Fire Safety of Curtain Wall Facades

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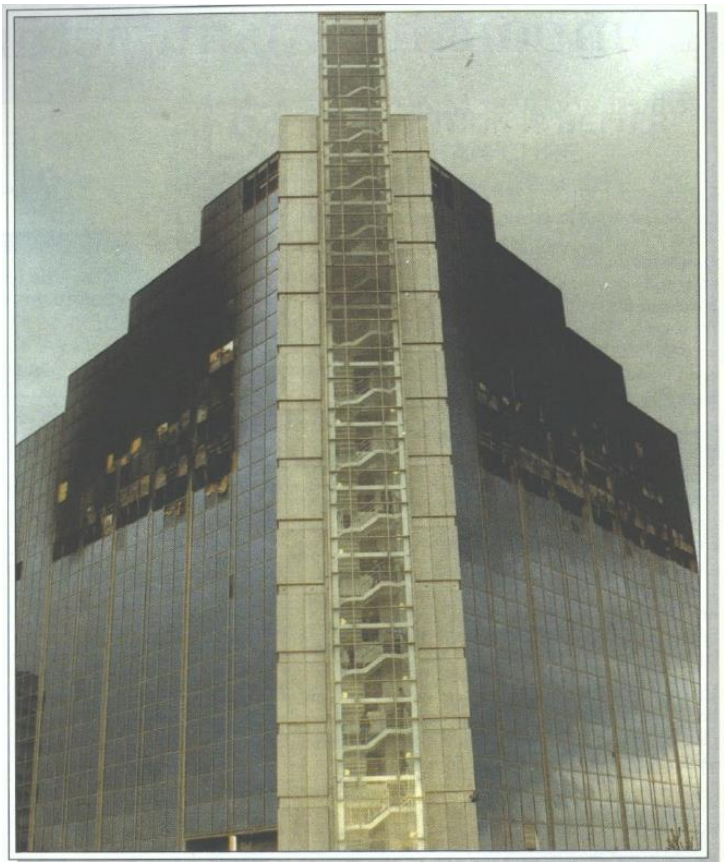
HISTORY OF CURTAIN WALL FIRES

One Meridian Plaza
Philadelphia, USA (1991)
Economic losses: $325 m

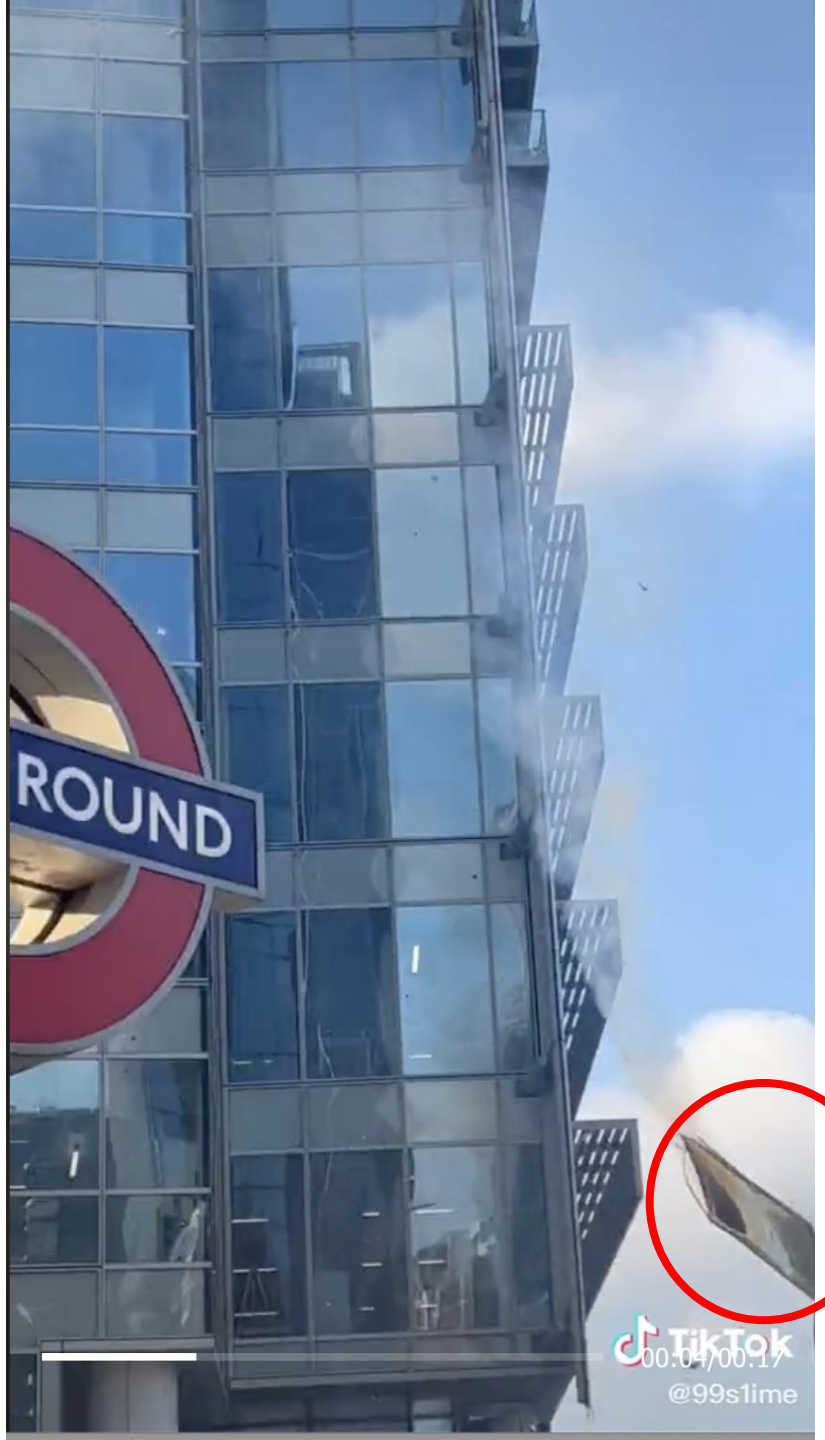


Mercantile credit building
Basingstoke, UK (1991)
Economic losses: $16 m

Office building
Bucharest, Romania (2011)

Lotus business park
Mumbai, India (2014)

