMBUSTIBLE FAÇADE
WITH A GAP BEHIND IT!**

**Vertical spread not as rapid as WFC
(max 8m/min)**

Fire separation of flats at Wang Fuk Court

- All walls between flats, or between flats and common areas: FRR > 60 mins
- Flat entrance door: FRR > 30 mins
- Kitchen door: FRR > 30 (some kitchen doors were replaced)
- Meter room and refuse room doors: FRR > 30 mins
- Wired glass windows (WGWs) on external wall of the lift hall and staircases: No FRR

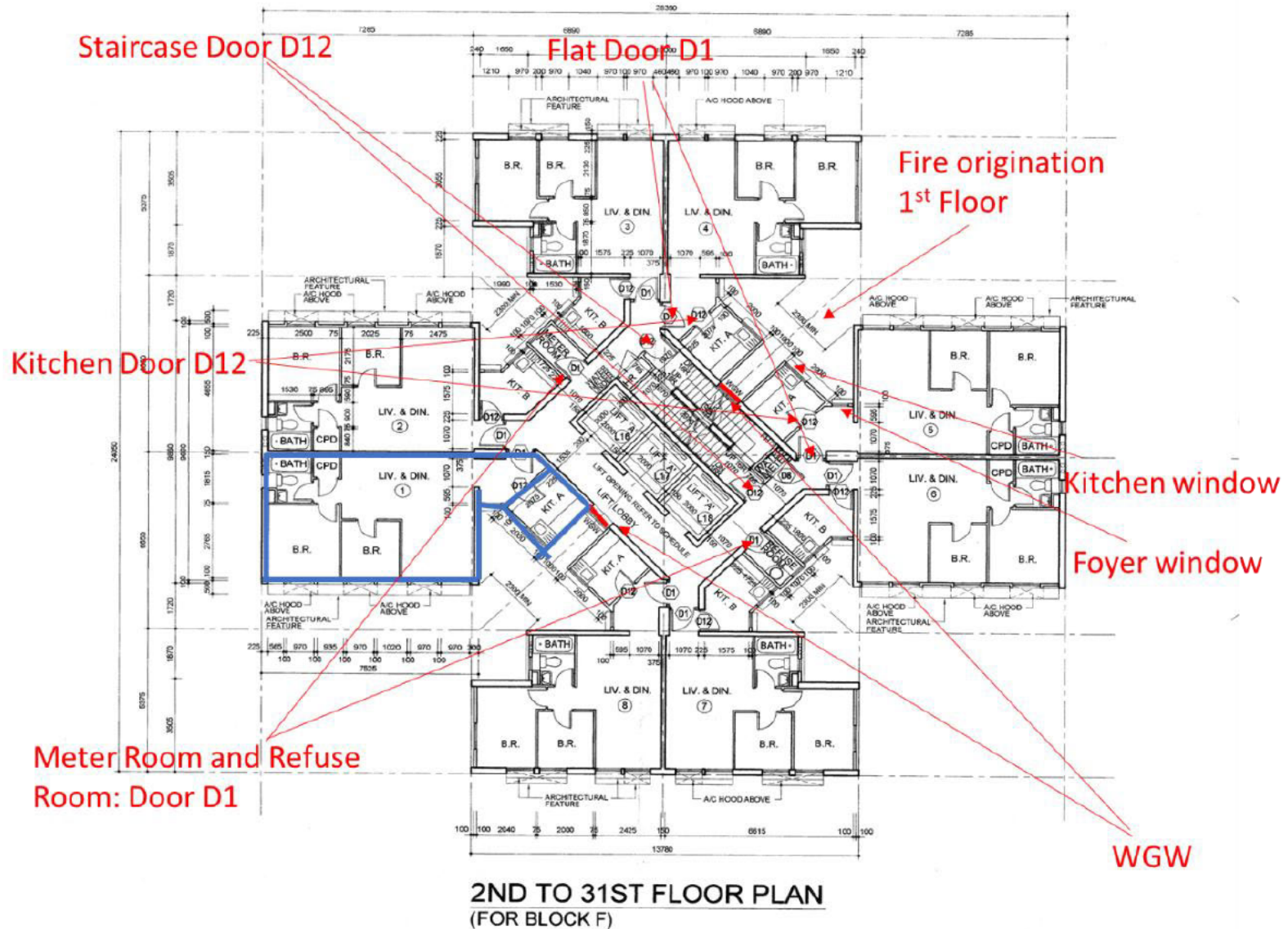


Figure 4.1. Wang Cheong House Floor Plan, as-built drawing

Timeline analysis for fire evacuation (**ASET/RSET**)

Available Safe Egress Time (**ASET**): the period before conditions within the fire environment or evacuation pathways become untenable

Required Safe Egress Time (**RSET**): the total evacuation or escape time, including the time elapsed from ignition to alarm activation/occupant notification, is the pre-movement time (encompassing recognition, decision-making, and coping/preparation time), and the physical travel time required for occupants to traverse the discharge paths to reach a place of safety.

To guarantee occupant safety, the following condition must be satisfied:
$$RSET < ASET$$

Timeline analysis

In analysis, RSET represents the total evacuation or escape time t_{esc} , which can be expressed with the following equation:

$$t_{esc} = t_{alarm} + t_{pre} + t_{flow}$$

Where:

- t_{alarm} is the time elapsed from ignition to alarm activation/occupant notification.
- t_{pre} is the pre-movement time (encompassing recognition, decision-making, and coping/preparation time).
- t_{flow} is the physical travel time required for occupants to traverse the discharge paths to reach a place of safety.

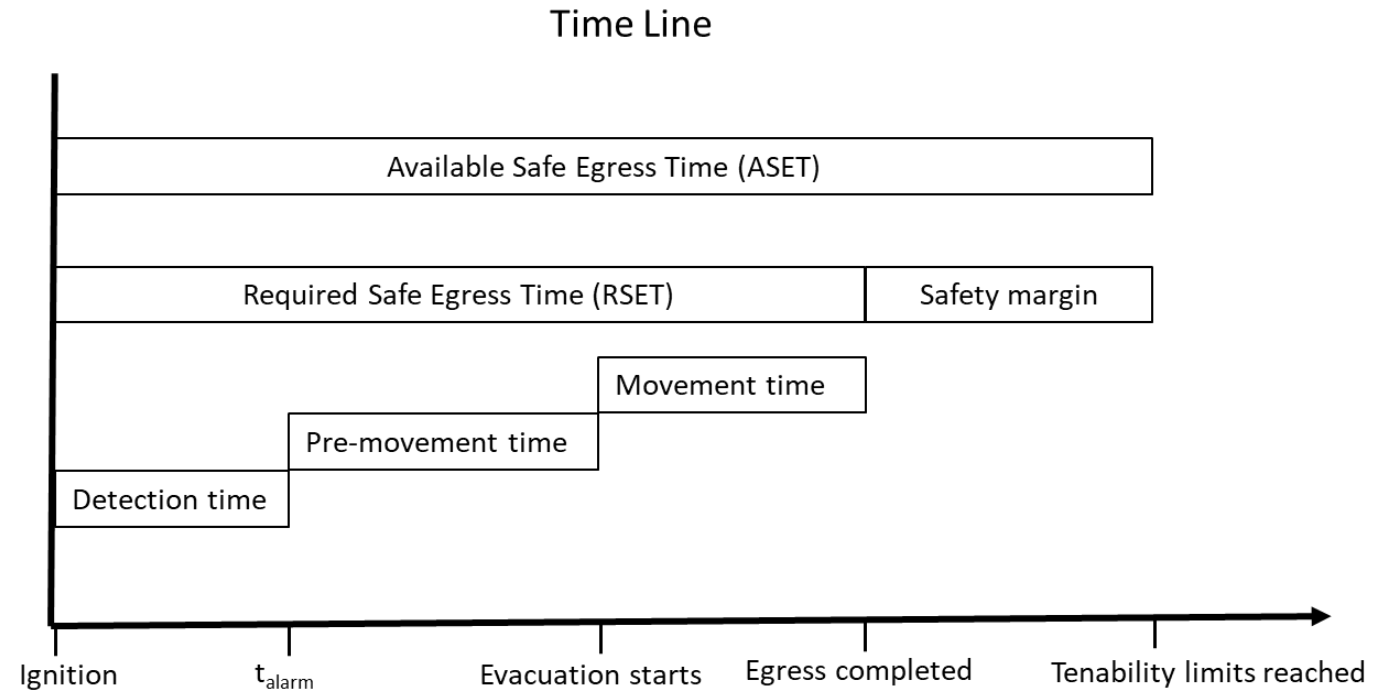


Figure 4.13. Graphical Representation of a Timeline Assessment

Timeline analysis

Localized fire at the re-entrant platform of Wang Cheong House (situated between Units 4 and 5), was first recorded at 14:50.

The 14th Floor was already heavily filled with thick black smoke between 14:56 and 14:57. The witness statement of construction worker Mr. LI [REDACTED] (李[REDACTED], as detailed in Appendix A-24 of the IFITF Final Report)

At this precise stage (14:56), the designated protected staircase of Wang Cheong House (Block F) had ceased to function as a place of safety. Additionally, the vast majority of the building's occupants had not yet recognized that a fire had occurred due to a lack of alarm activation and blockage of the windows with polystyrene foam cover.

Consequently, the Available Safe Egress Time (i.e. ASET) within the primary escape route was reduced to zero before the occupant evacuation process (i.e. RSET) could even be initiated. This absolute overlap of untenability and lack of occupant notification renders the ASET/RSET timeline analysis inapplicable for this case, as safe egress was physically impossible for occupants on all floors from the outset of the vertical fire spread.

Section 2

Wang Fuk Court

Fire Spread Analysis

Presented by Prof Liming Jiang

PART

1

Restructuring the Fire Spread at Wang Fuk Court

An Introductory Summary of Wang Fuk Court Fire



Initiation of fire at Flat roof of Re-entrant of Block F
14:50 | 26 Nov 2025



Intense Re-entrant Fires
Block F, E, C, B, G, A



Multi-unit room fires
26-27 Nov 2025

(F1) 1st Re-entrant fire of Block F
14:58 Peak time of re-entrant fire

Fast-developing Re-entrant Fires



Re-entrant Fires

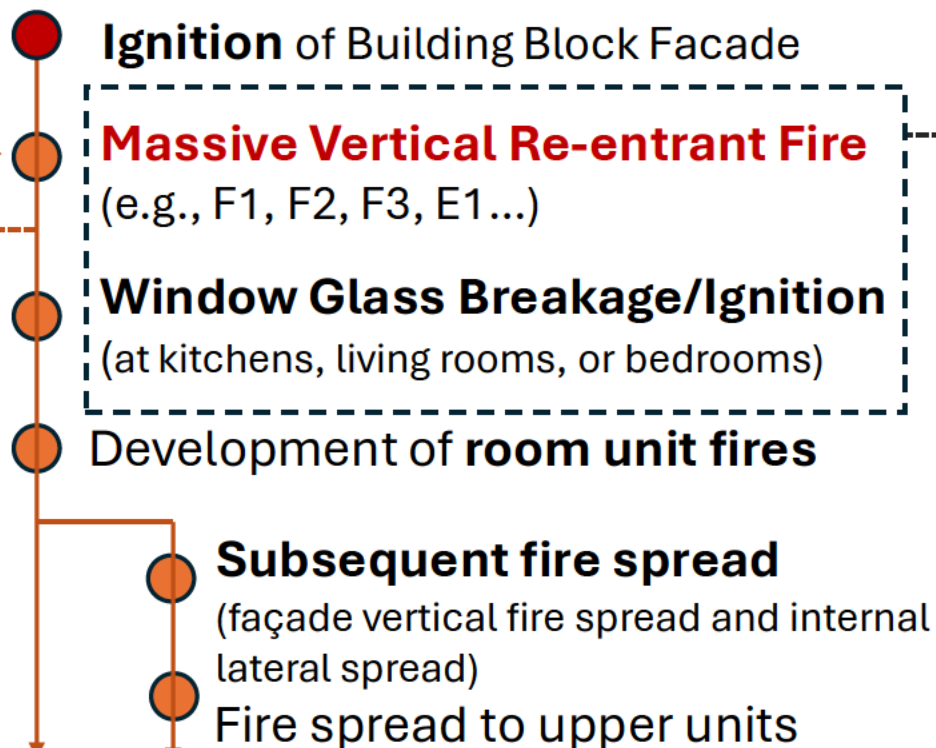
(Block B re-entrant fire captured by Cable News as example)

- **Typical and dominant fire behaviour**
- **High intensity but short period**
- **Causing fire spread to room units**
- **Causing smoke filling the buildings**

Restructuring the Fire Spread: Critical Events

Critical Events of Fire Spread at Each Building Block (Block F, E, C, B, G, A)

→ **Peak Time of Re-entrant Fires**



- Observed Start of Fire
14:50 at Block F Re-entrant (F1)
- BLOCK F
F1, 14:58; F2, 15:04; F3, 15:09
- BLOCK E
E1, 15:16; E2, 15:17; E3, 15:30
- BLOCK C
C1, 16:01; C2, 16:36; C3, 16:43
- BLOCK B
B1, 16:11
- BLOCK G
G1, 16:22
- BLOCK A
A1, 18:32

Multi-room fires in Multiple Building Blocks

Before Re-entrant Fires | Initiation at Block F

BLOCK F

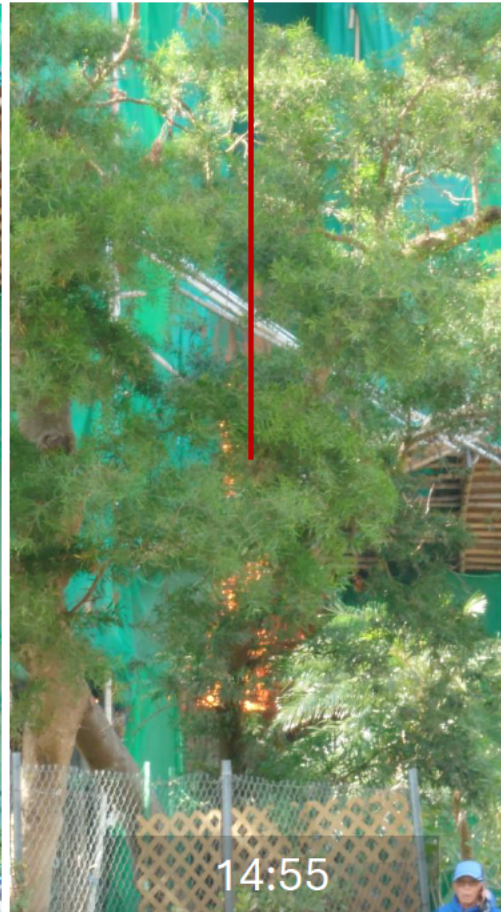
Wang Cheong House (宏昌閣)

Scattered flames
at flat roof

After minutes of
fire development



A large localised fire
above flat roof



1st fast-spreading re-entrant
fire of Block F



Observed Origin of fire

Fast Development of re-entrant fire F1

Before Re-entrant Fires | Initiation at other re-entrants

Early transitions of re-entrant fires at Block F

- Very short period between each two re-entrant fires
- Likely due to ground fire spread
- Burning of collapsed scaffolding materials together with combustible construction materials on the ground

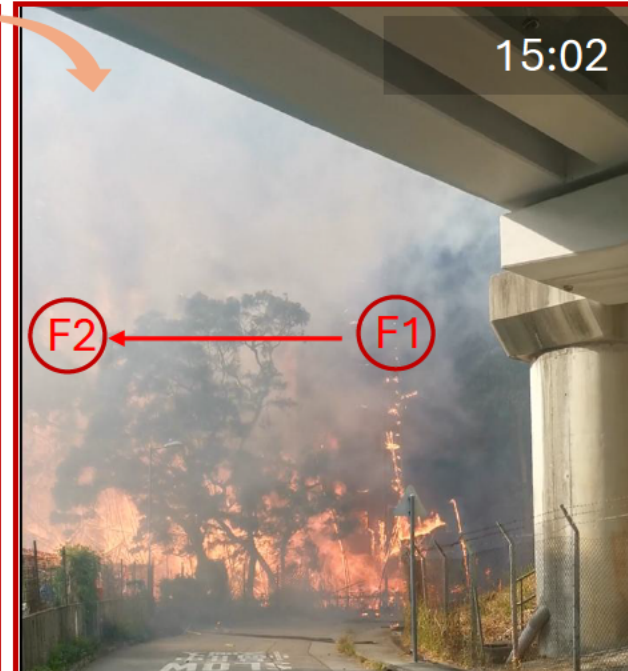


6 min

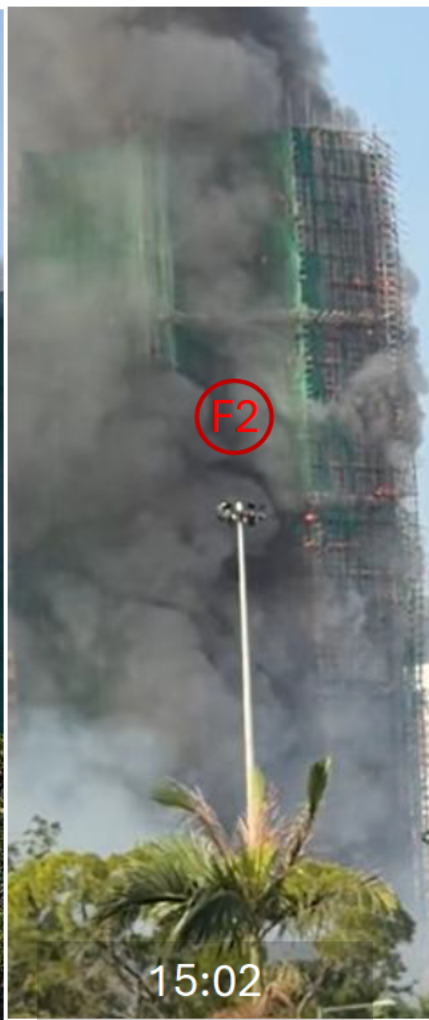


Ground combustibles

5 min



During Re-entrant Fires | Re-entrant fires of Block F



Re-entrant fire of F1

Re-entrant fire of F2

Re-entrant fire of F3

During Re-entrant Fires | Re-entrant fires of Block E,C, B,G, A

BLOCK E

Wang Tai House (宏泰閣)



