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Department of Civil and Environmental Engineering

A round-robin study from 12 UK fire services on the fire safety design of open-sided car parks

Structure in Fire Forum

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Research Background

Research Background

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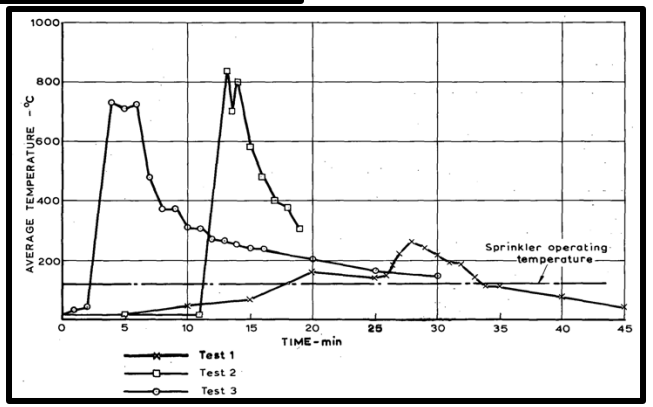
Introducing car parks as specific type of "storage buildings"

1967 BRE UK

1. Series of experiments on fire risk of open-sided car park
2. Minimum fire resistance: 30 minutes
3. Negligible possibility of fire spread between cars
4. Fire growth depends on calorific value of vehicles



Formed the foundation of Approved Document B

1966-1970 BRE Statical Review

1. Observed fire incidents in multi-storey car parks over 4 years
2. Confirmed low fire spread risk
3. No reported major fire spread cases
4. No structural damage

Research Background

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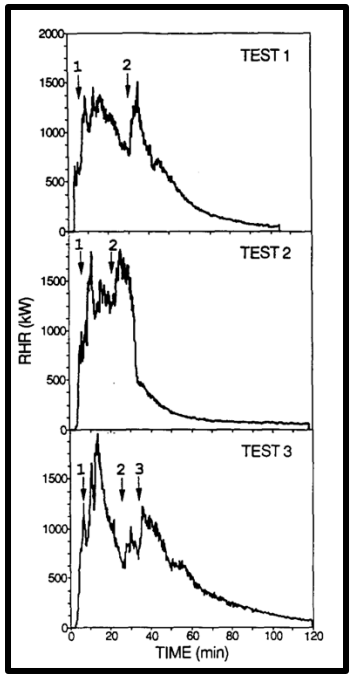
1994 — **VTT Fire tests Finland**

1. 3 fire tests on 1990s medium passenger car targeting calorific value measurement
2. **Max HRR: 1.8 MW per vehicle**



1995 — **FRS study UK**

1. Fire tests on 1980s and 1970s vehicles
2. **Max HRR: 8.5 MW PHRR** increase from 1970s models to 1980s
3. **Ventilation** significantly affects **fire behavior**

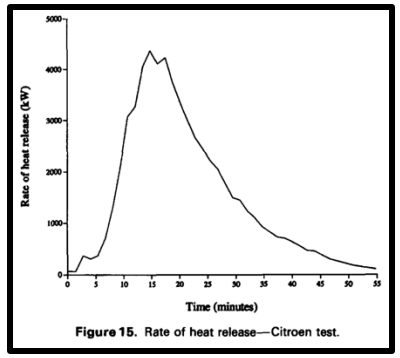


Figure 15. Rate of heat release—Citroen test.

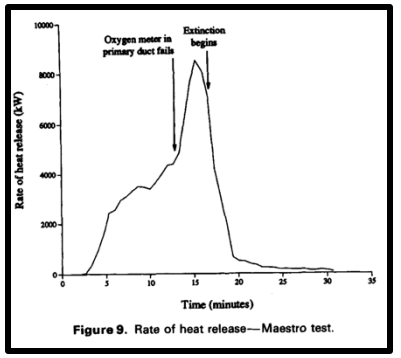


Figure 9. Rate of heat release—Maestro test.

Research Background

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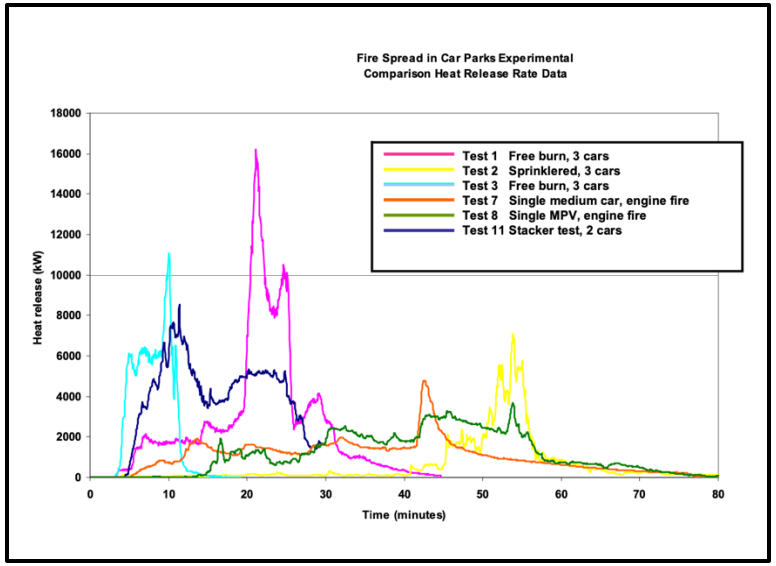
2002 CTICM statistical report

1. Analyzed fire data from 1995-1997
2. 98.7% of fire cases involved less than 3 burning cars
3. 10 fire tests for both single vehicle and multiple vehicles fire scenarios
4. 1990s vehicles HRR: Max of 8.3MW
5. 1980s vehicles HRR: Max of 2.1 MW
6. 12 minutes for fire spread between cars
7. No structural collapse
8. No additional fire protection required

2010 BRE Report (BD2552)-UK

1. Fire spread in enclosed car parks
2. Less severity in open-sided car parks due to better ventilation
3. No additional fire spread control required in open-sided car parks
4. Minimum fire resistance requirements: 15 minutes

2019 Current ADB Version



Research Background

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Liverpool 2017:
Kings Dock Car Park Fire

What are the lessons learnt?

1. Lack of suppression system

B3: Internal Fire spread (Structure)

Fire Safety Concern:
Is automatic suppression system required?

2. Drainage system design

B2: Internal Fire spread (Linings)

Fire Safety Concern:
Is 30 minutes means of escape fire protection adequate?

3. Fuel tank disruption: Fuel running

B3: Internal Fire spread (Structure)

Fire Safety Concern:
Is 15 minutes structural fire protection adequate?

Source: https://www.bbc.co.uk/news/uk-england-merseyside-46290095

Research Background

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2019 **Current ADB Version**

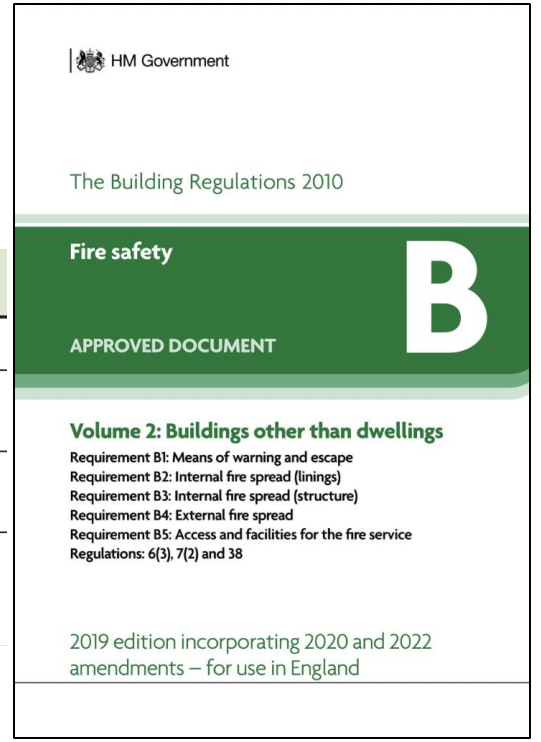
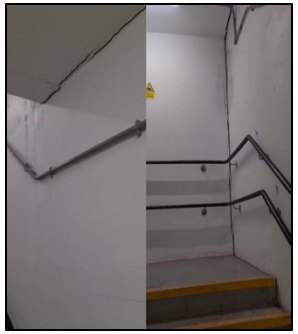


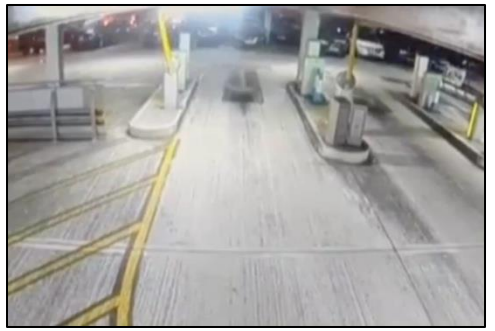
Table A2 Minimum periods of fire resistance