Relay Building, London 2022

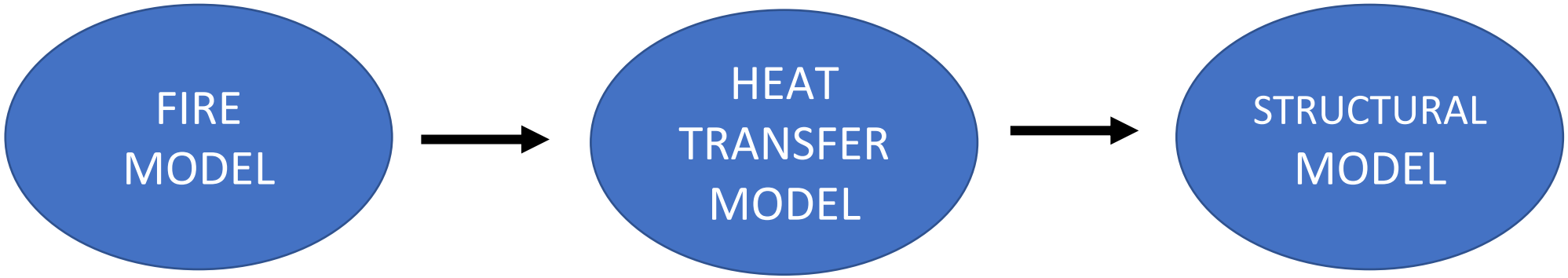


Technical Note on The Relay Building Fire

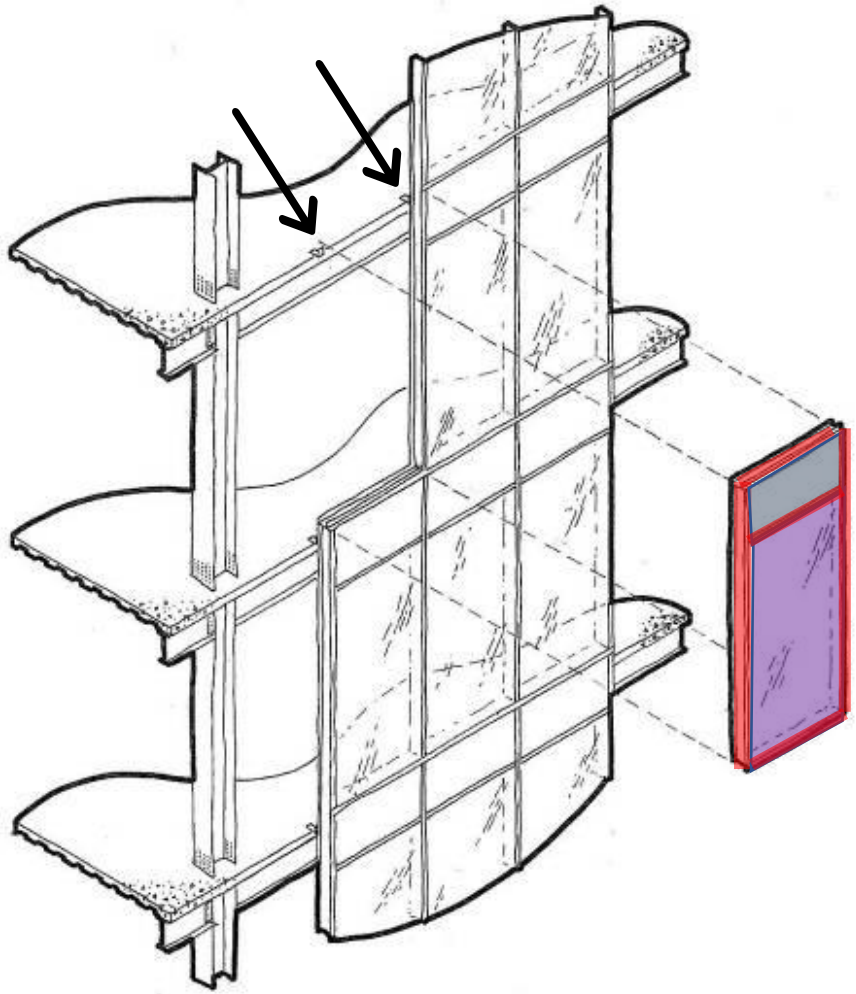
https://zenodo.org/record/6473162#.Y2proHZ_paQ

Understand and predict failure mechanisms

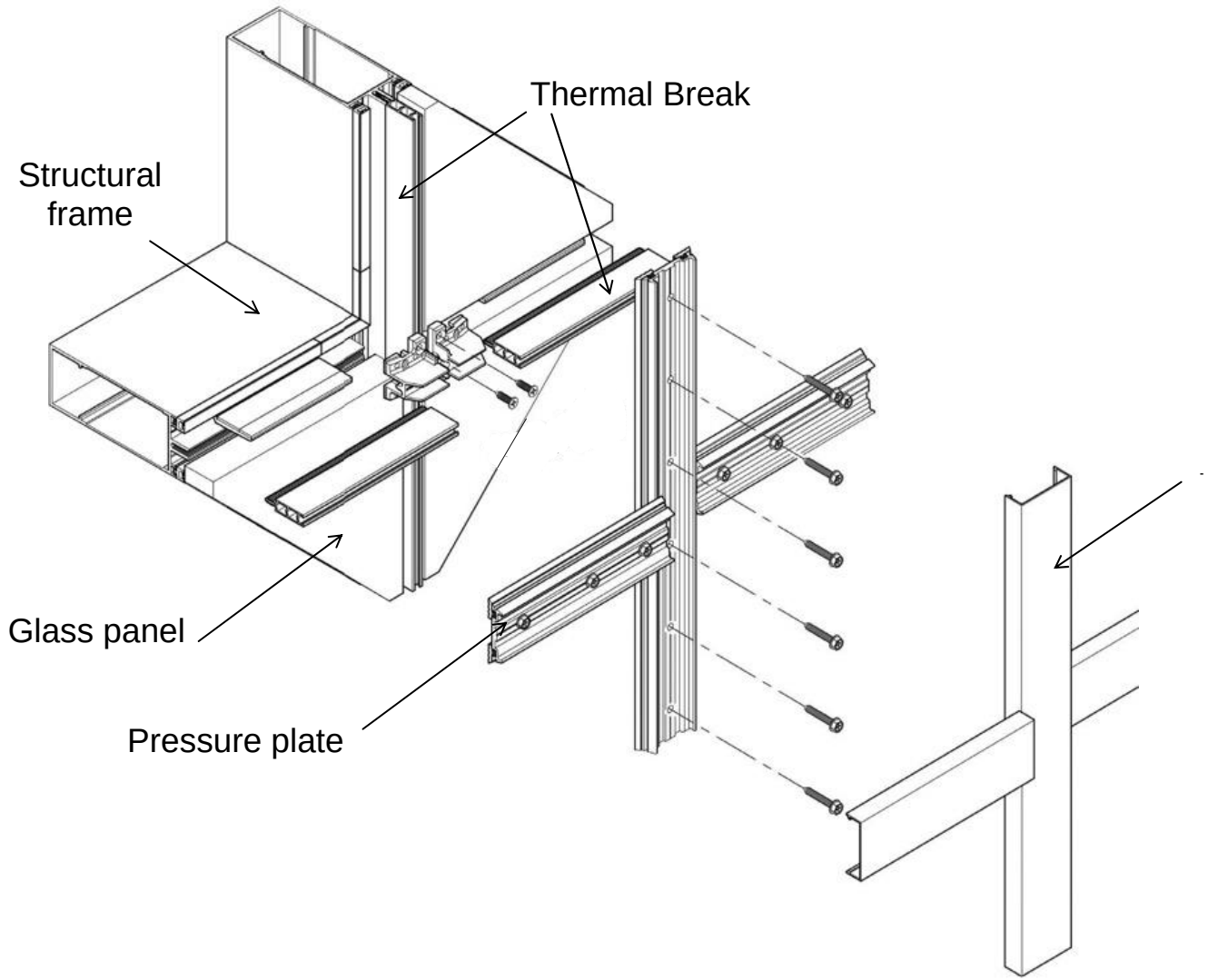
What can we do? Build a model !