E1

BLOCK C

Wang Sun House (宏新閣)



16:01

BLOCK B

Wang Tao House (宏道閣)



16:11

BLOCK G

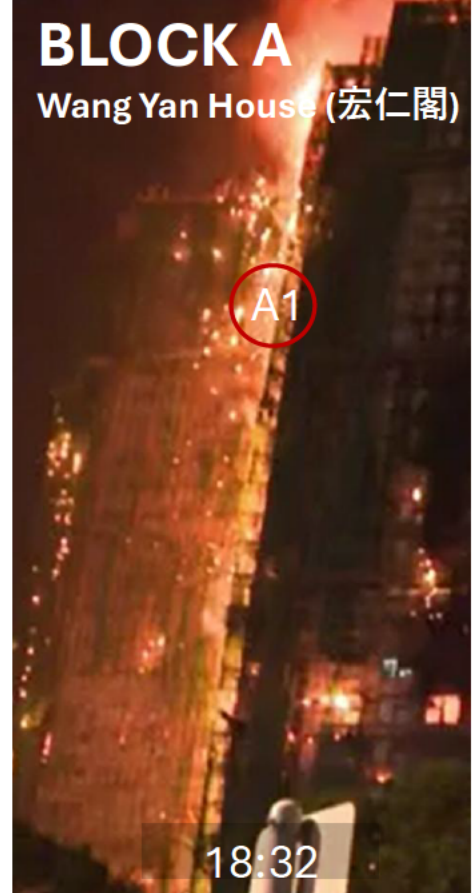
Wang Shing House (宏盛閣)



16:22

BLOCK A

Wang Yan House (宏仁閣)

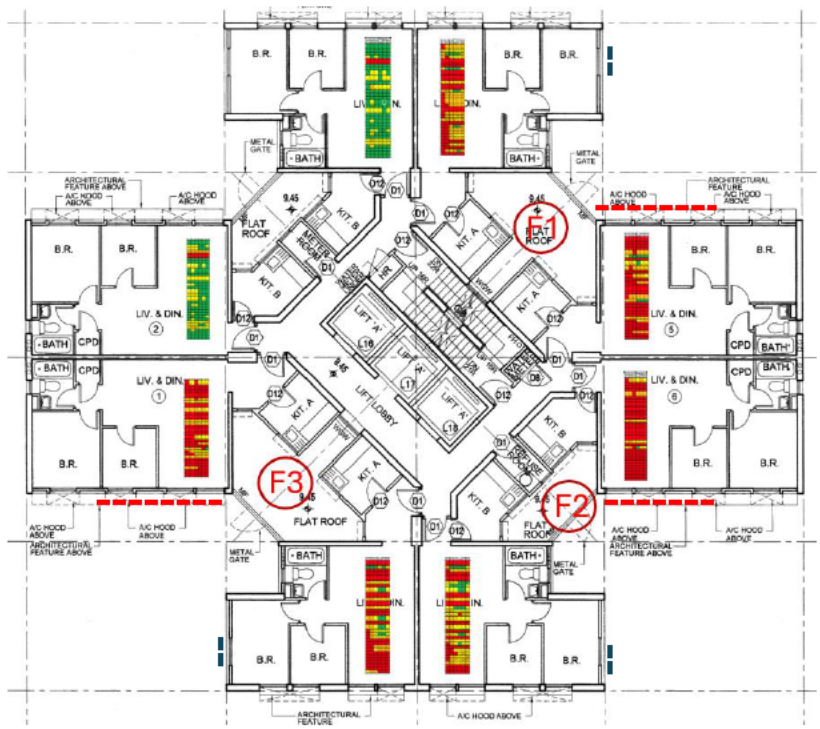


18:32

PART
1.3

During Re-entrant Fires | Window Glass Breakage

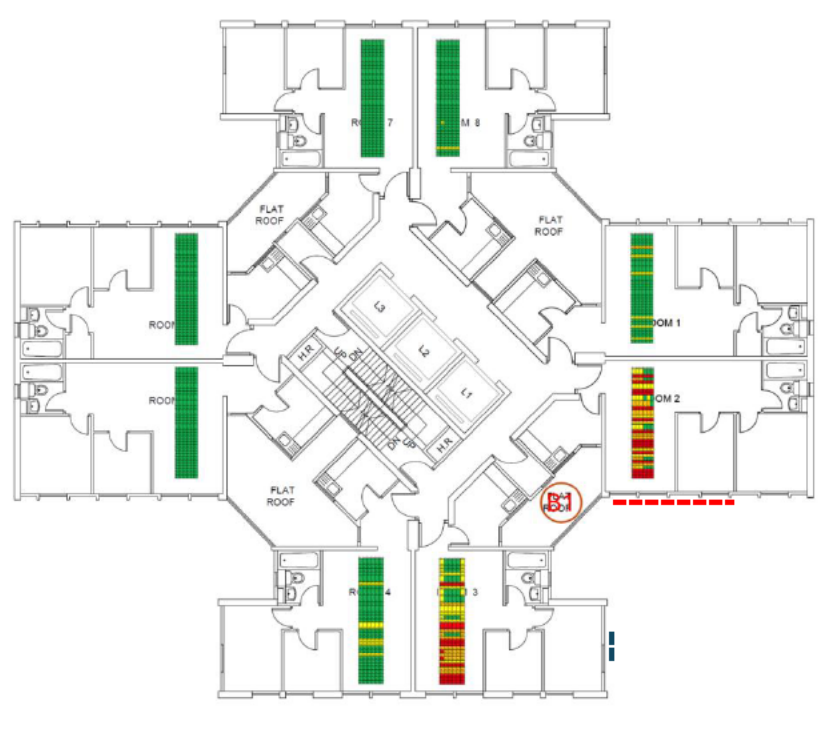
Room Unit Fire Damage Map



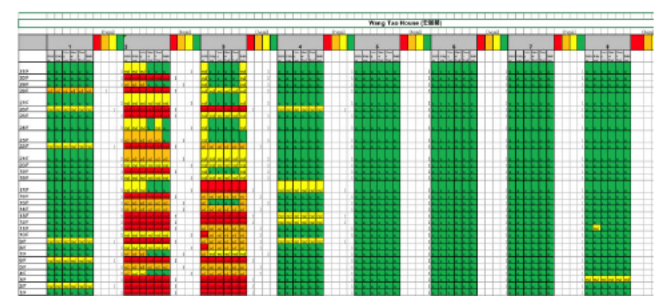
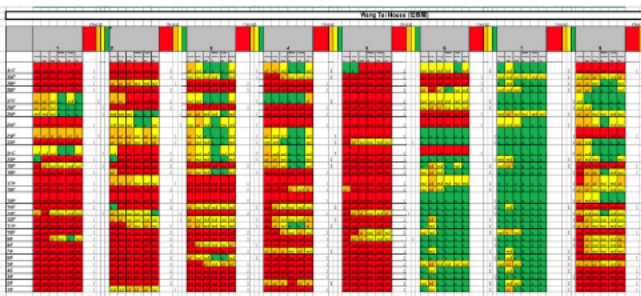
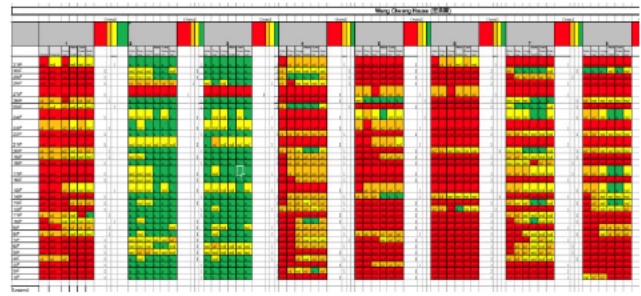
Block F



Block E



Block B



Room Damage closely linked to re-entrant fires | Different levels of damage in each re-entrant fire

During Re-entrant Fires | Window Glass Breakage

Window-Fire Damage Mapping



Type B Room Units

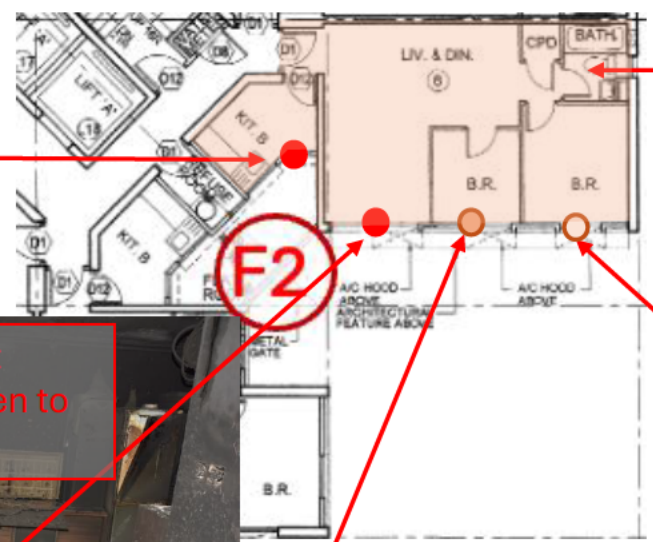
- **Main bedroom side windows** exposed to extended re-entrant fire
- Possible Fire starting locations: kitchens, corridors near gates, bathrooms, main bedrooms

Type A Room Units

- **Living room windows** exposed to extended re-entrant fire (near re-entrant, including hot smoke)
- Possible Fire starting locations: kitchens, corridors near gates, **living rooms**

During Re-entrant Fires | Window Glass Breakage in Type A Units

Type A Room Unit: Block F 06



Ignition
after living
room glass
breakage



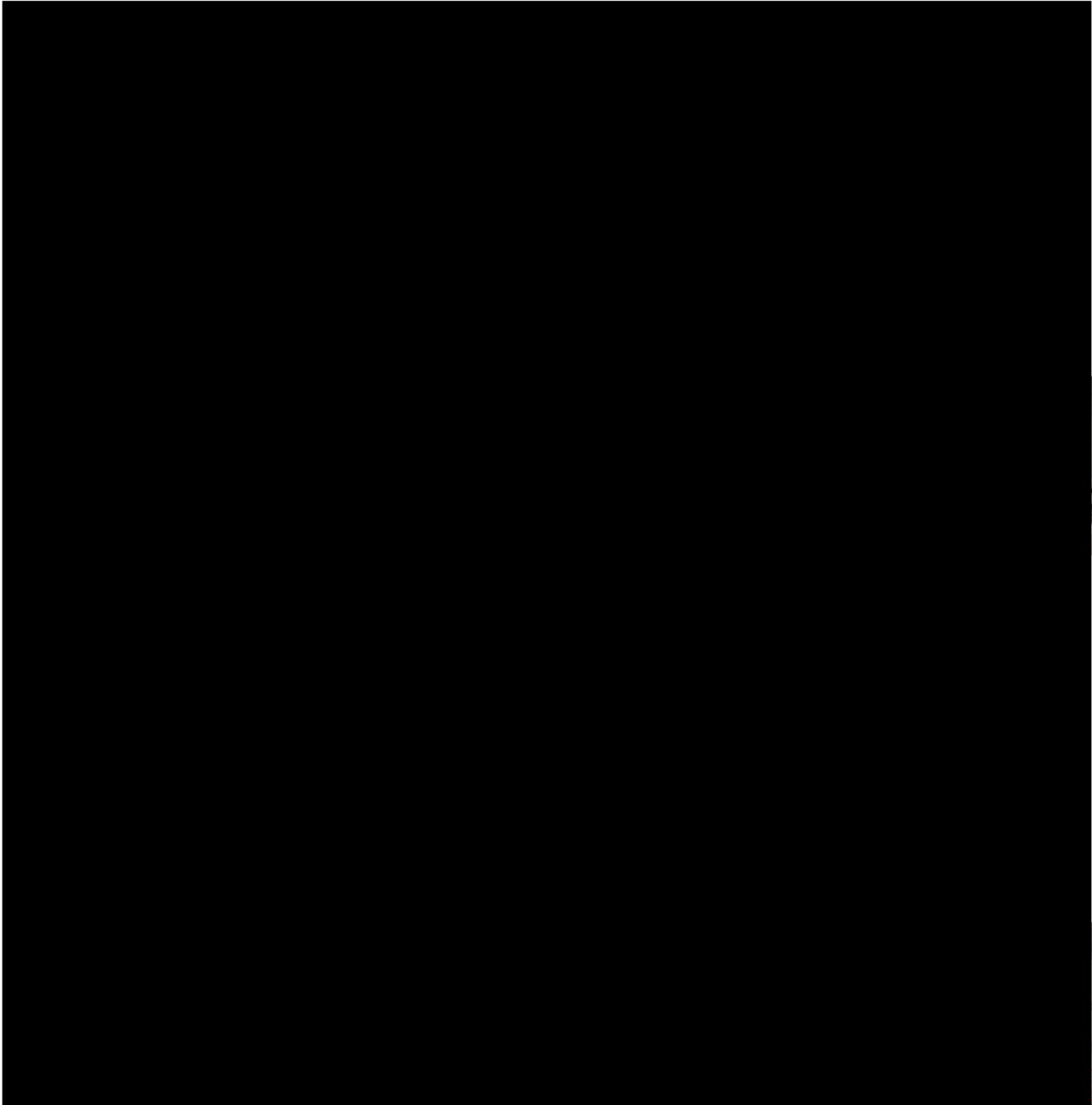
During Re-entrant Fires| Window-Fire Damage Mapping

Type A Room Units

Room 805 to 3105 of Block F

Block F	Living room Glass Breakeage	Living Room Fire
3105	Y	F
3005	Y	L
2905	Y	F
2805	Y	F
2705	Y	F
2605	Y (p)	0
2505	Y	F
2405	Y (p)	0
2305	Y	0
2205	Y	F
2105	Y	0
2005	Y	F
1905	Y	L
1805	Y	F
1705	Y	F
1605	Y	F
1505	Y	0
1405	Y	L
1305	Y	F
1205	Y	F
1105	Y	F
1005	Y	F
905	Y	F
805	Y	0

- 23/25 living room window glass broken and fell out
 - 2/25 living room window glass partially broken
 - Leading to various fire development consequences:
- 6 units of no fire (0);
- 3 units of localised burning (L)
- 15 units of fully developed fire (F)



PART
1.3

During Re-entrant Fires | 3 Different Window-Fire Damage Patterns

Room 05 (Type A)

- Fully-developed fire in whole room unit
- Sufficient fuel to sustain fire development after glass breakage



Room 05 (Type A)

- Localised fire in living room
- Limited fuel ignited after glass breakage
- Early glass fallout (“active opening”)



Room 05 (Type A)

- No fire in living room
- Full glass breakage, excluding internal fire, ejecting flames from lower floor
- Glass fallout only due to re-entrant fire