Purpose group of building	Minimum periods of fire resistance (minutes) in a:					
	Basement storey ($) including floor over		Ground or upper storey			
	Depth (m) of a lowest basement		Height (m) of top floor above ground, in a building or separated part of a building			
	More than 10	Not more than 10	Not more than 5	Not more than 18	Not more than 30	More than 30
5. Industrial:						
– not sprinklered	120	90	60	90	120	Not permitted
– sprinklered (2)	90	60	30*	60	90	120#
6. Storage and other non-residential:						
a. any building or part not described elsewhere:						
– not sprinklered	120	90	60	90	120	Not permitted
– sprinklered (2)	90	60	30*	60	90	120#
b. car park for light vehicles:						
i. open sided car park (3)	Not applicable	Not applicable	15*+	15*+ (4)	15*+ (4)	60
ii. any other car park	90	60	30*	60	90	120#

Car parks

London 2023: Luton Airport Car Park Fire





20:47 First call to 999

20:55 First crew attendance

21:10 approx. 6 vehicles on fire

21:26 Crew Withdrawal

21:37 Nearly 80% of 3rd floor engaged

22:09 External fire fighting and keep fire limited to 3rd floor

23:02 Structural collapse of second floor into the first floor

00:00 Final partial collapse

Rapid fire spread

Lack of water supply

Structural collapse

1. Lack of suppression system

Is automatic suppression system required? (B3)

2. Low flow rate of water supply

Is water supply system satisfactory?(B5)

3. Partial Structural Collapse

Is 15 minutes structural fire protection adequate?(B2)

https://www.bedsfire.gov.uk/sites/default/files/202410/Significant%20Incident%20Report%20LLA%20Car%20Park%202%20fire.pdf

Research Method

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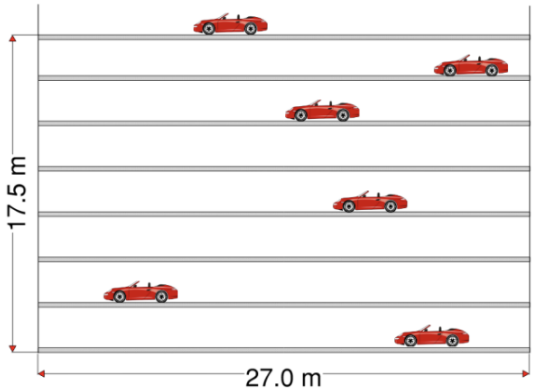
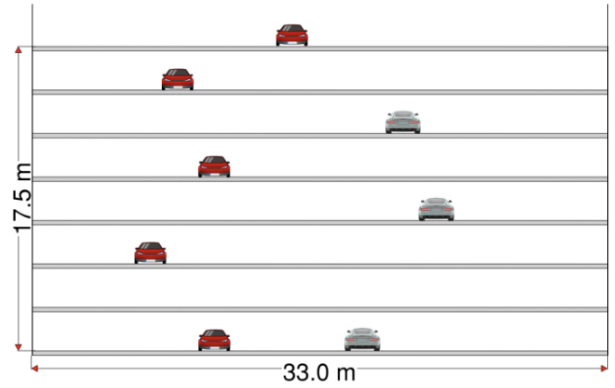
Detailed Fire Safety Strategy Gloucestershire Airport Overflow Car Park Cheltenham designed by Ashton Fire Ltd.

1	Fully compliant with Approved Document B (ADB) (volume 2)
2	Standalone multi-story car park with steel-concrete structure
3	8 stories (ground + 7)
4	192 vehicles capacity
5	17.5 m tall from the ground floor to the top floor
7	All Internal material of Class 1
8	No automatic suppression/detection system





Research Method

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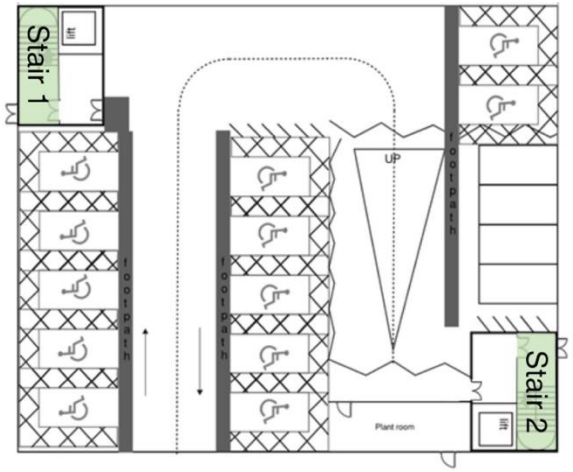
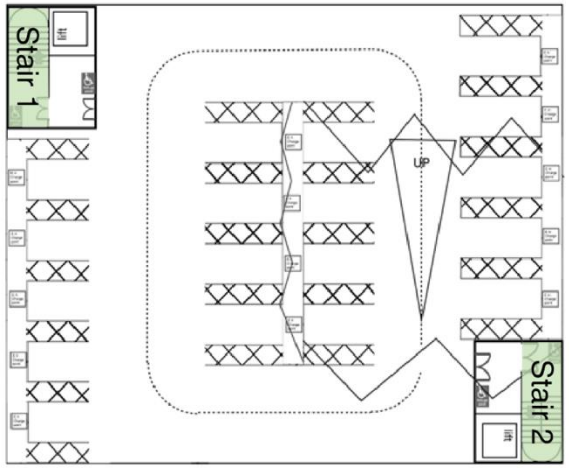
Detailed Fire Safety Strategy

Gloucestershire Airport Overflow Car Park Cheltenham



Ground floor

Individuals with disabilities + Plant room

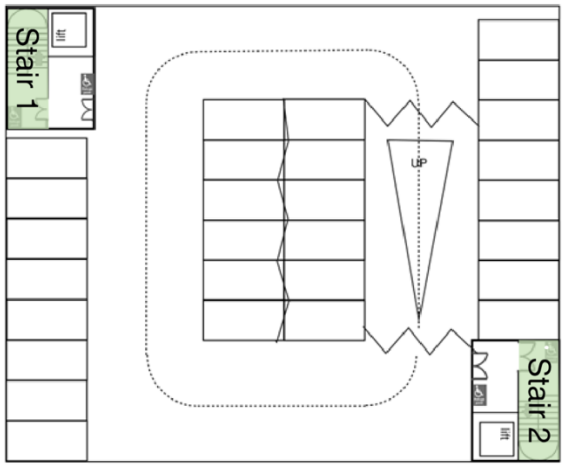


First floor

EV bays and EVCPs

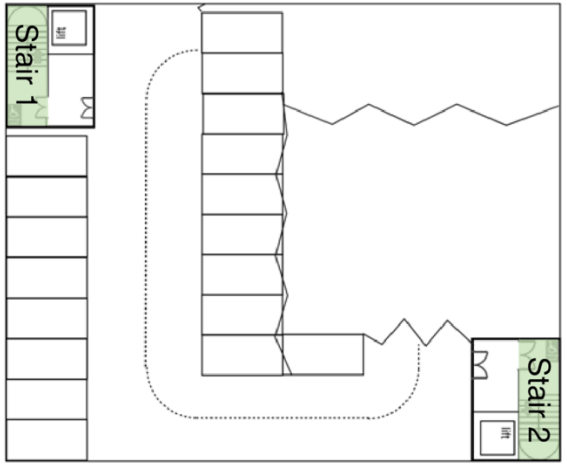
Two to sixth floors

Normal ICVEs



Seventh floor

Normal ICVEs



Research Method

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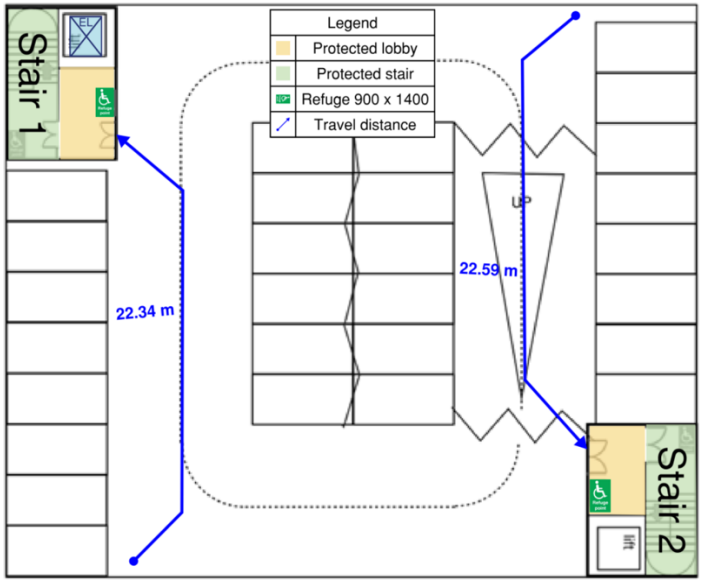
Detailed Fire Safety Strategy

B1-Means of Warning and Escape

Horizontal Means of Escape



Two to sixth floors

Minimum Exit Requirements

Floor	Area	Estimated occupancy (persons)	Number of exits	Minimum exit width (mm)
Ground floor	Plant room	0	2	850
	Car park	32	2	850
1st floor	Car park	36	2	850
2nd to 6th floors	Car park	56	2	850
7th floor	Car park	36	2	850

Vertical Means of Escape

1. 30 minutes fire resistance of internal escape routs
2. Assisted evacuation of disabled people
3. Two protected staircases at opposing corners
4. Passenger lift