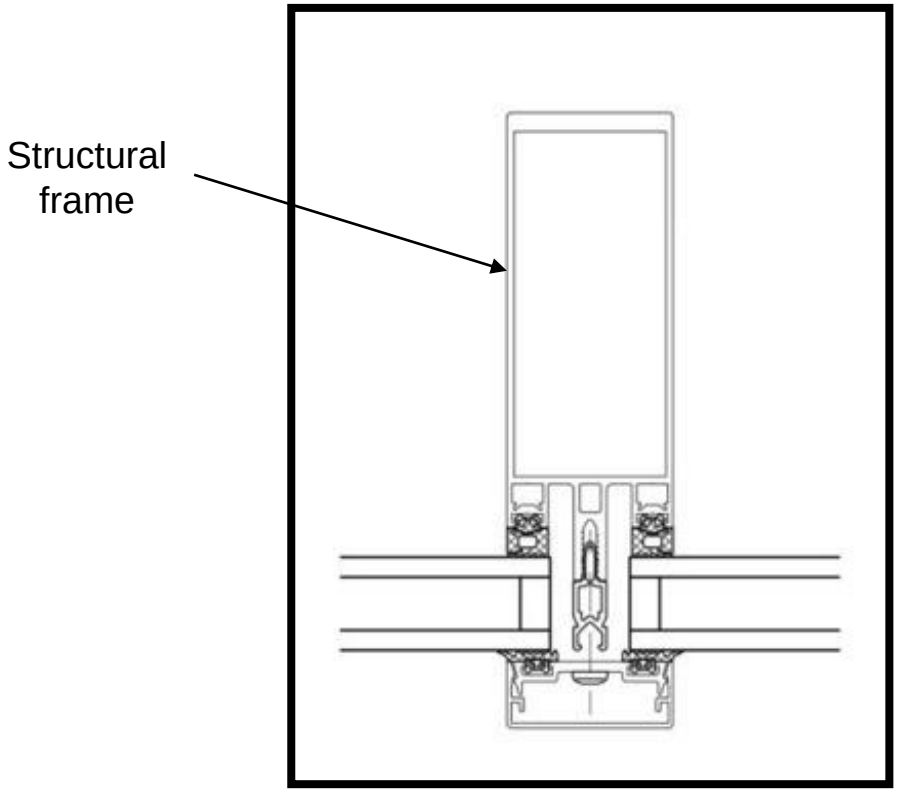


CURTAIN WALL SYSTEMS

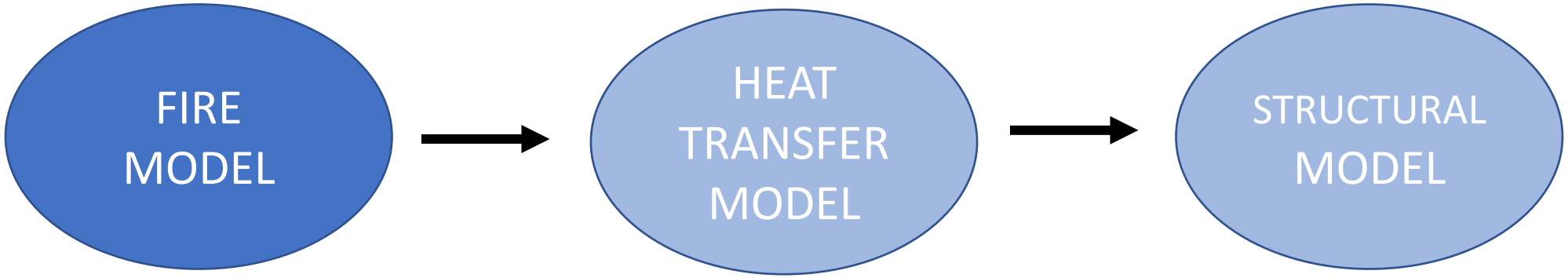


Frame components





section

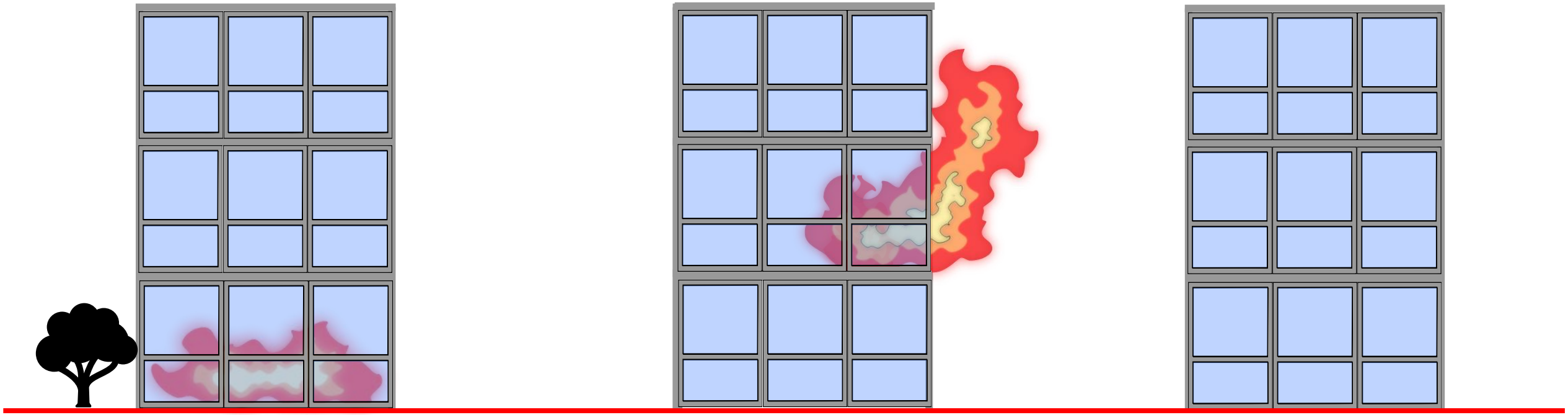

FIRE MODEL
HEAT TRANSFER MODEL
STRUCTURAL MODEL

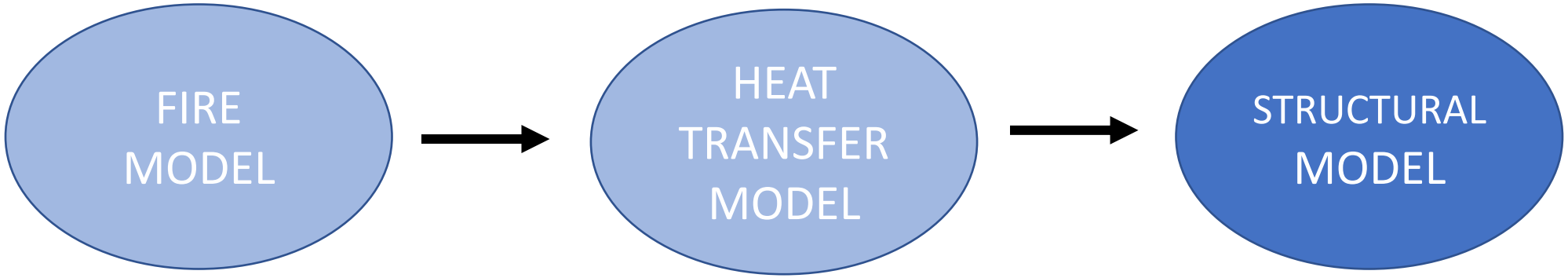
FIRE SCENARIOS

Compartment fire heating the inside of the facade

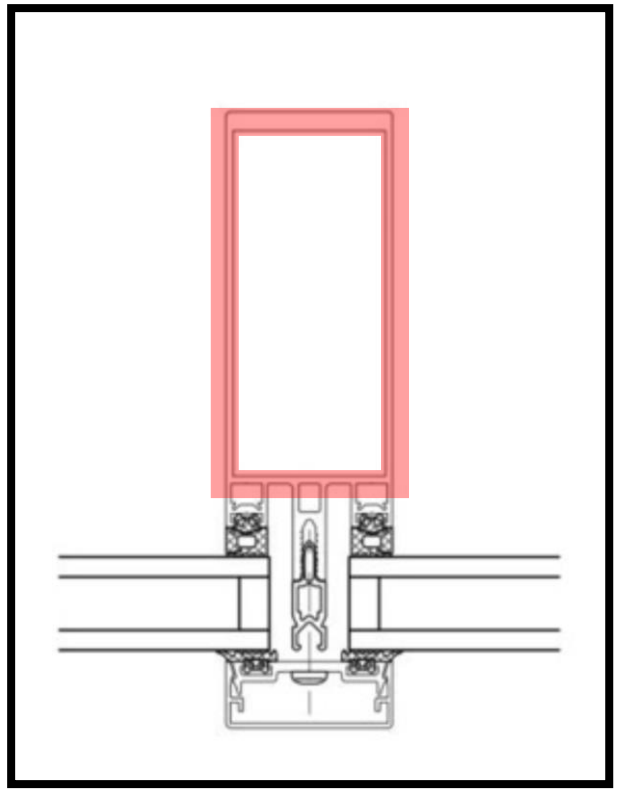