During Re-entrant Fires | Window Glass Breakage in Type B Units

Type B Room Unit: Block F 04



No glass breakage
No fire



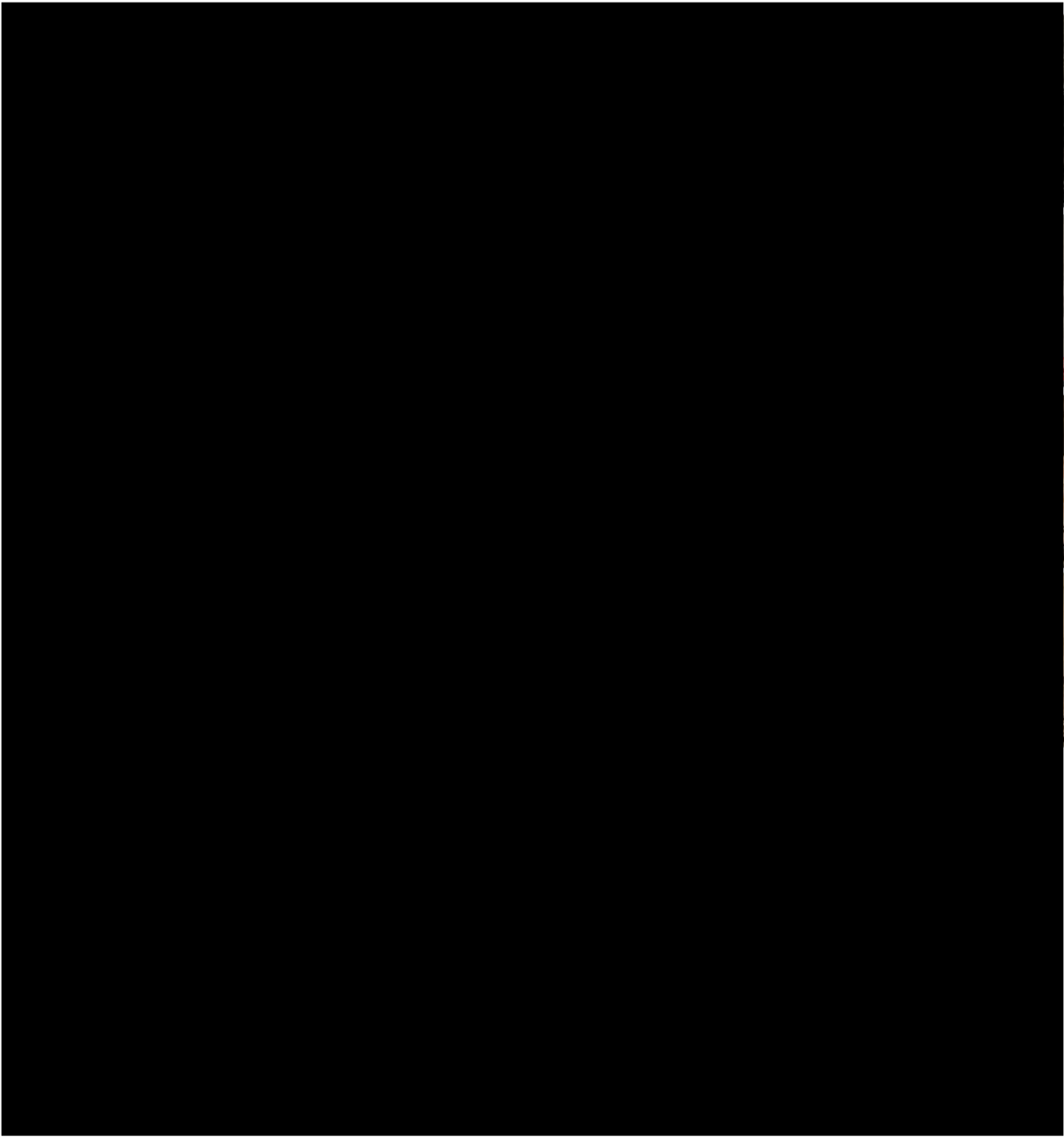
During Re-entrant Fires | Window-Fire Damage Mapping

Type B Room Units

Room 804 to 3104 of Block F

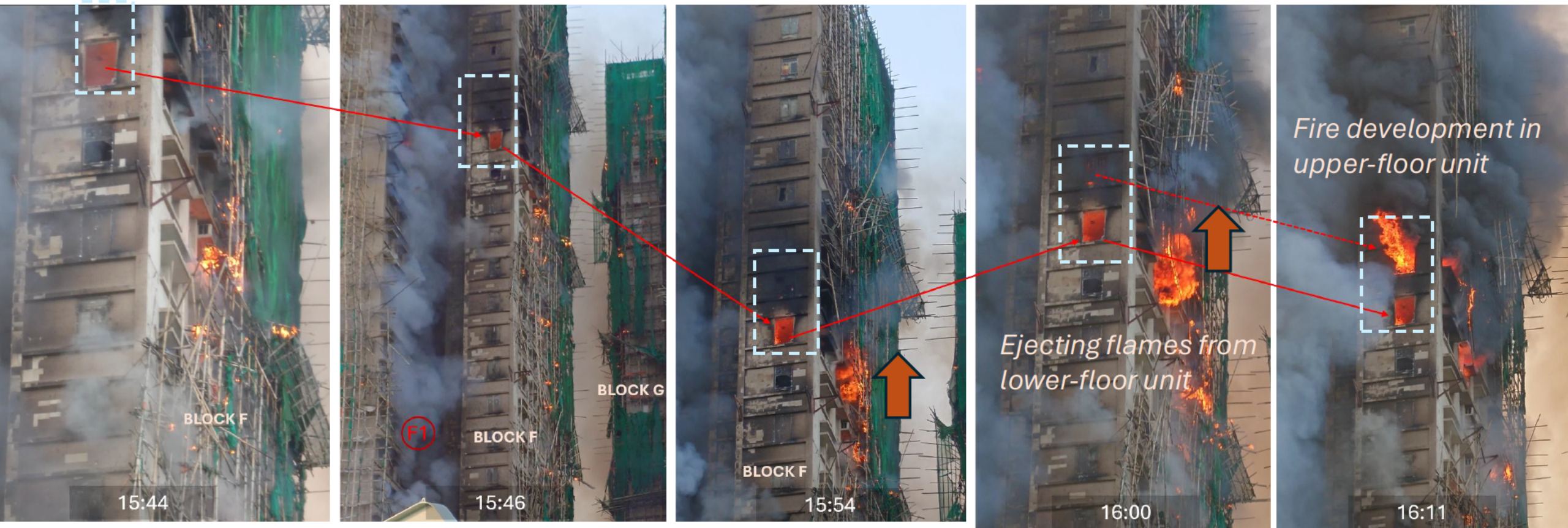
Block F	Bedroom Glass Breakage	Bedroom Fire	Living room Fire
3104	Y(p)	0	0
3004	Y(p)	0	0
2904	Y(p)	0	0
2804	Y(p)	0	0
2704	Y	F	F
2604	Y	F	F
2504	Y(p)	0	0
2404	Y	F	F
2304	Y	F	F
2204	Y	0	0
2104	Y	F	F
2004	NI	0	0
1904	NI	0	0
1804	NI	0	0
1704	NI	0	0
1604	NI	0	0
1504	Y	F	F
1404	Y(p)	0	0
1304	Y (p)	0	0
1204	Y	0	0
1104	Y	F	F
1004	N	0	0
904	N	0	0
804	N	0	0

- 9/25 bedroom window glass broken and fell out
- 7/25 bedroom window glass partially broken with cracks
- 8/25 bedroom window glass of no or not identified damage
- Leading to two typical fire development histories:
18 units of no fire in living room and bedrooms (0);
7 units of fully developed fire (F)



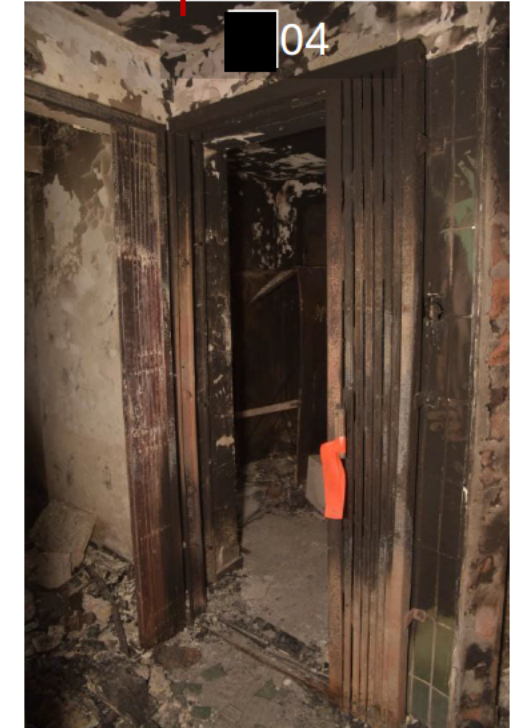
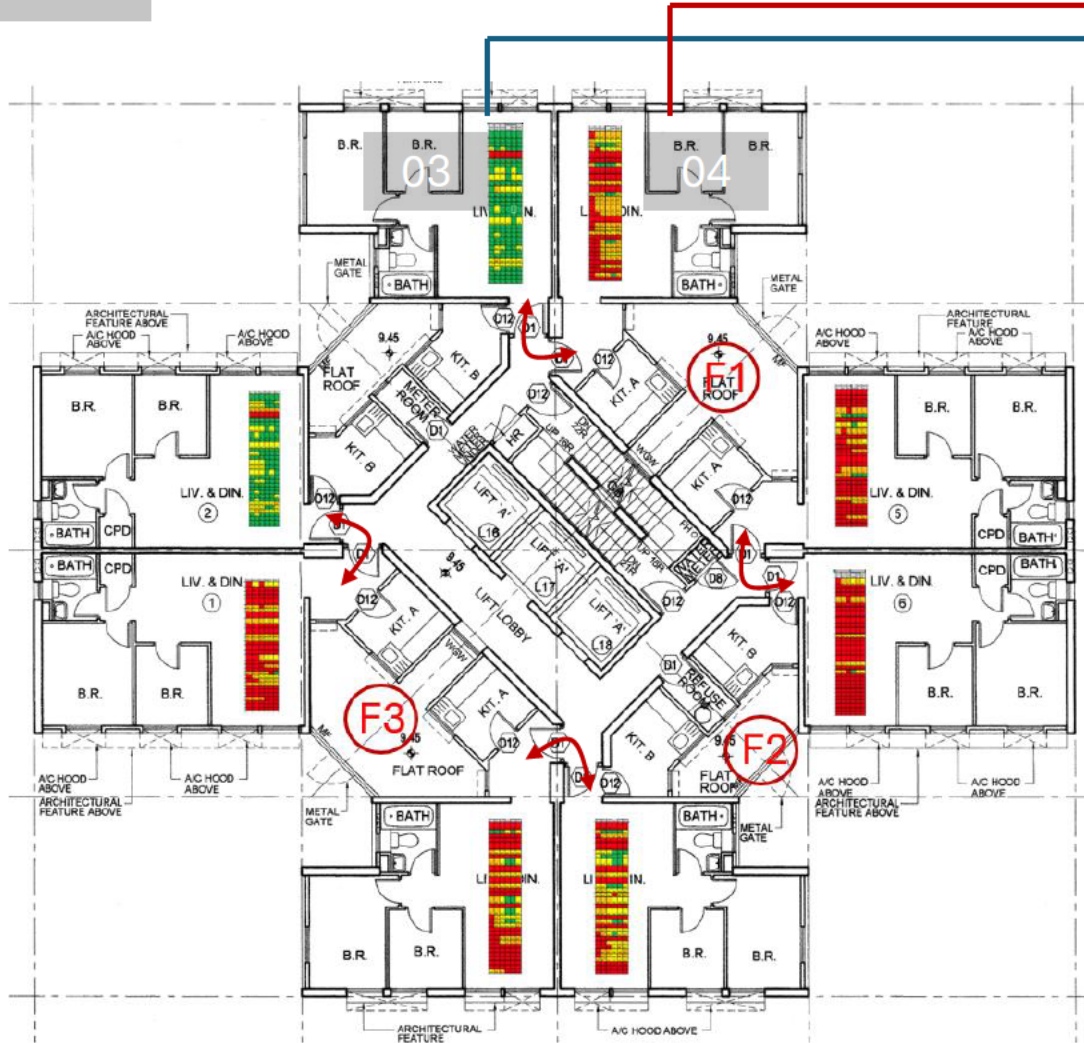
After Re-entrant Fires | Subsequent façade fire spread

Vertical Spread: Burning of remaining façade scaffoldings leading to vertical fire spread



(According to Video of Cable News on Block F)

After Re-entrant Fires | Subsequent internal fire spread



Possible internal fire spread:

Fully-developed Room fire spread to adjacent room unit through neighboring front doors

Fully developed fires in both units

After Re-entrant Fires | Multi-point Room Unit Fires

- Multi-point ignition of room units through broken windows
- Subsequent façade fire spread to non-ignited units
- Subsequent internal fire spread through front doors
- Continuous fire development and internal & external spread from units to units
- Buildings with multi-point room fires prevent effective firefighting operation



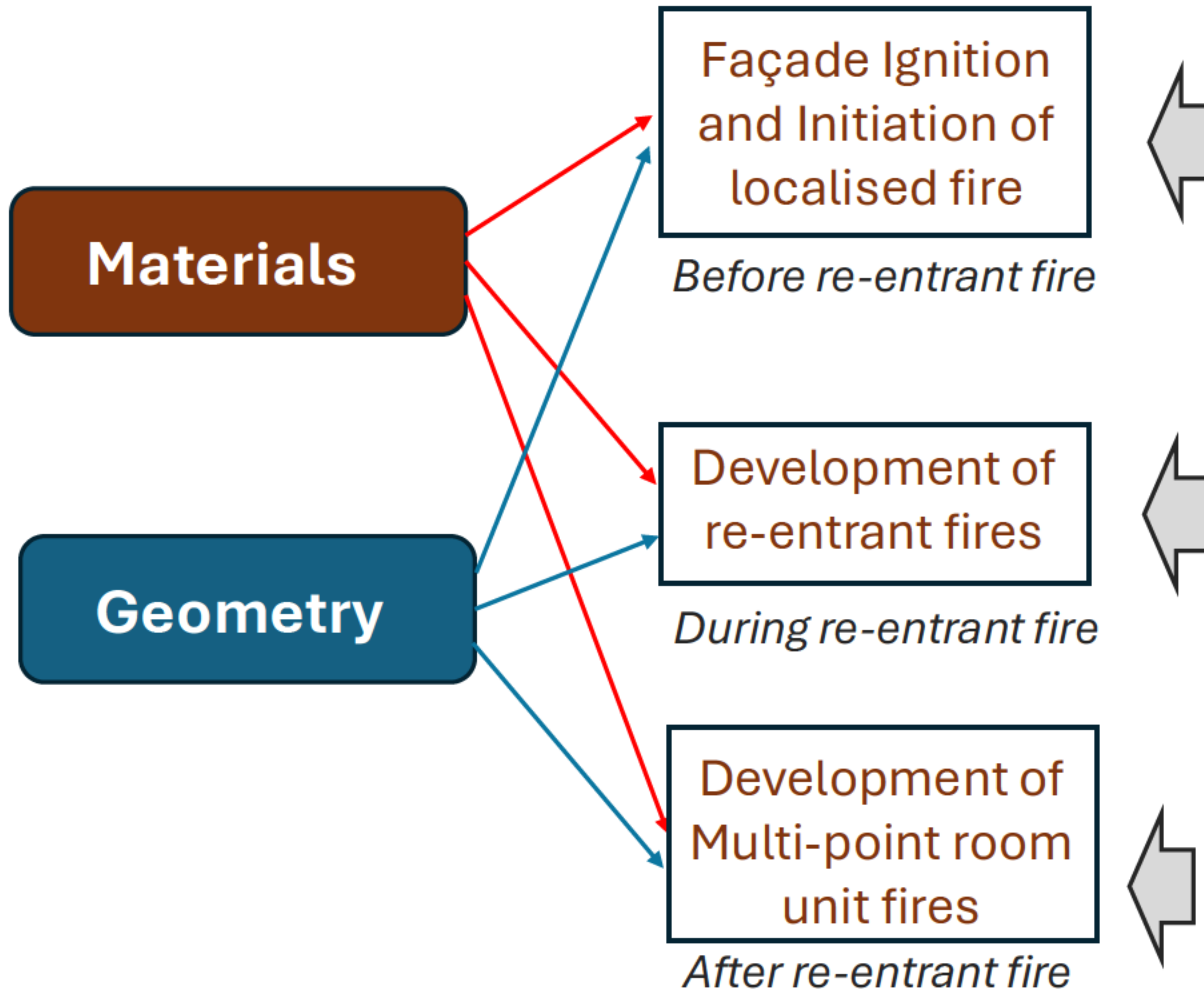
(According to Video of Cable News on Wang Fuk Court fire, live broadcast on 26 Nov 2025)

PART
2

Causes of fire spread

Observations, hypotheses, tests, and simulation

Causes of fire spread | Roles of materials and building geometry



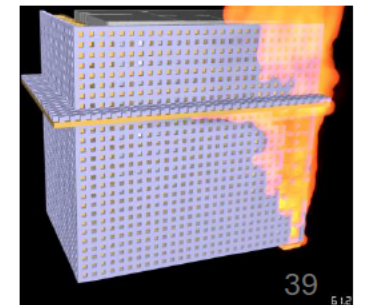
Observation



Tests



Simulation



50.0

39

Causes of fire spread | Role of materials

Before Re-entrant Fire : Initiation of fire and ignition of building facade

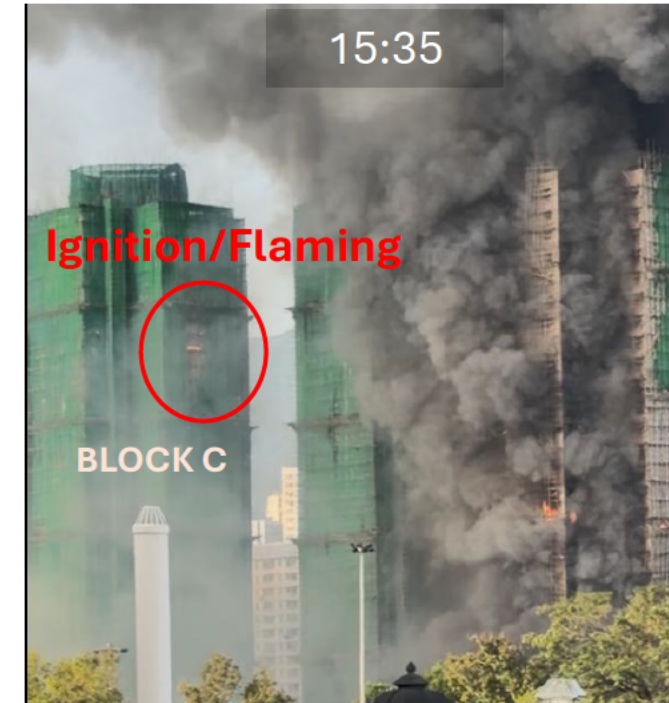
- Flames at building façade are likely the burning of safety net
- The burning of safety net was caused by unknown fire source at the flat roof area of F1
- The burning of safety net of other buildings could be caused by flying ember, flaming debris