Estimated Occupancy

Floor	Use	Floor area (m^2) / no. of parking spaces	Floor space factor	Occupancy (persons)
Ground floor	Accessible parking	12 parking bays	2 persons/parking bay	24
	Normal parking	4 parking bays	2 persons/parking bay	8
	Plant room	n/a	n/a	0
First floor	EV parking	18 parking bays	2 persons/parking bay	36
Second floor	Normal parking	28 parking bays	2 persons/parking bay	56
Third floor	Normal parking	28 parking bays	2 persons/parking bay	56
Fourth floor	Normal parking	28 parking bays	2 persons/parking bay	56
Fifth floor	Normal parking	28 parking bays	2 persons/parking bay	56
Sixth floor	Normal parking	28 parking bays	2 persons/parking bay	56
Seventh floor	Normal parking	18 parking bays	2 people/parking bay	36
Total occupancy:				384

Research Method

Detailed Fire Safety Strategy

B2-Internal Fire Spread-Linings

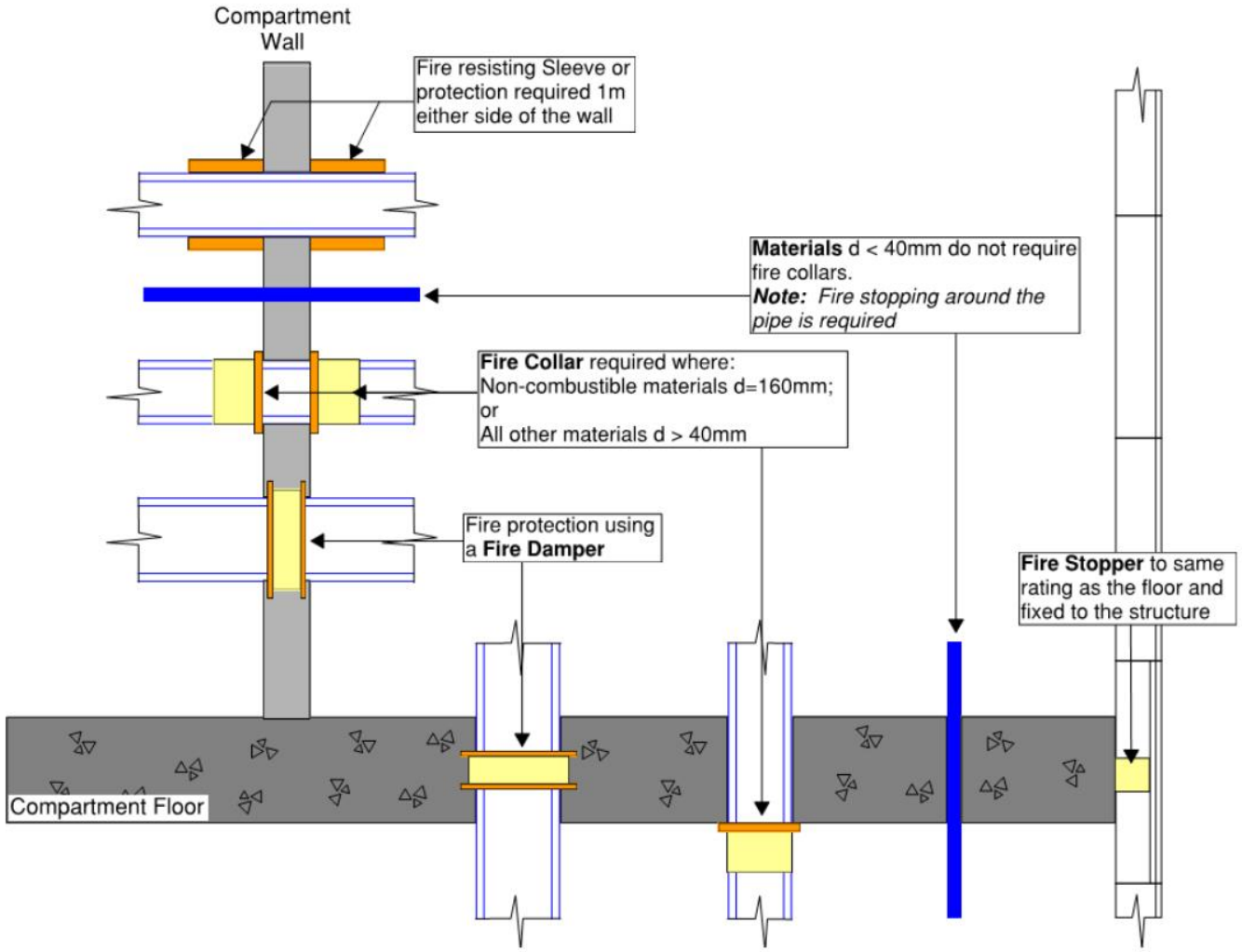
Internal walls and ceiling linings
→ Class A1 materials

B3-Internal Fire Spread-Structure

1. Building height of 17.5 m → 15 minutes structural fire resistance based on ADB

2. Protected staircase and lobbies→ 30 minutes structural fire resistance

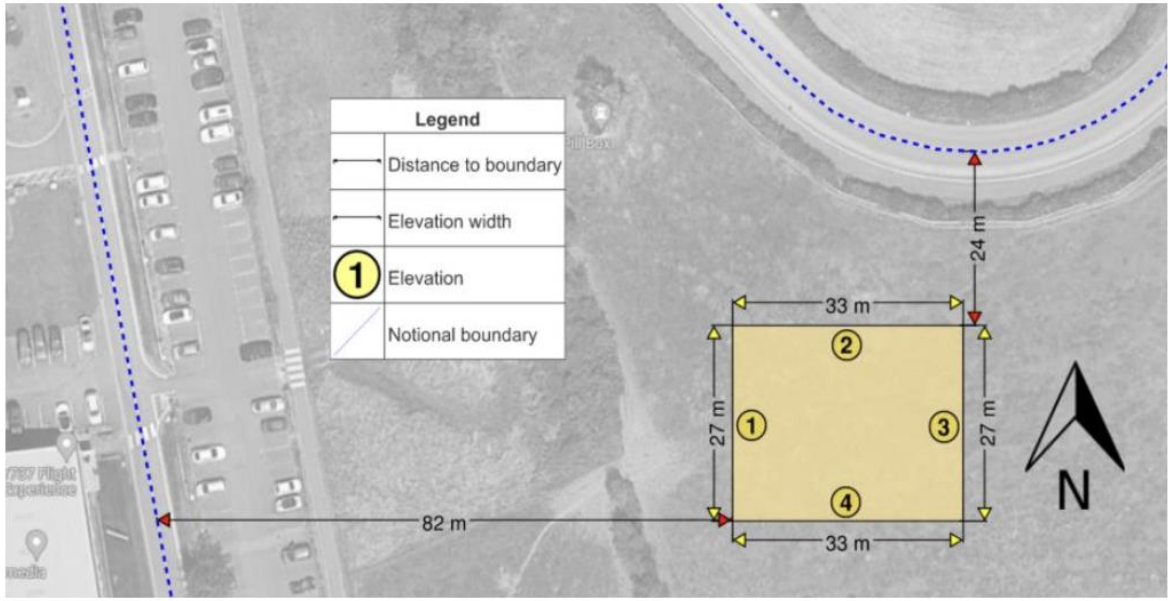
3. Penetrations and Fire stopping



Research Method

Detailed Fire Safety Strategy

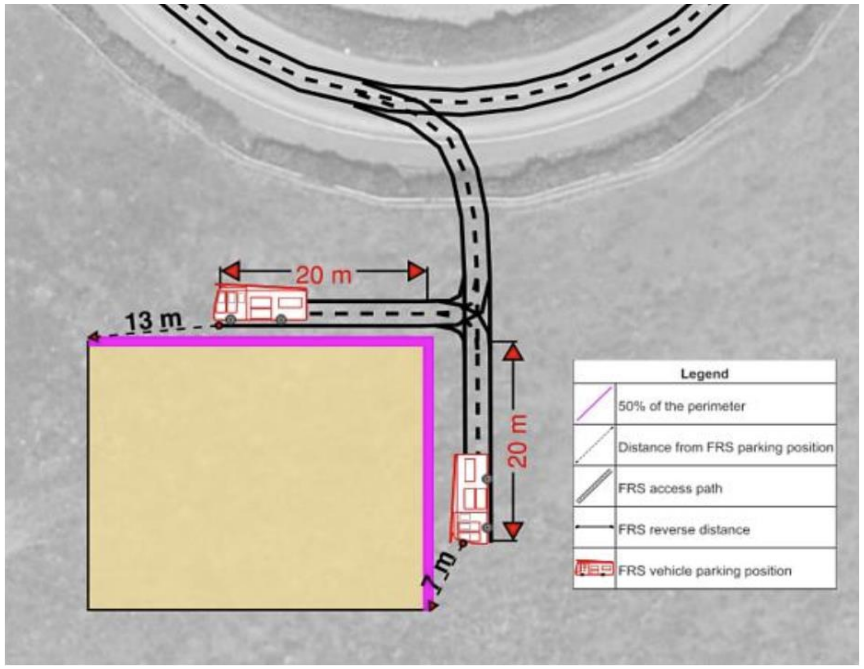
B4-External Fire Spread



Safe distance to the building based on BR 187

Elevation	Enclosing rectangle dimensions (m)		Sprinklers considered	Radiation intensity (kW/m^2)	Minimum distance to achieve 100% unprotected area (m)
	W	H			
1	27	17.5	No	84	14.4
2	33	17.5	No	84	15.8
3	27	17.5	No	84	14.4
4	33	17.5	No	84	15.8