External fire in contact with facade

External fire at distance

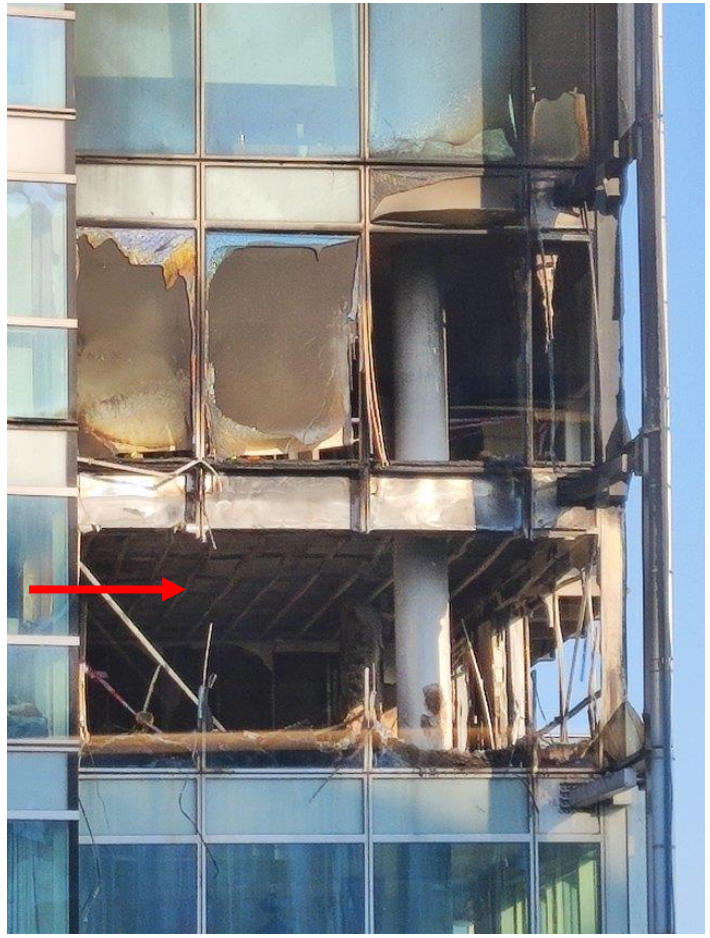



FIRE MODEL
HEAT TRANSFER MODEL
STRUCTURAL MODEL

Frame failure mechanisms



aluminium frame



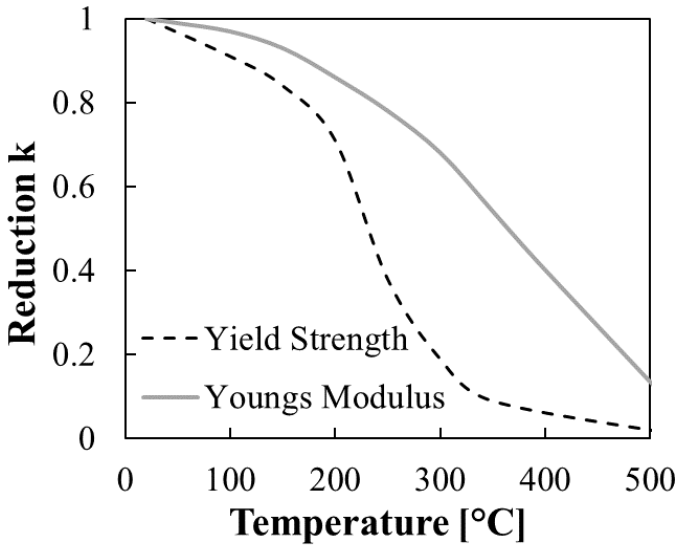
Lugaresi, F et al. (2022). Review of the mechanical failure of non-combustible facade systems in fire, Construction and Building Materials.