Initiation of fire at flat roof



A large localised fire
To trigger re-entrant
fire

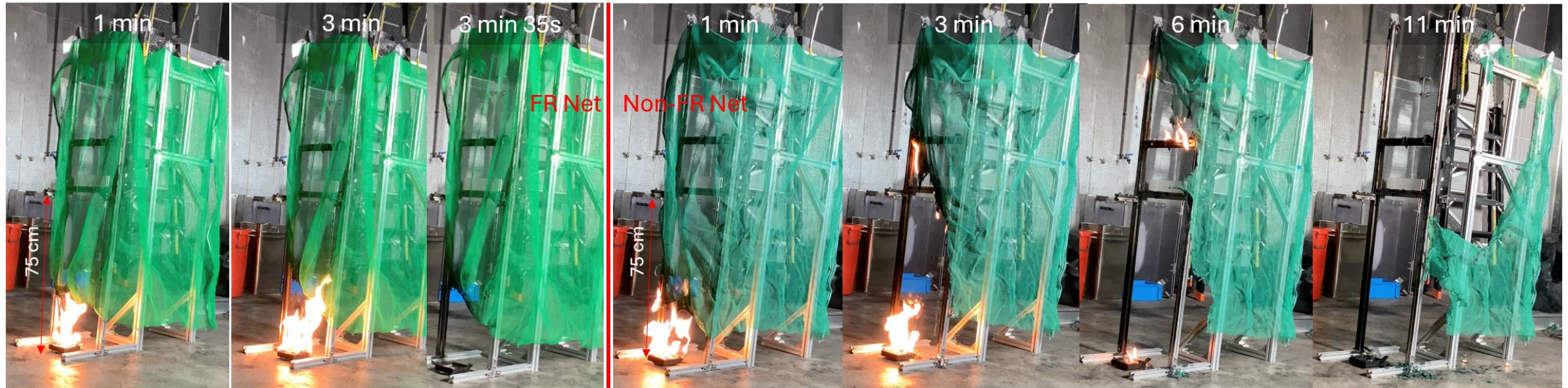


Ignition of adjacent building
scaffolding

Causes of fire spread | Role of materials

Burning tests on safety net samples

- Both samples in Test B1 and Test B2 were burnt using a 90 kw propane pool fire
- Safety net sample in **Test B1**: Collected from Block D(ground level); Safety net in **Test B2**: Collected from Block H
- FR behaviour shown in **Test B1**: Melting and shrinking when being heated; no flames sustained after the exhausting of pool fire.
- Non-FR behaviour shown in **Test B2**: Fast melting and shrinking; flames sustained and propagated'

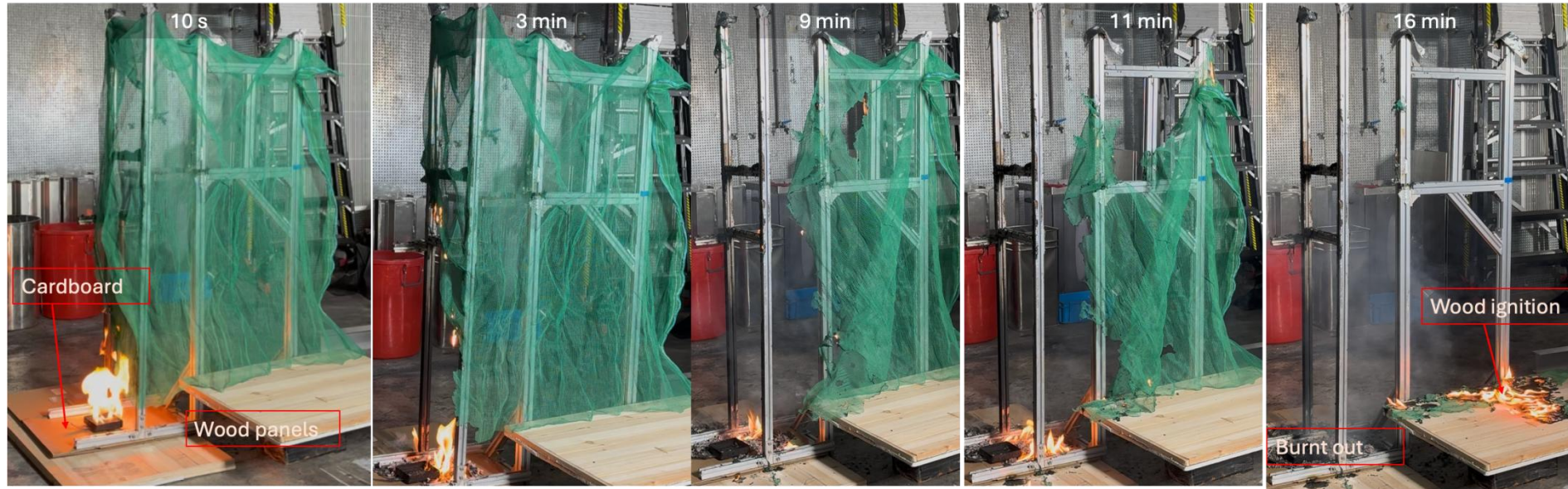


Test B1 on safety net sample of fire-retardant (FR) behaviour

Test B2 on safety net sample of non-FR behaviour

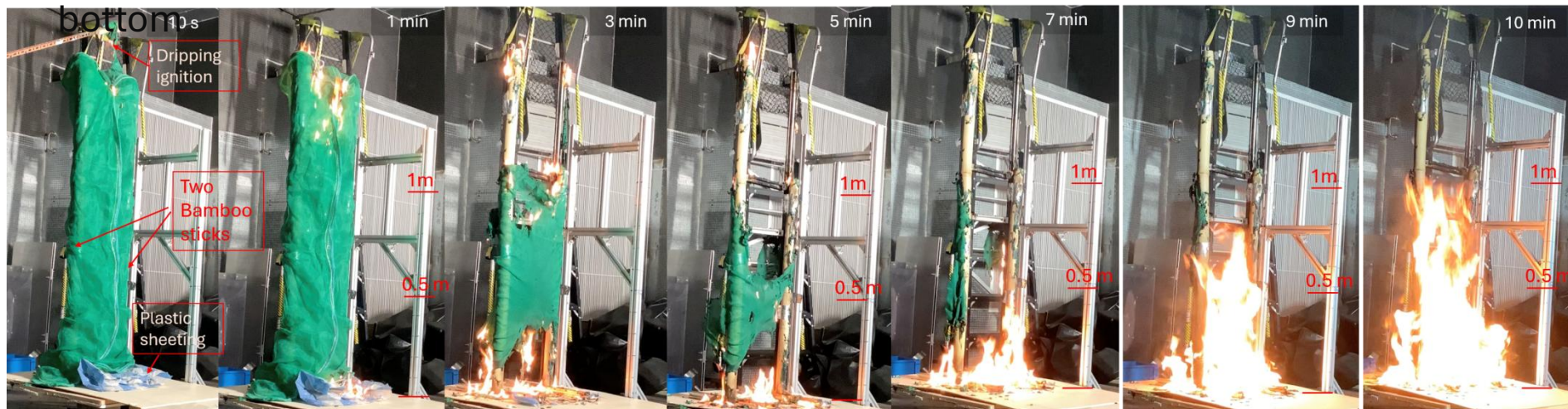
The use of non-FR safety net is likely to facilitate the ignition of building scaffolding

Causes of fire spread | Role of materials



Test D1: cardboard and wood panels are ignited by dripping safety net, causing sustained flames for 16 minutes until being manually extinguished

Test D1 on safety net sample with cardboard and wood panel at



Test D2: Continuous dripping of safety net caused the burning of canvas, bamboo, and wood board.

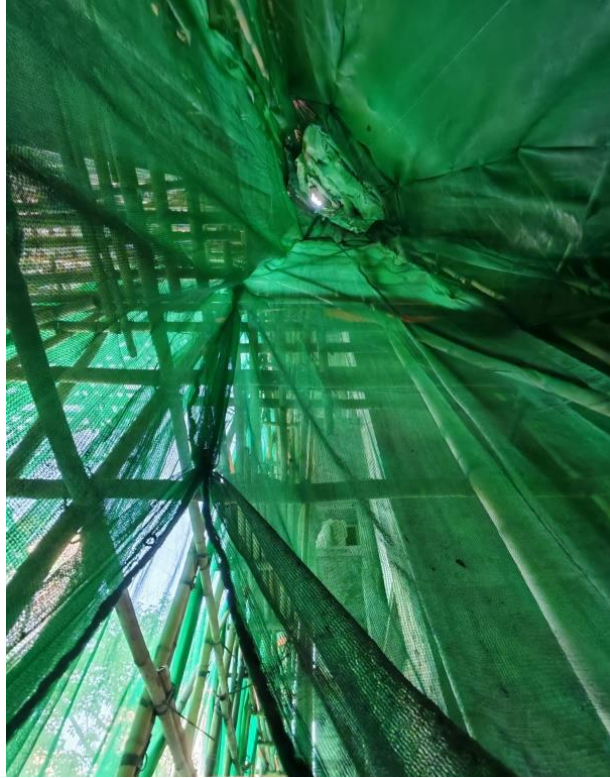
A localised fire of 1m flame height is formed.

Test D2 considering increased safety net and joint burning

Causes of fire spread | Role of materials

During Re-entrant Fires: Rapid fire spread in re-entrant regions

- A sufficiently large localised fire leading to pyrolysis of wood and bamboo
- Large amount of pyrolysis gas released from the heated items intensified the fire (demonstrated in Test E1)
- The intensified fire further prompted the release of pyrolysis gas
- In such intensive re-entrant fires, all combustible items contributed to fire development



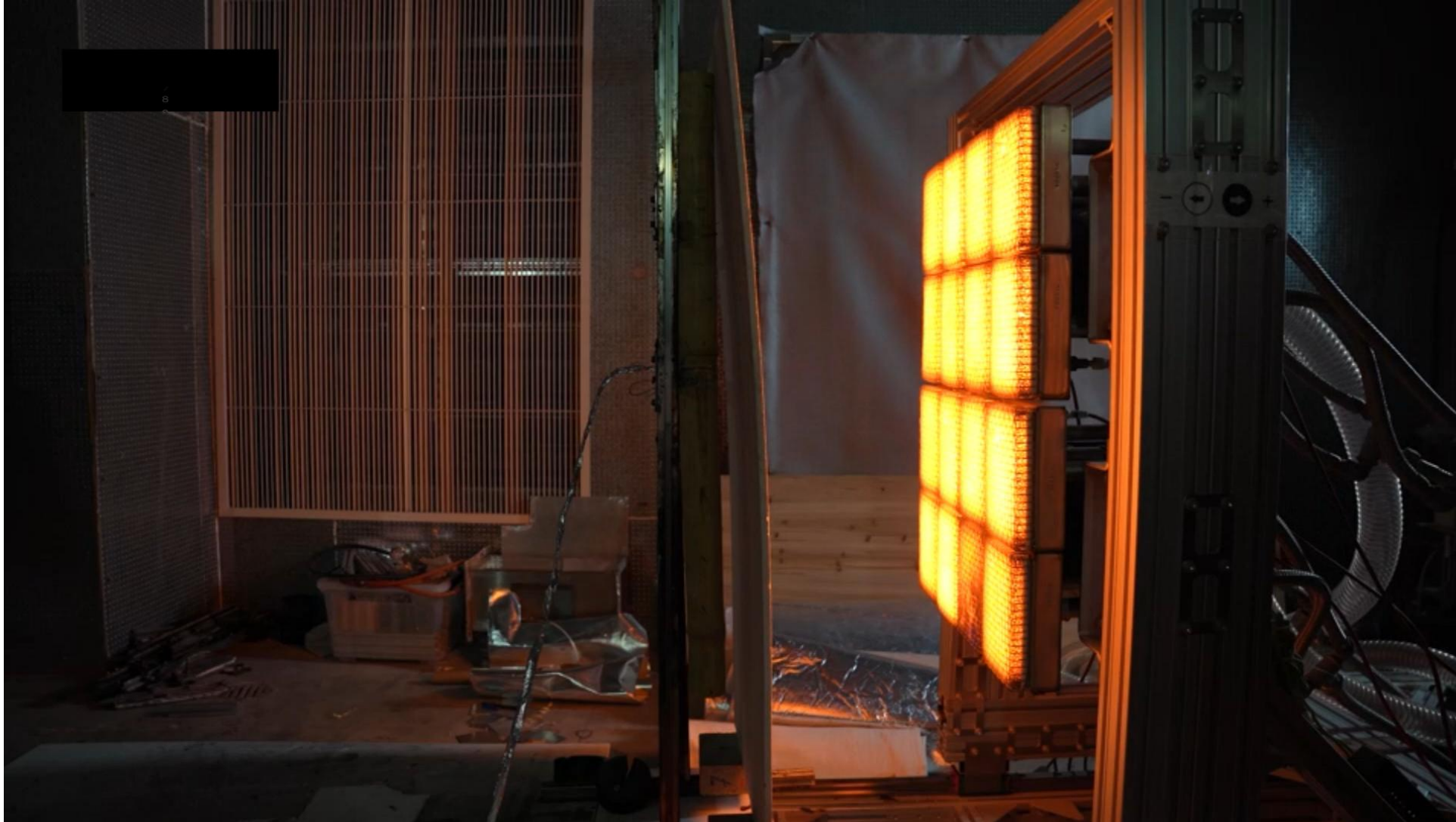
Causes of fire spread | Role of materials



Radiant Panel Fire Testing System

- Originated from H-Tris system developed at University of Edinburgh
- Strategically built at PolyU for laboratory fire testing on building materials subjected to extreme heating conditions
- Gas-burner based radiant panels allow intensive heating conditions **equivalent to large-scale real fires** (Heat flux up to 200kw/m^2)

Causes of fire spread | Role of materials



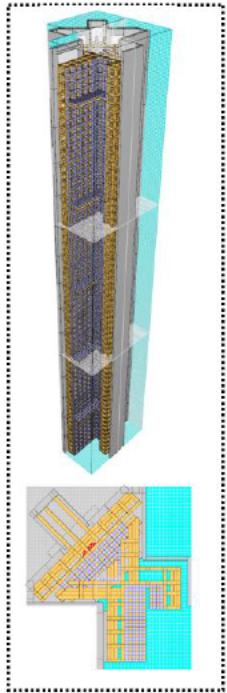
Demonstration Test E1

- **Rapid Pyrolysis and burning** of bamboo in heating conditions approximating re-entrant fire
- Using high-intensity radiant panel testing system at PolyU
- Surrounding temperature: approx. 1000°C

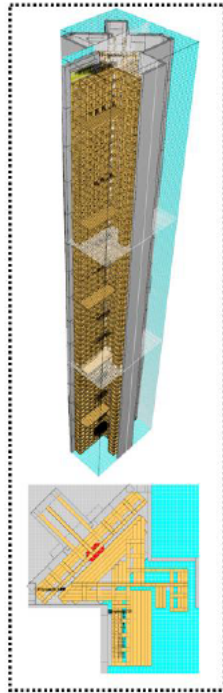
Causes of fire spread | Role of materials

During Re-entrant Fire: Rapid fire spread in re-entrant regions

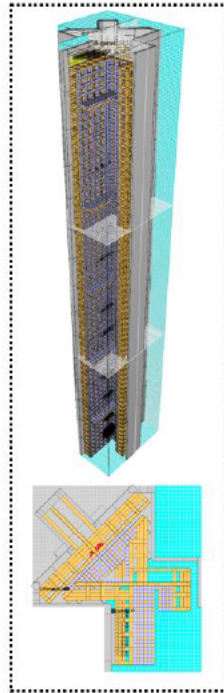
- Five case studies to simulate the re-entrant fire development



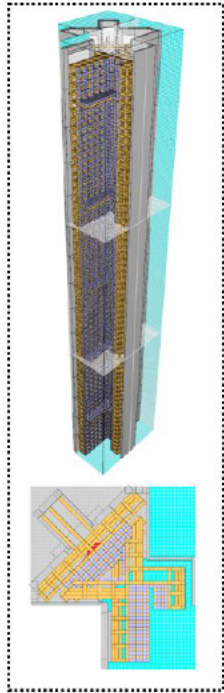
Case 1 All façade materials in Case 4 Assumed Non-combustible