B5-Access and Facilities for FRS



1. No automatic FRS notification

2. Hardstanding areas will be provided for a high reach appliance to within 18 m of a minimum of 50% of the buildings perimeter (resulting in access to at least 60 m of the perimeter)

Minimum access route specification	Appliance type	
	Pump	High reach
Width between kerbs (m)	3.7	3.7
Width between gateways (m)	3.1	3.1
Turning circle between kerbs (m)	16.8	26.0
Turning circle between walls (m)	19.2	29.0
Clearance height (m)	3.7	4.0
Carrying capacity (tonnes)	12.5	17.0

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Detailed Fire Safety Strategy

Gloucestershire Airport Overflow Car Park Cheltenham

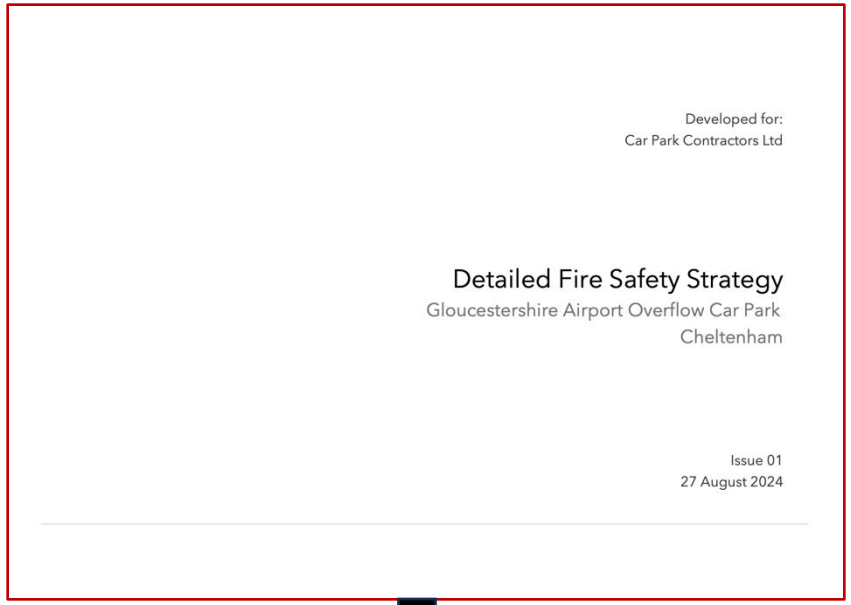
Part of building	Minimum fire resistance rating when tested to the relevant European standard (minutes)	Methods of exposure
Structural frame, beam or column	R 15	Exposed faces
Loadbearing walls	R 15	Each side separately
Floors	REI 15	From underside
Roofs: Performing the function of a floor	REI 15	From underside
External walls: Any part less than 1,000 mm from a point on the relevant boundary	REI 15	Each side separately
Any part more than 1,000 mm from the relevant boundary	REI 15	From the inside
Any part adjacent to an external escape route	RE 30	From the inside
Enclosure (not forming part of a protected shaft) to a: Protected stairway	REI 30	Each side separately
Lift shaft	REI 30	Each side separately
Enclosure to a protected lobby	REI 30	Each side separately
Note: In the European classification, the resistance to fire is specified in terms of loadbearing capacity 'R', integrity 'E' and insulation 'I'.		

Fire resistance is compliant with ADB, what about previous fire accidents with same design?

Research Method

- Buckinghamshire Fire Rescue and Service
- Cambridgeshire Fire Rescue and Service
- Essex County Fire Rescue and Service
- Hampshire and Isle of Wight Fire Rescue and Service
- London Fire Brigade
- Leicestershire Fire Rescue and Service
- National Fire Chiefs Council
- Bedfordshire Fire and Rescue Service
- North Yorkshire Fire and Rescue Service
- Scottish Fire and Rescue Service
- West Midlands Fire and Rescue Service
- Merseyside Fire and Rescue Service

Anonymous Review



12 UK Fire Services feedback on the Fire strategy

Research Method

ADB	Key Questions
B1	Is **evacuation** design satisfactory?
	Are **emergency Voice communications** (EVCs) efficient?
	Are **manual call points** (MCP) adequate?
B2 & B3	Is **30 minutes means of escape** fire protection adequate?
	Is **automatic suppression** system required?
	Is **15 minutes** structural fire protection?
B4	Are designed safe **separation distances** satisfactory?
B5	Is **water supply system** satisfactory?
	Is **applicable access** to and around the building provided?
EVs	Are there any further consideration required regarding **EVs**?

12 UK Fire Services Feedback?

Research Outcomes

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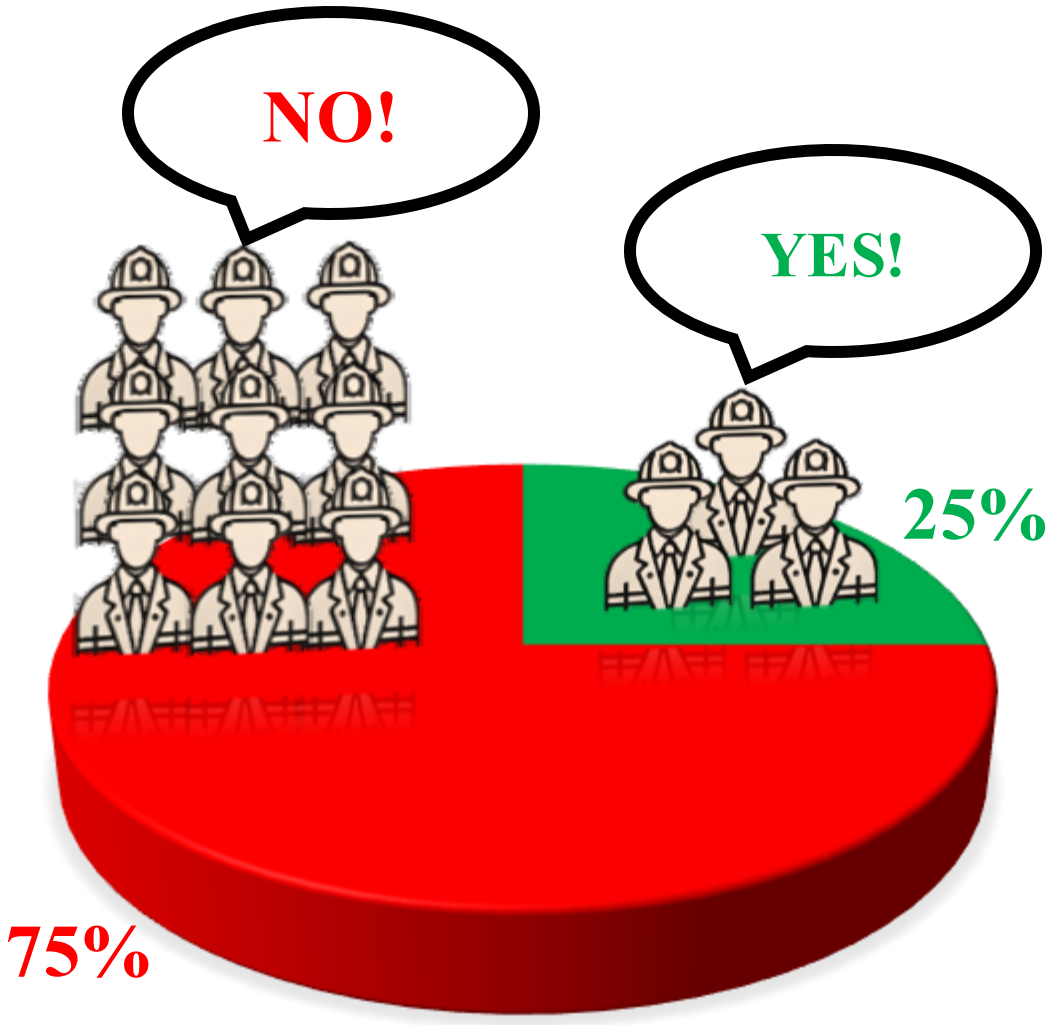
Is evacuation design satisfactory?