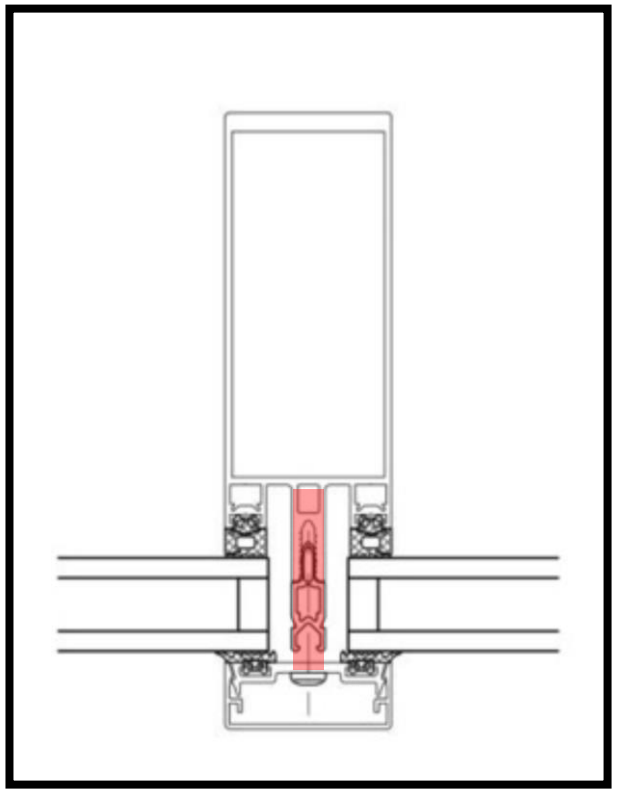
Frame failure mechanisms

Pressure lost → glass fall-out

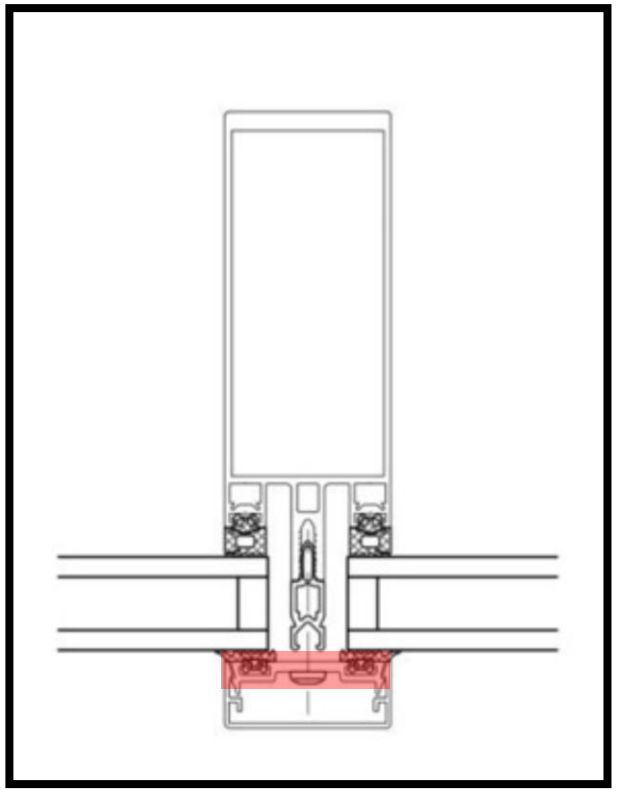
Complete thermal degradation:

- Polyamide – 260°C
- Aluminium – 600°C
- Stainless steel – 1500°C



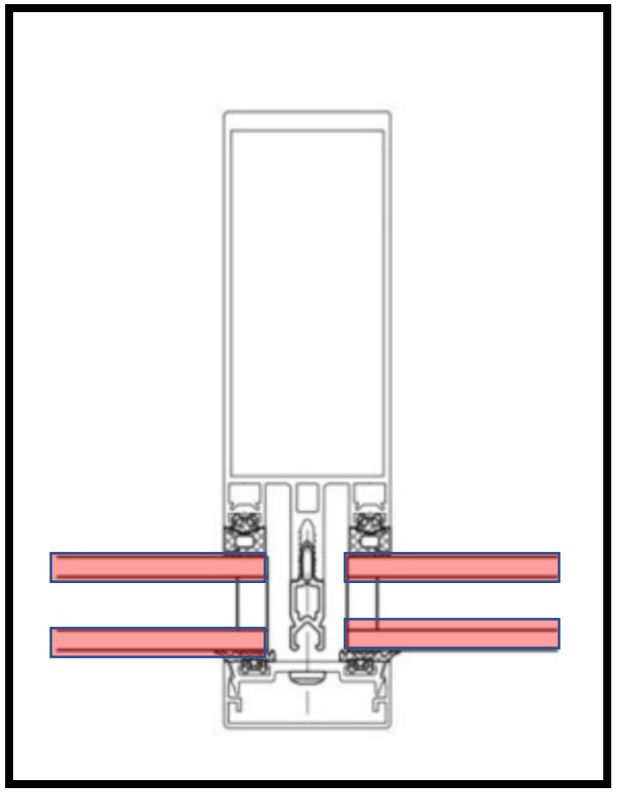


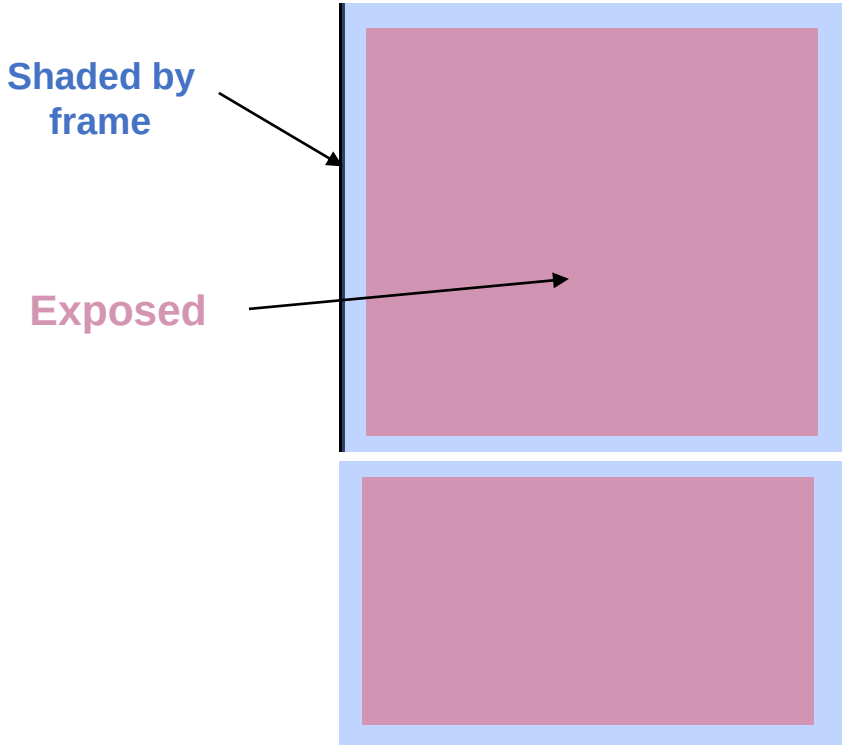
connector



pressure plate

Glass failure mechanisms



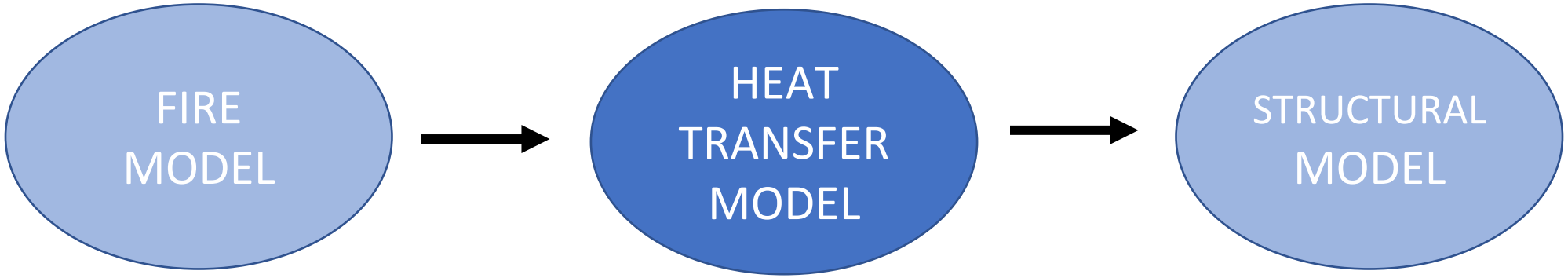


Brittle failure:

- thermal shock
- thermal stress due to differential heating

Laminated glass:

- delamination
- flammable


FIRE MODEL
HEAT TRANSFER MODEL
STRUCTURAL MODEL

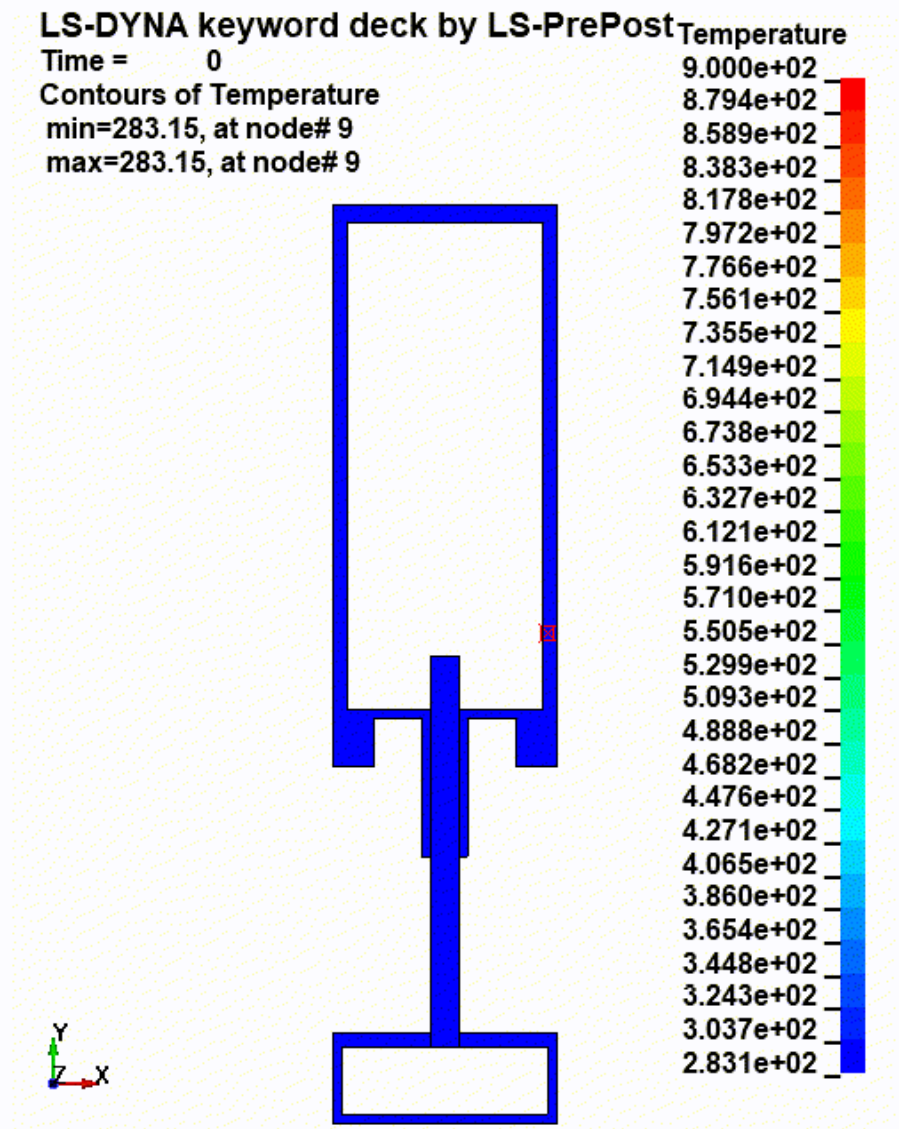
HEAT TRANSFER MODEL

Previous attempts have assumed a **uniform** temperature for the frame (0D model) or have not been validated.

By neglecting the gradients, we cannot predict thermal bowing, shift of the neutral axis and local effects.

Ls-dyna model

- 2D
- transient
- non-linear



Lugaresi, F., Kotsovinos, P., & Rein, G. (2021). Computational study on the thermal response of curtain wall systems exposed to fire. https://doi.org/10.14264/1d50302