Case 2 Bamboo scaffolding only



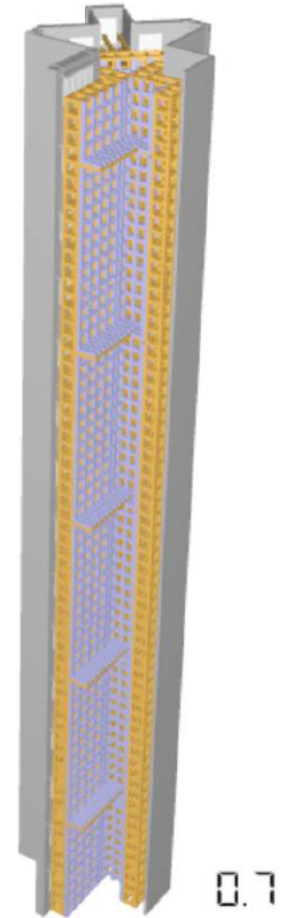
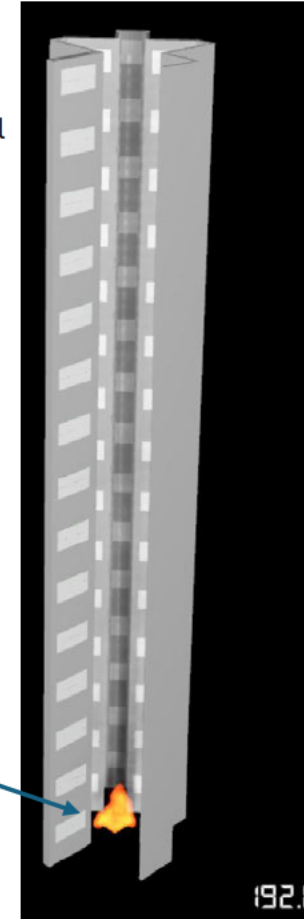
Case 3 Bamboo scaffolding + Non-FR safety net



Case 4 Bamboo + Non-FR safety net+ foam boards

CFD fire model
hiding
scaffolding
materials

Localised fire
to initiate re-
entrant fire
(HRR:4140kW)



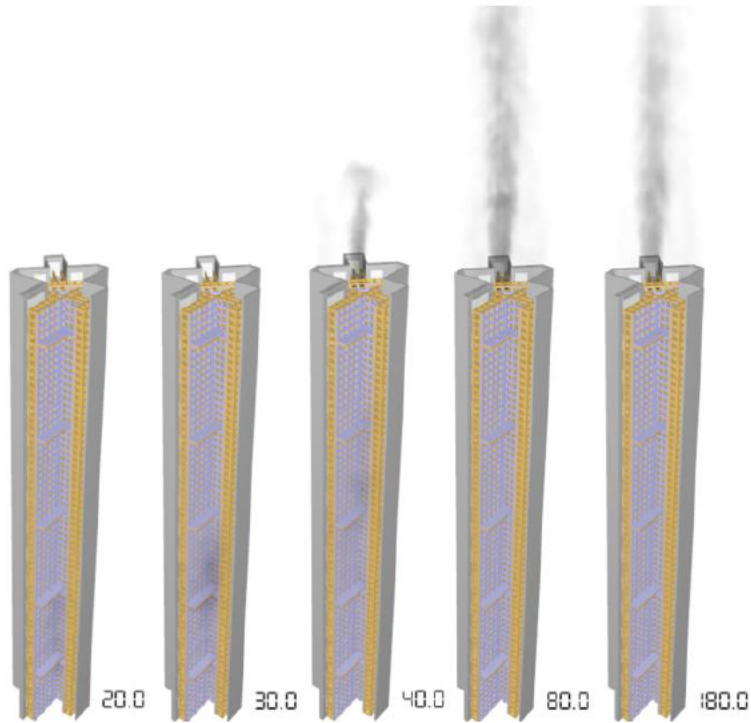
Case 4 Model

Note: CFD fire simulations have many limitations in reproducing such large-scale fires (e.g., the falling behaviour of scaffolding during burning)

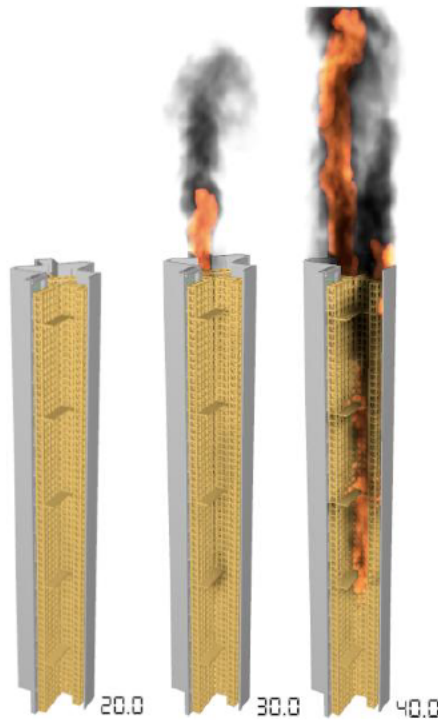
Causes of fire spread | Role of materials

During Re-entrant Fire: Rapid fire spread in re-entrant regions

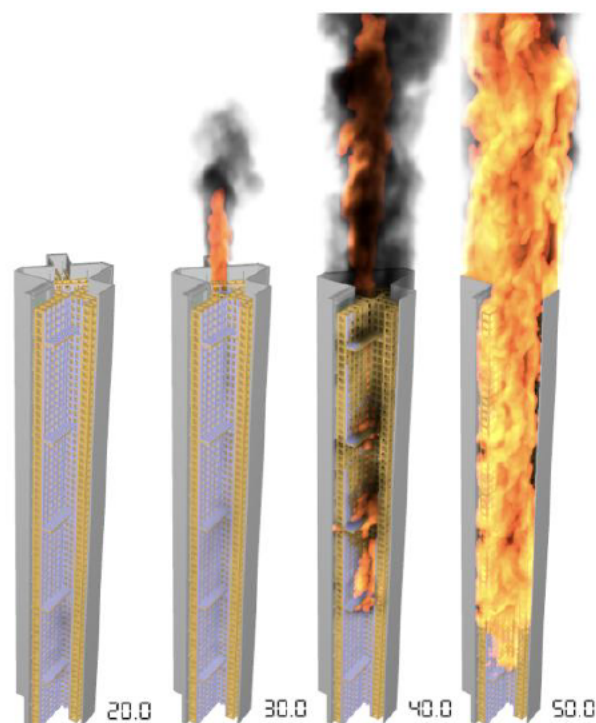
- Case 1, Case 2, Case 3, and Case 4 simulation results



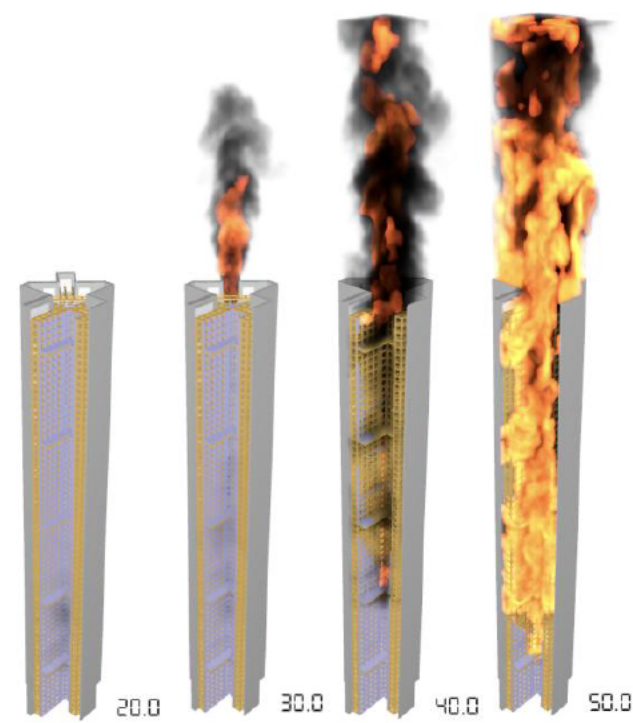
Case 1 All façade materials in Case 4 Assumed Non-combustible



Case 2 Bamboo scaffolding only



Case 3 Bamboo scaffolding + Non-FR safety net

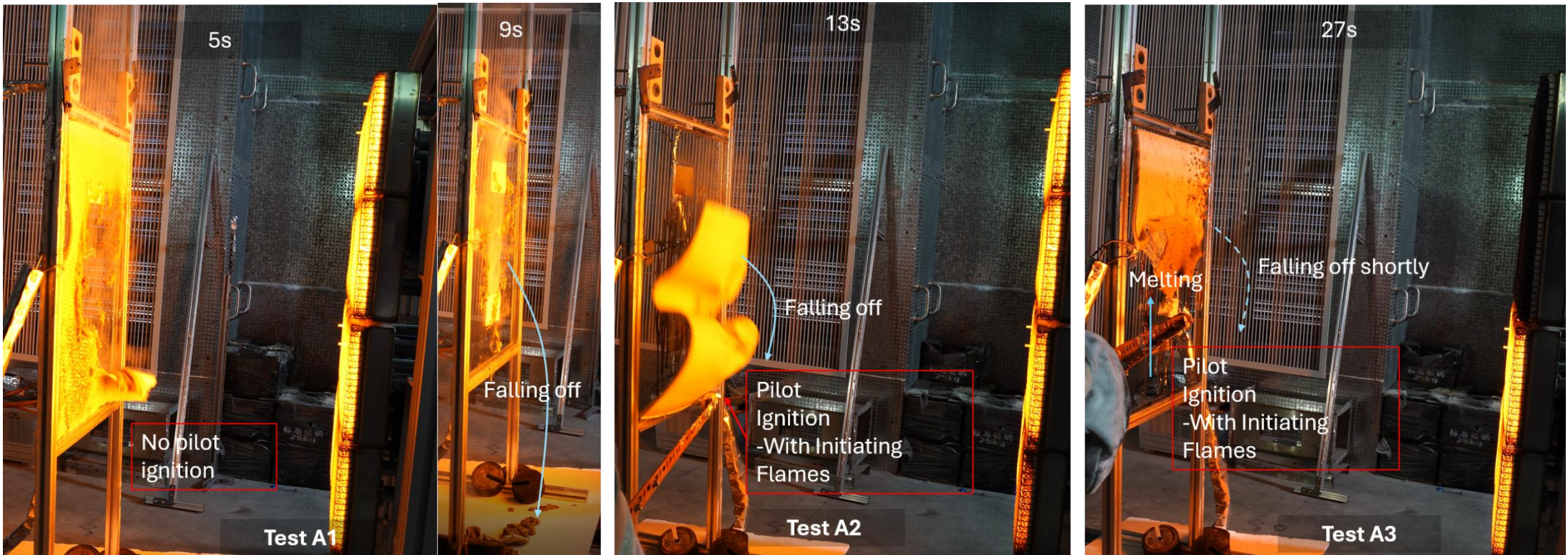


Case 4 Bamboo + Non-FR safety net+ foam boards

Causes of fire spread | Role of materials

During Re-entrant Fires: Glass breakage and ignition of room items

- The effect of Polystyrene foam boards pasted on glass panels is tested
- Under the heating of radiant panel to approximate fire heating, foam boards quickly melted and shrank



Causes of fire spread | Role of materials

During Re-entrant Fire: Glass breakage and ignition of room items

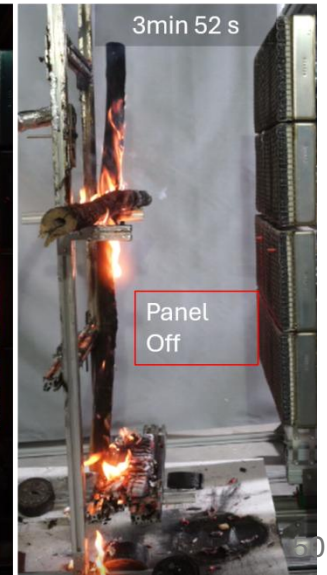
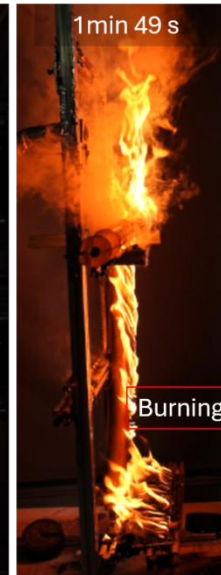
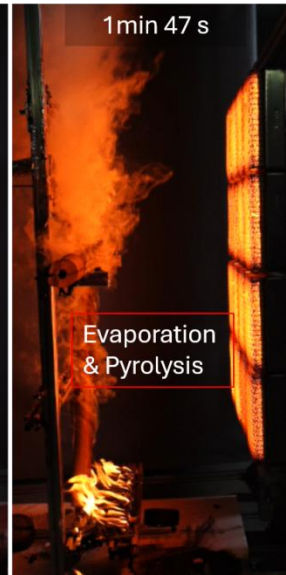
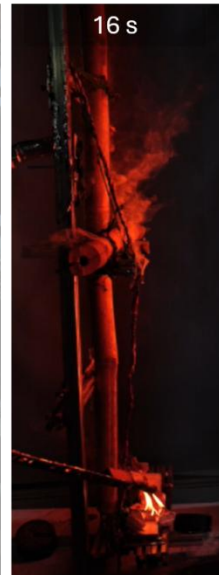
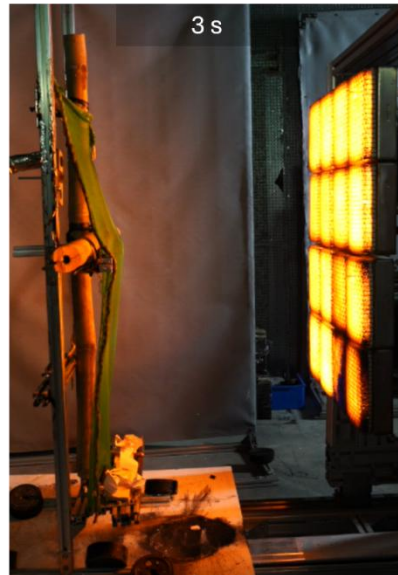
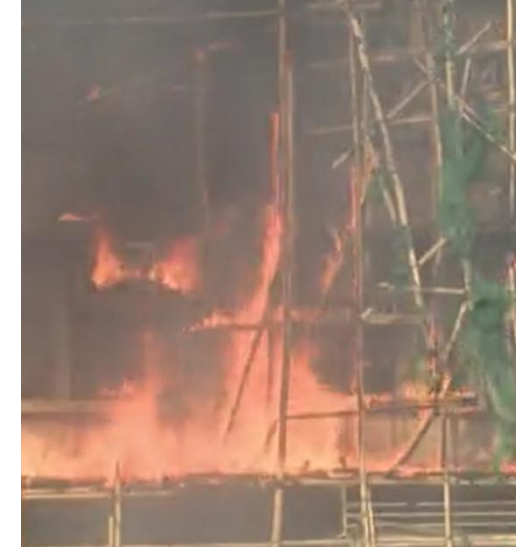
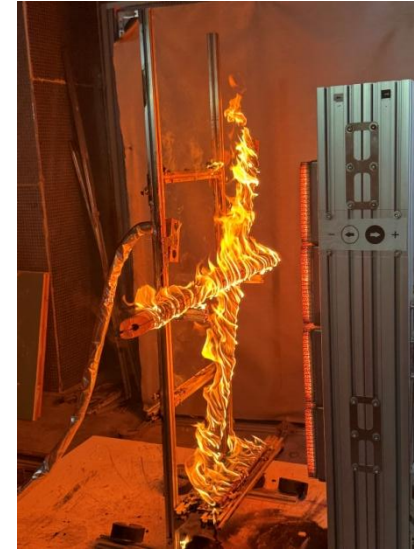
- Falling polystyrene foam boards can maintain a fire for several minutes if being ignited
- Glass breakage occurred and the small wood panel behind window (representing in-room item) was ignited.