1. Evacuation Lift
2. Organized Evacuation of disabled people
3. Requirement for ASET/RSET Analysis

B1

Research Outcomes

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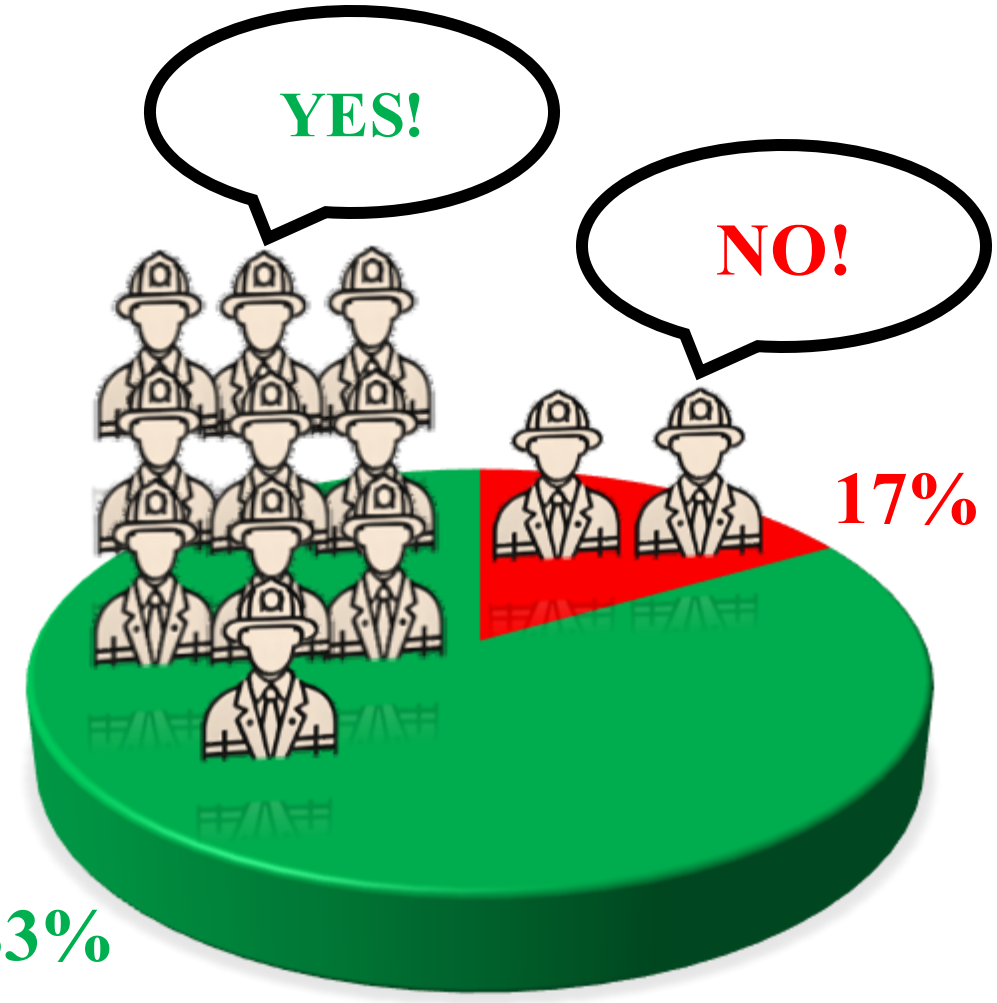
Are emergency Voice communications (EVCs) efficient?



Clarifying communication points management

B1

Research Outcomes

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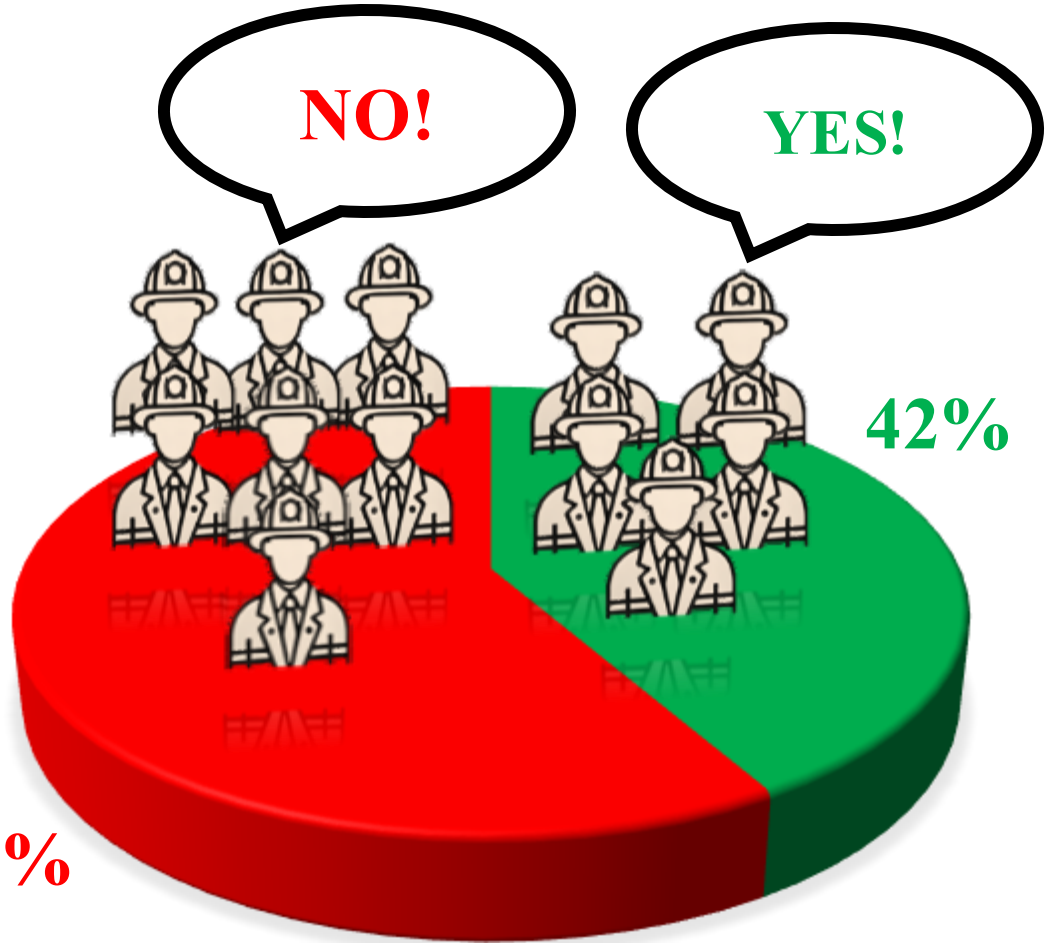
Are manual call points (MCP) adequate?



Requirement for automatic detection:

- Mobility degree variation
- EVs hazards

B1

Research Outcomes

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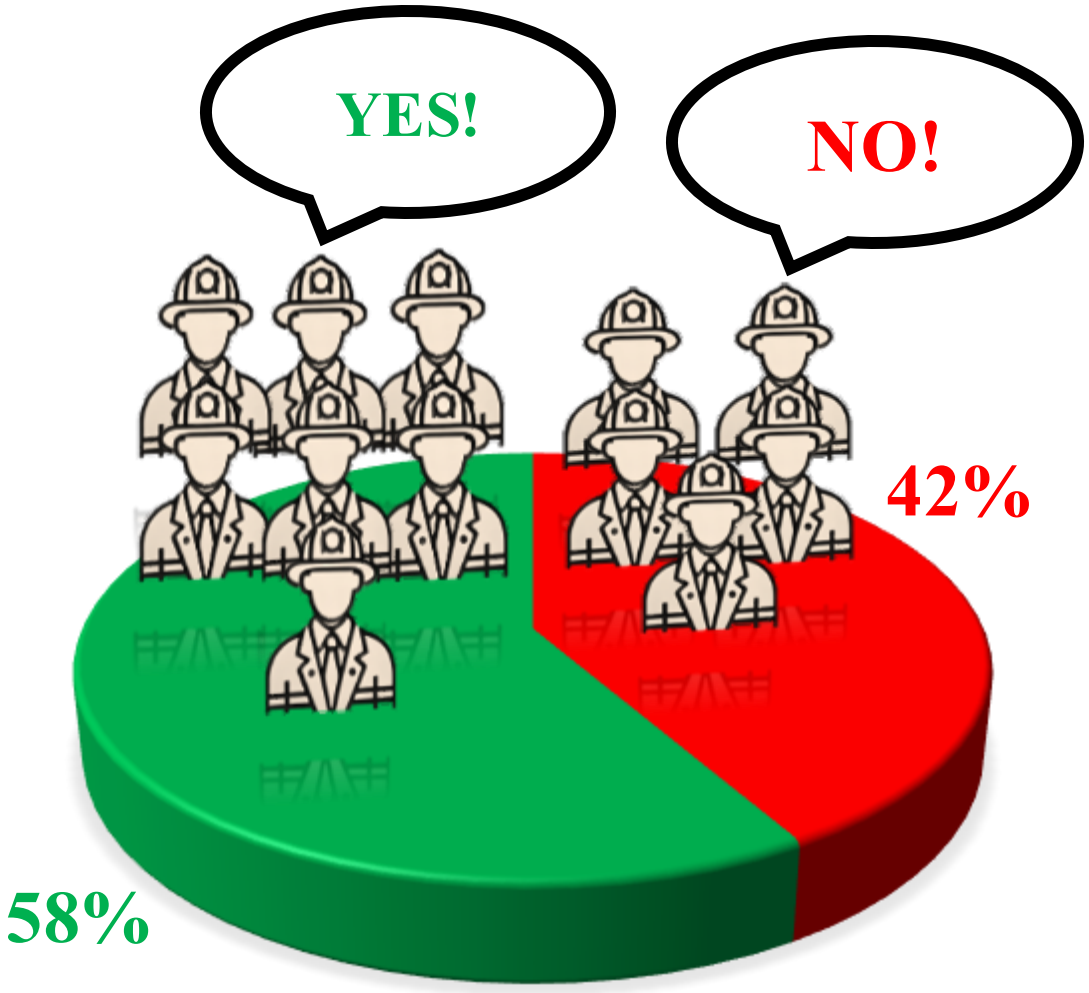
Is 30 minutes means of escape fire protection adequate?