BOUNDARY CONDITIONS

Heating radiation

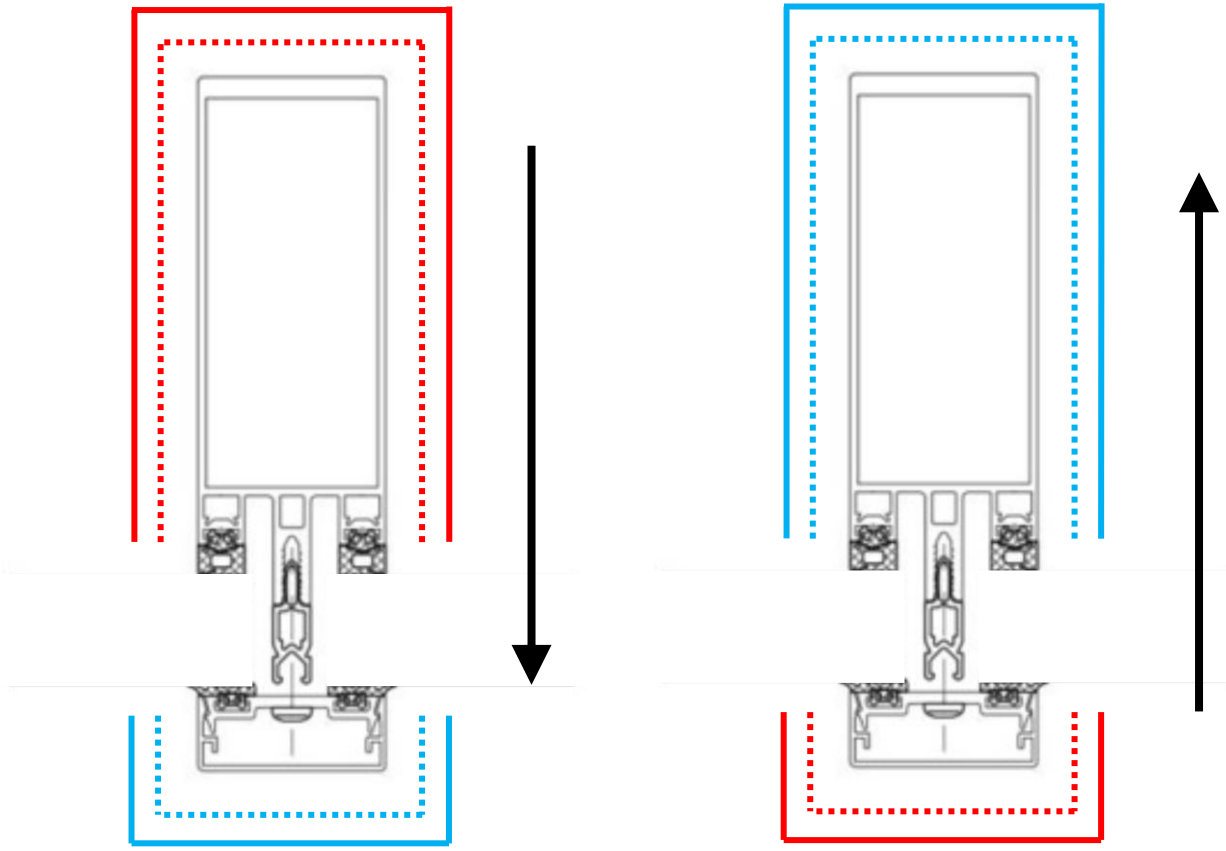
Heating convection

Cooling radiation

Cooling convection

Compartment fire

External fire



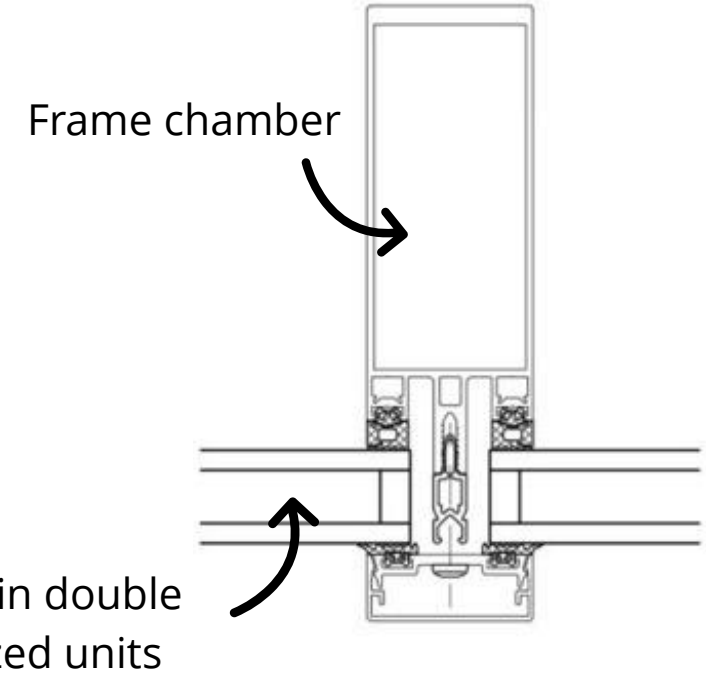
MODEL ASSUMPTIONS

Frame chambers

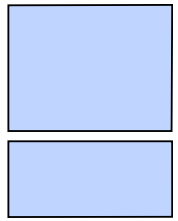
- Convection - air will flow inside the frame chamber.
- Radiation – internal walls of cavity will exchange heat