Causes of fire spread | Role of materials

After Re-entrant Fire: Subsequent façade fire spread

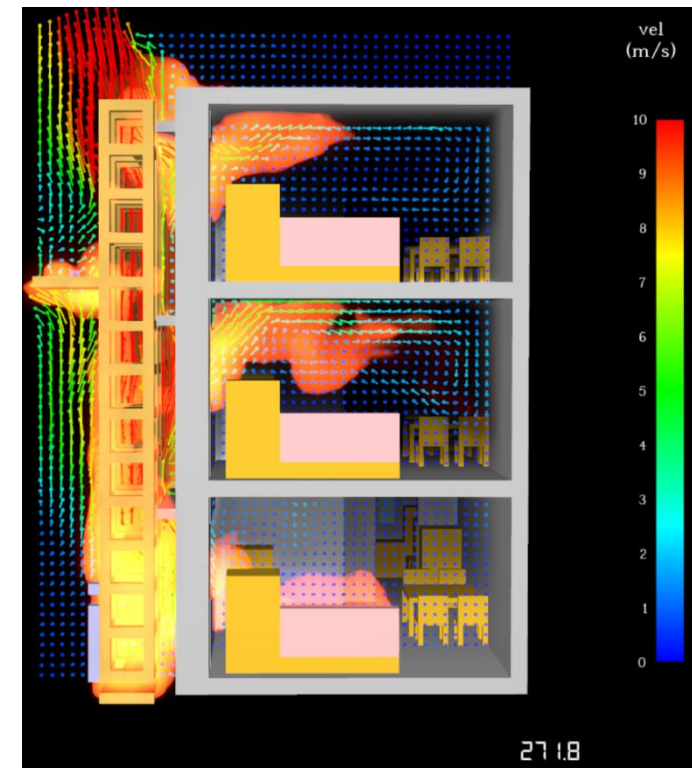
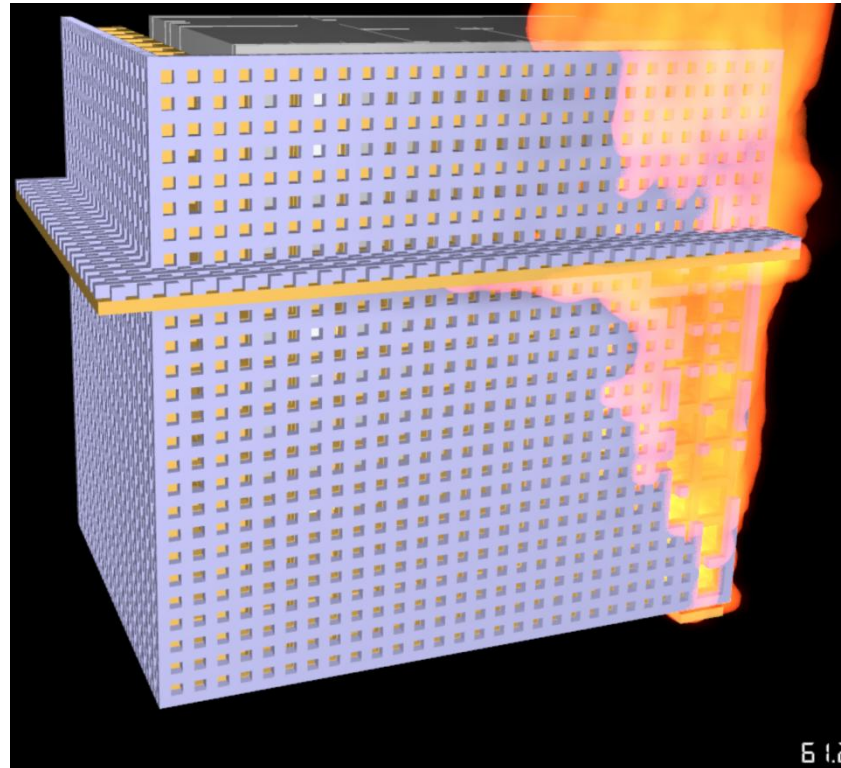
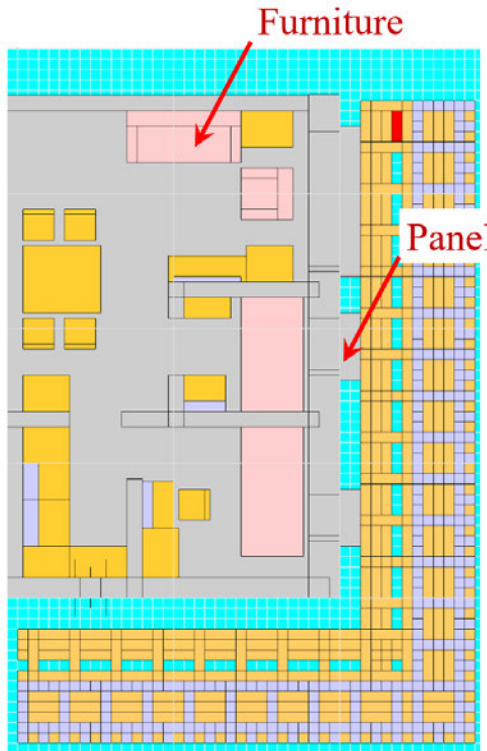
- Possibly triggered by ejecting flames from room units
- Burning of remaining scaffolding fire at façade
- Bamboo, wood boards, non-FR safety net, and polystyrene foam boards are likely to contribute in the subsequent fire spread



Causes of fire spread | Role of materials

After Re-entrant Fire: Subsequent façade fire spread

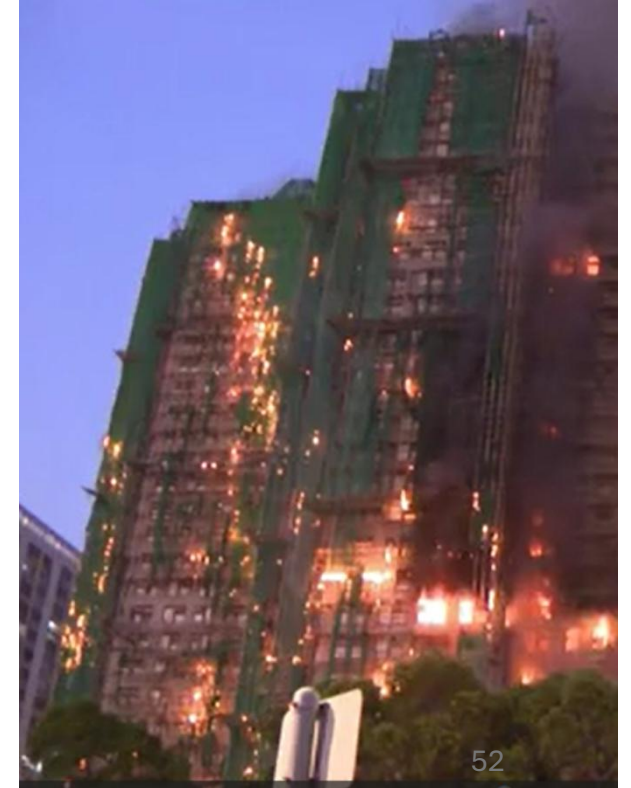
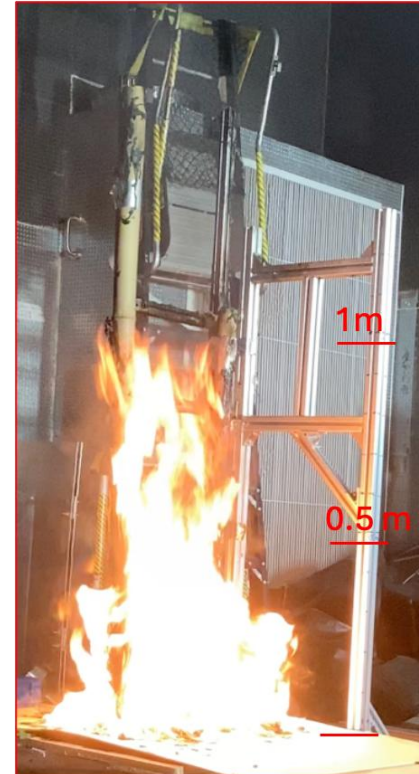
- FDS simulation



Causes of fire spread | Role of Geometry

Before Re-entrant Fire : A flat roof to allow initial development

- Each re-entrant of the buildings has a flat roof above the ground floor
- The flat roof facilitated the accumulation of dripping flames and joint burning of itmes
- The existence of flat roof facilitated the key localised fire initiating re-entrant fire
- Noted other source of localised fire (e.g., random fires from room units) may lead to re-entrant fire



Causes of fire spread | Role of Geometry

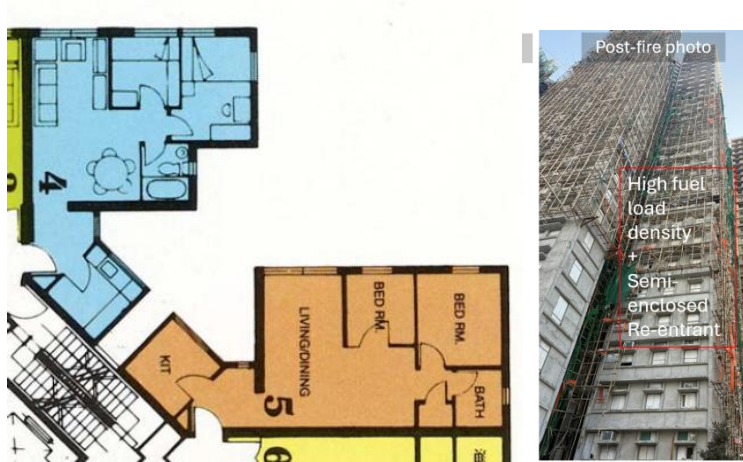
Fire spread from Building to Building

- Short distances between buildings
- High-momentum air flow in re-entrant fire and Wind effect

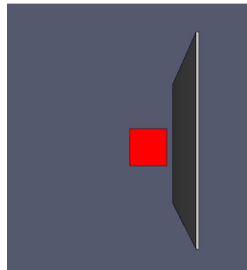


Causes of fire spread | Role of Geometry

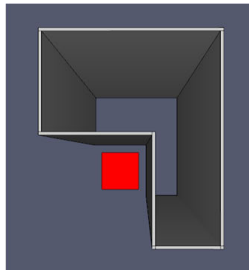
During Re-entrant Fire : Semi-enclosed re-entrant geometry



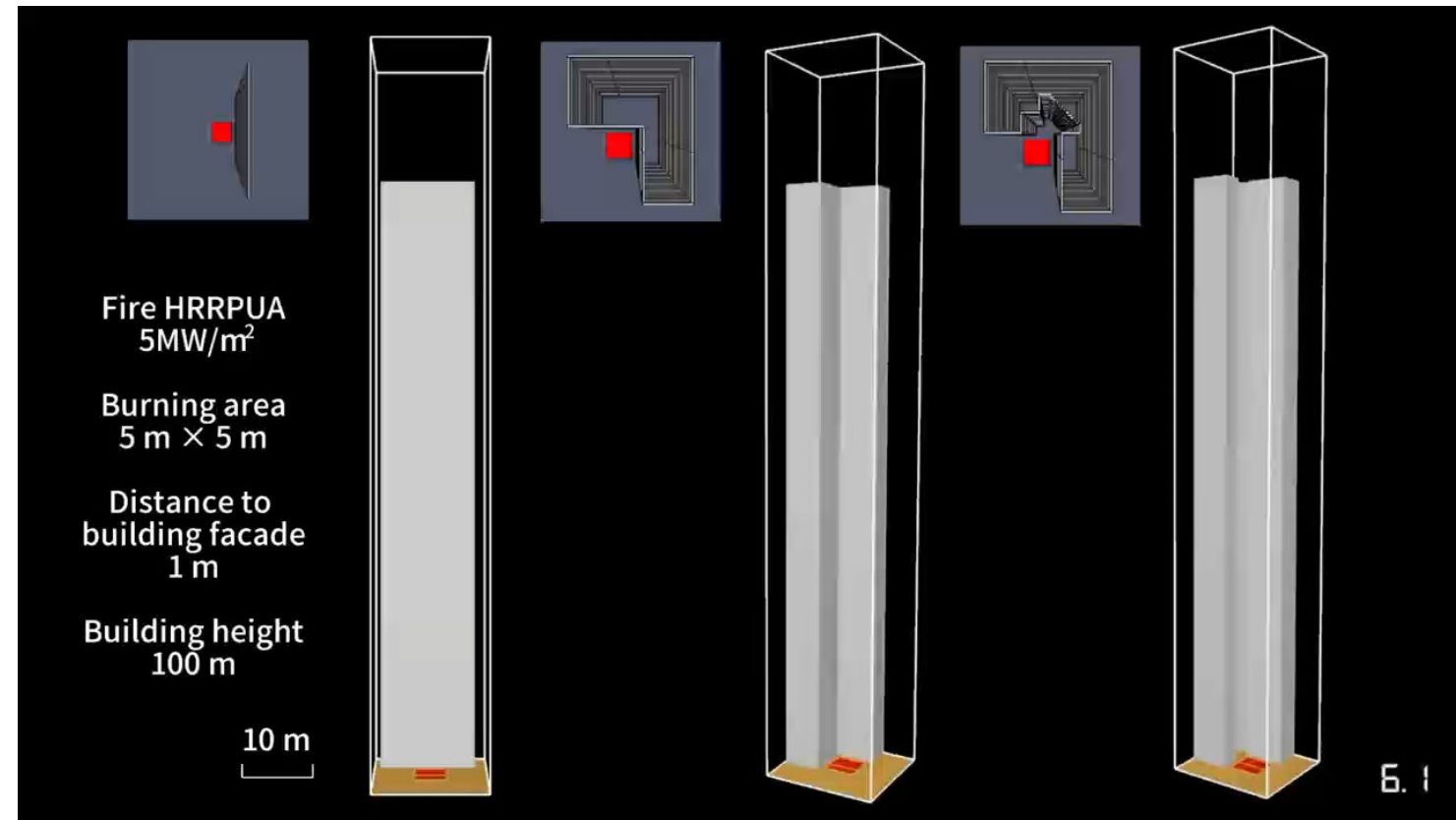
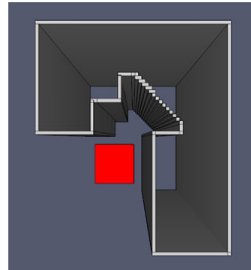
(a) Case 1:
Single Flat Wall



(b) Case 2:
L-shaped Corner Wall



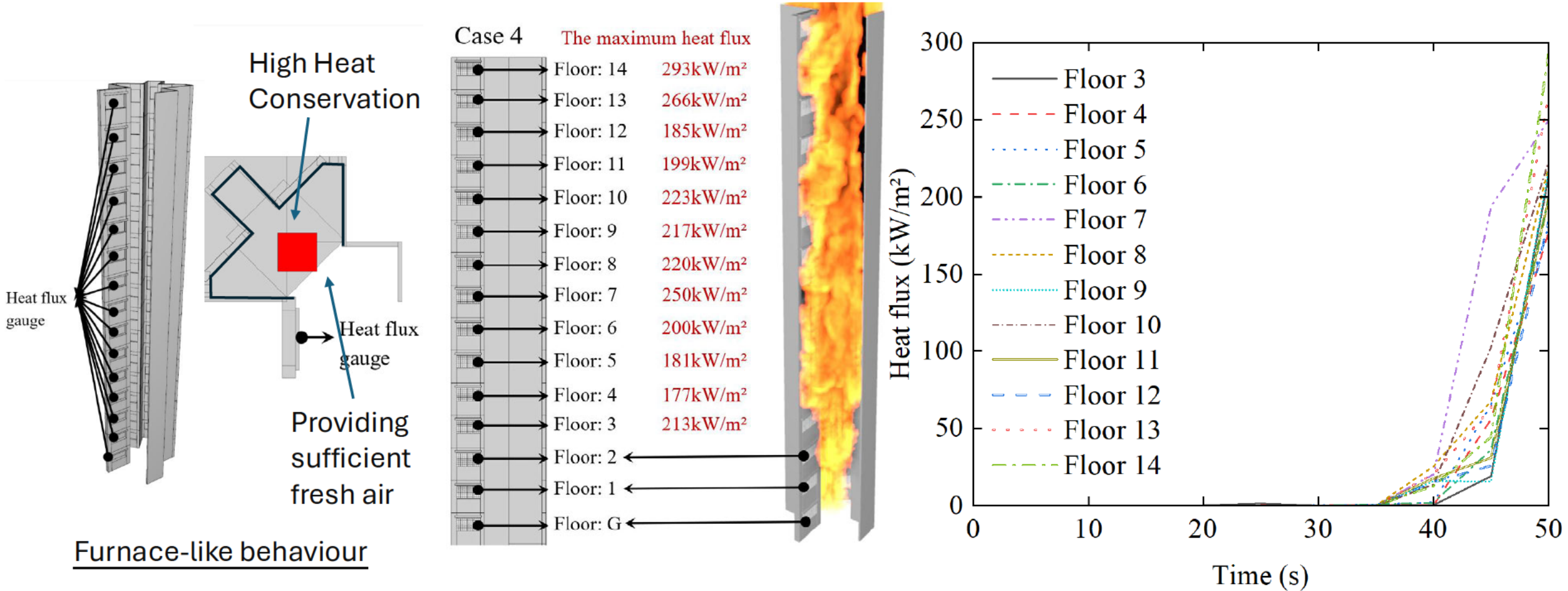
(c) Case 3:
Wang Cheong House
South Re-entrant