1. Increased HRR of modern cars
2. Fuel running effect
3. Prolonged evacuation and firefighting condition
4. Fire Breaks as radiation barriers

B1

B2 & B3

Research Outcomes

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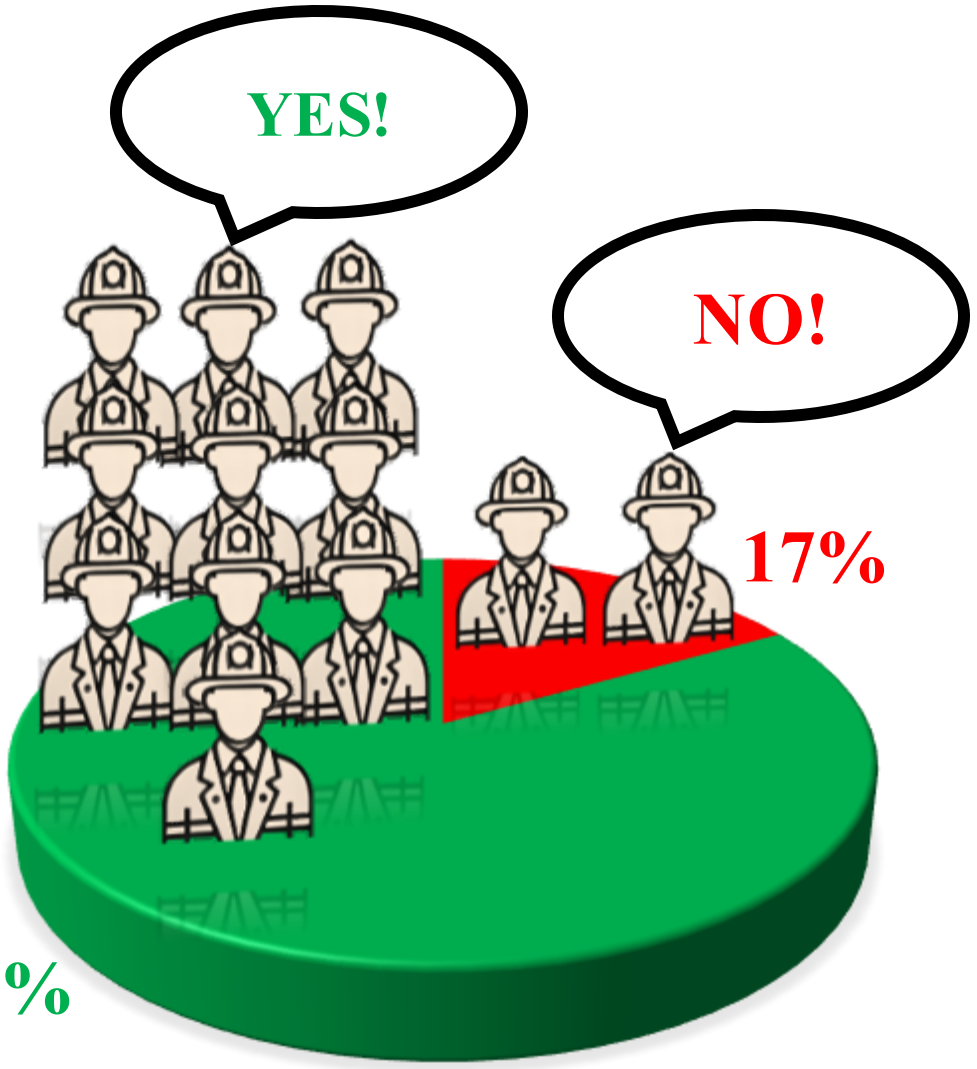
Is automatic suppression system required?



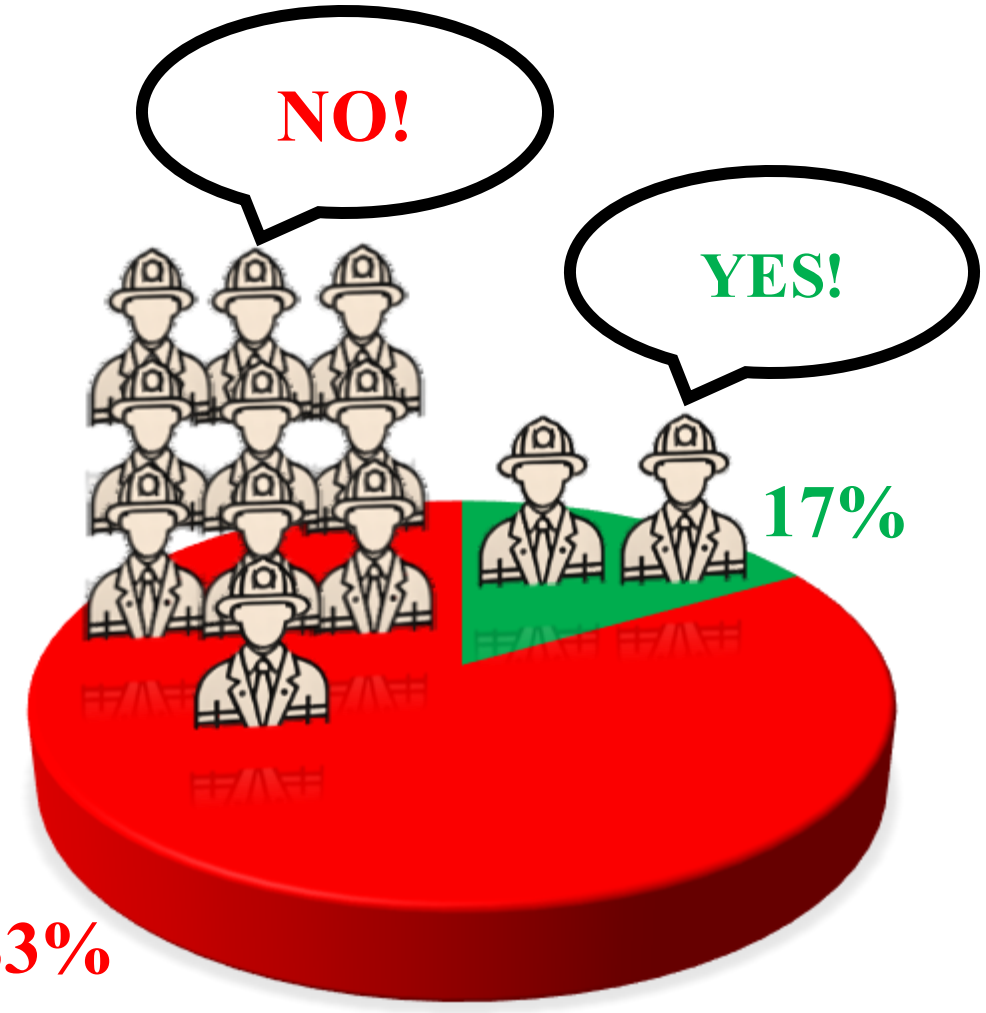
Controlling fire spread between **ICEVs** and **EVs** jet flames

B1

B2 & B3

Research Outcomes

Is 15 minutes structural fire protection?



1. "Fire load is NOT well-defined"
   - Modern cars with higher calorific value and larger in size
   - Unstaffed hours
2. FRS attendance prolonged duration

B1

B2 & B3

Research Outcomes

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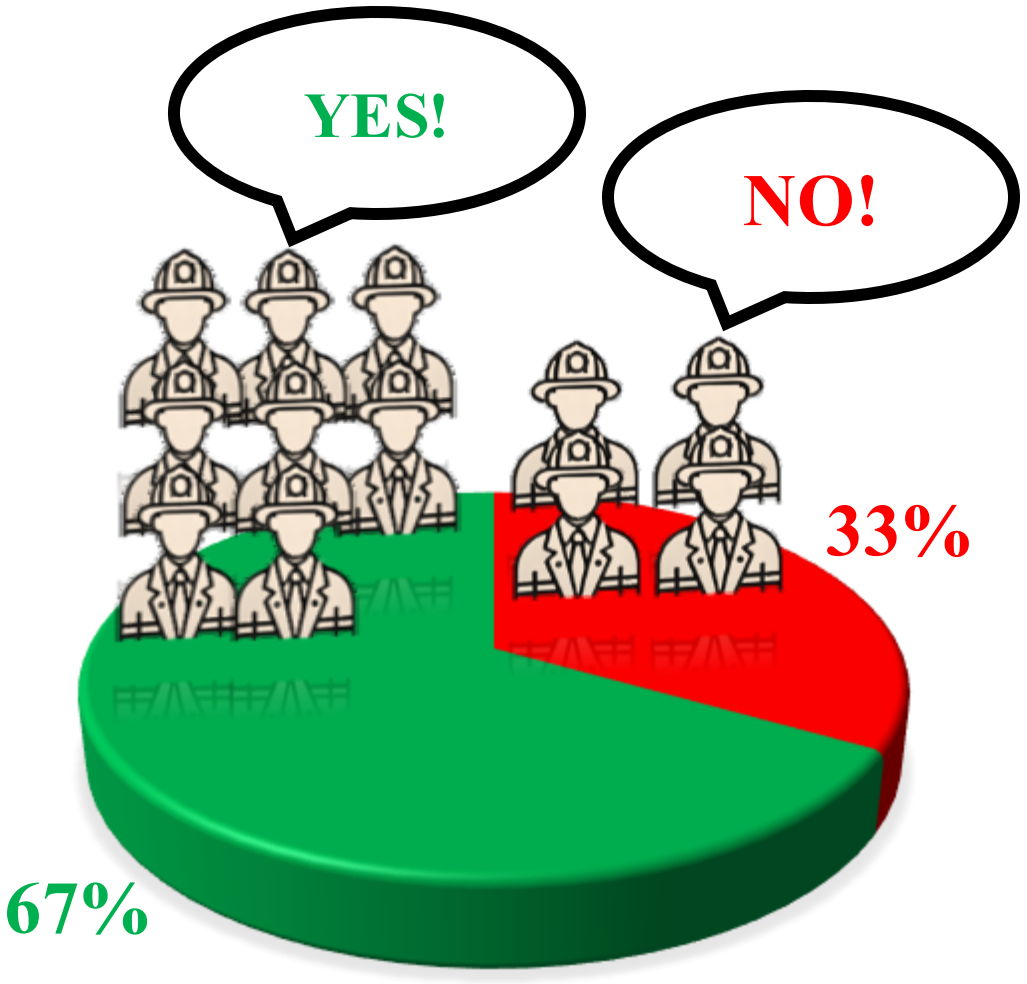
Are designed safe separation distances satisfactory?