Gap in-between glass panes

- Conduction - air is near stationary



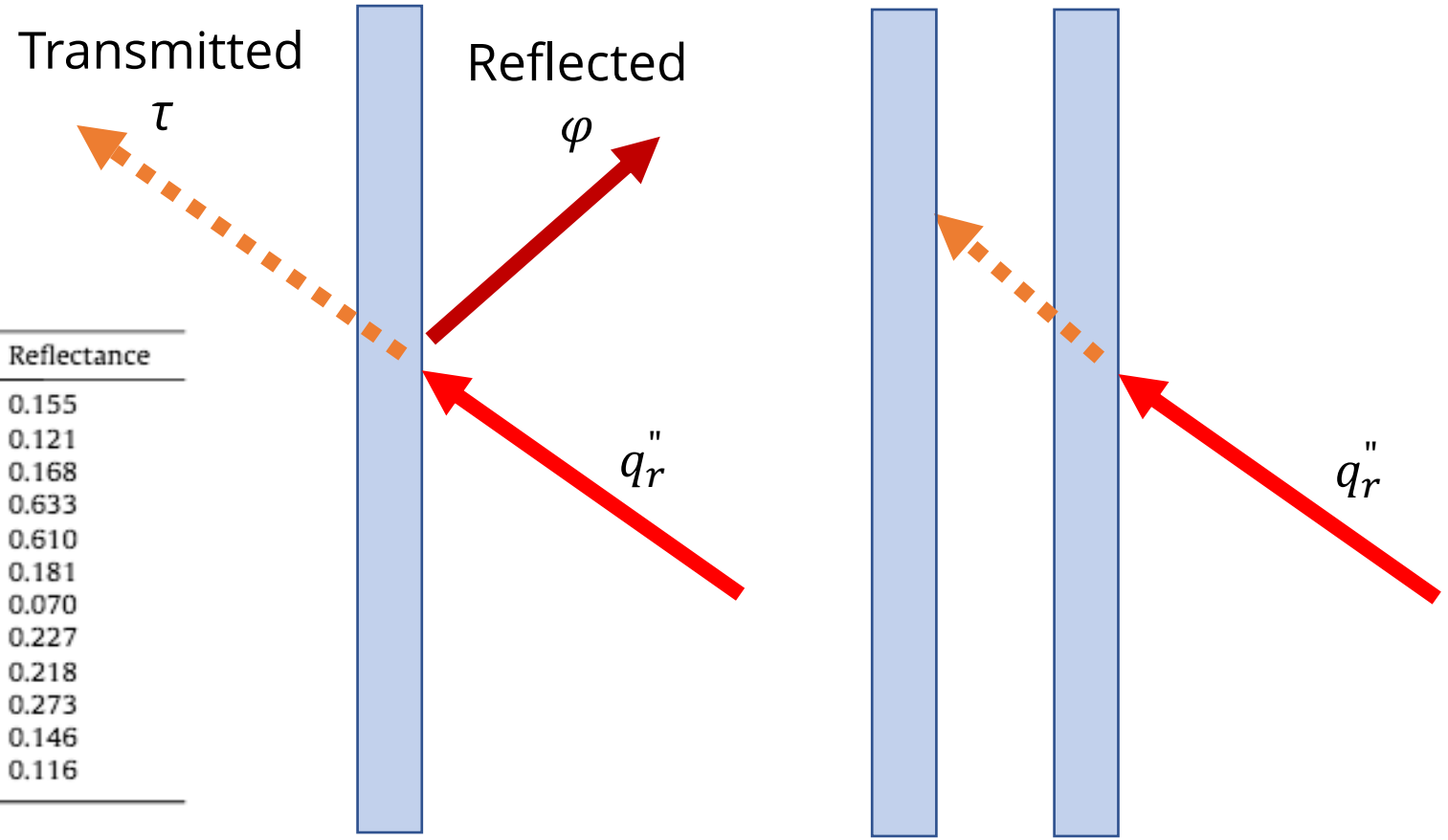
BOUNDARY CONDITIONS
SEMITRANPARENT MEDIUM AND RADIATION



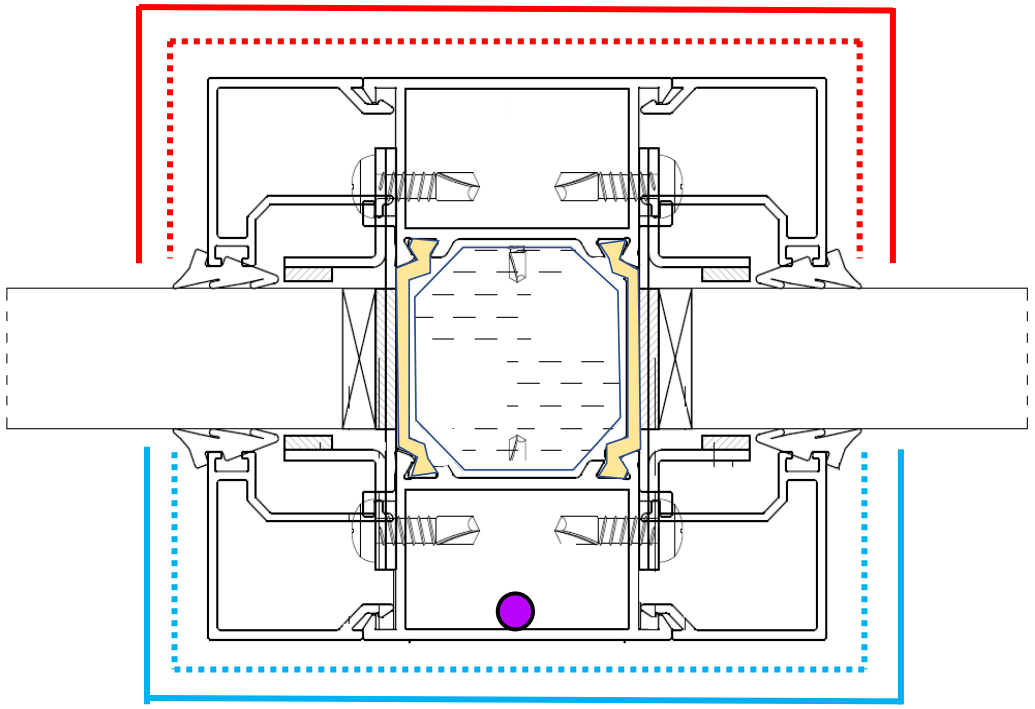
Glass panel

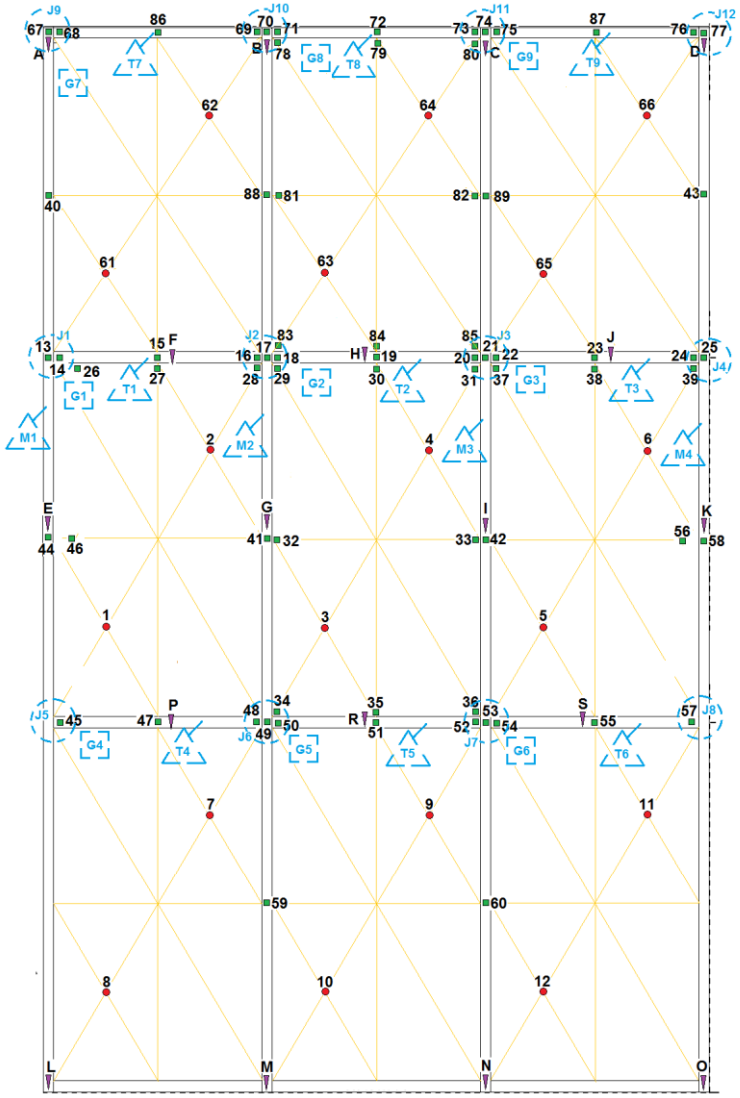
Specimen configuration	Absorptance	Transmittance	Reflectance
6	0.583	0.263	0.155
10	0.629	0.250	0.121
15	0.657	0.175	0.168
6 low-E 1	0.304	0.063	0.633
6 low-E 2	0.326	0.064	0.610
6106.2 PVB	0.732	0.087	0.181
6106.4 PVB 1	0.876	0.055	0.070
6106.4 PVB 2	0.730	0.043	0.227
6106.4 PVB 3	0.747	0.035	0.218
6106.4 PVB 4	0.669	0.059	0.273
6106 SG 1	0.813	0.041	0.146
6106 SG 2	0.715	0.037	0.116

Debuyser et al. CBM, 2017.



MODEL VALIDATION





○ **Thermocouple**

CONCLUSIONS

- Understanding the fire behavior of **curtain walls** is important for life safety, property protection and compartmentalization.
- Both compartment and external fires must be considered.
- The failure can be predicted ONLY by taking into account the thermal and mechanical response .

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