Causes of fire spread | Role of Geometry

During Re-entrant Fire: Semi-enclosed re-entrant geometry

- High gauge heat fluxes in re-entrant region simulated



Section 3

Analysis on fatality causes

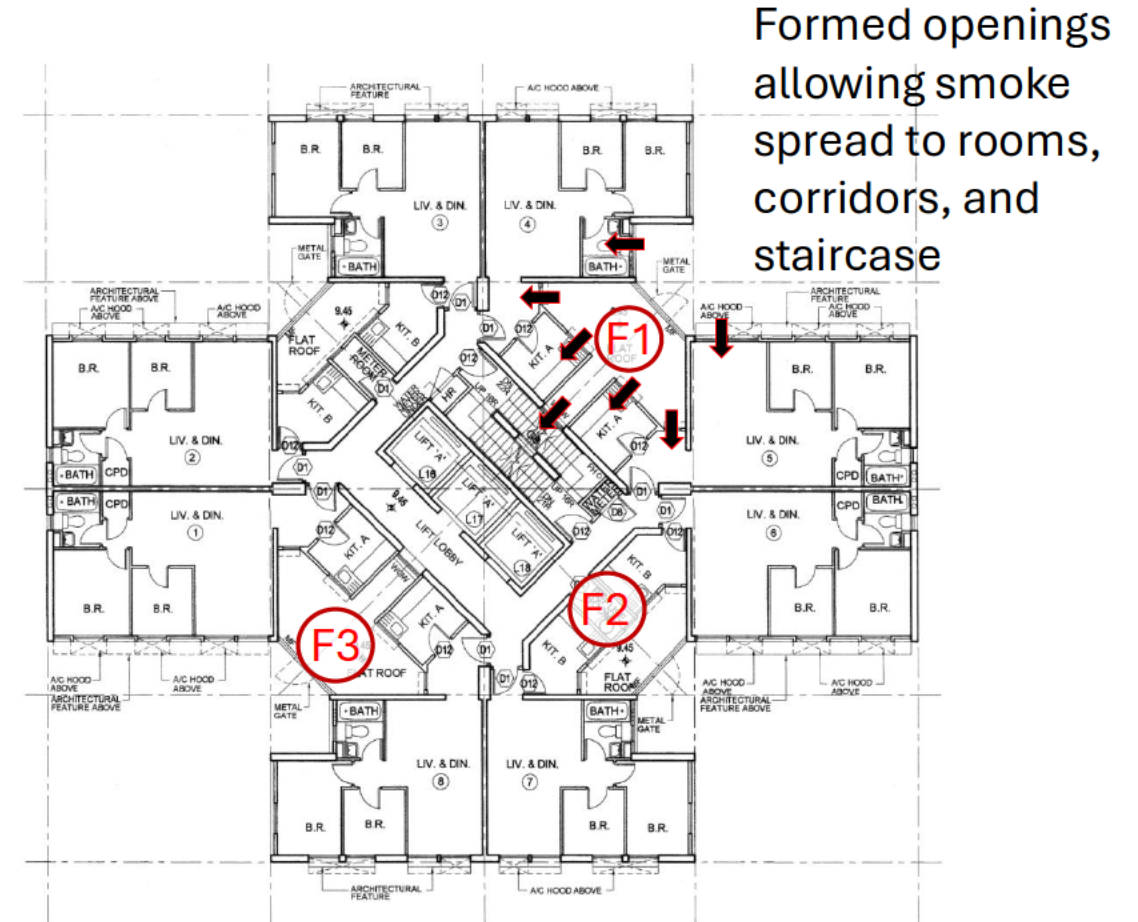
Presented by Prof Liming Jiang

Impact of fire/smoke spread on fatalities



Rapid smoke accumulation:

- 1) ineffective burning of re-entrant scaffolding materials
- 2) Ignition of room items



Smoke spread through window openings in Block F Unit ■ 05



05
Block F

Living room



Room corridor



Kitchen

Openings at staircase leading to smoke spread



Replaced temporary wooden door burnt out

Figure 4.7. Wired glass window (WG) in (a) staircase; (b) lift lobby

BLOCK F Fatalities

Wang Cheong House (宏昌閣)

Floor No	Unit No								C/C	SC	Remarks
	1	2	3	4	5	6	7	8			
31									1 esd/sd		Numbers represent number of fatalities
30	1 esd	2 md/u						2 md/u			
29									6 esd/md		
27	2 esd	1 esd						4 esd			
26		1 u (2602)	2603					5 sd/md	1 sd/md		
25							1 md/u				C/C: Common Corridor
24							2				
23		1 md/u				4 esd				1 esd	
22	1 esd									1 esd	
21	2 esd						1 esd		1 esd/md		
19		2 md/u						1 esd			SC: Staircase
18	1 esd										
17	1 esd					1 esd					
16							1 esd				
15									1 esd/sd		
12		4 u (1202)							1 sd/md		CC faces re-entrant between Units 1 and 8
11									2 md		
10							1 esd/sd/md/u	1 esd/sd		1 md	
9							2 esd		1 esd/sd/md		
8		1 md/u						1 esd/sd/md			
7								3 esd/sd/md	1 esd		esd: Extremely Severe Damage
6				1 esd/sd							
5		2 sd/md						1 esd			
4					2 esd						
3									1 sd/md		
2					2 esd				1 esd/sd	1 esd/sd	md: Minor Damage u: Unaffected
G										3 sd/md	
									Fatalities in C/C and SC: 24		Total: 81

Locations of fatalities and correlation with damage of flats

- Wang Cheong House (Block F): 24 of 81 victims died in common corridors and staircases
- Wang Tai House (Block E): 38 of 82 victims died in common corridors and staircases

The likely cause of death in these locations is smoke inhalation.

- Wang Cheong House (Block F): 15 fatalities occurred in 9 flats where at least one room in each flat was unaffected by flame
- Wang Tai House (Block E): 17 people died in 8 flats in which at least one room remained unaffected by flame

It is reasonable to infer that these occupants were initially able to move away from the flames and high heat into unaffected areas before losing consciousness. The cause of death in these flats is therefore most likely to be smoke inhalation.

- Wang Cheong House (Block F): Unit ■■■02 and Unit ■■■02 were unaffected, yet one and four occupants, respectively, died in these flats.
- Wang Tai House (Block E): There are 2 unaffected flats, one fatality occurred in each of these 2 flats.

Key focus is to analyse how smoke spread into Unit ■■■02 and Unit ■■■02 of Wang Cheong House.

Fast fire and smoke spread in re-entrant

- Video footage showed fire spread from the bottom to the top within 10 seconds.
- The upper part of WGWs is left open for ventilation.
- Some WGWs were replaced by wooden doors. The wooden doors have gaps or left open or burnt through during the fire.
- The CFD simulation results indicate a very rapid vertical spread of fire gases in the re-entrant, with smoke entering the staircases and lift hall on all floors.

Smoke spread simulation

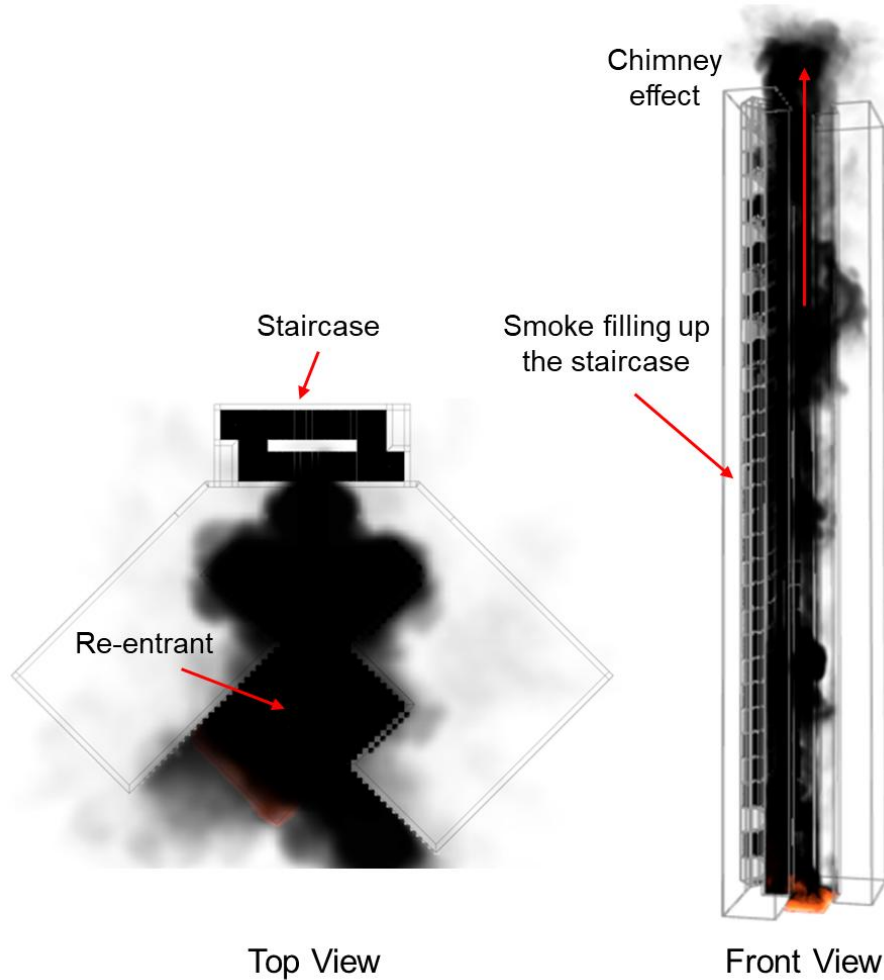


Figure 4.8. Simulation results of smoke spread from the re-entrant into the staircase

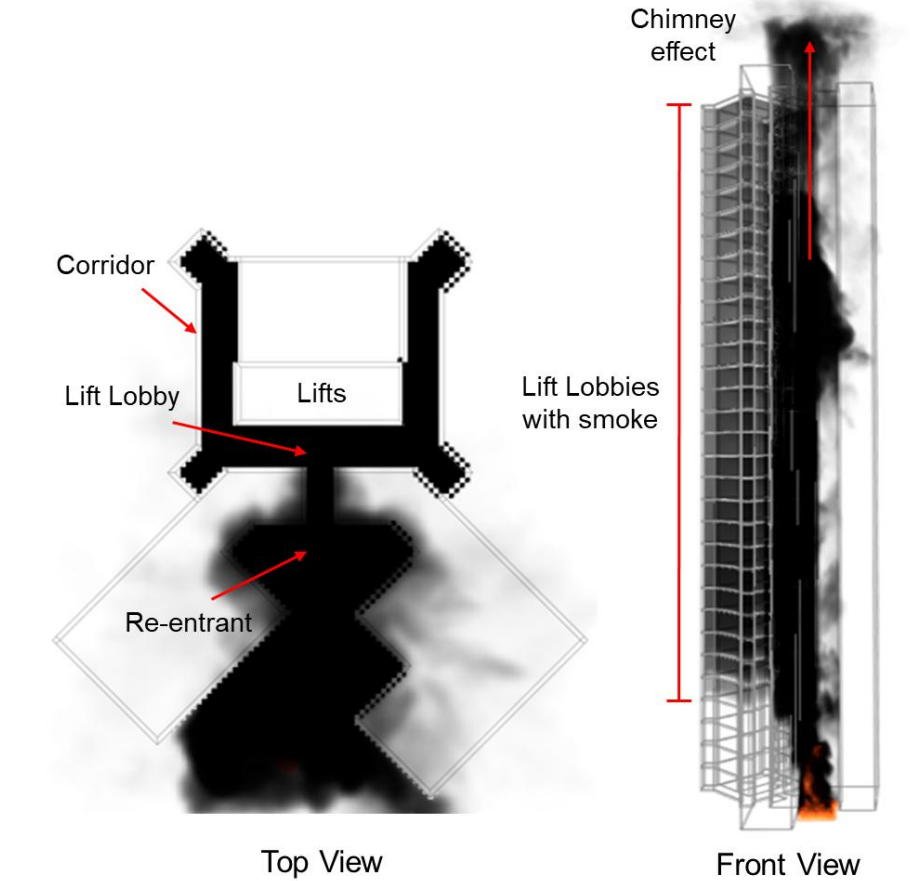


Figure 4.9. Simulation results of smoke spread from the re-entrant into lift halls.

Smoke spread simulation

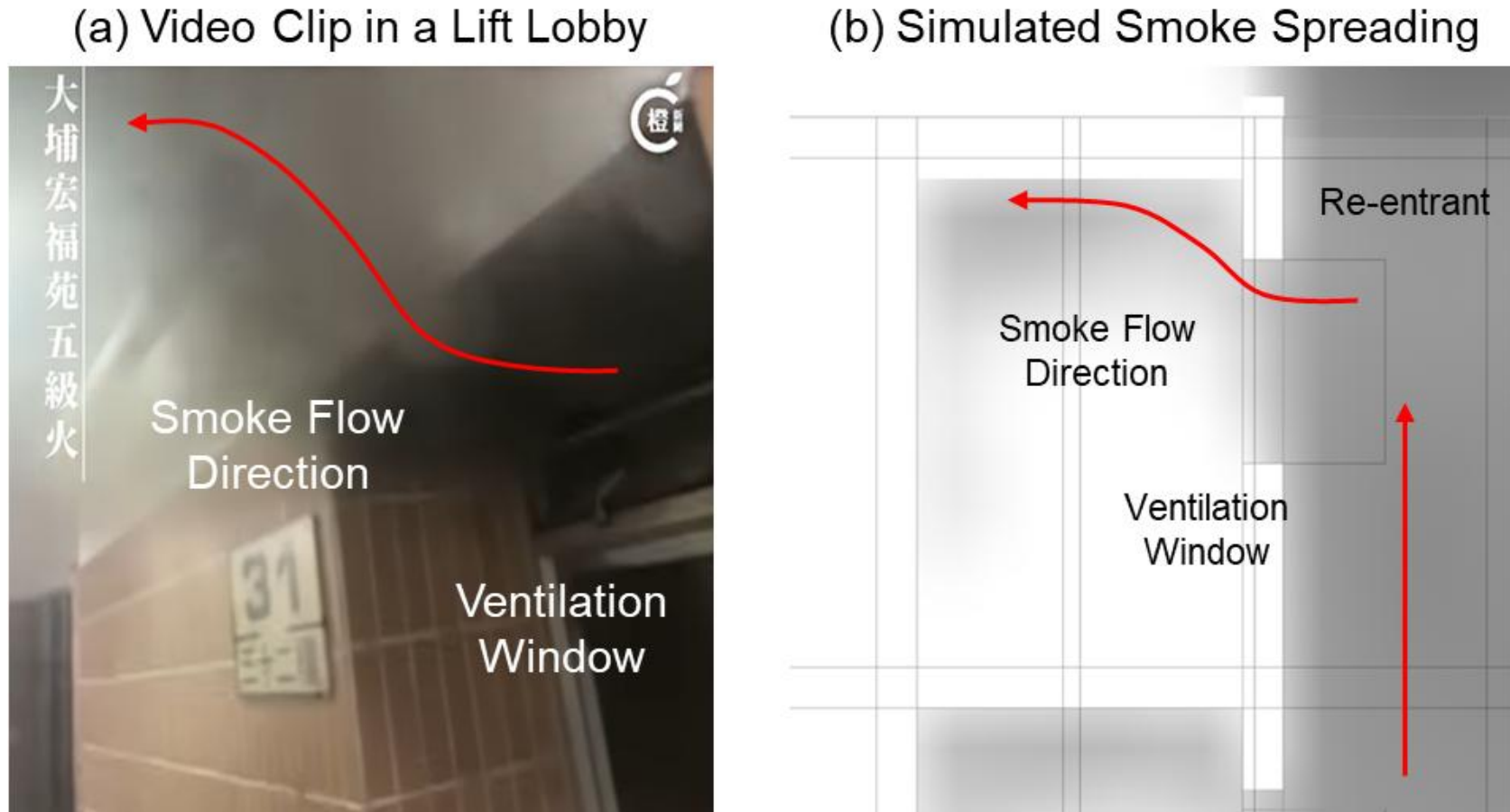
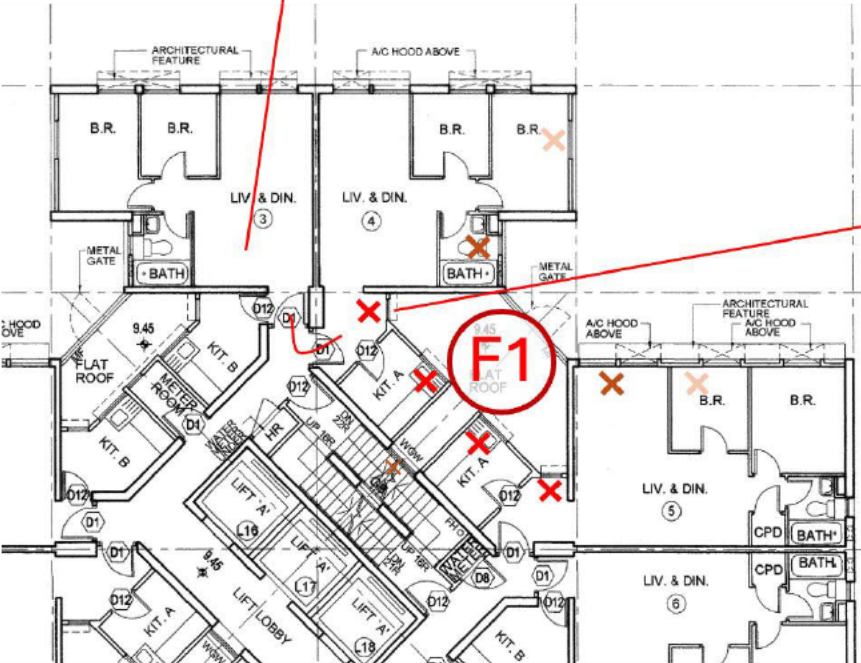
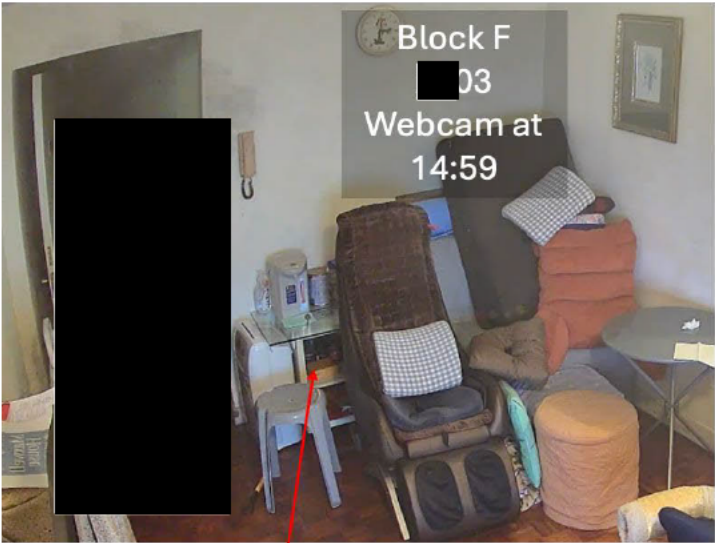


Figure 4.10. Smoke spreading conditions in the lift lobby: (a) video, and (b) simulation result

General observations on smoke fatalities correlation

- Carbon monoxide, smoke concentrations, and toxic gases from burning plastics increased rapidly during and after re-entrant fires.
- The deactivated fire alarm system, combined with polystyrene window covers that blocked the occupants' view of the developing fire, likely to have delayed occupant awareness and evacuation.
- Consequently, both staircases—which formed the primary means of escape—became heavily smoke-logged.
- The ignite room units might have also generated large amount of smoke leaking through the doors, mitigating evacuation conditions at corridors.
- The CFD-predicted visibility in the common corridors of the lower floors dropped below 10 m in less than one minute, breaching the threshold of tenable conditions for safe evacuation.