Higher distance due to higher HRR

B1

B2 & B3

B4

Research Outcomes

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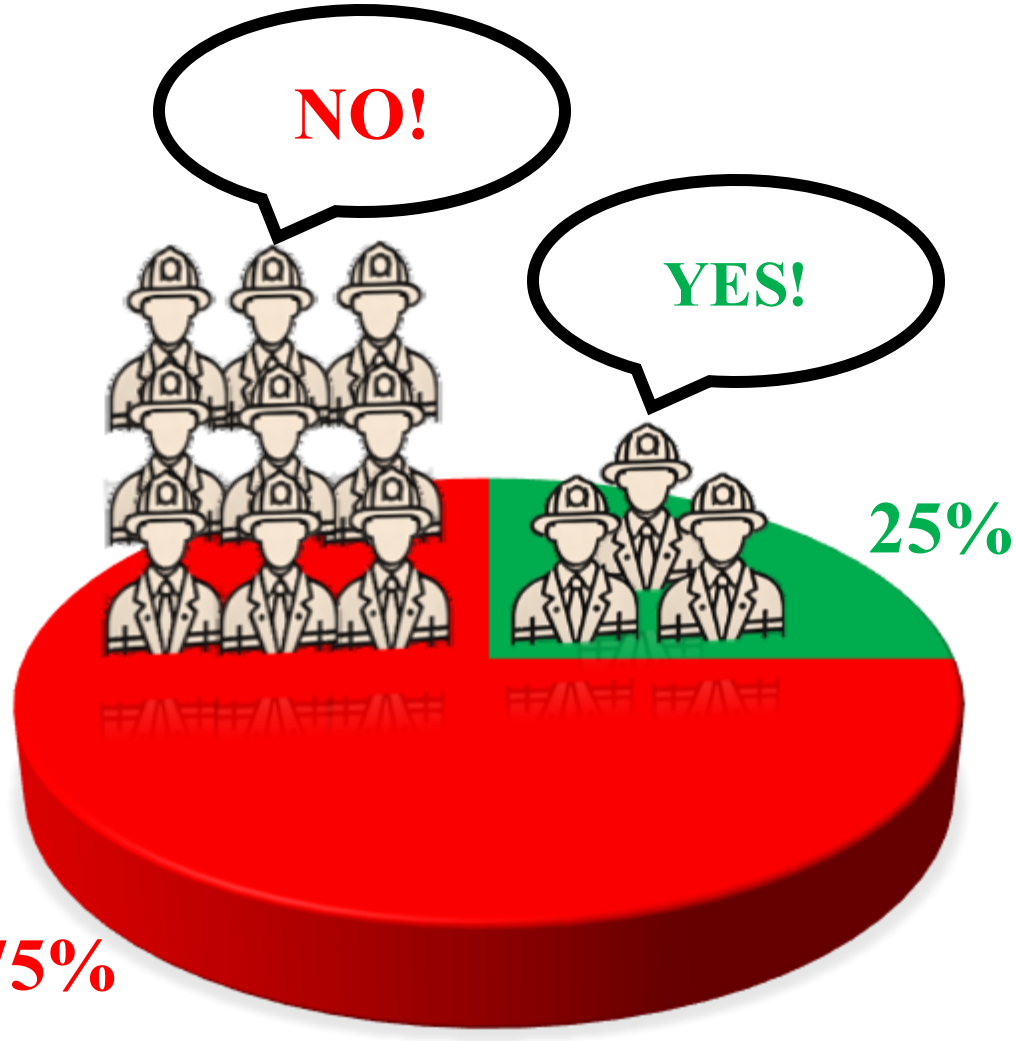
Is water supply system satisfactory?



1. Larger hose-run distance
2. Number of hydrants
3. Higher water flow rate

B1

B2 & B3

B4

B5

Research Outcomes

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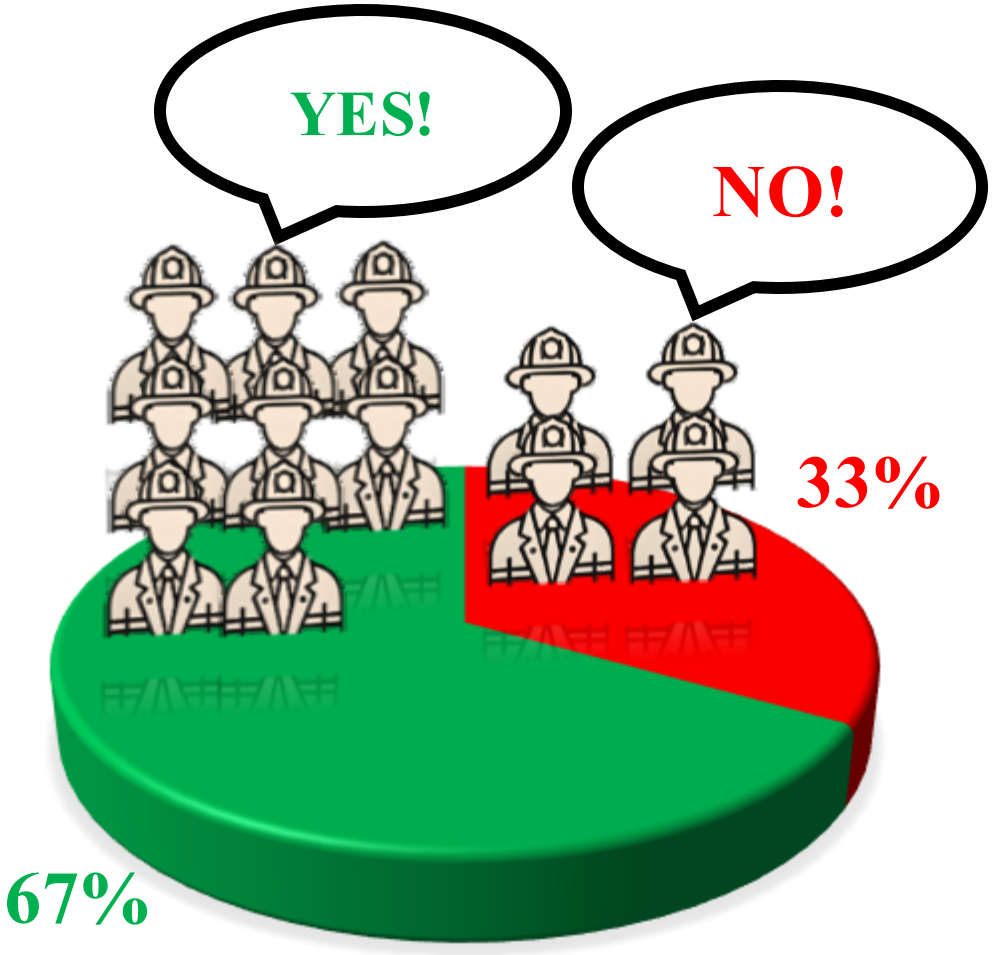
Is applicable access to and around the building provided?



Automatic doors opening

B1

B2 & B3

B4

B5

Research Outcomes

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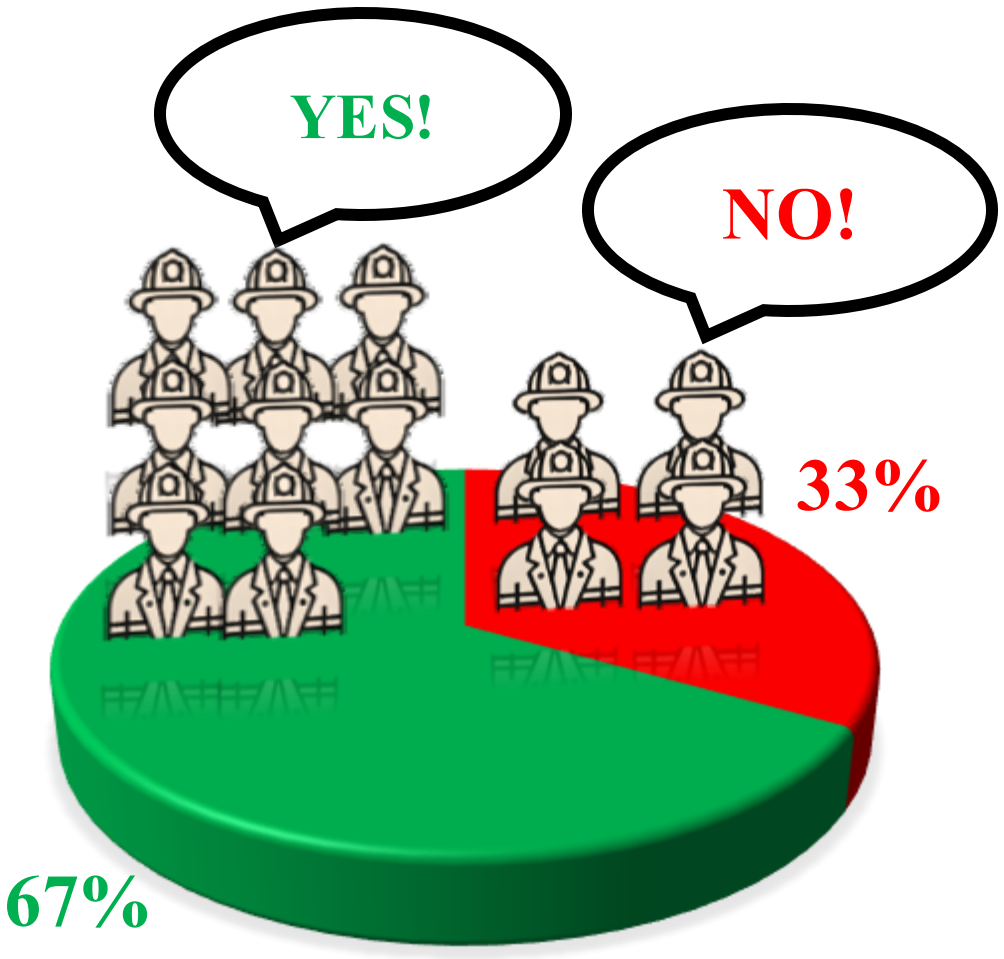
Are there any further consideration required regarding EVs?



1. **No relevant guidance** from ADB
2. **AWSS required** for horizontal jet flames control
3. **EVs placement** within the building?
4. **EVs toxic gas** production while burning
5. **EVCPs isolation** via detection/suppression system

B1

B2 & B3

B4

B5

EVs

Conclusion

B1:

- **9 Fire Services** recommended adjustments in **evacuation design** and some aligning with BS EN 81-76 and FSO guidance.
- **7 Fire Services** found **manual call points (MCPs)** inadequate, suggesting automated detection systems for first floor with EVs due to unsupervised hours.

B2 & B3:

- **5 Fire Services** called for increasing **escape route fire resistance from 30 mins** to higher ratings, especially for areas near to EVs due to their higher calorific value and prolonged burning.
- **15 mins structural fire resistance** was deemed insufficient, with **9 Fire Services** urging extensions to address modern vehicles increased fire loads.

B4:

- **4 Fire Services** recommended considering 84 kW/m2 radiation intensity due to presence of **EVs with higher calorific value.**

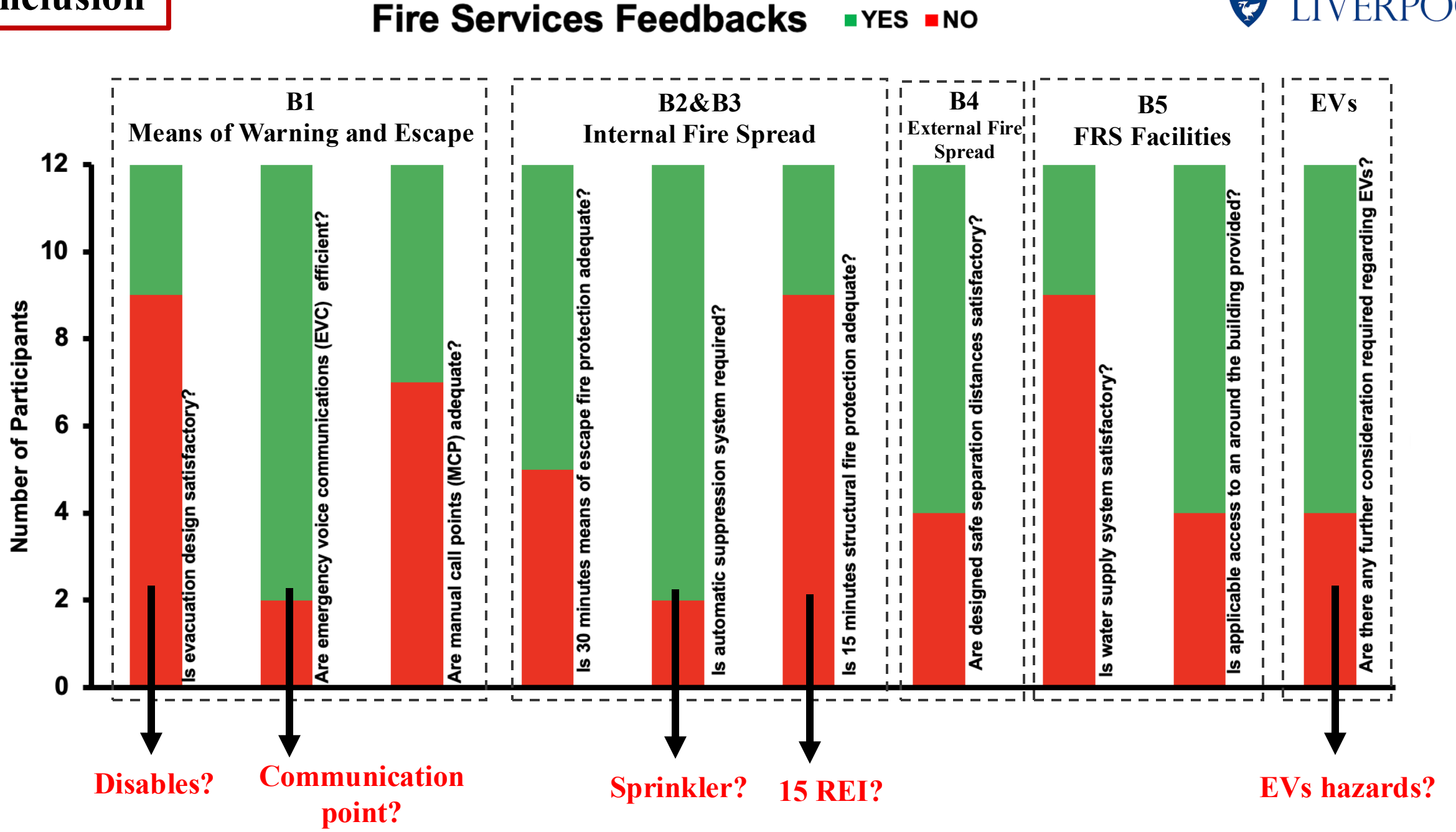
B5:

- **All Fire Services** sought improved **firefighting access**, including shafts, dry risers, and higher water flow rates.

EVs:

- **8 Fire Services** commented on suggestions including: **isolating charging point power supplies**, **relocating** EVs to upper floors targeting enhanced ventilation, and **increasing spacing between cars** to limit fire spread.

Conclusion


Fire Services Feedbacks
YES
NO
B1
Means of Warning and Escape
B2&B3
Internal Fire Spread
B4
External Fire Spread
B5
FRS Facilities
EVs
Number of Participants
0
2
4
6
8
10
12
Is evacuation design satisfactory?
Are emergency voice communications (EVC) efficient?
Are manual call points (MCP) adequate?
Is 30 minutes means of escape fire protection adequate?
Is automatic suppression system required?
Is 15 minutes structural fire protection adequate?
Are designed safe separation distances satisfactory?
Is water supply system satisfactory?
Is applicable access to an around the building provided?
Are there any further consideration required regarding EVs?
Disables?
Communication point?
Sprinkler?
15 REI?
EVs hazards?

Acknowledgements

Funding Bodies

UNIVERSITY OF LIVERPOOL

ASHTON | FIRE

UKRI Research England

Upcoming presentations

2025 SFPE EUROPEAN CONFERENCE & EXPO FIRE SAFETY ENGINEERING

9–10 APRIL 2025
EDINBURGH, UK

interflam 2025

About myself

UNIVERSITY OF LIVERPOOL

PhD student of Fire safety Engineering (July 2024-present)

Sharif University of Technology

MSc and BEng of Material Science and Engineering

Project title: "Design of car parks against fire: is the current guidance adequate?"

Supervisors: Dr Xu Dai, Dr Martina Manes and Dr Charlie Hopkin

In the next steps...

Numerical and experimental investigations for an open-sided car park case study

UNIVERSITY OF LIVERPOOL

ANY QUESTIONS?

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7th April 2025

Supervisors:
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