Referring to In-room webcam video of Block F Unit 03



Fatalities in Unit 02

Four fatalities in Unit 02, two victims (D54 and D56) originated from Unit 04.

On floor, Units 04 and 05 were destroyed. In Unit 04, the kitchen was fully burned out and no remains of the kitchen door were found, indicating that it was either removed prior to the incident or completely consumed by fire. Units 06, 07 and 08 were also seriously damaged.

Unit 01 was totally consumed; the entrance door is immediately adjacent to the entrance door of Unit 02, and was burnt through.

Hot smoke penetrated into Unit 02 through the door gaps while other units on the same floor were burning for an extended period.

The post-fire photograph of the Unit 02 entrance door shows significant charring on the upper portion of the leaf and heavy soot deposition on the ceiling of the entrance foyer inside of Unit 02.



Figure 4.12. Entrance door of (a) Unit 01 and (b) Unit 02, Wang Cheong House

Unit 02 of Wang Cheong House

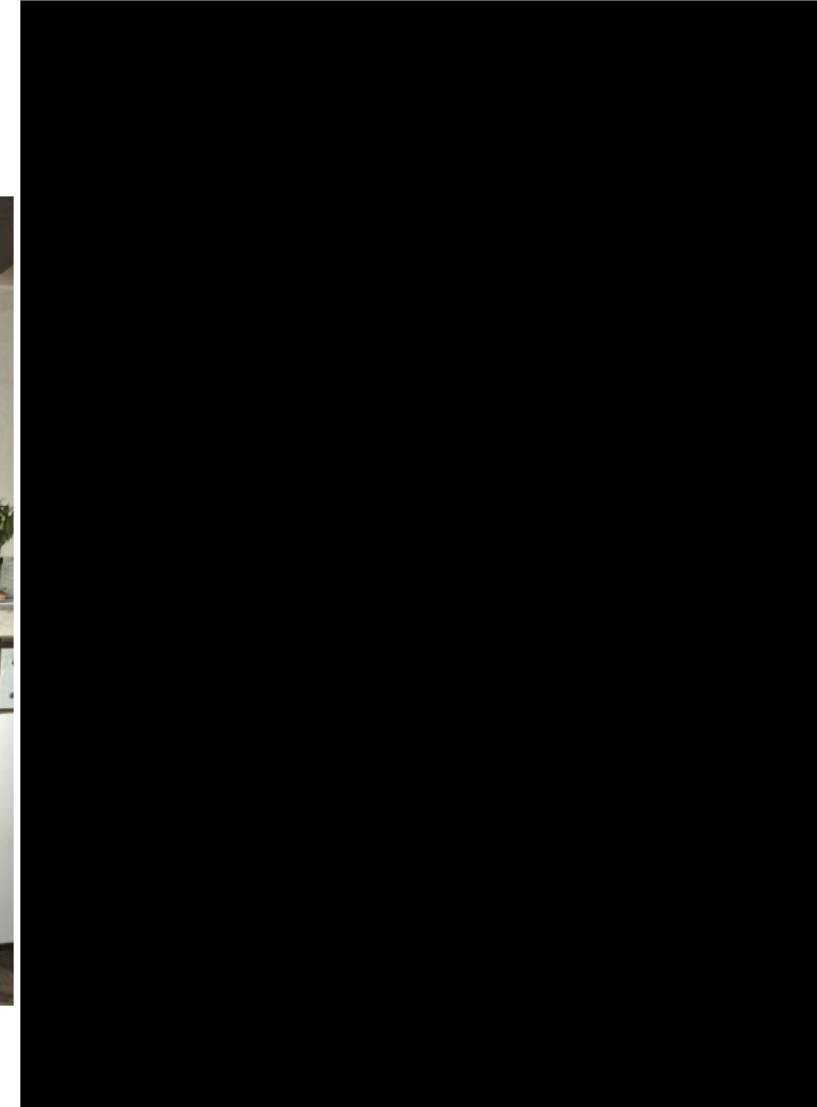
Heavy soot deposition and char on the entrance door leaf and on the ceiling of Unit 02 close to the entrance door



Entrance Door



Entrance door leaf



The probable sequence of events for the four fatalities in Unit ■02 of Wang Cheong House:

- 14:59 Fire developed fully within the re-entrant between Units 4 and 5, two occupants (D44 and D45) were inside Unit ■02.
- 15:00 The re-entrant fire likely caused failure of the kitchen window of Unit ■04; flames and hot gases to enter the flat.
- 15:00 – Two occupants of Unit ■04 (D54 and 56) exited into the common corridor; the staircase and lift lobby were already heavily smoke logged (4th Witness Statement of Yiu Men-yeung).
- 15:00 – D54 and D56 then knocked on the door of Unit ■02 and entered. Together with the two original occupants of Unit ■02 (D44 and D45), four people remained in Unit ■02 shortly after 15:00.
- 15:09 The re-entrant between Unit ■01 and ■08 was fully involved with fire. The kitchen window of Unit ■01 was probably failed, allowing the fire to develop within Unit ■01.
- 15:10 – 15:30 Fire in Unit ■01 was developing to flashover.
- 15:30 – 16:00 The entrance door of Unit ■01 broke through.
Hot smoke and flames from Unit ■01 would have impinged directly on the entrance door of Unit ■02; then smoke leaked into Unit ■02 through door gaps and overcame 4 victims in Unit ■02.

Detailed analysis showed that the fire in Unit ■01 likely lasted for more than 2 hours.

Fatality (D87) in Unit ■02

- On ■ floor, Units ■04 and ■06 were totally consumed, and the entrance door of Unit ■04 was burnt through. Both flats are remote from Unit ■02. Unit ■01 adjacent to Unit ■02 was seriously damaged internally; its entrance door remained intact.
- Unit ■02's entrance door had light soot deposition on the upper portion facing the corridor, indicating that fires in other flats on this floor had limited impact on conditions inside Unit ■02 via the corridor.
- Within Unit ■02, most windows were found open in the post-fire photographs, particularly the living room window. It is likely that smoke is from the exterior. The re-entrant between Units ■02 and ■03 did not catch fire; the source of exterior smoke was likely the fire involving the safety netting, bamboo scaffolding and other combustible materials along façade and resulting in the fatality of occupant D87.

Summary of assessment of fatalities in Units ■02 and ■02

The fatalities in Units ■02 and ■02 illustrate two distinct lateral fire/smoke spread mechanisms:

- Unit ■02: Fatalities were mainly caused by smoke from internal flat fires on the same floor. Fire spread from the re-entrant into Unit ■04 and other units, fully involving those compartments and eventually breaching the fire-rated entrance door of Unit ■01. Subsequent hot smoke and flame impingement on the entrance door of Unit ■02 led to significant smoke leakage into Unit ■02 via door gaps, resulting in lethal conditions for the four occupants sheltering inside.
- Unit ■02: The fatality was predominantly due to smoke from external façade fires involving safety nets, bamboo scaffolding and other combustibles. With windows (especially the living room window) open, smoke from the façade entered Unit ■02 directly from outside, despite minimal impact from corridor fires on that floor.

Section 4

Review of IFITF Report

Presented by Prof Asif Usmani

Review of firefighting procedures

The Fire Services Communications Centre (FSCC) received the first building fire call at 1451. The Senior Station Officer (SStno) arrived on site at 1456, indicating a five-minute response time and demonstrating that frontline firefighting response was both effective and efficient.

During firefighting operations, the Pre-determined Attendance (**PDA**) alarm level was escalated as follows:

- No. 1 Alarm at 1451;
- Upgraded to No. 3 Alarm at 1502;
- Upgraded to No. 4 Alarm at 1534; and
- Upgraded to No. 5 Alarm at 1822.

Review of firefighting procedures

- Resource deployment increased significantly in line with the PDA levels.
- There was a delay in upgrading No. 4 Alarm to No. 5 Alarm, the PDA deployed at No. 4 Alarm had already exceeded No. 5 Alarm requirements.
- The incident was unprecedented in both scale and circumstances, in practical terms very limited additional action that the FSD could have taken on site to materially alter the outcome.

Fire statistics

Statistical report of 27 to 57 countries / regions worldwide, representing populations ranging from 0.9 to 3.8 billion people, the averaged statistical results from 1993 to 2023 are as follows:

- The average number of fires per 1,000 inhabitants: 1.6
- The average number of fire deaths per 100,000 inhabitants: 1.6
- The average number of fire deaths per 100 fires: 1.0

The Hong Kong FSD publishes statistical information annually. The results of statistics for Hong Kong from 2005 to 2024 are given below:

- The average number of fires per 1,000 inhabitants: 1.07
- The average number of fire deaths per 100,000 inhabitants: 0.26
- The average number of fire deaths per 100 fires: 0.31

Fire statistics

The fire fatalities in Hong Kong were significantly lower than the global average fire fatalities before the Wang Fuk Court fire.

Unfortunately, the Wang Fuk Court fire itself contributed to 2.24 deaths per 100,000 inhabitants, which is significantly higher than the previous statistical average in Hong Kong and illustrates the unprecedented nature of the incident.

It suggests:

Strong firefighting performance and fast response from the FSD cannot compensate for weaknesses in other areas (in this case primarily the regulation and management of temporary works).

Review of IFITF Report

The report summarised the key observations into 4 categories:

- Safety nets & canvas related;
- Staircase openings related;
- Polystyrene window covers related; and
- Fire development related.

We are in general agreement with the IFITF expert's findings and greatly appreciate their effort in carrying out a large scale fire test on a mock up of the re-entrant in Sichuan. We have a couple of key observations in this regard:

- There are inherent limitations in a 3 storey fire test, as a 31 storey building fire will develop a more significant chimney effect
- IFITF report highlights that a large enough fire would consume FR safety net
- Caution must be exercised in assuming the FR materials could prevent the fire
- FR materials are only FR materials because they have passed some test – which may be inadequate – Grenfell is a salutary lesson that should not be forgotten!

Section 5 Summary and Recommendations

Presented by Prof Asif Usmani

How temporary works in buildings are regulated

- **Building regulations are primarily focused on fires originating inside building compartments.** External fires in Hong Kong buildings are not considered likely as regulations expressly prohibit the use of combustible materials on building exterior facades.
- **Firefighting strategies and training are also focused on indoor fires** which constitute vast majority of the fire emergencies in Hong Kong. There are no effective firefighting strategies for façade fires in tall buildings globally.
- **Combustible materials are allowed for temporary works** as it is not considered a part of the building façade (the exception are lift wells post Garley Building fire), leading to frequent fires in buildings under renovation and/or repair.
- **Multiple adjacent buildings being clad in the same envelope simultaneously for prolonged** periods of time (well over one year), challenges the use of the term “temporary,” severely increasing the risk.
- **This is primarily a systemic failure and must be reviewed at the level of public policy** and appropriate changes must be made in how temporary works are regulated

The chain of events leading to a major disaster

1. **Collection of combustible materials** (whether FR or not) within all re-entrants on the building façade temporary works, scaffolding and flat roof
2. **The geometry of the re-entrant governed the fire development** and extremely rapid upward spread which is unprecedented in the history of major building fires (up to a high of 10m/s) to beyond the top of a building almost like a jet flame
3. **Direct connection of the re-entrant space to the public areas including the fire escape staircases** and ingress of smoke and hot gases blocking evacuation paths through window openings
4. **Breaking of windows with single panes of glass located inside of the re-entrant facade** and spreading the fires directly into the apartment units.
5. **Breakage of the living room windows** adjacent to the re-entrant enabled fires to find another route to enter the apartment units directly causing burnout of the high fuel loads in many of the units and contributed to fire spread internally from unit to unit.
6. **Spreading of the fire from the first re-entrant fire to other re-entrants in the same building and then on to re-entrants in neighbouring buildings** because of fire induced fountains of embers

Recommendations for immediate implementation

1. Do not permit simultaneous cladding of high-rise buildings with combustible temporary works that are adjacent or in the vicinity of each other.
2. Architectural features such as the re-entrants in Wang Fuk Court should be considered as a part of the building, as a special kind of the vertical shaft.
3. For high-rise building facades under renovation a higher regulatory bar should be set where buildings remain occupied during the works.
4. In addition to the duration of the project, other considerations in approval of the repair/renovation works should be any special features of the building, such as its geometry, distribution and locations of windows and openings and any exits and entrances, provision of refuge floors etc.
5. Continuous monitoring of the site should be undertaken using currently available automated monitoring systems based on computer vision with independent detection and potentially suppression systems.
6. No combustibles should be allowed on any part of the building façade that could enable heat and smoke to enter the building and block evacuation routes.
7. No combustibles should be present above the ground level exits that could allow materials from the temporary works to fall and block exits.
8. Stricter oversight must be maintained to ensure that all the materials used in temporary works have been adequately treated with fire retardant compounds with proper certification and source identification.
9. Site workers must receive regular training to maintain awareness of fire hazards and remain vigilant.
10. An intensive induction of occupants and workers must be conducted before the commencement of the repair/renovation works followed by routine fire drills.
11. The building management structure (PMC/OC) and their coordination with HA and MBIS regimes should be reviewed.

Recommendations that require research

1. A well thought-out and well-designed risk-based methodology must be developed for approval of renovation/repair work for all buildings in Hong Kong enabling a bespoke building specific temporary works solution to be implemented with appropriate safety measures including redundant FSI.
2. Development of new less combustible light-weight materials that could be used in temporary works.
3. Development of bespoke redundant FSI systems especially for temporary works (such as temporary sprinkler systems).
4. Dedicated apps for each building should be developed to provide personal information, reporting and alarm portal to each resident, including live video feeds. The more eyes the more the likelihood of early fire detection.
5. In the longer term smarter technologies could enable real time monitoring of high-risk sites using digital twins and identifying the most serious potential hazards and disaster scenarios in advance through AI based simulations and AI based automated building safety management.

Recommendations for policy level changes

1. Building regulations, codes of practice, building codes and standards etc. provide essential guidance to engineers and practitioners. Compliance with them ensures a certain level of assurance of safety against severe demands during the life of a building. The flip side of this is that often compliance with regulations and codes is seen as adequate by highly cost-conscious clients and the construction industry promoting a tick-box culture of ensuring safety against expected hazards that a building may face in its lifetime. As a society we must address this culture and promote more rigorous engineering analyses and judgement to be exercised, especially when making decisions that could have a bearing upon the life safety implications of an engineering design. **Since every building project is different and may have features that may throw up unforeseen challenges to occupant safety, a certain level of rigour and engineering judgement should be mandated for each individual case.**
2. Without the risk of “throwing the baby out with the bathwater”, **it is recommended that a committee is formed to review Hong Kong building regulations and codes of practice to ensure that some level of responsibility is borne by stakeholders** when things go wrong and compliance with regulations should not become a shield for them.
3. “How to interpret and execute the public policy” and “how does the system check and ensure that the policy is fully executed?” There is no effective mechanism to learn from past incidents and make changes to fire safety policy. **Strategic level routine risk assessment of urban hazards should be mandated.**

HAD RE-ENTRANTS FACED THE SAME RESTRICTIONS AS LIFT WELLS (POST GARLEY BUILDING) THIS TRAGEDY COULD NOT OCCUR!